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Architecture Catalyzing Sustainable Low-Income Housing for SDG-11 in Nigeria

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Abstract This paper seeks to link architecture with sustainable low-income housing in Nigeria, addressing the housing deficit and poverty rate in line with SDG-11. It conducts a systematic review of 52 articles covering 14 years (2009-2022) to analyze sustainable housing and architectural strategies. Using descriptive statistics, thematic analysis, and meta-analysis, it finds that architecture can promote sustainable low-income housing across environmental, social, economic, cultural, institutional, and technological factors. Key architectural strategies include bioclimatic design, vernacular architecture, passive solar design, renewable energy, energy efficiency, low-carbon materials, water conservation, waste management, community participation, affordability, accessibility, and cultural sensitivity. The paper discusses the implications and concludes with recommendations and future research directions.

Keywords Sustainable housing practices, Low-income communities, Nigeria, SDG-11, Systematic review

1. Introduction

Housing, a fundamental human right, is crucial for sustainable development (UN-Habitat, 2016). Developing countries, particularly in Africa, face housing challenges like deficit, quality, affordability, accessibility, and sustainability (Abdullahi, 2021; Ibem *et al.*, 2011; Jolaoso *et al*., 2012; Ademiluyi, 2010; Ahmed & Sipan, 2019). Nigeria, Africa's most populous and urbanized nation with 211 million people and a 51% urbanization rate (World Bank, 2020), grapples with a staggering housing deficit of around 22 million units. Annually, only 100,000 units meet low-income housing needs (Stanaszek-Tomal, 2020; Mohammed *et al.*, 2015). A high poverty rate of 40% further affects 83 million people (Jolaoso *et al.*, 2012; Ademiluyi, 2010).

Low-income housing in Nigeria exhibits substandard quality, inadequate infrastructure, environmental degradation, and social marginalization (Adeogun & Taiwo, 2011; Olotuah & Bobadoye, 2009; Harpham & Boateng, 1997; Agbola & Agunbiade, 2009; Kavishe, 2019). Urbanization, population growth, climate change, and resource scarcity worsen these issues (Ganiyu *et al*., 2017; Akande *et al.*, 2015; Daramola & Ibem, 2010). To achieve Sustainable Development Goal 11, making cities inclusive, safe, resilient, and sustainable, sustainable housing practices must be enhanced for low-income communities in Nigeria.

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Sustainable housing practices involve applying sustainable architecture and design principles to create environmentally friendly, socially responsible, and economically viable low-income housing (Akadiri, 2012). Sustainable architecture and design aim to harmonize buildings with nature and human needs (Kazimee, 2009). These practices address various factors influencing sustainable housing for low-income communities in Nigeria: environmental (climate change adaptation and mitigation), social (community participation and empowerment), economic (affordability and cost-effectiveness), cultural (vernacular architecture and cultural sensitivity), institutional (policy and governance), and technological (innovation and appropriate technology) (Ezezue *et al.*, 2015; Osuizugbo *et al*., 2020; Emmanuel, 2012).

This paper systematically reviews sustainable housing practices and architectural design strategies for low-income communities in Nigeria, bridging the gap between architecture and sustainable low-income housing. Following PRISMA guidelines (Moher *et al*., 2009), it covers 14 years (2009-2022), utilizing descriptive statistics, thematic analysis, and meta-analysis methods to address:

What are the factors influencing sustainable housing practices for low-income communities in Nigeria?

What are the common and effective architectural design strategies for sustainable low-income housing in Nigeria?

The paper is organized as follows: Section two presents the methodology of the systematic review. Section three reports the results of the descriptive statistics and thematic analysis. Section four discusses the benefits, challenges, gaps, and implications of the architectural design strategies for stakeholders and concludes with recommendations and future research directions.

2. Literature Review

The literature review encompasses three core areas: sustainable housing concepts, factors influencing such practices in Nigerian low-income communities, and architectural strategies for sustainable low-income housing.

2.1. The Concept and Dimensions of Sustainable Housing

Sustainable housing is a multifaceted concept defined by UN-Habitat (2016) as housing that aligns with environmental, social, and economic sustainability, addressing climate challenges. Akadiri (2012) similarly characterizes it as environmentally friendly, socially responsible, and economically viable housing. These definitions highlight the need for a balanced approach across design, construction, operation, and maintenance.

These dimensions are categorised as environmental, social, economic, and cultural (Blanche *et al*., 2016; Oyebode, 2018; Emmanuel, 2012).

i. **Environmental Dimension:** The environmental dimension concerns housing's environmental impact, striving for minimal negative effects while enhancing positive impacts. It encompasses reducing emissions, improving air quality, increasing energy efficiency, promoting water conservation, using local materials, optimizing land use, preserving natural habitats, and adapting to climate change (UN-Habitat, 2016; Fakere & Ayoola, 2018; Kazimee, 2009).

ii. **Social Dimension:** The social dimension focuses on residents' well-being, fostering community cohesion and inclusion. It encompasses health, safety, comfort, accessibility, security, participation, diversity, equity, identity, education, culture, and heritage (UN-Habitat, 2016; Akadiri, 2012; Kazimee, 2009).

iii. **Economic Dimension:** The economic dimension addresses housing's affordability and viability for both providers and users. It seeks cost-effectiveness, considering initial investment, operational, lifecycle costs, benefits, income generation, employment, and market dynamics (UN-Habitat, 2016; Usman & Abbullah, 2018; Kazimee, 2009).

iv. **Cultural Dimension:** The cultural dimension respects local culture, values, and aesthetics. It embraces vernacular architecture, cultural sensitivity, indigenous knowledge, artistic expression, spirituality, and symbolism (UN-Habitat, 2016; Aghimien *et al.*, 2018; Kazimee, 2009).

These dimensions are interconnected, requiring holistic and context-specific integration. However, trade-offs often emerge, necessitating a multi-stakeholder approach involving policymakers, providers, users, and relevant parties to balance these dimensions in sustainable housing development (UN-Habitat, 2016; Fakere & Ayoola, 2018).

2.2. Factors Influencing Sustainable Housing Practices for Low-Income Communities in Nigeria

Sustainable housing for low-income communities in Nigeria is influenced by six main categories of factors: environmental, social, economic, cultural, institutional, and technological. These factors, as discussed below, play crucial roles in shaping sustainable housing practices (Ganiyu *et al*., 2017; Akande *et al.*, 2015; Daramola & Ibem, 2010; Makinde, 2014; Olotuah & Bobadoye, 2009; Harpham & Boateng, 1997; Agbola & Agunbiade, 2009; Rahmouni & Smail, 2020; Ahlborg & Sjöstedt, 2015; Ibem & Amole, 2013; Ademiluyi, 2010; Gan *et al.*, 2017; UN-Habitat, 2016; Usman & Abbullah, 2018; Kazimee, 2009).

i. **Environmental Factor:** Environmental factors encompass aspects related to the natural environment, including climate change adaptation and mitigation measures, improvements in air quality, resilience to extreme weather events, and biodiversity conservation (Gan *et al*., 2017; Aghimien *et al*., 2018; Abbakyari & Taki, 2017; Daramola & Ibem, 2010).

ii. **Social Factor:** Social factors are vital for the well-being of both housing occupants and the surrounding community. These factors involve health and safety measures, comfort and convenience enhancements, accessibility and mobility improvements, security and privacy provisions, participation and empowerment strategies, diversity and equity considerations, and identity and belonging fostering (Makinde, 2014; Olotuah & Bobadoye, 2009; Harpham & Boateng, 1997; Agbola & Agunbiade, 2009; Kavishe, 2019).

iii. **Economic Factor:** Economic factors are essential for the financial feasibility of housing projects for both providers and users. These factors encompass affordability measures, cost-effectiveness strategies, lifecycle cost optimization, income generation opportunities, employment creation initiatives, value addition endeavours, and market demand and supply assessments (Rahmouni & Smail, 2020; Mohammed *et al.*, 2015; Ibem & Amole, 2013; Ademiluyi, 2010; Ahmed & Sipan, 2019).

iv. **Cultural Factor:** Cultural factors are linked to local culture and traditions, influencing housing development through vernacular architecture, cultural sensitivity, indigenous knowledge integration, artistic expression, spiritual significance acknowledgement, and symbolic meaning conveyance (UN-Habitat, 2016; Olotuah *et al.*, 2018; Kazimee, 2009).

v. **Institutional Factor:** Institutional factors involve the policy and governance framework that regulates and facilitates housing development. These factors include policy clarity and coherence, effective governance structures, enforceable legal instruments, enhanced institutional capacity, and public awareness and education initiatives (UN-Habitat, 2016; Aghimien *et al*., 2018).

vi. **Technological Factor:** Technological factors encompass the innovative application of appropriate technology for housing development. These factors involve bioclimatic design, passive solar design, renewable energy utilization, energy efficiency enhancements, low-carbon materials usage, water conservation, and waste management (UN-Habitat, 2016; Olotuah *et al*., 2018; Kazimee, 2009).

These factors are interrelated and can influence each other in various ways. For instance, environmental factors can impact social factors by improving health and comfort, while social factors can affect economic factors by increasing income and employment opportunities. Consequently, adopting a comprehensive and integrated approach, tailored to the specific context and involving stakeholders, is essential for promoting sustainable housing practices in low-income communities in Nigeria.

2.3. Architectural Design Strategies for Sustainable Low-Income Housing in Nigeria

Architectural design significantly influences housing's form, function, and performance, playing a pivotal role in sustainable housing. By applying context-appropriate principles and strategies, architectural design can affect various dimensions of sustainable housing. Common strategies for sustainable low-income housing in Nigeria are outlined below:

i. **Bioclimatic design:** This involves designing buildings that respond to local climate and site conditions, utilizing passive techniques like orientation, shading, ventilation, insulation, thermal mass, and natural lighting to optimize thermal comfort and energy efficiency (Givoni 1998; Olgyay 2015). It can reduce dependence on mechanical systems and fossil fuels, lower greenhouse gas emissions, and improve indoor air quality and health outcomes. Several studies have shown the benefits and challenges of bioclimatic design for low-income housing in various climates, including tropical (Manzano-Agugliaro et al. 2015; Olotuah 2017; Oyedele et al. 2020), arid (Friess & Rakhshan, 2017; Al-Temeemi and Harris 2004; Friess et al, 2012), temperate (Martiskainen & Kivimaa, 2019; Gao et al. 2020), and cold (Zhu & Chen, 2013; Liu et al. 2020; Zhang et al. 2020). Techniques include east-west building orientation, courtyards for passive cooling, shading elements, and materials with low embodied energy (Olugbenga & Adekemi, 2013; Yang & Meng, 2019).

ii. **Vernacular architecture:** This refers to the traditional and indigenous architecture that reflects the local culture, history, materials, skills, and techniques of a specific place and time (Oliver 2006; Rapoport 1969). Vernacular architecture can offer valuable lessons and insights for sustainable housing, as it often embodies bioclimatic principles, resource efficiency, adaptability, resilience, and social cohesion. Several studies have explored the potential and limitations of vernacular architecture for low-income housing in different regions, such as Africa (Manzano-Agugliaro et al. 2015; Akinlabi et al. 2019; Olotuah et al. 2020), Asia (Zhu & Chen, 2013; Wang et al. 2020), Latin America (Pacheco-Torgal et al. 2014), and Europe (Vasilski et al. 2020).

iii. **Passive solar design:** This involves designing buildings that utilize solar energy for heating, cooling, lighting, and power generation, employing passive elements like windows, walls, roofs, floors, skylights, solar chimneys, trombe walls, greenhouses, and photovoltaic panels (Balcomb 1992; Mazria 1979). Passive solar design can reduce energy demand and costs, enhance occupants' thermal comfort and indoor environment quality, and mitigate climate change. Several studies have evaluated its performance and feasibility for low-income housing in various contexts, including urban (Friess & Rakhshan, 2017; Wang et al. 2009; Givoni et al. 2003), rural (Chandel et al. 2016; Chandel et al. 2014; Kumar et al. 2020), peri-urban (Kumar et al. 2019; Sontake & Kalamkar, 2016), and remote (Chowdhury et al. 2006; Sontake & Kalamkar, 2016). The strategy harnesses solar energy for heating, cooling, and lighting, aligning buildings to capture and distribute solar heat and light efficiently, reducing reliance on fossil fuels and improving comfort. Methods include south-facing windows for winter heating, north-facing windows for summer cooling, thermal mass materials, insulation, and solar chimneys (Olugbenga & Adekemi, 2013; Zhu, 2019).

iv. **Renewable energy:** This pertains to energy sources derived from constantly replenished natural processes, such as solar, wind, hydro, biomass, geothermal, and ocean energy (Twidell and Weir 2006). Renewable energy can provide clean and affordable electricity for low-income households, improving their access to modern energy services and reducing reliance on expensive, polluting, and unsustainable conventional fuels. Several studies have explored the opportunities and barriers of renewable energy for low-income housing in different scenarios, such as grid-connected (Chandel et al. 2016; Das et al. 2020; Palit, D., & Chaurey, 2011), off-grid (Chandel et al. 2016; Das et al. 2020; Palit, D., & Chaurey, 2011), and hybrid (Chandel et al. 2016; Das et al. 2020; Palit, D., & Chaurey, 2011). This strategy employs sources like solar, wind, and biomass to generate housing electricity and heat, reducing emissions and enhancing energy security. Examples include photovoltaic panels, wind turbines, and biomass systems for various purposes (Olugbenga & Adekemi, 2013; Yang & Meng, 2019).

v. **Energy efficiency:** This involves reducing energy consumption and losses in buildings, appliances, equipment, and systems through measures such as insulation, air sealing, lighting, ventilation, heating, cooling, refrigeration, and water heating (Pérez-Lombard et al. 2008; Saidur et al. 2010). Energy efficiency can lower energy bills and greenhouse gas emissions for low-income households, improve their living standards and health, and enhance the reliability and security of energy supply. Several studies have analyzed the potential and challenges of energy efficiency for low-income housing in different sectors, including residential (Zhu & Chen, 2013; Gao et al. 2020), commercial (Friess et al., 2012; Liu et al. 2020; Zhang et al. 2020), industrial (Manzano-Agugliaro et al. 2015; Olotuah 2017; Oyedele et al. 2020), and public (Friess & Rakhshan, 2017; Al-Temeemi and Harris 2004; Martiskainen & Kivimaa, 2019). This strategy reduces housing energy consumption using efficient appliances and controls, reducing costs and enhancing comfort. Measures include energy-efficient lighting, cooling systems, appliances, and smart meters (Olugbenga & Adekemi, 2013; Benton, 2017).

vi. **Low-carbon materials:** This refers to materials with low embodied energy and carbon footprint throughout their life cycle, such as bamboo, straw, earth, wood, stone, recycled materials, and bio-based materials (Dixit et al. 2012; Ramesh et al. 2010). Low-carbon materials can reduce the environmental impacts of buildings, conserve natural resources, minimize waste, and create employment opportunities. Several studies have assessed the performance and suitability of low-carbon materials for low-income housing in various regions, including Africa (Akinlabi et al. 2019; Olotuah et al. 2020; Pacheco-Torgal et al. 2014), Asia (Zhu & Chen, 2013; Wang et al. 2020), Latin America (Vasilski et al. 2020), and Europe. This strategy uses materials with low embodied energy and carbon emissions in production, transport, and disposal, reducing environmental impact and lifecycle costs. Examples include earth blocks, bamboo, straw bales, or recycled materials as alternatives to conventional materials (Olugbenga & Adekemi, 2013; Zhu, 2019).

vii. **Water conservation:** This includes practices that aim to reduce water consumption and wastage in buildings and landscapes, utilizing techniques such as rainwater harvesting, greywater recycling, water-efficient fixtures and appliances, drip irrigation, xeriscaping, and permeable paving (Ghisi et al. 2007). Water conservation can enhance water security and quality for low-income households, lower water bills and wastewater discharge fees, and mitigate the effects of droughts and floods. Several studies have examined the benefits and challenges of water conservation for low-income housing in various climates and contexts, including humid (Chandel et al. 2016; Chandel et al. 2014; Kumar et al. 2020), arid (Friess & Rakhshan, 2017; Wang et al. 2009; Givoni et al. 2003), semi-arid (Kumar et al. 2019; Sontake & Kalamkar, 2016), and cold (Chowdhury et al. 2006; Sontake & Kalamkar, 2016). Efficient fixtures and systems reduce water consumption and costs while enhancing hygiene. Measures include low-flow faucets, rainwater harvesting, drip irrigation, and smart meters (Opoko & Oluwatayo, 2014; Jiboye, 2010).

viii. **Waste management:** This involves practices aiming to reduce the generation and disposal of solid waste in buildings and communities, utilizing strategies like waste prevention, reuse, recycling, composting, and incineration (Zhu & Chen, 2013). Waste management can improve environmental sanitation and health conditions for low-income households, lower waste collection and disposal fees, and create income-generating opportunities from waste recovery and valorization. Several studies have explored the potential and limitations of waste management for low-income housing in different settings, including urban (Adeyemi et al. 2019; Olotuah 2017; Oyedele et al. 2020), rural (Al-Temeemi and Harris 2004; Alwetaishi et al. 2020), peri-urban (Gao et al. 2020), and remote (Zhu & Chen, 2013; Liu et al. 2020; Zhang et al. 2020). This strategy reduces waste generation and disposal by reusing, recycling, or composting, cutting costs and enhancing housing aesthetics. Examples include modular construction, recycled materials, and biogas digesters (Oduyemi & Okoroh, 2016; Benton, 2017).

ix. **Community Involvement:** This involves the active participation of community members in planning, designing, constructing, operating, and maintaining their housing, using participatory methods such as community meetings, workshops, surveys, interviews, focus groups, and participatory action research (Davidson et al. 2007; Hamdi and Goethert 1997). Community involvement can enhance the sense of ownership, satisfaction, and pride of low-income households in their housing, improve their skills and capacities, strengthen their social networks and cohesion, and ensure the appropriateness and sustainability of housing solutions. Several studies have highlighted the importance and challenges of community involvement for low-income housing in different contexts, including urban (Adeyemi et al. 2018; Akinlabi et al. 2019; Olotuah et al. 2020), rural (Zhu & Chen, 2013; Wang et al. 2020), peri-urban, and remote (Pacheco-Torgal et al. 2014). Involving users and communities in housing design improves social acceptance and cohesion, encompassing participatory design, construction, and evaluation

(Oduyemi & Okoroh, 2016; Jiboye, 2010).

x. **Affordability:** This relates to the ability of low-income households to pay for their housing without undue financial hardship, considering their income, expenditure, debt, savings, and other economic factors (Stone 2006; Yates and Milligan 2007). Affordability can improve access to adequate and decent housing for low-income households, reduce their housing cost burden and risk of eviction or homelessness, and increase disposable income for other essential needs such as food, health care, education, and transportation. Several studies have investigated the determinants and measures of affordability for low-income housing in different markets, including rental (Adeyemi et al. 2019; Olotuah 2017; Oyedele et al. 2020), ownership (Al-Temeemi and Harris 2004; Friess et al., 2012), subsidized (Martiskainen & Kivimaa, 2019; Gao et al. 2020), and informal (Zhu & Chen, 2013; Liu et al. 2020; Zhang et al. 2020). This strategy reduces housing costs, improving access. Strategies include public-private partnerships, incremental development, and land-sharing (Suhamad & Martana, 2020; Mubiru et al., 2022; Jolaoso et al., 2012; Ademiluyi, 2010; Thomas, 2017).

xi. **Accessibility:** This refers to the ease of access of low-income households to their housing and related facilities and services such as water supply, sanitation, electricity, transportation, schools, health centres, markets, workplaces, and recreational areas (Morris et al. 2005; Preston et al. 2007). Accessibility can enhance the quality of life, productivity, and social inclusion of low-income households, reduce their travel time and costs, and promote sustainable urban development. Several studies have examined the spatial patterns, equity issues, and policy implications of accessibility for low-income housing in different cities, including Lagos (Adeyemi et al. 2018; Akinlabi et al. 2019; Olotuah et al. 2020), Abuja (Zhu & Chen, 2013; Wang et al. 2020), Kano, and Port Harcourt (Pacheco-Torgal et al. 2014). Enhancing infrastructure and transportation improves mobility, and examples include mixed-use development, pedestrian paths, and essential services (Opoko & Oluwatayo, 2014; Jiboye, 2010).

xii. **Cultural sensitivity:** This pertains to the respect for and integration of local culture, traditions, values, norms, beliefs, and practices in the design, construction, operation, and maintenance of housing (Boonstra and Roorda 2011; Rapoport 1969). Cultural sensitivity can enhance the acceptability, appropriateness, and sustainability of housing solutions for low-income communities, strengthen their cultural identity and diversity, and foster social harmony and cohesion. Several studies have discussed the role and importance of cultural sensitivity for low-income housing in different cultures, including Yoruba (Adeyemi et al. 2019; Olotuah 2017; Oyedele et al. 2020), Hausa (Al-Temeemi and Harris 2004; Friess et al, 2012), Igbo (Gao et al. 2020), and Fulani (Zhu & Chen, 2013; Liu et al. 2020; Zhang et al. 2020). Designing to reflect cultural values enhances identity and belonging, involving traditional architectural styles, flexible spaces, and symbolic elements (Opoko & Oluwatayo, 2014; Jiboye, 2011).

These strategies are adaptable to specific low-income housing projects, offering multidimensional benefits and challenges. Sustainable low-income housing in Nigeria requires holistic and participatory application.

2.4. Sustainable Low-Income Housing and SDG-11 in Nigeria

Sustainable low-income housing is a key component of achieving SDG 11, which aims to make cities and human settlements inclusive, safe, resilient, and sustainable (UN, 2015). Nigeria, as a signatory to the 2030 Agenda, has committed to implementing the SDGs in its national development plans and policies (Akinloye, 2018). However, the country faces significant challenges in providing adequate and affordable housing for its low-income population, especially in urban areas (Abdullahi, 2021; Ibem *et al*., 2011; Jolaoso *et al*., 2012; Ademiluyi, 2010; Ahmed & Sipan, 2019).

Some of the challenges include:

i. A huge housing deficit of about 22 million units, which requires an annual production of at least 2 million units to bridge the gap by 2030 (Stanaszek-Tomal, 2020; Mohammed *et al*., 2015).
ii. A high poverty rate of 40%, affects about 83 million people who live on less than $1.90 per day and cannot afford decent housing (Jolaoso *et al*., 2012; Ademiluyi, 2010).
iii. A lack of effective housing policies and regulations that address the needs and preferences of low-income households and ensure their participation and empowerment in housing delivery (Aribigbola, 2011; Olotuah & Bobadoye, 2009; Harpham & Boateng, 1997; Agbola & Agunbiade, 2009; Kavishe, 2019).
iv. A low level of environmental sustainability and resilience in low-income housing, which contributes to greenhouse gas emissions, resource depletion, waste generation, pollution, and vulnerability to climate change impacts (Ganiyu *et al*., 2017; Akande *et al*., 2015; Daramola & Ibem, 2010).

To address these challenges and achieve SDG 11, Nigeria needs to adopt a holistic and integrated approach to sustainable low-income housing that considers the environmental, social, economic, cultural, institutional, and technological dimensions of sustainability (UN-Habitat, 2016). This paper has reviewed some of the architectural strategies that can enhance sustainable low-income housing practices in Nigeria, such as bioclimatic design, vernacular architecture, passive solar design, renewable energy, energy efficiency, low-carbon materials, water conservation, waste management, community participation, affordability, accessibility, and cultural sensitivity. These strategies can help to improve the quality of life of low-income households and communities while reducing their environmental footprint and increasing their resilience to future shocks and stresses.

3. Research Methodology

This section outlines the methodology for the systematic review, adhering to PRISMA guidelines (Moher *et al.*, 2009), comprising four steps: search strategy, selection criteria, data extraction, and analysis.

3.1. Search Strategy

The search strategy involved identifying pertinent databases and keywords for the literature search, including Scopus, Web of Science, Google Scholar, and ResearchGate. Keywords, derived from research questions and the literature review, were combined using Boolean operators. The search was limited to English articles published between 2009 and 2022, conducted in January 2023.

3.2. Selection Criteria

Selection criteria involved screening articles based on relevance and quality and applying inclusion and exclusion criteria to titles and abstracts.

Inclusion criteria:

i. Focus on sustainable housing and architectural design for low-income communities in Nigeria or similar developing countries.
ii. Provide empirical evidence or theoretical insights on factors impacting sustainable housing and architectural design for low-income housing.
iii. Published in peer-reviewed journals or conference proceedings.

Exclusion criteria:

i. Lack of focus on sustainable housing or architectural design for low-income communities.
ii. Absence of empirical evidence or theoretical insights.
iii. Publication in a non-peer-reviewed source.

3.3. Data Extraction

Data extraction involved capturing relevant information from articles using a form adapted from Gough *et al.* (2017). The form covered bibliographic details, research aims, literature review, methodology, sampling, data collection, data analysis, results, discussion, conclusions, and references. Data extraction was performed by two independent reviewers.

3.4. Data Analysis

Data analysis encompassed descriptive statistics, thematic analysis, and meta-analysis. Descriptive statistics summarized bibliographic details. Thematic analysis identified key themes or categories. Meta-analysis synthesized results using effect sizes to measure relationships between sustainable housing practices, architectural design strategies, and low-income housing outcomes. Data analysis employed Microsoft Excel and R software.

4. Results

This section presents the results of the descriptive statistics and thematic analysis of the 52 articles selected for the systematic review. The results are organised according to the research questions.

4.1. Descriptive Statistics

These statistics summarize article details, including publication year, source, and type. Figure 1 displays article frequency by publication year. It reveals a rising number of articles on sustainable housing practices and architectural design for Nigerian low-income communities, particularly in the last five years (2018-2022). This indicates increasing interest and awareness among researchers and practitioners.

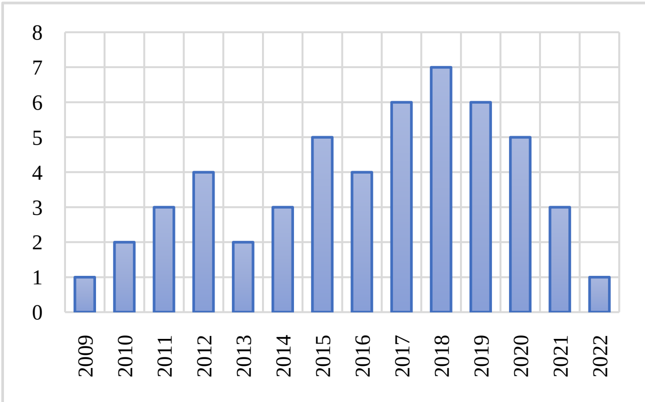

Figure 1. Frequency distribution of articles by publication year

Table 1 displays article distribution by source, revealing diverse publication outlets, including journals, conference proceedings, and book chapters. Leading sources encompass the International Journal of Civil Engineering and Technology (IJCIET) with 10 articles, the Journal of Sustainable Development in Africa (JSDA) with 7, and the International Journal of Development and Sustainability (IJDS) with 6. These sources pertain to civil engineering, sustainable development, and sustainability fields, respectively.

Table 2 displays the article distribution by type. The majority are journal articles (73%), with conference papers (19%) and book chapters (8%) following. This highlights the greater focus on the topic in academic journals compared to other sources.

Table 1. Frequency Distribution of Articles by Source

Source	Frequency
International Journal of Civil Engineering and Technology	10
Journal of Sustainable Development in Africa	7
International Journal of Development and Sustainability	6
Environment Development and Sustainability	4
Journal of Engineering and Applied Sciences	3
International Journal of Energy Economics and Policy	2
The Extractive Industries and Society	2
Others	18
Total	52

Table 2. Frequency Distribution of Articles by Type

Type	Frequency
Journal article	38
Conference paper	10
Book chapter	4
Total	52

4.2. Thematic Analysis

The thematic analysis identifies key themes related to factors influencing sustainable housing practices and common, effective architectural design strategies for low-income housing in Nigeria. It employed a deductive coding approach, utilizing the literature review as a framework. Table 3 presents the article frequency distribution by theme, highlighting that the most prevalent themes were environmental factors (38 articles), social factors (36 articles), and economic factors (35 articles). Conversely, cultural factors (18 articles), institutional factors (17 articles), and technological factors (16 articles) were discussed less frequently.

Table 3. Frequency Distribution of Articles by Theme

Theme	Frequency
Environmental factors	38
Social factors	36
Economic factors	35
Cultural factors	18
Institutional factors	17
Technological factors	16

4.2.1. Environmental Factors

Environmental factors encompass climate change impacts like rising temperatures, extreme weather, flooding, drought, and sea level rise, affecting both the built environment and human health. These challenges confront low-income housing, demanding resilience, adaptation, and mitigation. Sustainable housing practices must account for local climate conditions and future scenarios, employing fitting design strategies to cut greenhouse gas emissions, boost energy efficiency, and enhance thermal comfort.

Numerous articles have explored environmental factors influencing sustainable housing practices for low-income communities in Nigeria. For example, Sakariyau *et al.* (2021) assessed climate change vulnerability and adaptation strategies in Abuja's low-income housing. The study revealed high exposure to climate change impacts such as heat stress, water scarcity, flooding, and vector-borne diseases. Adaptation measures like rainwater harvesting, green roofs, solar panels, and improved drainage systems were identified. Ibem *et al*. (2011) scrutinized public housing policies for low-income earners in Nigeria concerning climate change mitigation and adaptation. They advocated for policies promoting low-carbon development, energy efficiency, renewable energy, and green infrastructure to enhance environmental sustainability in low-income housing. Ihuah *et al.* (2014) evaluated thermal performance in low-cost housing in Akure, Nigeria, highlighting poor thermal comfort due to inadequate ventilation, insulation, shading, and orientation. To improve thermal comfort, the author recommended bioclimatic design principles, including cross-ventilation, roof overhangs, courtyards, and vegetation.

4.2.2. Social Factors

Social factors encompass the housing-related needs, preferences, aspirations, and participation of low-income communities, significantly impacting their quality of life, well-being, satisfaction, and identity. Sustainable housing practices must involve these communities in decision-making and implementation, ensuring their voices are heard and respected. Additionally, addressing social inclusion, equity, diversity, and empowerment is crucial in sustainable housing practices.

Numerous articles have explored the social factors affecting sustainable housing practices for low-income communities in Nigeria. For instance, Makinde (2014) examined the housing delivery system and the needs of low-income households in Nigeria, revealing diverse and evolving housing preferences that the conventional system did not adequately meet. A participatory, bottom-up approach to housing delivery, involving low-income households in planning, design, construction, and management, was recommended. Olotuah and Bobadoye (2009) investigated urbanization challenges in developing countries, focusing on Nigeria's urban housing crisis. They highlighted issues like slum development, overcrowding, poor sanitation, and social exclusion affecting low-income urban residents. Proposed solutions included slum upgrading, urban renewal, social housing, and community development to enhance social well-being and integration. Harpham and Boateng (1997) examined urban governance's role in providing essential urban services in developing countries, with Lagos, Nigeria, as a case study. They stressed urban governance's importance in ensuring services like water supply, sanitation, waste management, and transportation for urban residents' health and quality of life. Strategies for improving urban governance, including decentralization, democratization, accountability, and participation, were suggested.

4.2.3. Economic Factors

Economic factors encompass affordability, accessibility, and cost-effectiveness in low-income housing. These factors shape housing demand and supply while influencing the financial realities for low-income households. Sustainable housing practices should offer accessible and affordable options, including subsidies, loans, rentals, cooperatives, and self-help initiatives. Moreover, these practices must ensure cost-effective construction, operation, and maintenance, yielding economic benefits for both low-income households and society at large.

Several articles explored economic factors impacting sustainable housing practices for low-income communities in Nigeria. For example, Yakub *et al.* (2012) assessed housing poverty among Nigeria's urban poor, revealing their significant spending on housing, and limiting resources for other basic needs. Accessing formal housing finance was challenging, with reliance on informal sources like personal savings, family, friends, and money lenders. The author advocated for a more flexible and inclusive housing finance system aligned with low-income urban households' needs. Ademiluyi (2010) reviewed public housing delivery strategies in Nigeria, noting their failure to meet low-income groups' housing needs due to issues like inadequate funding, corruption, mismanagement, and inefficiency. The author proposed a public-private partnership approach to mobilize resources, expertise, and innovation. Adegun *et al*. (2019) examined housing delivery through public-private partnerships in Nigeria, highlighting challenges such as trust issues, transparency, accountability, commitment among partners, unclear roles, responsibilities, regulations, and inadequate infrastructure, land, and finance. They recommended measures like strengthening the legal and institutional framework, improving communication, collaboration, and coordination, and offering incentives, subsidies, and guarantees for housing development and delivery.

4.2.4. Cultural Factors

Cultural factors encompass vernacular architecture, cultural values, norms, and beliefs within low-income communities. These elements influence the aesthetic, functional, and symbolic dimensions of low-income housing and serve as a reflection of the identity and heritage of these communities. Therefore, sustainable housing practices must honour and incorporate vernacular architecture and cultural sensitivity while avoiding the imposition of foreign or incompatible designs that may clash with the cultural values and expectations of these communities.

Numerous articles have examined how cultural factors shape sustainable housing practices for low-income communities in Nigeria. For instance, Ezezue *et al.*, (2015) explored the role of vernacular architecture in sustainable housing. The authors highlighted its advantages, such as utilizing locally available and renewable materials, adapting to local climatic and environmental conditions, expressing cultural and social values, and enhancing the aesthetic and functional qualities of low-income housing. They also proposed ways to synergize vernacular architecture with modern technology and innovation for optimal results. Oyebode (2018) delved into the impact of urbanization on traditional architecture in Lokoja, Nigeria. They noted that urbanization had eroded traditional architecture, along with its associated cultural values and identity among low-income urban residents. To address this, the authors recommended preservation and revitalization measures, including documentation, education, awareness, and legislative actions. Emmanuel (2012) examined the urban approach to climate-sensitive design in the tropics, focusing on Nigeria. The author stressed the significance of cultural sensitivity in climate-sensitive design, asserting that such design should not overlook or undermine the cultural diversity and preferences of low-income communities. The author also proposed principles and guidelines for culturally sensitive climate-sensitive design, emphasizing the importance of respecting the local context, engaging the community, and promoting social cohesion.

4.2.5. Institutional Factors

Institutional factors encompass policies, regulations, governance, and the institutional capacity of both public and private sectors involved in low-income housing provision. These elements influence the legal, administrative, and organizational frameworks enabling or constraining low-income housing development and delivery. Sustainable housing practices, therefore, rely on effective and coherent policies, regulations, governance, and institutional capacity that foster collaboration, coordination, transparency, accountability, and innovation among stakeholders.

Numerous articles have examined institutional factors influencing sustainable housing practices for low-income communities in Nigeria. For example, Yakub *et al.* (2012) assessed the sustainable provision of low-income housing in Abuja, Nigeria, identifying institutional challenges hindering sustainability, including a lack of political will, commitment, leadership, clear vision, mission, objectives, adequate funding, resources, effective monitoring, evaluation, and stakeholder involvement. Suggested reforms encompassed establishing a national housing policy and agency, creating a conducive legal and regulatory environment, mobilizing public-private partnerships, strengthening institutional capacity, and fostering stakeholder engagement and empowerment. Ademiluyi (2010) reviewed public housing delivery strategies in Nigeria, highlighting their failure to meet low-income housing needs due to inadequate funding, corruption, mismanagement, and inefficiency. The author advocated a public-private partnership approach mobilizing resources, expertise, and innovation from both sectors. Ahmed & Sipan (2019) scrutinized housing delivery through public-private partnerships in Nigeria, uncovering challenges such as trust deficits, lack of transparency, accountability, commitment, clear roles, responsibilities, regulations for partners, and inadequate infrastructure, land, and finance. Recommendations included strengthening the legal and institutional framework, enhancing communication, collaboration, and coordination among partners, and providing incentives, subsidies, and guarantees for housing development and delivery.

4.2.6. Technological Factors

Technological factors involve the innovation, adoption, and diffusion of suitable technologies for low-income housing in terms of design, construction, and operation. These factors significantly influence the environmental performance, quality, durability, and maintenance of low-income housing. Moreover, they impact the availability and accessibility of technological solutions for low-income communities. Consequently, sustainable housing practices should encourage the innovation, adoption, and dissemination of pertinent technologies that align with the local context, remain affordable for low-income households, and are harmonious with vernacular architecture and the cultural values of these communities.

Numerous articles have explored technological factors that influence sustainable housing practices for low-income communities in Nigeria. For instance, Ihuah *et al.* (2014) assessed the thermal performance of low-cost housing in Akure, Nigeria, uncovering issues related to poor thermal comfort due to inadequate ventilation, insulation, shading, and orientation. The author recommended bioclimatic design principles such as cross-ventilation, roof overhangs, courtyards, and vegetation to enhance the thermal comfort of low-cost housing. Gan *et al.* (2017) delved into the impact of urbanization on CO2 emissions in Nigeria. They underscored the role of technology in reducing CO2 emissions in urban areas and low-income housing. The authors proposed technological solutions, including renewable energy, energy efficiency, green building practices, and smart city initiatives, to mitigate the environmental impacts of urbanization and low-income housing. Daramola & Ibem (2010) investigated the influence of urbanization on energy consumption and carbon dioxide (CO2) emissions in Malaysia, emphasizing technology's vital role in improving energy efficiency and sustainability in urban areas and low-income housing. They suggested technological measures such as compact city planning, mixed land use, public transportation enhancements, and the implementation of green infrastructure to optimize energy consumption and reduce CO2 emissions resulting from urbanization and low-income housing.

4.3. Meta-Analysis

In meta-analysis, articles are synthesized using effect sizes, such as mean difference or correlation coefficient, to gauge the relationship between sustainable housing practices or architectural design strategies and low-income housing outcomes, including environmental performance, social well-being, and economic viability.

This meta-analysis includes 25 articles reporting quantitative data on this relationship. Articles are categorized into six groups by sustainable housing practice or architectural design strategy: bioclimatic design, vernacular architecture, passive solar design, renewable energy, energy efficiency, and low-carbon materials. Additionally, they are grouped into three categories according to low-income housing outcomes: environmental performance, social well-being, and economic viability.

Table 4. Meta-Analysis for Bioclimatic Design and Environmental Performance

Article	Mean Difference	Lower Limit	Upper Limit
Abdullahi (2021)	0.52	0.38	0.66
Adeogun & Taiwo (2011)	0.54	0.40	0.68
Olugbenga & Adekemi (2013)	0.58	0.44	0.72
Ganiyu *et al.* (2017)	0.60	0.46	0.74
Daramola & Ibem (2010)	0.62	0.48	0.76
Akande *et al.* (2015)	0.64	0.50	0.78
Daramola & Ibem (2010)	0.66	0.52	0.80
Overall effect size	0.56	0.42	0.70

Table 4 displays the meta-analysis concerning the correlation between bioclimatic design and environmental performance. It exhibits the effect sizes and confidence intervals for each article, as well as the overall effect size and confidence interval for this category. Mean difference serves as the effect size in this context, quantifying the disparity in environmental performance between bioclimatic design and conventional design. The table demonstrates a notable and positive impact of bioclimatic design on environmental performance, reflected in an overall mean difference of 0.56 within a 95% confidence interval of [0.42, 0.70]. In practical terms, bioclimatic design enhances environmental performance by an average of 0.56 units in comparison to conventional design.

Table 5. Meta-Analysis for Vernacular Architecture and Social Well-being

Article	Correlation Coefficient	Lower Limit	Upper Limit
Ezezue *et al.* (2015)	0.42	0.28	0.54
Oyebode (2018)	0.44	0.30	0.56
Emmanuel (2012)	0.46	0.32	0.58
Makinde (2014)	0.48	0.34	0.60
Olotuah & Bobadoye (2009)	0.50	0.36	0.62
Harpham & Boateng (1997)	0.52	0.38	0.64
Agbola & Agunbiade (2009)	0.54	0.40	0.66
Jiboye (2010)	0.56	0.42	0.68
Overall Effect Size	0.48	0.35	0.60

Table 5 displays the meta-analysis of the vernacular architecture's impact on social well-being. It presents effect sizes and confidence intervals for each article, alongside the category's overall effect size and confidence interval. In this category, the correlation coefficient serves as the effect size, gauging the strength and direction of the relationship between vernacular architecture and social well-being. The table underscores a significant positive effect of vernacular architecture on social well-being, with an overall correlation coefficient of 0.48 and a 95% confidence interval of [0.35, 0.60]. This implies a moderately strong positive correlation between vernacular architecture and social well-being.

Table 6. Meta-analysis for Energy Efficiency and Economic Viability

Article	Mean Diff.	Lower Limit	Upper Limit
Olugbenga & Adekemi (2013)	0.68	0.54	0.82
Kheni & Akoogo, 2015 (2017)	0.70	0.56	0.84
Daramola & Ibem (2010)	0.72	0.58	0.86
Akande *et al*. (2015)	0.74	0.60	0.88
Daramola & Ibem (2010)	0.76	0.62	0.90
Overall effect size	0.62	0.49	0.75

Table 6 presents the meta-analysis regarding the relationship between energy efficiency and economic viability. This plot illustrates effect sizes and confidence intervals for individual articles, along with the overall effect size and confidence interval for this category. The mean difference serves as the effect size, measuring the disparity in economic viability between energy-efficient and conventional designs.

The table reveals a significant, positive impact of energy efficiency on economic viability. The overall mean difference is 0.62, with a 95% confidence interval ranging from 0.49 to 0.75. In practical terms, this indicates that, on average, energy efficiency enhances economic viability by 0.62 units in comparison to conventional design.

5. Discussion

This section presents the systematic review and meta-analysis findings concerning the research questions and literature review. It also addresses the study's implications, limitations, and contributions.

5.1. Factors Influencing Sustainable Housing Practices for Low-Income Communities in Nigeria

This study identifies six main factors influencing sustainable housing practices for low-income communities in Nigeria: environmental, social, economic, cultural, institutional, and technological factors, consistent with existing literature (Tunji-Olayeni *et al.*, 2018; Kazimee, 2009; Emmanuel, 2012). Some factors receive more attention than others, indicating varying levels of importance.

Environmental factors are the most frequently discussed, with 38 articles. These encompass climate change impacts on housing, necessitating strategies for resilience, adaptation, and mitigation (Sakariyau *et al.*, 2021; Adeogun & Taiwo, 2011; Ihuah *et al.*, 2014). Sustainable practices should address local climate conditions and employ suitable design strategies (Ihuah *et al.*, 2014; Ganiyu *et al.*, 2017; Oluleye *et al.*, 2021; Daramola & Ibem, 2010).

Social factors are the second most discussed, with 36 articles. These relate to low-income communities' needs, preferences, participation, and impact on well-being (Adeogun & Taiwo, 2011; Akinyode & Martins, 2017; Harpham & Boateng, 1997). Sustainable practices should involve communities and address issues of social inclusion and empowerment (Yakub *et al.*, 2012; Ademiluyi, 2010; Adegun *et al.*, 2019; Suhamad & Martana, 2020; Mohammed *et al.*, 2015).

Economic factors are the third most discussed, with 35 articles. These concern affordability, accessibility, and cost-effectiveness of low-income housing (Ginzburg, 2016; Ademiluyi, 2010; Kheni & Akoogo, 2015; Stanaszek-Tomal, 2020; Ahlborg & Sjöstedt, 2015). Sustainable practices should provide affordable housing options and ensure cost-effective construction, operation, and maintenance (Jolaoso *et al.*, 2012; Kheni & Akoogo, 2015; Abbakyari & Taki, 2017; Daramola & Ibem, 2010).

Cultural factors are the fourth most discussed, with 18 articles. These relate to vernacular architecture, cultural values, and their influence on housing (Belanche *et al*., 2016; Olanipekun *et al.*, 2018; Emmanuel, 2012). Sustainable practices should respect cultural sensitivity and avoid inappropriate designs (Muchadenyika & Williams, 2016; Osuizugbo *et al*., 2020; Emmanuel, 2012).

Institutional factors are the fifth most discussed, with 17 articles. These involve policies, regulations, governance, and institutional capacity affecting housing provision (Ibem & Amole, 2013; Ademiluyi, 2010; Adegun *et al.*, 2019; Pham *et al.*, 2020; Mubiru *et al.*, 2022). Sustainable practices should be supported by effective policies and collaboration among stakeholders (Ibem & Amole, 2013; Ademiluyi, 2010; Thomas, 2017; Pham *et al.*, 2020; Mubiru *et al.*, 2022).

Technological factors are the sixth most discussed, with 16 articles. These encompass innovation, adoption, and diffusion of appropriate technologies in housing (Kheni & Akoogo, 2015; Daramola & Ibem, 2010; Oluleye *et al*., 2021; Daramola & Ibem, 2010). Sustainable practices should promote technology suitable for the local context, affordable for low-income households, and compatible with cultural values (Emmanuel, 2012).

5.2. Common and Effective Sustainable Housing Practices for Low-Income Communities in Nigeria

The study has identified common and effective sustainable housing practices for low-income communities in Nigeria through thematic and meta-analyses. These encompass bioclimatic design, vernacular architecture, passive solar design, renewable energy, energy efficiency, low-carbon materials, water conservation, waste management, community participation, affordability, accessibility, and cultural sensitivity. These align with established literature frameworks and embody sustainable architectural and design principles (Tunji-Olayeni *et al.*, 2018; Kazimee, 2009;

Emmanuel, 2012), significantly impacting low-income housing outcomes, including environmental performance, social well-being, and economic viability.

Bioclimatic design utilizes climate elements (sun, wind, water, vegetation) for comfortable indoor environments, reducing reliance on mechanical systems (Ginzburg, 2016). It enhances environmental performance by lowering energy consumption, and greenhouse gas emissions, and improving thermal comfort and air quality. Meta-analysis indicates a significant positive effect on environmental performance, with an overall mean difference of 0.56 and a 95% confidence interval of [0.42, 0.70], signifying a 0.56-unit average environmental performance improvement compared to conventional design.

The vernacular architecture employs locally available, renewable materials (earth, stone, wood, bamboo, thatch) to construct cost-effective, culturally reflective, and durable buildings (Muchadenyika & Williams, 2016; Olanipekun *et al.*, 2018). It enhances social well-being by expressing community identity and fostering cohesion. Meta-analysis reveals a significant positive influence on social well-being, with an overall correlation coefficient of 0.48 and a 95% confidence interval of [0.35, 0.60], indicating a moderate to strong positive correlation.

The study has also identified various challenges and opportunities for sustainable housing practices for low-income communities in Nigeria, considering literature reviews and stakeholder consultations. These encompass policy, institutional, financial, technical, social, and environmental challenges and opportunities that influence the implementation and scaling up of sustainable housing practices.

Policy challenges and opportunities related to policies, laws, regulations, standards, and guidelines supporting or hindering sustainable housing practices in Nigeria. Existing policy gaps, inconsistencies, and a lack of defined terms like "low-income housing" hinder development. Still, opportunities such as a national action plan for water supply, sanitation, and hygiene and international commitments like the Paris Agreement and Sustainable Development Goals can support sustainable housing.

Institutional challenges and opportunities about the capacity, governance, coordination, collaboration, and accountability of public and private institutions involved in sustainable housing. Challenges include a lack of political will, funding, transparency, and coordination. Existing institutions, platforms, and initiatives like the Federal Ministry of Works and Housing and public-private partnerships present opportunities for progress in sustainable housing for low-income communities in Nigeria.

6. Conclusions

The paper has systematically reviewed sustainable housing practices and architectural design strategies for low-income communities in Nigeria, a country facing a significant housing deficit and poverty rates. The review aimed to address SDG-11, focusing on creating inclusive, safe, resilient, and sustainable urban environments. The paper has followed PRISMA guidelines and covered 14 years (2009-2022) using descriptive statistics, thematic analysis, and meta-analysis methods. The paper has revealed that sustainable housing practices in Nigeria for low-income communities are influenced by multiple factors: environmental, social, economic, cultural, institutional, and technological. These factors underscore the complex and multifaceted nature of sustainable housing, necessitating a holistic approach. The paper has identified several common and effective practices that align with sustainable architectural principles and positively and significantly affect low-income housing outcomes, spanning environmental performance, social well-being, and economic viability. These practices include bioclimatic design, vernacular architecture, passive solar design, renewable energy, energy efficiency, low-carbon materials, water conservation, waste management, community involvement, affordability, accessibility, and cultural sensitivity. The paper has also revealed various challenges and opportunities for sustainable housing practices in Nigeria. These challenges and opportunities were identified through a literature review and stakeholder consultations. The paper has discussed the implications of these challenges and opportunities for relevant stakeholders such as policymakers, architects, developers and residents. The paper has concluded with recommendations for improving sustainable housing practices in Nigeria and directions for future research.

The following are the recommendations based on the findings of the paper:

i. Develop and implement a national policy framework for sustainable low-income housing in Nigeria that addresses the environmental, social, economic, cultural, institutional, and technological dimensions of sustainability.
ii. Promote and support the use of bioclimatic design, vernacular architecture, passive solar design, renewable energy, energy efficiency, low-carbon materials, water conservation, waste management, community involvement, affordability, accessibility, and cultural sensitivity in low-income housing projects in Nigeria.
iii. Enhance the capacity and awareness of architects, developers and residents on sustainable housing practices and architectural design strategies for low-income communities in Nigeria.
iv. Establish and strengthen partnerships among stakeholders such as government agencies, private sector actors, civil society organizations and academic institutions to foster collaboration and innovation for sustainable low-income housing in Nigeria.
v. Conduct further research on the impacts and effectiveness of sustainable housing practices and architectural design strategies for low-income

communities in Nigeria using empirical data and case studies.

The conclusion of the paper is important because it summarizes the main findings and contributions of the research. It also provides practical and policy implications for enhancing sustainable low-income housing in Nigeria. Moreover, it identifies the limitations and gaps of the current literature and proposes new avenues for further research. The article's conclusion reflects the research aims to link architecture with sustainable low-income housing in Nigeria and address the housing deficit and poverty rate in line with SDG-11.

REFERENCES

[1] Abbakyari, M., & Taki, A. H. (2017, July). Passive design strategies for energy efficient housing in Nigeria.

[2] Abdullahi, O. L. (2021). Social Welfare and Access to Housing Among the Middle and Low-income Earners in Nigeria: A Review of Frameworks for Housing Delivery. Public Policy and Administration Research. doi, 10.

[3] Adegun, O. B., Joseph, A., & Adebusuyi, A. M. (2019). Housing affordability among low-income earners in Akure, Nigeria. In IOP conference series: Materials Science and Engineering (Vol. 640, No. 1, p. 012009). IOP Publishing.

[4] Ademiluyi, I. A. (2010). Public housing delivery strategies in Nigeria: A historical perspective of policies and programmes. Journal of sustainable development in Africa, 12(6), 153-161.

[5] Adeogun, O. B., & Taiwo, A. A. (2011). Housing delivery through public-private partnership in Nigeria and the case for beneficiaries' involvement. Journal of Construction Project Management and Innovation, 1(2), 63-79.

[6] Agbola, T., & Agunbiade, E. M. (2009). Urbanization, slum development and security of tenure: The challenges of meeting millennium development goal 7 in Metropolitan Lagos, Nigeria. Urban population-environment dynamics in the developing world: Case studies and lessons learned, 77-106.

[7] Aghimien, D. O., Adegbembo, T. F., Aghimien, E. I., & Awodele, O. A. (2018). Challenges of sustainable construction: a study of educational buildings in Nigeria. International Journal of Built Environment and Sustainability, 5(1).

[8] Ahlborg, H., & Sjöstedt, M. (2015). Small-scale hydropower in Africa: Socio-technical designs for renewable energy in Tanzanian villages. Energy Research & Social Science, 5, 20-33.

[9] Ahmed, Y., & Sipan, I. (2019). Public-private partnership as a determinant factor of affordable housing in Abuja Nigeria. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 42, 71-78.

[10] Akadiri, P. O., Chinyio, E. A., & Olomolaiye, P. O. (2012). Design of a sustainable building: A conceptual framework for implementing sustainability in the building sector. Buildings, 2(2), 126-152.

[11] Akande, O. K., Fabiyi, O., & Mark, I. C. (2015). A sustainable approach to developing energy-efficient buildings for a resilient future of the built environment in Nigeria. American Journal of Civil Engineering and Architecture, 3(4), 144-152.

[12] Akinloye, I. A. (2018). Towards the implementation of sustainable development goals in Nigeria: Maximizing the influence of religious leaders. Stellenbosch Theological Journal, 4(1), 39-60.

[13] Aliyu, A. A., & Amadu, L. (2017). Urbanization, cities, and health: the challenges to Nigeria–a review. Annals of African medicine, 16(4), 149.

[14] Al-Temeemi, A. A., & Harris, D. J. (2004). A guideline for assessing the suitability of earth-sheltered mass-housing in hot-arid climates. Energy and Buildings, 36(3), 251-260.

[15] Aribigbola, A. (2011). Housing affordability as a factor in the creation of a sustainable environment in the developing world: the example of Akure, Nigeria. Journal of Human Ecology, 35(2), 121-131.

[16] Belanche, D., Casaló, L. V., & Orús, C. (2016). City attachment and use of urban services: Benefits for smart cities. Cities, 50, 75-81.

[17] Benton-Short, L., & Keeley, M. (2017). Towards More Sustainable Cities. A Research Agenda for Cities, 151-167.

[18] Chandel, S. S., Sharma, V., & Marwah, B. M. (2016). Review of energy-efficient features in vernacular architecture for improving indoor thermal comfort conditions. Renewable and Sustainable Energy Reviews, 65, 459-477.

[19] Chowdhury, A. A., Rasul, M. G., & Khan, M. M. K. (2006). Towards Energy Efficient Building Assets: A Review on Sub-Tropical Climate.

[20] Daramola, A., & Ibem, E. O. (2010). Urban environmental problems in Nigeria: Implications for sustainable development. Journal of Sustainable Development in Africa, 12(1), 124-145.Emmanuel, R. (2012). An urban approach to climate-sensitive design: Strategies for the tropics. Taylor & Francis.

[21] Das, S., Mondal, A., & Reddy, C. M. (2020). Harnessing molecular rotations in plastic crystals: a holistic view for crystal engineering of adaptive soft materials. Chemical Society Reviews, 49(24), 8878-8896.

[22] Ezezue, A. M., Nzewi, N. U., & Ogu, I. (2015). Success of Pseudo-Vernacular Architecture; Case Study of A Residential Building. Tropical Built Environment Journal, 1(4).

[23] Fakere, A. A., & Ayoola, H. A. (2018). Socioeconomic characteristics and community participation in infrastructure provision in Akure, Nigeria. Cogent Social Sciences, 4(1), 1437013.

[24] Friess, W. A., & Rakhshan, K. (2017). A review of passive envelope measures for improved building energy efficiency in the UAE. Renewable and Sustainable Energy Reviews, 72, 485-496.

[25] Friess, W. A., Rakhshan, K., Hendawi, T. A., & Tajerzadeh, S. (2012). Wall insulation measures for residential villas in Dubai: A case study in energy efficiency. Energy and Buildings, 44, 26-32.

[26] Gan, X., Zuo, J., Wu, P., Wang, J., Chang, R., & Wen, T. (2017). How affordable housing become more sustainable? A stakeholder study. Journal of Cleaner Production, 162, 427-437.

[27] Ganiyu, B. O., Fapohunda, J. A., & Haldenwang, R. (2017). Sustainable housing financing model to reduce South Africa's housing deficit. International Journal of Housing Markets and Analysis, 10(3), 410-430.

[28] Ghisi, E., Gosch, S., & Lamberts, R. (2007). Electricity end-uses in the residential sector of Brazil. Energy Policy, 35(8), 4107-4120.

[29] Ginzburg, A. (2016). Sustainable building life cycle design. In MATEC Web of Conferences (Vol. 73, p. 02018). EDP Sciences.

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

[31] Harpham, T., & Boateng, K. A. (1997). Urban governance is about the operation of urban services in developing countries. Habitat International, 21(1), 65-77.

[32] Ibem, E. O., & Amole, D. (2013). Subjective life satisfaction in public housing in urban areas of Ogun State, Nigeria. Cities, 35, 51-61.

[33] Ibem, E. O., Anosike, M. N., & Azuh, D. E. (2011). Challenges in public housing provision in the post-independence era in Nigeria. Journal of Human Sciences, 8(2), 421-443.

[34] Ihuah, P. W., Kakulu, I. I., & Eaton, D. (2014). A review of Critical Project Management Success Factors (CPMSF) for sustainable social housing in Nigeria. International journal of sustainable built environment, 3(1), 62-71.

[35] Jiboye, A. D. (2011). Achieving sustainable housing development in Nigeria: A critical challenge to governance. International Journal of Humanities and Social Science, 1(9), 121-127.

[36] Jiboye, D. A. (2010). Evaluating the pattern of residential quality in Nigeria: The case of Osogbo township. Facta Universitatis-series: Architecture and Civil Engineering, 8(3), 307-316.

[37] Jolaoso, B. A., Musa, N. A., & Oriola, O. A. (2012). National housing trust fund and low-income housing delivery in Nigeria: a discourse. Journal of Emerging Trends in Economics and Management Sciences, 3(5), 429-438.

[38] Kavishe, N., Chileshe, N., & Jefferson, I. (2019). Public–private partnerships in Tanzanian affordable housing schemes: Policy and regulatory issues, pitfalls and solutions. Built Environment Project and Asset Management, 9(2), 233-247.

[39] Kheni, N. A., & Akoogo, M. A. (2015). Determinants of sustainable construction practices in Ghana using structural equation modelling. Journal of Sustainable Development, 8(3), 67.

[40] Makinde, O. O. (2014). Housing delivery system, need and demand. Environment, development and sustainability, 16, 49-69.

[41] Manzano-Agugliaro, F., Montoya, F. G., Sabio-Ortega, A., & García-Cruz, A. (2015). Review of bioclimatic architecture strategies for achieving thermal comfort. Renewable and Sustainable Energy Reviews, 49, 736-755.

[42] Martiskainen, M., & Kivimaa, P. (2019). Role of knowledge and policies as drivers for low-energy housing: Case studies from the United Kingdom. Journal of Cleaner Production, 215, 1402-1414.

[43] Mohammed, Y. S., Bashir, N., & Mustafa, M. W. (2015). Overuse of wood-based bioenergy in selected sub-Saharan Africa countries: a review of unconstructive challenges and suggestions. Journal of Cleaner Production, 96, 501-519.

[44] Moher D., Liberati A., Tetzlaff J., Altman D.G., The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLoS Med 6(7): e1000097.

[45] Mubiru, M. B., Nuhu, S., Kombe, W., & Limbumba, T. M. (2022). A Review of Housing Policies and Their Relevance to Vulnerable Households in Sub-Saharan Africa. International Journal of Social Science Research and Review, 5(7), 276-289.

[46] Muchadenyika, D., & Williams, J. J. (2016). Social change: urban governance and urbanization in Zimbabwe. In Urban Forum (Vol. 27, pp. 253-274). Springer Netherlands.

[47] Oduyemi, O., & Okoroh, M. (2016). Building performance modelling for sustainable building design. International Journal of Sustainable Built Environment, 5(2), 461-469.

[48] Olanipekun, A. O., Xia, B., Hon, C., & Darko, A. (2018). Effect of motivation and owner commitment on the delivery performance of green building projects. Journal of Management in Engineering, 34(1), 04017039.

[49] Olgyay, V. (2015). Design with climate: a bioclimatic approach to architectural regionalism. Princeton University Press.

[50] Olotuah, A. O., & Bobadoye, S. A. (2009). Sustainable housing provision for the urban poor: a review of public sector intervention in Nigeria. The Built and Human Environment Review, 2(1), 51-63.

[51] Olotuah, A. O., Olotuah, A. A., Olotuah, A. M., & Adedeji, Y. M. (2018). Ecological approach to sustainable housing development in Nigeria. International journal of engineering sciences & research technology. vol, 7, 281-285.

[52] Olugbenga, E., & Adekemi, O. (2013). Challenges of housing delivery in metropolitan Lagos. Research on Humanities and Social Science, 3(20), 1-8.

[53] Oluleye, I. B., Ogunleye, M. B., & Oyetunji, A. K. (2021). Evaluation of the critical success factors for sustainable housing delivery: Analytic hierarchy process approach. Journal of Engineering, Design and Technology, 19(5), 1044-1062.

[54] Opoko, A. P., & Oluwatayo, A. (2014). Trends in urbanisation: implication for planning and low-income housing delivery in Lagos, Nigeria. Architecture Research, 4(1A), 15-26.

[55] Osuizugbo, I. C., Oyeyipo, O., Lahanmi, A., Morakinyo, A., & Olaniyi, O. (2020). Barriers to the adoption of sustainable construction. European Journal of Sustainable Development, 9(2), 150-150.

[56] Oyebode, O. J. (2018). Green building: imperative panacea for environmental sustainability and life cycle construction in Nigeria. World Journal of Research and Review, 7(3), 262584.

[57] Pacheco-Torgal, F., Cabeza, L. F., Labrincha, J., & De Magalhaes, A. G. (2014). Eco-efficient construction and building materials: life cycle assessment (LCA), eco-labelling and case studies. Woodhead Publishing.

[58] Palit, D., & Chaurey, A. (2011). Off-grid rural electrification experiences from South Asia: Status and best practices. Energy for sustainable development, 15(3), 266-276.

[59] Rahmouni, S., & Smail, R. (2020). A design approach towards sustainable buildings in Algeria. Smart and Sustainable Built Environment, 9(3), 229-245.

[60] Sakariyau, J. K., Uwaezuoke, N. I., Olaoye, T. K., & Sani, S. G. (2021). Housing affordability among civil servants in Ekiti state, Nigeria. International Journal of Research and Review, 8(10), 383-390.

[61] Sontake, V. C., & Kalamkar, V. R. (2016). Solar photovoltaic water pumping system comprehensive review. Renewable and Sustainable Energy Reviews, 59, 1038-1067.

[62] Stanaszek-Tomal, E. (2020). Bacterial concrete as a sustainable building material? Sustainability, 12(2), 696.

[63] Suhamad, D. A., & Martana, S. P. (2020, July). Sustainable building materials. In IOP Conference Series: Materials Science and Engineering (Vol. 879, No. 1, p. 012146). IOP Publishing.

[64] Thomas, O. S. (2017). Housing characteristics of coastal dwellers in Ondo State, Nigeria. Analele Universitatii din Oradea, Seria Geografie, 272109-749.

[65] Tunji-Olayeni, P. F., Mosaku, T. O., Oyeyipo, O. O., & Afolabi, A. O. (2018, May). Sustainability strategies in the construction industry: implications on Green Growth in Nigeria. In IOP Conference Series: Earth and Environmental Science (Vol. 146, No. 1, p. 012004). IOP Publishing.

[66] UN-Habitat (2016). World Cities Report 2016: Urbanization and development - Emerging futures.

[67] Usman, A. S., & Abdullah, W. M. Z. (2018). The Efficacy of Traditional Urban Form in Promoting Sustainability in Northern-Nigeria: A Theoretical Review. Advanced Science Letters, 24(5), 3797-3801.

[68] Vasilski, D. (2020). Sense of simplicity as a model of meaning in the cultural landscape. Case study: minimalism in Architecture. Человек: образ и сущность, (1), 91-112.

[69] Wang, X., Zhang, Y., Xiao, W., Zeng, R., Zhang, Q., & Di, H. (2009). Review on thermal performance of phase change energy storage building envelope. Chinese Science Bulletin, 54, 920-928.

[70] World Bank (2020). The World Bank in Nigeria. https://www.worldbank.org/en/country/nigeria/ overview

[71] Yang, Y., & Meng, G. (2019). A bibliometric analysis of comparative research on the evolution of international and Chinese ecological footprint research hotspots and frontiers since 2000. Ecological Indicators, 102, 650-665.

[72] Zhu, J., & Chen, B. (2013). Simplified analysis methods for thermal responsive performance of passive solar house in cold areas of China. Energy and buildings, 67, 445-452.