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Sustainable Architecture and Design in Nigeria's Built Environment

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Abstract

The built environment significantly impacts the planet, with traditional construction practices contributing to resource depletion and environmental degradation. This paper explores sustainable architecture and design as a response to these challenges. Drawing on the existing literature, it examines core principles such as the life cycle approach, site optimization, and energy efficiency strategies. The paper highlights the importance of sustainable material selection and building envelope design in minimizing environmental impact. Challenges associated with initial costs and collaboration are addressed, along with the crucial role of policy and regulations in promoting sustainable practices. The concluding recommendations emphasize the need for education, technological innovation, supportive policies, and life cycle cost analysis to move towards a more sustainable built environment. By embracing these strategies, sustainable architecture and design can create environmentally responsible buildings, promote human well-being, and contribute to a more sustainable future.

Keywords: Sustainable, Architecture, Built Environment, Energy Efficiency, Green Building.

Introduction

Sustainable architecture and design encompass a multidimensional approach that integrates environmental, social, and economic considerations to create buildings that minimize negative impacts on the environment while enhancing the well-being of occupants. This concept has evolved to address the shortcomings of superficial "green" practices and traditional building methods, emphasizing the use of local materials, energy efficiency, waste reduction, and cultural relevance (Pantoja et al., 2022) (Bertei, 2023) (Shull, 2012).By incorporating elements of sustainable manufacturing and architectural design competitions into education, students can develop a comprehensive understanding of sustainable practices, encouraging the integration of these principles into future architectural projects. (Venkatesh, 2023) Sustainable architecture aims to harmonize modern technological advancements with traditional wisdom to create buildings that are not only environmentally friendly but also culturally significant and socially responsible. (Li et al., 2023). Sustainable design practices are crucial in engineering to address environmental impacts and societal needs. Perma engineering emphasizes the shift from a culture of control to a culture of care, aligning engineering with strong sustainability contexts (Grimal et al., 2023). Additionally, a sustainable simulation framework offers a way to reduce CO2 emissions by 25% through efficient simulation practices (Gopsill et al., 2023). Engineering systems must consider the environment and cultures they interact with to avoid obsolescence and promote sustainable development (Acero & Ramírez Cajiao, 2023). The emerging bio-digital industry showcases how material-based biological paradigms can lead to more sustainable manufacturing processes by mimicking nature's strategies and fostering cooperation between humans, biology, and machines (Rotondi, 2023). Furthermore, project design practices play a significant role in telecommunication sustainability, emphasizing the importance of budget, risk, and scope considerations in achieving social and environmental sustainability goals (“Project Design Practices and Sustainability of Telecommunication Project in Rwanda A Case of IHS Rwanda Ltd,” 2023). Sustainable architecture and design in Nigeria's built environment face significant challenges and opportunities, as highlighted by recent studies. The 2030 Agenda for Sustainable Development emphasizes the crucial role architects play in creating sustainable built environments that align with local community needs(Chidimma et al., 2020). Integrating green architecture, particularly in the savannah region, can mitigate environmental challenges, enhance energy efficiency, and improve public health, while also fostering economic resilience through job creation in green construction (Alkali, et al., 2024). A historical review indicates that sustainable construction in Nigeria has evolved through distinct phases, revealing increased awareness but

moderate implementation, necessitating stronger collaboration among stakeholders to enforce green policies (Isang, 2023). Furthermore, climate resilience strategies, such as the use of sustainable materials and innovative design, are essential for adapting to climate change impacts, although financial and regulatory barriers remain significant obstacles (Unegbu et al., 2024). Lastly, the construction practices in Anambra State illustrate the urgent need for sustainable policies to address eco-degradation and promote green initiatives in commercial building designs (U-Dominic et al., 2023). Sustainable architecture offers numerous benefits, including promoting resource efficiency, sustainable economic development, and encouraging sustainability in architectural projects (Li et al., 2023), (Bertei, 2023). It also involves disruptive innovations like incorporating microbial technologies and bio-construction techniques, leading to regenerative architecture that reduces environmental impact and improves building performance (Armstrong, 2023). Additionally, the integration of blockchain technology in supply chains enhances transparency, reduces operational costs, and increases sustainability by improving monitoring and supervision throughout the product lifecycle (Radmanesh et al., 2023). Critically, a conceptual framework for sustainable design practice allows architects to oscillate between positivistic and non-positivistic ideologies, fostering a more multi-dimensional and inclusive worldview in sustainable architecture (Sutar & G, 2022). Overall, sustainable architecture benefits the environment and contributes to economic efficiency, resource optimization, and improved building performance.

CONCEPTUAL REVIEW

Sustainable architecture and design have become critical in addressing the environmental challenges posed by traditional construction practices. This paper aims to explore the principles, strategies, and benefits of sustainable architecture and design, highlighting their importance in creating environmentally friendly and energy-efficient buildings. Sustainable architecture revolves around the principles of reducing resource consumption, minimizing waste, and promoting the health and well-being of occupants. Key principles include energy efficiency, use of renewable resources, and sustainable site planning (Baird, 2010). For instance, energy efficiency can be achieved through the incorporation of high-performance insulation and windows, while renewable resources might include materials such as bamboo or recycled steel (Mendler & Odell, 2000). Implementing sustainable design strategies involves various approaches. One essential strategy is the integration of passive solar design, which utilizes building orientation, window placement, and thermal mass to optimize natural light and heating (Gonzalo & Habermann, 2006). Green roofs and living walls are also popular strategies, providing insulation, reducing urban heat islands, and improving air quality (Dunnett & Kingsbury, 2004).

Another significant strategy is the use of sustainable materials. These materials are often locally sourced to reduce transportation emissions and are chosen for their durability and low environmental impact. Examples include reclaimed wood, recycled metal, and non-toxic paints (Kibert, 2016). The benefits of sustainable architecture are multifaceted, encompassing environmental, economic, and social aspects. Environmentally, sustainable buildings reduce greenhouse gas emissions and lower energy and water consumption (Mora, 2007). Economically, they often result in lower operational costs due to energy savings and increased building longevity (Kats, 2003). Socially, sustainable buildings provide healthier living and working environments, which can improve occupant well-being and productivity (Fowler & Rauch, 2008). Sustainable architecture and design are crucial in mitigating the environmental impacts of traditional construction practices. By adhering to principles of resource efficiency, employing innovative design strategies, and recognizing the broad benefits, the architectural community can significantly contribute to a more sustainable future.

THEORETICAL FRAMEWORK

Within the field of architecture, there is a need of a body of hypothesis to back the think about of building plan strategies (Plowright, 2014). Therefore, in order to understand the development of these strategies and how they can be adjusted to the demands of the display and the longer term, it is necessary to consider, examine, and reinterpret ideas from other field of study, particularly the common field of arranging, plan strategies developments, and urban arranging schools. We will be adopting the triple bottom line theoretical framework to offer an approach for comprehending and evaluating sustainable architecture and design, as well as a variety of perspectives for evaluating sustainable activities.

1. TRIPLE BOTTOM LINE (TBL) THEORY:

TBL is described as the collaborative evaluation of environmental, social, and economic sustainability, which forms the foundation for resource efficiency and sustainability (Arslan & Kısacık, 2017). Consequently, The Triple Bottom Line (TBL) approach addresses sustainability from three angles:

A. **Individuals (Social Advancement)**: The effects of housing on social fairness, community cohesion, and human health and well-being are all covered by social development in housing (Arowoshegbe, Uniamikogbo, & Gina, 2018). Important things to think about are: -
    i. **Indoor Environmental Quality (IEQ)**: Proper ventilation, natural light, thermal comfort, and acoustics are designed into buildings. The well-being of

occupants is improved by features like moveable windows, non-toxic materials, and an abundance of natural light.

ii. **Health and Safety**: Ensuring the safety of buildings contributes to the promotion of users' health. This entails utilizing non-toxic building supplies, making sure there is enough ventilation, and adding elements that promote physical activities

iii. **Community Impact:** Constructing structures that strengthen local social structures, foster communal spaces, and improve social cohesiveness. These could be community centers, open spaces, or mixed-use structures that house office, retail, and recreational space.

B. Earth (Sustainable Environmental Practices): Among other things, conserving the natural balance and cutting greenhouse gas emissions are examples of effective energy use. According to Breesam and Jawad (2021) the TBL framework's environmental component directs future generations toward actions that protect environmental sources from danger. Sustainable practices, such as lowering energy consumption, utilizing renewable energy sources, using recyclable materials, and safely disposing of toxic waste, should be a priority for environmentally conscious institutions.

C. Profitability (Economic Sustainability): The effect that organizations' work practices have on the economy is represented by the economic component. (Elkington, 1998). The organization's ability to support the next generation is enhanced by the economic value it adds to the surrounding system. The economic dimension can be viewed as a connection between the expansion of an organization and the rate of economic growth as well as the degree to which it contributes to that growth. The economic dimension includes capital movement, business financial performance, and economic involvement in society. Businesses that use TBL reports focus on how their operations affect society by adhering to internal and externally determined criteria (Khan et al., 2021). In this study, the Triple Bottom Line (TBL) framework serves as a conceptual and thematic structure rather than a direct tool for empirical data analysis. It provides a holistic lens through which sustainable architecture and design principles are discussed and organized—framing the discourse into three interconnected dimensions: social development, environmental sustainability, and economic viability.

METHODOLOGY

This study adopts a narrative and thematic review approach, aimed at synthesizing diverse perspectives on sustainable architecture and design within Nigeria’s built environment. The review integrates conceptual insights, theoretical frameworks, and selected empirical

case studies to offer a holistic view of current practices, strategies, and challenges in sustainable design.

Case studies were purposefully selected to reflect geographical diversity, building typology (e.g., educational, commercial, mixed-use), and the integration of key sustainable design features such as energy efficiency, passive ventilation, renewable materials, and environmental responsiveness. Sources were cross-verified using reputable institutional websites, journal articles, and official green building assessments where available, to ensure authenticity and reliability.

While not employing a systematic or quantitative analysis, the paper uses a thematic synthesis approach to organize findings under the Triple Bottom Line (TBL) framework, focusing on social, environmental, and economic dimensions of sustainability in architectural practice.

EMPIRICAL REVIEW

The following review of empirical data and case studies is guided by the methodology outlined above, using thematic lenses aligned with sustainable design objectives. This section presents a synthesis of empirical findings from both domestic and international studies that demonstrate the relevance, performance, and implications of sustainable design practices. The studies reviewed address measurable outcomes in areas such as material usage, energy efficiency, indoor environmental quality, and cost effectiveness, thus supporting the key dimensions of the Triple Bottom Line (TBL) framework. In the context of material sustainability, Nadarajan & Kirubakaran (2016) provide strong empirical backing for the use of local, low-impact materials like bamboo, adobe, and recycled content. These materials are shown to significantly reduce embodied carbon and contribute to environmental conservation, especially in climates where transportation emissions are high.Studies by Alkali et al. (2024) and Isang (2023) provide insights into the evolving implementation of sustainable practices. These works emphasize increasing awareness but slow adoption, often hindered by weak regulatory support and cost perceptions. However, the socioeconomic benefits, such as job creation in green construction and improved public health, are increasingly recognized by local stakeholders. Collectively, these empirical findings reinforce the relevance of sustainable design strategies within Nigeria's built environment. While empirical coverage in sub-Saharan Africa is still emerging, available data supports the need for architectural approaches that are resource-efficient, socially responsive, and economically viable closely aligning with the principles of the TBL framework.

SELECTED CASE STUDIES ON SOME EXISTING SUSTAINABLE BUILDING

1. **Heritage Place, Alfred Rewane (Kingsway) Road, Lagos:** Nigerian sustainable architecture is exemplified by the Heritage Place in Lagos. This commercial office

building was created by Architecture Studio and includes energy-efficient design components like rooftop solar panels, natural ventilation systems, and high-performance glazing (Oyebode, 2019). These elements give residents a comfortable interior atmosphere while assisting in lowering energy usage and greenhouse gas emissions.



Figure 1: Hertage iPlace, Ikoyi.
Source: heritageplaceikoyi.com

2. **The Civic Center Tower**: The Civic Center Tower in Lagos showcases sustainable architecture through different green building hones. It utilizes sun powered boards and Driven lighting to improve vitality productivity, decreasing dependence on the network and bringing down vitality utilization. Water preservation is accomplished through reusing frameworks for water system and latrine flushing, in conjunction with low-flow plumbing installations that cut water utilize by up to 30%. The development utilized reused materials, counting steel and concrete, and reasonably sourced wood for insides wraps up. The building advances characteristic ventilation and day lighting, minimizing the require for counterfeit lighting and discuss conditioning (Evans, 2020). Extra maintainable highlights incorporate a green roof that diminishes the urban warm island impact and water gathering frameworks for arranging. These hones lead to diminished operational costs and made strides tenant well being and efficiency.



Figure 2: Civic Center Tower

The Civic Center Tower Source: Civic Tower (Lagos). (2023, September 23). In *Wikipedia*. https://ig.wikipedia.org/wiki/Civic_Tower_(Lagos)

3. **The Lagos Business School (LBS) in Lekki:** The Lagos Business School (LBS) in Lekki is another notable example of sustainable architecture in Nigeria. The campus has been designed to minimize environmental impact while providing a conducive learning environment. Key sustainable design strategies include the use of solar panels for energy generation, energy- efficient building materials, and a greywater recycling system. The design also incorporates green spaces and natural ventilation to enhance the indoor environment. The practicality and advantages of sustainable design in educational institutions have been demonstrated by the considerable energy and water savings achieved by LBS's sustainable design (Adebayo, 2019).



Figure 3: The Lagos Business School (LBS) in Lekki

Source: https://www.lbs.edu.ng/about-lbs/campus/

4. **Nestoil Tower, Victoria Island, Lagos**: Nestoil Tower is a modern office building located on the Victoria Island in Lagos, Nigeria, and was developed with a focus on energy efficiency and sustainability. Rainwater harvesting, energy-efficient HVAC systems, and a high-performance façade are some of the tower's features. In addition, it has terraces and green roofs, which lessen the heat island effect and promote urban biodiversity. The building has demonstrated the potential of sustainable high-rise structures in Nigeria by achieving notable energy savings and receiving multiple green building certifications (Adeyemi, 2019).



Figure 4: Nestoil Tower, Victoria Island

Source: https://nestoilgroup.com/major-milestones/the-nestoil-tower/

CHALLENGES AND BARRIERS TO SUSTAINABLE DESIGN IMPLEMENTATION

1. **High Initial Costs:** Globally, one of the most significant barriers to the implementation of sustainable design is the high upfront cost associated with sustainable building materials and technologies. In the United States, the upfront costs of installing energy-efficient systems and renewable energy sources like solar panels are often higher compared to conventional systems. Despite long-term savings, the initial investment can be a deterrent (Matisoff, 2020). High initial costs can discourage developers and homeowners from investing in sustainable design, particularly in markets where financial incentives are lacking.

2. **Lack of Awareness and Education**: Architects, engineers, developers, and the general public are among the stakeholders in the building industry who generally lack

awareness and comprehension of sustainable design concepts. A large number of experts in Nigeria's building sector lack sufficient training in sustainable design methodologies. A skills gap results from educational institutions' frequent lack of comprehensive curricula concentrating on sustainability (Odeleye, 2021).

3. **Inadequate Regulatory Frameworks**: Sustainable design principles are not sufficiently encouraged or enforced by Nigeria's regulatory framework. Specific rules for sustainability are typically absent from building codes and standards. Developers are not required to address sustainability in their projects because there are no statutory green building rules or incentives for sustainable development (Oyebode, 2019). The adoption of sustainable design principles by developers is hindered in the absence of explicit laws and incentives, which impedes the advancement of sustainable architecture.

4. **Limited Access to Sustainable Building Materials**: The use of sustainable building materials in construction projects is severely hampered by the fact that they are not always easily accessible in Nigeria. Importing a large number of sustainable materials results in higher expenses and logistical difficulties. The building industry has not yet embraced locally produced, sustainable materials like adobe and bamboo (Ogunbodede & Owoeye, 2020). Achieving sustainable building standards is challenging since sustainable resources are expensive and scarce.

5. **Cultural Resistance and Preferences**: Adoption of sustainable design approaches can also be impeded by cultural attitudes and preferences. Individuals could be wary of new techniques and technology or resistive to change. Adoption of more sustainable yet unconventional solutions can clash with traditional preferences for specific architectural styles and materials, such steel and concrete (Odeleye, 2021). The adoption and use of sustainable design principles may be slowed by this cultural opposition, especially in residential projects where homeowner preferences are important.

6. **Technological and Infrastructure Challenges**: Another significant obstacle is the absence of the sophisticated technology infrastructure and support systems required to put sustainable solutions into practice. It is difficult to integrate renewable energy solutions in buildings due to a lack of infrastructure for renewable energy, such as a shortage of solar panel installers and maintenance services (Adeyemi, 2019). It is challenging to maintain and optimize sustainable building systems without the required infrastructure and technology support, which results in less- than-ideal performance and increased operating expenses.

7. **Political and Institutional Barriers**: The use of sustainable design principles may be hampered by political unpredictability and inadequate institutional frameworks. Political unrest has resulted in uneven support for sustainability programs in a number of Middle Eastern countries. Furthermore, ineffective bureaucracy might impede or stall environmentally friendly initiatives (Al-Saadi, 2021). Long-term planning and investment are discouraged by the unpredictable environment that political and institutional issues produce for sustainable development.

CONCLUSION AND RECOMMENDATIONS

Sustainable design has made significant strides in various fields, such as furniture design, seismic- resistant structures, and school architecture, showcasing its importance in environmental conservation and economic viability. Research on sustainable furniture design has surged since 2012, with themes evolving from furniture-human body scale match to broader concerns like carbon emissions reduction and industry chain sustainability (Zhu et al., 2023). In seismic design, the concept of Sustainable Seismic Design (SSD) emphasizes economic benefits and environmental protection, focusing on preventing collapse and facilitating post-earthquake repairs (Grigorian et al., 2023). Additionally, integrating sustainability criteria early in the design process using digital tools like Building Information Modeling (BIM) has proven effective in enhancing environmental performance without significant economic investments (Rodríguez, 2023). These achievements underscore the growing recognition and implementation of sustainable design principles across various disciplines, highlighting its crucial role in shaping a more eco-conscious and resilient future.

Reducing energy consumption and optimizing resource utilization are crucial for environmental Efforts to reduce energy consumption and resource use offer significant environmental benefits, contributing to climate protection and sustainability. Research highlights various strategies to achieve this, such as optimizing wire drawing technology to decrease energy consumption by 37% and reduce CO2 emissions (Gill & Page, 2023). Additionally, the implementation of deep learning time-series analysis techniques can lead to greener and more sustainable data centers by predicting and influencing computer resource usage, resulting in significant reductions in carbon footprint, particularly in CPU usage (Lutzenberger & Dosch, 2021). Furthermore, the introduction of instruments like the Resource Score label evaluates the lifecycle-wide utilization of essential resources in buildings, awarding those with low CO2 emissions and primary energy consumption, thus promoting resource efficiency and environmental conservation (Suliga et al., 2023). These findings underscore the importance of adopting innovative technologies and practices to mitigate environmental impact and promote a more sustainable future.

Recommendations for the Future

The path towards a more sustainable built environment requires a multifaceted approach:

- **Promote Education and Awareness:** Increased awareness of the environmental impact of buildings and the benefits of sustainable design is crucial for stakeholders, including architects, developers, and the public. Educational programs and outreach initiatives can play a vital role in driving change.
- **Advance Technological Innovation:** Continued research and development in sustainable materials, energy technologies, and building automation systems will enhance performance and create more cost-effective solutions.
- **Strengthen Policy and Incentives:** Government policies that incentivize sustainable design through tax breaks, subsidies, and streamlined permitting processes can significantly impact the industry. Existing rating systems like LEED need further development and broader adoption to create a strong market signal for sustainable buildings.
- **Embrace Life Cycle Cost Analysis:** Shifting the focus from initial investment costs to life cycle cost analysis, which considers the total cost of ownership over a building's lifespan, will highlight the long-term economic benefits of sustainable design.

By addressing these recommendations, the field of sustainable architecture and design can continue to evolve, creating a built environment that is environmentally responsible, promotes human well-being, and contributes to a more sustainable future.

REFERENCES

Acero, A., & Ramírez Cajiao, M. C. (2023). Analyzing Sustainable Practices in Engineering Projects: A Systemic Approach. *Sustainability (Switzerland)*, *15*(7), 1–14. https://doi.org/10.3390/su15076022

Adebayo, K. (2019). "Energy Efficiency in Educational Buildings: A Case Study of Lagos Business School." *Nigerian Journal of Environmental Sciences*, 11(1), 67-79.

Adeyemi, O. (2019). "Sustainable Design in High-Rise Buildings: The Case of Nestoil Tower, Lagos." *Journal of Sustainable Architecture and Urban Design*, 3(2), 88-105

Alkali, A. A., Mohammad, B. U., & Usman, H. A. (2024). Benefits of Integrating Green Architecture in Public Buildings within the Savannah Region of Nigeria. *African Journal of Environmental Sciences and Renewable Energy*, *15*(1), 104–112. https://doi.org/10.62154/4bzbq615

Al-Saadi, A. (2021). "Sustainability in the Middle East: Overcoming Political and Institutional Barriers." *Middle Eastern Journal of Sustainable Development*, 9(2), 45-58.

Arowoshegbe, A. O., Uniamikogbo, E., & Gina, O. O. (2018). Sustainability and triple bottom line: An overview of two interrelated concepts. Igbinedion University Journal of Accounting, 2, 88-104.

Arslan, M. C., & Kısacık, H. (2017). *The corporate sustainability solution: triple bottom line*. http://earsiv.hitit.edu.tr/xmlui/handle/11491/3418

Armstrong, R. (2023). Towards the microbial home: An overview of developments in next- generation sustainable architecture. *Microbial Biotechnology*, *16*(6), 1112–1130. https://doi.org/10.1111/1751-7915.14256

Bertei, A. C. (2023). *Arquitetura para o comportamento sustentável: análise de construções por meio da tipologia vernacular e da bioconstrução Architecture for sustainable behavior: analysis of constructions through the vernacular typology and bioconstruction*. 1–7.

Breesam, H. K., & Jawad, Z. a. K. (2021). Application of the Triple Bottom Line (TBL) concept to measure the maintenance performance of buildings. *IOP Conference Series. Materials Science and Engineering*, *1090*(1), 012079. https://doi.org/10.1088/1757- 899x/1090/1/012079

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st- century business. *Environmental Quality Management*, *8*(1), 37–51. https://doi.org/10.1002/tqem.3310080106

Evans, G. (2020). Civic Center Tower: A beacon of sustainability in Lagos. Green Building News. Retrieved from https://www.greenbuildingnews.com/civic-center-tower

Gill, S., & Page, R. S. (2023). Doing our bit to save the planet: Identifying and abandoning low value surgery. *ANZ Journal of Surgery*, *93*(11), 2565–2566. https://doi.org/10.1111/ans.18569

Gopsill, J., Hicks, B., Schiffmann, O., & McClenaghan, A. (2023). a Sustainable Computational Design Concept Using Web Service Methods. *Proceedings of the Design Society*, *3*(JULY), 425–434. https://doi.org/10.1017/pds.2023.43

Grigorian, M., Moghadam, A. S., & Massumi, A. (2023). Sustainable Seismic Design of Triple Steel Structures. *Sustainability (Switzerland)*, *15*(13). https://doi.org/10.3390/su151310336

Grimal, L., Di Loreto, I., & Troussier, N. (2023). Defining Permaengineering: New Practices for Strong Sustainable Contexts of Design. *Proceedings of the Design Society*, *3*(JULY), 1167– 1176. https://doi.org/10.1017/pds.2023.117

Isang, I. W. (2023). A historical review of sustainable construction in Nigeria: a decade of development and progression. *Frontiers in Engineering and Built Environment*, *3*(3), 206–218. https://doi.org/10.1108/FEBE-02-2023-0010

Khan, I. S., Ahmad, M. O., & Majava, J. (2021). Industry 4.0 and sustainable development: A systematic mapping of triple bottom line, Circular Economy and Sustainable Business Models perspectives. *Journal of Cleaner Production*, *297*, 126655. https://doi.org/10.1016/j.jclepro.2021.126655

Li, L., Yang, X., Xiang, X., Kong, L., Dai, J., & Zeng, Q. (2023). Integrating Sustainable Manufacturing into Architectural Design Teaching through Architectural Design Competitions. *Buildings*, *13*(4). https://doi.org/10.3390/buildings13041023

Lutzenberger, A. K., & Dosch, K. M. (2021). Development and implementtion of resource- labeling. *European Biomass Conference and Exhibition Proceedings*, 1116–1121. https://doi.org/10.4324/9781003244196-21

Matisoff, D. (2020). "Cost-Benefit Analysis of Green Buildings in the United States." *Journal of Sustainable Construction*, 8(2), 156-172.

Odeleye, T. (2021). "Innovative Sustainable Design Features in the Upbeat Recreational Center, Lagos." *Architectural Review Nigeria*, 12(3), 45-52.

Ogunbodede, A., & Owoeye, F. (2020). "Challenges of Sustainable Residential Construction in Nigeria." *Construction and Building Materials*, 85, 123-135.

Omidire, D. (n.d.). Heritage Place, Alfred Rewane (Kingsway) Road, Ikoyi - Lagos. Estate Intel. Retrieved June 9, 2024, from [https://estateintel.com/news/heritage-place ikoyi]

Oyebode, K. (2019). "Promoting Sustainable Architecture in Nigeria: Initiatives of the Nigerian Institute of Architects." *Journal of Green Building*, 7(4), 67-78

Oyebode, K., & Ufondu, A. (2018). "Success Factors in Sustainable Architectural Projects: Lessons from Nigeria." Sustainable Development Journal, 15(3), 189-202.

Pantoja, M. F. F., Póvoas, R. H. F., Pantoja, J. C., & Sales, A. C. M. N. (2022). Design and Sustainable Construction in the Contemporary Work of Norman Foster. *IOP Conference Series: Earth and Environmental Science*, *1123*(1), 0–10. https://doi.org/10.1088/1755- 1315/1123/1/012040

Plowright, P. D. (2014). *Revealing architectural design: Methods, frameworks and tools.*

Project Design Practices and Sustainability of Telecommunication Project in Rwanda A Case of IHS Rwanda Ltd. (2023). *Journal of Entrepreneurship & Project Management*, *7*(2), 78–92. https://doi.org/10.53819/81018102t5164

Radmanesh, S. A., Haji, A., & Fatahi Valilai, O. (2023). Blockchain-Based Architecture for a Sustainable Supply Chain in Cloud Architecture. *Sustainability (Switzerland)*, *15*(11). https://doi.org/10.3390/su15119072

Rodríguez, J. F. F. (2023). Sustainable Design Protocol in BIM Environments: Case Study of 3D Virtual Models of a Building in Seville (Spain) Based on BREEAM Method. *Sustainability (Switzerland)*, *15*(7). https://doi.org/10.3390/su15075787

Rosemary Chidimma, N.-O., Francis Ogochukwu, O., & Chinwe, S.-A. (2020). The 2030 Agenda for Sustainable Development in Nigeria: The Role of the Architect. *Science, Technology & Public Policy*, *4*(1), 15. https://doi.org/10.11648/j.stpp.20200401.13

Rotondi, C. (2023). How the informed relations between physical, digital and biological dimensions are changing the design practice, as well as the sustainability paradigm. *Frontiers in Bioengineering and Biotechnology*, *11*(May), 1–7. https://doi.org/10.3389/fbioe.2023.1193353

Shull, A. (2012). *Digital Commons @ Andrews University. The Design and Creation of a Portable Water Purification System Thank you for your interest in the Andrews University Digital Library Please honor the copyright of this document by*.

Suliga, M., Wartacz, R., Kostrzewa, J., & Hawryluk, M. (2023). Assessment of the Possibility of Reducing Energy Consumption and Environmental Pollution in the Steel Wire Manufacturing Process. *Materials*, *16*(5). https://doi.org/10.3390/ma16051940

Sutar, A. S., & G, D. Y. (2022). Green Architecture: A Notion of Sustainability. *Technoarete Transactions on Renewable Energy, Green Energy and Sustainability*, *2*(3), 23–28. https://doi.org/10.36647/ttregs/02.03.a005

U-Dominic, C. M., C. Igbokwe.N.C., N., Ono, G. C., & Okoro, B. U. (2023). Sustainability in Construction of Commercial Buildings in Anambra State, Nigeria: Re-Orienting the Antique Construction Ethics. *East Asian Journal of Multidisciplinary Research*, *2*(9), 3835–3852. https://doi.org/10.55927/eajmr.v2i9.5697

Venkatesh, G. (2023). Environment, Economy and Society – the Body, Mind and Soul of Sustainable Design of Buildings. *Problemy Ekorozwoju*, *18*(2), 249–253. https://doi.org/10.35784/preko.4038

Zhu, L., Yan, Y., & Lv, J. (2023). A Bibliometric Analysis of Current Knowledge Structure and Research Progress Related to Sustainable Furniture Design Systems. *Sustainability (Switzerland)*, *15*(11). https://doi.org/10.3390/su15118622