

BUILDING SUSTAINABILITY AND SUSTAINABLE BUILT ENVIRONMENTS IN NIGERIA: THE WAY FORWARD

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Abstract

Decarbonization of the built environment has become a major focus of economies worldwide due to the huge impacts of global over population and an increase in the global floor area of buildings which is expected to double by the year 2060. Delivering sustainable built environments therefore according to the world green building council is all about protecting peoples, places and natural environments and in addition they further believe that not only are sustainable built environments critical in offering solutions to the current climate change crisis being experienced, but they will also help in creating resilient, thriving communities and also aid in driving economic growth. This study aims to contribute to the field of sustainable built environments by engaging on an extensive analysis of existing literature on sustainability and sustainable built environments in Nigeria in the light of sustainable development with the view of highlighting key performance indexes of building stakeholders in achieving sustainability and reductions in carbon footprints of the building stock. The primary objective of the study is to develop a systematic approach at enabling sustainability decision making processes towards achieving sustainable built environments in the long run. It engages in qualitative research methodology through an extensive literature review of key studies on sustainable built environments in the Nigerian Building Space. The findings of the study highlight the lack of knowledge on the importance of sustainability and sustainable built environments in Nigeria and this could serve as a beaming searchlight by construction stakeholders and policy makers on the importance of this area of study that needs urgent attention.

Key Words: *Building, Built, Environment, Sustainability, Sustainable*

Introduction

It is the belief of Newton and Rogers (2020) that in the 21st century, the creation of Built Environments that are carbon neutral and water sensitive is crucial for addressing sustainable urban development

challenges. This multifaceted solution is based on the premise that the former involves mitigating the effects of greenhouse gases emissions and the later to adapt to climate change impacts. In addition, Global warming, environmental

pollution, energy consumption and depletion of limited natural resources are the key crisis that are facing the built environment currently and their management plays a vital role in achieving sustainable built environments (Sedighi *et al.*, 2023). Reducing greenhouse gases emissions directly linked to buildings will play a very significant role in tackling the consequences of global warming in the long run and further addressing the effects of global energy deficiencies (Almusaed *et al.*, 2023). It is as a result of these negative environmental indices that abound in the built environment that Sustainable architectural designs have been proposed towards reducing the negative environmental effects of buildings by improvements in buildings energy efficiency capacities, improvements in health, comfort, safety and liveability for occupants and the ecosystem at large (Singh and Singh 2023). In addition, achieving healthier, comfortable and more productive ways of living has further fuelled transitions in technology and regenerative built environments have emerged as the tagline for sustainable development (Agboola *et al.*, 2023). In defining the built environment, (Khan *et al.*, 2021) defines it as humankind's daily lives and activities, sophistication, efficiency and effectiveness. The built environment is referred also as man's creation otherwise referred to as human-made spaces that integrates working, living and recreation while also including physical structures, supporting infrastructure designed and managed green and blue spaces for people to interact and perform their daily activities (He *et al.*, 2023). In addition, the authors suggest that human activities have transformed the natural urban landscape

through a population agglomeration, technological advancements and economic growth often referred to as urbanization. However, (Bao *et al.*, 2023) attributes the intensity and scale of human activities as promoting the accumulation and distribution of materials in the built environment which can cause a long lasting change in terms of the built environments density, diversity and design. These changes can eventually lead to long term environmental and sustainability impacts. In the long run, human activities continue to pose a threat to the built environment and there currently is an urgency to reduce greenhouse gases emissions followed by the alarming predictions that urbanization is estimated to add 2.5 billion people to the global urban population by 2050 (Passer *et al.*, 2020) and with increases in population, the ripple effects of housing provision follows which poses a threat to sustainable built environment standards.

While agreeing that capital developments are key strategies at enhancing urban growth, (Hurliman *et al.*, 2023) attribute urbanization and industrialization as key detrimental phenomenon's that have changed the earth's natural environment while (Gupta and Bharat 2023) are of the opinion that Urbanization is an irreversible process which drastically affects the availability and quality of the earth's ecosystem. Following the establishment of the United Nations Sustainable Development Goals (SDGs), sustainability has become the primary focus of major economies worldwide in the agenda towards making the built environment safer and more habitable (Goh *et al.*, 2023). It is based primarily on three cardinal goals namely environment, economy and the society.

(Jain, 2023) asserts that sustainable development tends to promote harmony between humans and nature while further agreeing that sustainable built environments encompass places and buildings where people inhabit, where people also work and relax and are interconnected by transportation systems, facilities and services.

In a study conducted in Mauritius in 2018, the effects of rapid Urbanization have been observed since majority of the green spaces in the countries built environment house many buildings which has resulted in the effects of urban heat islands caused by hardscapes resulting in global warming and emissions of greenhouse gases Gooroochurn and Chooneea (2023). Therefore, because of global warming on the built environment, this has resulted in the promulgation of the sustainable development goals by the United Nations with particular interest in Agenda Thirteen (Agenda-13) calling for urgent actions at combating Climate Change and its impacts across different spheres of human interactions (Olaniyan 2023). Previous authors, (Okoye *et al.*, 2023) agrees that Nigeria being a major partner of international conventions and treaties still falls short of adhering to sustainable construction practices thereby exposing the Nigerian built environment to further deterioration and harmful effects of unsteady weather patterns worldwide. This has resulted in the negative impacts on the welfare of many people in Nigeria and as a result, (Akah *et al.*, 2023) suggest that building sustainability is an essential strategy at reducing climate change and adapting to it. Further to this is their suggestion that erecting sustainable structures can help in lowering greenhouse gas emissions, assist

in consumption of lower energy, preservations in water consumption and an extreme risk resistance to climate-related threats. While it is important to note that buildings and the built environment should be associated by symbiotic relationships offering each other mutual and exclusive benefits, it is the belief of (Adewale *et al.*, 2023) that buildings should contribute and renew their environment rather than drain them much as plants and animals do when they adapt to their surroundings. This is not the case in the Nigerian Building construction space since buildings have contributed to the effects of climate change and global warming disasters. (Oribuyaku, 2015) therefore suggests that faced with an increasingly extreme climatic conditions, dwindling natural assets and all manners of pollution, African countries should go past the idea that economic development and poverty eradication are more important than sustainable development but should place sustainable development on their top burner since they are guilty of environmental pollutions destruction of the ecosystem.

In addressing the research gaps, this study aims to investigate building sustainability and sustainable built environments in Nigeria. By doing this, the research seeks to gain insights and knowledge into design practices that enable sustainability in the Nigerian Built Environment in mitigating against the effect of global warming and climate change.

The primary objective of the study is to develop a systematic approach at enabling sustainability decision making processes towards achieving sustainable built environments in the long run.

It is believed that through this study, a better understanding of sustainability and sustainable built environments in Nigeria will be developed, thereby providing better insight of strategies and design requirements and methods and measures that are applicable in achieving sustainable design in the Nigerian Built Environment. It will further give insight into achieving reductions in greenhouse gas emissions into the Nigerian Built Environment. The findings of the research will contribute to the existing knowledge on sustainability and sustainable built environment practices in Nigeria and giving valuable insights into future research into this study area.

The Concept of Sustainability

Sustainability has always been a cardinal point in preserving the environment since the olden days especially in rural areas which (Hariram *et al.*, 2023) associate with ancient cultures worship and religious convictions with environmental conservation. It is the belief of the authors that two definitions of sustainability capture the complete essence of the term which firstly is that of the Brundland Report (1987) which defines sustainability as a process of change wherein exploitation of resources and institutional changes is made with the future as well as the present needs are met. Secondly, (Hariram *et al.*, 2023) have defined Sustainability according to the Earth Centre as meaning that all living things on earth have an obligation to each other, the larger biosphere and subsequently future generations. In addition, they have identified three principles of sustainability namely economy, environment and society which are typically prioritized when discussing sustainable development. A sustainable

structure is usually built on three pillars which are often referred to as the three intersecting circles of sustainability and include economic, social and environmental (or ecological) which highlights further that three domains of the economy, the environment and the social domain must be considered when discussing sustainability.

Hariram *et al.* (2023) address the various challenges associated with attaining sustainability as being pollution, global warming, Land Degradation and Agricultural Constraints, Habitat and Biodiversity Loss, Water Scarcity, Food Security and hunger, Waste Management, Industrialization and Sustainability Nexus, Urbanization and Sustainability Nexus, Globalization and Sustainability Nexus, Climate Change and Sustainability Nexus, Natural Disasters and Sustainability Nexus and finally Population Rise and Sustainability Nexus. Further research by Islam and Wang (2023) argues that environmental sustainability plays a very crucial role in enhancing the successful maintenance of natural environmental elements such as air, soil, water, forests, wetlands, the atmosphere and all living things on the planet.

Sustainability In Construction

Sustainability has always been about looking ahead and meeting both the needs of the present and future generations while also taking the needs of the built environment into consideration (Kazemi *et al.*, 2023). Sustainability in construction has become a major issue of discussion in the current body of knowledge from planning to deconstruction which according to (Regúlez *et al.*, 2023) is due to building developments being performed at huge environmental costs

which have led to urgent steps being sought to reduce the effects of buildings on the built environment and mitigating global warming. The construction sector continues to temper with the environment in three major ways which are firstly, over extraction of environmental resources such as fossils and minerals. Secondly, (Kazemi *et al.*, 2023) conclude that there is the over usage of generic resources like land, water, air and energy and thirdly environmental pollution from odors, dust, vibration, chemical pollution, solid waste and waste disposal. Lin *et al.* (2023) agree that various schemes have been adopted by governments and organizations worldwide to checkmate the effects of global warming like the carbon emission's trading scheme which encourages companies emitting less CO₂ including the construction sector thereby enhancing sustainable practices in the construction industry that further assists in preserving the built environment. One of the steps at achieving this is by the decarbonation of cement based composites used in construction projects. Another is the use of plant panels as an effective building



Fig. 1.1: The Construction Industry Is Going Greener
Source: Chris Jackson 2021

component in future building designs which has also become one of the next generation in sustainable building structures which has been believed to enhance building indoor environments (Almusaed *et al.*, 2023). In addition, the use of compressed earth blocks has become a very effective solution to sustainability of buildings in Burkina Faso which have become an essential characteristics of most hot tropical environments in Africa (Bibang *et al.*, 2023). As part of sustainable construction methods in the built environment, it has become expedient that buildings adopt green design concepts whereby building have less harmful effects on the built environment. These are highlighted in Figure 1 where the use of green elements like plants and water bodies enhance the preservation of the environment. Secondly, in Nigerian Hausa Traditional Architecture of the North, it is important to note that the use of clay as a walling material was an initial process of ensuring that the buildings designed by this method do not release greenhouse gases into the environment as highlighted in Figure 1.2.



Figure 1.2: The Art of Hausa Architecture and Sustainability
Source: Baty Al Fann 2021

The Concept of Sustainable Built Environments in Nigeria

It has come to be accepted that the construction industry has a major role to play in achieving sustainable built environments and sustainable development (Aigbavboa *et al.*, 2017). The built environment is a critical part of the climate action plan in terms of its sustainability and resilience and as a result, sustainable development could reform the practice in the construction sector where buildings are a major culprit in CO₂ and greenhouse gases emissions into the environment Goh and Chong (2023). Suggestions have been made that the application of bioactive elements on building facades is one of the new innovations in solving the problems of CO₂ emissions reductions due to their environmentally friendly nature (Sedighi *et al.*, 2023). In addition, integration of different green strategies like green squares, trees, green walls and green roofs have the ability to reduce thermal comfort within buildings in research conducted in Italy Cascone and Leuzzo (2023). Gorji and Martek (2023) have emphasized the importance of green growth technologies in the form of renewable energy development as innovative strategies for addressing environmental concerns while also promoting economic developments in a study carried out on developing and developed economies. Further promoting the preservation of the built environment, (Henda *et al.*, 2023) believe that the applications of Perovskite solar cells as a sustainable building material will further assist in its preservation.

Yusuf *et al.* (2023) in highlighting the significance of landscape in the scheme of things regarding sustainable built environments in Nigeria suggest that

involving landscape Architects in planning of the urban landscape will encourage sustainability and preservation of the urban identities of metropolitan cities in Nigeria. In addition, the use of eco-friendly construction materials has been associated with health benefits in the design of wellness centres for both interior and exterior works which include wood, stone and concrete as most beneficial building materials selection thereby also contributing to the attainment of the SDGs Ekhaese and Ndimako (2023). Of major significance also is the suggestion that construction industry stakeholders should consider the sustainable sourcing of building materials since local sourcing of building materials can considerably reduce CO₂ emissions associated with freight transport (Valentini, 2023). This the author stated has resulted in the use of local clay soil as raw materials to produce sustainable cement while also introducing the fact that in Ghana, clam shells are currently being used as an alternated source of calcium carbonate and also other shells like aragonite are alternatives. On the other hand, diverse types of agro-waste ranging from rice husk ash, sugarcane bagasse ash and bamboo leaves ash are currently being used as potent building materials solutions towards the development of sustainable construction materials (Maraveas, 2020). As a result of the research, six different construction materials made using agro waste were studied with achieved advantages and these were brick masonry elements, green concrete products, insulation and reinforcement materials for buildings, particle boards and bio-based plastics thereby enhancing higher durability advantages with their use.

Implementing smart-sustainable practices also in the construction industry have enhanced a lot of gains in terms of their environmental friendliness because of their applications. Olawunmi *et al.* (2023) have identified as renewable energy sources, waste reduction and recycling, water conservation and carbon capture techniques since these can greatly enhance energy efficiency and improvements in buildings. It was observed by the study that the key benefits of implementing smart sustainable practices in Nigeria includes facilitating the buildings energy performance simulation, enhancement of project quality and productivity, and better design products with low-environmental impact. On the other hand, (Lembi *et al.*, 2021) have identified advantages derived from the implementation of the principles of green architecture and sustainable building materials because of the need for the provision of affordable housing and sustainable built environments in Nigeria. Thus, the sustainable materials identified from the study are pozzolans and blended cement, natural fibre-reinforced roofing tiles, lignocellulosic fibres combined with cement and used as ceiling boards. Others are Saw dust-reinforced concrete hollow blocks and clay bricks as walling materials, Natural fibre-reinforced floor and wall tiles and the use of substitute reinforcing materials like canes of rattan species. All these contribute to achieving sustainable built environments during building construction projects. Therefore, (Oribuyaku, 2015) believes that Nigeria needs to develop a specialized policy framework for the built environment which will focus more on mitigation strategies rather on adaptation strategies as currently being practiced thereby

enhancing sustainability in the built environment and also enhancing sustainable built environments in the Nigerian Building development space.

Methodology

The study adopted a qualitative approach to achieve the research aims. (Bhangu *et al.*, 2023) defines qualitative research as techniques of investigation that employ non-statistical and non-numerical methods of data collection, analysis and evidence production. Qualitative research allows for an in-depth understanding of the subject matter, capturing nuances and contextual factors that quantitative methods might overlook. In the context of this study, qualitative research is apt because it enables the exploration of diverse perspectives, opinions, and experiences related to sustainable practices in the construction sector of Nigeria. The methodology employed qualitative-content analysis on the secondary data from the reviewed literature from forty-four (n=44) relevant articles sourced from Google Scholar, Proquest Semantics, and Scopus covering the periods from 2015 to 2023. Therefore, the study was conducted by mainly employing an extensive and comprehensive evaluation of the forty-four (n=44) literature reviewed for achieving its goal on the fields of sustainability, sustainability in construction, sustainable built environments, sustainable built environments in Nigeria and Modern Practices at achieving sustainability and sustainable built environments. These were all carried out to identify how all the studied sub-topics fit together on the larger scheme of attainment of the Sustainable Development Goals target of

2030. In addition, the method of applying the sequence of information collection procedure which includes creation of the study questions, selection of relevant studies, evaluation of the value and substance of the studies reviewed, grouping and analysis of the findings and interpretation and clarity of the research was further adopted towards arriving at a comprehensive evaluation (Adedeji *et al.*, 2023). Between August and October 2023, the study began with a thorough search and assessment of articles published, conference papers, scientific journals with Google Scholar acting as the major source of literature and ProQuest and Semantics Scholar and Scopus acting as alternatives. Due to its wide repository of journal coverage and unique features in web search engines, the Google Scholar system was selected as the major provider of the literature source. The relevant literature for the study were then carefully selected through exclusion and inclusion techniques which allowed the irrelevant data to be removed in order to concentrate on the key indices of the key focus of the research namely sustainability, sustainability in construction, sustainable built environments, sustainable built environments in Nigeria and Modern Practices at achieving sustainability and sustainable built environments. Further to this, the paper titles and abstracts were examined to determine which ones will have their entire texts examined and used in the study. However, it is essential to acknowledge the limitations of this research. One potential limitation lies in the selection bias of the literature. The choice of articles and studies might be influenced by the availability of sources, leading to the omission of relevant materials. Additionally, there might be

inherent biases in the literature itself, as certain perspectives or regions might be overrepresented, while others are underrepresented. These biases could impact the overall conclusions drawn from the study. To mitigate these limitations, the study employed a rigorous process of article selection and evaluation. Grading the chosen articles based on relevance helped in prioritizing the most pertinent sources.

Results

Sustainable construction and sustainability in the built environment have become important issues in construction research and while developed economies have harnessed the use of technology and innovation to mitigate the effects of global warming, developing economies like that of Nigeria are still not positioned positively at mitigating these harmful effects Madueme and Nnaji (2023). The construction industry in Nigeria is known for its dynamism and unpredictability Aliu and Aigbavboa (2023) and as a result, the principles of sustainability and sustainable built environments continue to elude the construction industry sector in developing economies. In addition, the construction industry has a higher mass exploitation of the earth's natural resources used for its development and survival compared to other developmental sectors over a longer period and replenishing these depleted resources are alarmingly low compared to the rates of depletion. (U-Dominic *et al.*, 2023). (Okoye *et al.*, 2023) in their research on implementation of sustainable construction practices in South-East Nigeria observed that the overall level of implementation and adoption of sustainable construction practice is still

very low in its awareness levels and practices amongst construction industry stakeholders. Madueme and Nnaji (2023) have agreed that the major reasons associated with a lack of practice of sustainable construction practices in Nigeria are associated to economic reasons, a lack of public knowledge and a lack of demand of sustainable constructions in the Nigerian Construction Industry space. It has also been reported that associated benefits exist in the use of urban green infrastructure in achieving sustainable development but the benefits and the main influences on people who visit such places has also not been understood thereby embarking on construction projects that do not provide for green infrastructure and making the attainment of sustainable built environments in Nigeria non realizable (Uzoannah *et al.*, 2023). Dipeolu and Ibe (2020) further agree that green infrastructure provides ecosystems services that aid in mitigating the effects of environmental sustainability challenges while also improving the health of residents and also improving the built environment.

One major way the construction industry also enhances sustainable built environments is the way they engage in their procurement activities. (Ogunsanya *et al.*, 2022) have shown that previous studies in Nigeria have highlighted the embrace of the tenets of sustainable procurement but the process has been very slow in taking off due to a lack of knowledge and understanding on the part of the stakeholders. (Kineber *et al.*, 2022) advice that sustainability concepts should be employed in all decision-making processes while embarking on the creation of building projects. (Nau *et al.*, 2023) in

advocating for sustainable built environments agree that this needs a systems approach at enhancement which involves the creation of environments that are conducive to sustainability which can be achieved by enactment of laws by government targeted at regulating the built environment for preservation. Also, by the enactment of laws that promote environmental sustainability, these will enhance systems changes and further have the capacity to orient the rules and goals of the existing system. Research and development grants by governments can also play a very important role in developing new products and processes that could promote sustainable built environments which agrees with (Newton *et al.*, 2020) highlighting the Australian Governments involvement in disbursing AUD 4.9billion to 225 corporate research centres mandated to find solutions to carbon neutrality in the Australian Built Environment. It is further suggested that if cities can identify interventions that will create sustainable environments and practices that will enhance their desired future built environments, then their transformations will be further accelerated. The types of innovative steps that are suggested are three pronged which are at the city scale whereby carbon accounting techniques are implemented. Secondly, the interventions could be at the prescient level which in the case of Nigeria is equivalent to the local government areas. Examples are considerations of new energy and/or water system technologies, enhancing the flood resilience of communities and finally at the household level where the interventions suggested are solar rooftop photovoltaics.

Conclusion

This study on building sustainability and sustainable built environments in Nigeria: the way forward provides valuable insight for the concept of sustainable built environments in Nigeria, sustainability in construction, the concept of sustainability and sustainable built environments. Carbon emissions continue to be the silent and invisible enemy mankind is currently grappling with that has resulted in severe built environment phenomenon's that have continued to be experienced worldwide in the form of global temperature rises, famine, floods and pollution. Nigeria has not been spared these huge environmental impacts that have affected the global centre. Its devastation if not checked or controlled can lead to far greater consequences than envisaged. Currently, Nigeria falls below the standard of achieving sustainable built environments due to a lack of effective policy frameworks that addresses these all-encompassing issues of sustainable development. The study has highlighted key areas of enhancing sustainability, sustainable built environments and sustainable development. It is suggested that governments at all levels enable the enactment of policy frameworks that will continue to enhance sustainable cities and future developments.

This study sheds light on the critical imperative of adopting sustainable practices in the Nigerian construction sector. The key findings underscore the significant disparities between current construction practices in Nigeria and the global mandate for sustainability. Notably, the challenges posed by rapid urbanization, a lack of awareness, and policy gaps have been systematically examined, emphasizing the urgent need

for strategic interventions. Furthermore, the primary objective of this research was to develop a systematic approach for enabling decision-making processes aimed at achieving sustainable built environments. Through extensive research and analysis, it has become evident that several critical areas demand immediate attention. However, aligning Nigeria's construction practices with global sustainability standards remains an extensive and necessary undertaking. In addition to these findings, this study makes a substantial contribution to the body of knowledge. It sheds light on existing challenges while simultaneously offering potential solutions. By delving into the complexities of sustainable construction within the Nigerian context, this research facilitates a more nuanced understanding of the underlying issues.

To bridge the current gap, it is imperative that the Nigerian government enact robust policies promoting sustainable construction and urban development. Specific policy recommendations include incentivizing the utilization of eco-friendly construction materials, enforcing stringent energy efficiency standards, and integrating green spaces into urban planning. Additionally, there is a critical need for educational initiatives aimed at raising awareness among construction industry stakeholders and the general populace. While this study lays the foundation by identifying challenges and suggesting policy pathways, there remains substantial room for further research and action. In the pursuit of sustainable built environments, future research should delve into innovative financing models for sustainable construction projects, conduct in-depth studies on the socio-economic

impact of sustainable practices, and explore the role of emerging technologies, such as Building Information Modeling (BIM), in enhancing construction efficiency and sustainability. Sustainable construction is not merely a choice; it is an urgent necessity. Collective efforts from policymakers, industry stakeholders, and researchers are indispensable to secure a sustainable and resilient future for Nigeria's built environment.

References

- Adewale, B.A., Omokanye, L.A. and Udemezue, C.N. (2023). User Satisfaction with Regenerative Architecture Principles in Selected Recreational Centres in Lagos, Nigeria. *African Journal of Environmental Research*, 4(2): 165-186.
- Adedeji, I., Deveci, G. and Salman, H. (2023). The Challenges in Providing Affordable Housing in Nigeria and the Adequate Sustainable Approaches for Addressing Them. *Open Journal of Applied Sciences*, 13(3): 431-448.
- Agboola, O.P., Alotaibi, B.S., Dodo, Y.A., Abuhussain, M.A. and Abuhussain, M. (2023). Built environment transformation in Nigeria: the effects of a regenerative framework. *Journal of Asian Architecture and Building Engineering*, 1-24.
- Aigbavboa, C., Ohiomah, I. and Zwane, T. (2017). Sustainable construction practices: “a lazy view” of construction professionals in the South Africa construction industry. *Energy Procedia*, 105: 3003-3010.
- Aliu, J. and Aigbavboa, C. (2023). Key generic skills for employability of built environment graduates. *International Journal of Construction Management*, 23(3): 542-552.
- Almusaed, A., Almssad, A., Alasadi, A., Yitmen, I. and Al-Samarraee, S. (2023). Assessing the Role and Efficiency of Thermal Insulation by the “BIO-GREEN PANEL” in Enhancing Sustainability in a Built Environment. *Sustainability*, 15(13): 10418.
- Bao, Y., Huang, Z., Li, L., Wang, H., Lin, J. and Liu, G. (2023). Evaluating the human use efficiency of urban built environment and their coordinated development in a spatially refined manner. *Resources, Conservation and Recycling*, 189: 106723.
- Bhangu, S., Provost, F. and Caduff, C. (2023). Introduction to qualitative research methods—Part I. *Perspectives in Clinical Research*, 14(1): 39.
- Bibang Bi Obam Assoumou, S.S., Zhu, L. and Francis Deng, C. (2023). A Conceptual Framework for Achieving Sustainable Building Through Compressed Earth Block: a Case of Ouagadougou, Burkina Faso. *Circular Economy and Sustainability*, 3(2): 1029-1043.
- Cascone, S. and Leuzzo, A. (2023). Thermal comfort in the built environment: a digital workflow for the comparison of different green infrastructure strategies. *Atmosphere*, 14(4): 685.
- Dipeolu, A.A. and Ibem, E.O. (2020). Green infrastructure quality and environmental sustainability in residential neighbourhoods in

- Lagos, Nigeria. *International Journal of Urban Sustainable Development*, 12(3): 267-282.
- Ekhaese, E.N. and Ndimako, O.O. (2023). Eco-friendly construction materials and health benefits in the design of an all-inclusive health resorts, Nigeria. *Frontiers in Built Environment*, 9: 1011759.
- Goh, C.S., Ting, J.N. and Bajracharya, A. (2023). Exploring social sustainability in the built environment. *Advances in Environmental and Engineering Research*, 4(1): 1-15.
- Goh, C.S. and Chong, H.Y. (2023). Opportunities in the Sustainable Built Environment: *Perspectives on Human-Centric Approaches. Energies*, 16(3): 1301.
- Gooroochurn, M., Choonea, M. and Bhoodoo, D. (2023, May). Development of a sustainability matrix for plant selection & analysis of the use of landscaping to promote energy efficiency and thermal comfort in the built environment. In AIP Conference Proceedings (Vol. 2584, No. 1). AIP Publishing.
- Gorji, A.A. and Martek, I. (2023). Renewable energy policy and deployment of renewable energy technologies: The role of resource curse. *Environmental Science and Pollution Research*, 1-19.
- Gupta, P. and Bharat, A. (2023). A hybrid scale to relate natural and built environments: a pragmatic approach to sustainable cities. *International Journal of Sustainable Development & World Ecology*, 30(1): 95-110.
- Hariram, N.P., Mekha, K.B., Suganthan, V. and Sudhakar, K. (2023). Sustainalism: An Integrated Socio-Economic-Environmental Model to Address Sustainable Development and Sustainability. *Sustainability*, 15(13): 10682.
- He, X., Gao, W., Guan, D. and Zhou, L. (2023). Impacts of urban shrinkage on the built environment and its environmental sustainability: An analytical review. *Environmental Research Letters*.
- Henda, M.B., Jebli, M., Dara, R.N. and Le, Q.H. (2023). The significance and effectiveness of combining integrated photovoltaic systems and biomaterials to improve renewable energy utilization in the built environment via molecular dynamics method. *Engineering Analysis with Boundary Elements*, 148: 15-21.
- Hurlimann, A., Beilin, R. and March, A. (2023). 'Rethinking the way we practice our professions': social-ecological resilience for built environment professionals. *Journal of Further and Higher Education*, 47(1): 118-133.
- Islam, M.Z. and Wang, S. (2023). Exploring the unique characteristics of environmental sustainability in China: Navigating future challenges. *Chinese Journal of Population, Resources and Environment*, 21(1): 37-42.
- Jain, A.K. (2023). An Agenda for Resilient, Green and Sustainable Built Environment. In *Climate Resilient, Green and Low Carbon Built Environment* (pp. 1-15). Singapore: Springer Nature Singapore.
- Kazemi, M.Z., Elamer, A.A., Theodosopoulos, G. and Khatib, S.F. (2023). Reinventing research

- on sustainability reporting in the construction industry: a systematic review and future research agenda. *Journal of business Research*, 167, 114145.
- Khan, S.A., Koç, M. and Al-Ghamdi, S.G. (2021). Sustainability assessment, potentials and challenges of 3D printed concrete structures: A systematic review for built environmental applications. *Journal of Cleaner Production*, 303: 127027.
- Kineber, A.F., Massoud, M.M., Hamed, M.M., Alhammedi, Y. and Al-Mhdawi, M.K.S. (2023). Impact of Overcoming BIM Implementation Barriers on Sustainable Building Project Success: A PLS-SEM Approach. *Buildings*, 13(1): 178.
- Lembi, J.J., Umar, I.A., Kobiba, H.A. and Tarni, A.M. (2021). Green architecture review and the responsive building materials towards a sustainable built environment in Nigeria.
- Madueme, N.B. and Nnaji, C.C. (2023). Assessment of the Perception and Practices of Sustainable Construction in the University of Nigeria. In *Construction Industry Development Board Postgraduate Research Conference* (pp. 92-102). Cham: Springer International Publishing.
- Maraveas, C. (2020). Production of sustainable construction materials using agro-wastes. *Materials*, 13(2): 262.
- Nau, T., Perry, S., Giles-Corti, B., Bellew, W., Bauman, A. and Smith, B.J. (2023). Mapping and analysis of laws influencing built environments for walking and cycling in Australia. *BMC Public Health*, 23(1): 1-25.
- Newton, P.W. and Rogers, B.C. (2020). Transforming built environments: Towards carbon neutral and blue-green cities. *Sustainability*, 12(11): 4745.
- Olawumi, T.O., Chan, D.W., Saka, A.B., Ekundayo, D. and Odeh, A.O. (2023). Are there any gains in green-tech adoption? Unearthing the beneficial outcomes of smart-sustainable practices in Nigeria and Hong Kong built environment. *Journal of Cleaner Production*, 410: 137280.
- Ogunsanya, O.A., Aigbavboa, C.O., Thwala, D.W. and Edwards, D.J. (2022). Barriers to sustainable procurement in the Nigerian construction industry: an exploratory factor analysis. *International Journal of Construction Management*, 22(5): 861-872.
- Olaniyan, S.A. (2023). Towards Achieving Sustainable Development Goal-2030 Agenda Thirteen: A Review of Technological Advances from the Built Environment Professionals. *International Journal of Built Environment and Sustainability*, 10(2): 53-69.
- Okoye, P.U., Ohazulume, G.C. and Odesola, I.A. (2023). Multi-Layered Approach to Sustainable Construction Practice: A Socio-Cultural PERSPECTIVES. *Tropical Built Environment Journal*, 9(1): 82 – 115.
- Oribuyaku, D. (2015). Code for a sustainable built environment in

- Nigeria: a proposed high-level vision of a policy framework.
- Passer, A., Lützkendorf, T., Habert, G., Kromp-Kolb, H., Monsberger, M., Eder, M. and Truger, B. (2020). Sustainable built environment: transition towards a net zero carbon built environment. *The international Journal of Life Cycle Assessment*, 25: 1160-1167.
- Regúlez, B., Faria, D.M., Todisco, L., Fernández Ruiz, M. and Corres, H. (2023). Sustainability in construction: The urgent need for a new ethics. *Structural Concrete*, 24(2): 1893-1913.
- Sedighi, M., Pourmoghaddam Qhazvini, P. and Amidpour, M. (2023). Algae-Powered Buildings: A Review of an Innovative, Sustainable Approach in the Built Environment. *Sustainability*, 15(4): 3729.
- Singh, D. and Singh, A. (2023). Role of Building Automation Technology in Creating a Smart and Sustainable Built Environment.
- U-Dominic, C. M., Ono, G.C. and Okoro, B.U. (2023). Sustainability in Construction Commercial Buildings in Anambra State, Nigeria: Re-Orienting the Antique Construction Ethics. *East Asian Journal of Multidisciplinary Research*, 2(9): 3835-3852.
- Uzonnah, O.E., Chukwu, I.N. and Ibem, E.O. (2023). Influence of perceived social benefits on motives for visiting urban green infrastructure spaces in small and medium-sized towns in Southeast Nigeria. *Cities*, 135: 104240.
- Valentini, L. (2023). Sustainable sourcing of raw materials for the built environment. *Materials Today: Proceedings*.
- Yusuf, D.A., Zhu, J., Nashe, S.A., Usman, A. M., Sagir, A., Yukubu, A., ... & Ahmed, A. (2023). A Typology for Urban Landscape Progression: Toward a Sustainable Planning Mechanism in Kano Metropolis, Nigeria. *Urban Science*, 7(2): 36.