



Sustainable Water Management Practices for Green Building Development in Nigeria

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ABSTRACT

This research aims to examine the strategies for sustainable water management in Nigeria for the construction of green buildings. Population growth, urbanization, and impacts of climate change have also magnified water resource scarcity hence the best practices of water management in Nigeria's green buildings. From the literature analysis presented in this paper, it is clear that sustainable water management practices such as rainwater harvesting, greywater recycling and efficient irrigation practices are instrumental in minimising water use in green buildings. It also digs deeper into the current laws regarding water resource management in Nigeria and reveals drawbacks accompanying policy enactment and compliance. Studying the environment and circumstances of Nigeria, the essential components of the further development of green construction are defined, in addition to the best international practices, the use of indigenous knowledge and the integration of modern water management technologies into the local conditions. It offers realistic implications for developers, relevant authorities and communities, focusing on confirming better enforcement of regulation, increasing understanding of the inhabitants, and supporting appropriate water systems that allow sustaining lease. Last but not least, the paper outlines directions for further research, specifically, about the economic feasibility of water-saving technologies and the application of decentralized water management systems in cities.

Keywords: Sustainable Water Management, Green Building Development, and Environmental Sustainability

1.0 Introduction

The problem of water availability or scarcity has emerged as a major challenge in Nigeria, especially as it relates to the availability of safe, portable and adequate water supply especially in the urban and semi-urban areas (Joshua, 2021). The increase of population growth, urbanization and climate change challenges have further compounded these through encouraging extraction of water resources beyond their natural potential supply as well as polluting the available sources. The United Nations reported that approximately 69 million people in Nigeria do not have access to safe drinking water, essential to collective health, food production, and general economic progress (Nwinyi et al., 2020; Guobadia, Mfon, and Eduzor, 2024). Lack of proper water resource management skills has manifested itself in water utilization wars, decayed water facilities, high dependence on unadmirable practices that are unfriendly to the environment and water scarcities.

Water management has, therefore, remained a significant factor in the possibility of solving those problems and is considered a central factor when planning green buildings. Green buildings seek to minimize the negative effects that the construction of buildings has on the environment, utilize resources sparingly, and encourage the creation of healthful buildings (Singata, 2023). This demonstrates that through the promotion of rainwater harvesting systems greywater recycling systems, and efficient irrigation systems green buildings can reduce water consumption greatly and increase the community's resilience. These practices not only take care of the quantity of water used but also assist in easing the stress that those supply systems undergo therefore aiding in the achievement of a green earth as a sustainable development agenda (Mondejar et al., 2021).

The practices of sustainable water management in green building projects therefore need to be adopted to address sustainable development in Nigeria (Abayomi, 2023; Ahmad, Aibinu and Stephan, 2019). This paper aims to explore how water management solutions can be implemented into construction and architecture to support sustainable development and help prevent further degradation of the environment in the midst of combating climate change. When implemented, stressing sustainability of water usage in green building development not only helps to overcome water shortages today but also encourages proper use and utilization of water in the future (Yannopoulos, Giannopoulou and Kaiafa-Saropoulou, 2019). This paper will review the current status of water management practices in Nigeria with emphasis on the impact and initiatives towards sustainability in the green building development processes for the construction industry in the present and future states.

Thus, sustainable water management is a component of environmental sustainability that has attracted much attention recently, mainly due to water scarcity and inadequate management in countries such as Nigeria (Abubakar and Aina, 2019). Due to increasing urbanization and the population explosion, it has become more common to look for ways through which water resources can be harnessed and developed to meet increasing demand.

According to Bungau et al. (2022), green building development which focuses on environmentally responsible construction solutions enables the provision of sustainable water management solutions. Therefore, this article is aimed at discussing the different sustainable water management practices that are relevant for green building development in Nigeria; to underline how they may help in solving water-related problems and at the same time supporting the idea of sustainable urban development.

The specific purposes of this paper entail evaluating the existing sustainable water management conditions for green building development; comparing and contrasting the Nigerian structure to determine the challenges and opportunities; and finally, providing recommendations that can improve water efficiency in the green building development in Nigeria. Therefore, while setting these objectives, the study aims to offer information to policymakers, architects and developers regarding the necessity of implementing sustainable water management in green buildings. The novelty of this research is rooted in the authors' offered perspectives that can be helpful in a further conversation about the sustainability of the Nigerian economy and its effects on the environment (Grover and Niederman, 2021). Also, it seeks to create a development objective for subsequent research and endeavours dedicated to promoting sustainable practices in construction activities in Nigeria towards boosting the country's coping mechanisms of water crises and cognate interventions towards the accomplishments of its sustainable development targets.

2.0 Literature Review

Sustainable water management entails the processes of designing, developing, implementing, and overseeing complex systems to use water resources for the greatest perceived benefit of the greatest number of people with minimal harm to the natural world (Ngene et al., 2021). It includes a system of principles and guidelines dealing with water conservation, water quality protection, as well as climate change and human impact on water systems. Sustainable water management under Integrated Water Resources Management (IWRM) encompasses the involvement of stakeholders and the effective use of technology to avoid wastage, and harnessing of water as well as complementary resources (Kumar and Choudhury, 2024; Twinomucunguzi et al., 2020). Through the implementation of these principles, the needs of future and present generations will be sufficiently met together with sufficient and efficient protection of main ecosystems.

On a global scale, sustainable water management has attracted significant attention as a critical strategy applied towards water insecurity. Concerns for water reuse and recycling have been on the rise in urban areas to increase the supply of water generated through the utilization of devices like greywater systems and rainwater harvesting among others (Silva, 2023; Radcliffe and Page, 2020). Furthermore, there is general adoption of green infrastructure including the use of permeable pavements, green roofs, and constructed wetlands as a measure that supports infiltration and reduces runoff and pollution. International policies are also coming up in an attempt to check misuse of water resources and these include policies on water pricing, pollution control policies and policies on the provision of infrastructure for water conservation. Comprehensive approaches, including sectoral and intersectoral collaborations and transnational cooperation, also improve global endeavours on water issues to work out locally implemented sustainable management to address the multifaceted world water management systems (Arredondo et al., 2021; Marín-González et al., 2022).

2.1 Green Building Concepts

Green buildings are structures that are planned, built, used and maintained in a way that has a minimum negative impact on the environment and provides healthy indoor environments for occupants (Bungau et al., 2022). Green buildings refer to several different activities that are used to improve energy use, water use, material use and indoor air quality. These structures, according to Munaro, Tavares and Bragança (2022), and Passoni et al. (2022), incorporate effective technologies and architectural elements that utilize renewable materials and products and avoid consumption in the buildings' life cycle, from construction to deconstruction. The purpose is to build constructs that are in complete balance with their environment are beneficial to the world and serve the necessary and desired purpose of being secure, beautiful, and comfortable for people to live or work in.

Green buildings deliver more than environmental value propositions and contribute significantly to sustainability initiatives on various fronts. Firstly, they enhance building performance and efficiency primarily through the incorporation of systems and renewable energies which lessen operation costs together with their negative impacts on the environment (Gan et al., 2020; Bungau et al., 2022; Geng et al., 2019). Second green buildings reduce pressure on water resources through efficient plumbing fixtures, rainwater harvesting and reusing of grey water. Furthermore, they enhance occupant's health and productivity by providing better indoor environment quality, light, and thermal conditions. Altogether, these benefits concretely promote the sustainability of the environment along with improving occupants' quality of life, and therefore, green buildings should become an integral part of future urbanisation processes (Borchers, Wittowsky and Fernandes, 2024).

2.2 Current Water Management Practices in Nigeria

Historically, there had always been some forms of water management in practice in Nigeria and these had developed and diversified with the advanced technology in present practice. Conventional practices include rainwater collection which involves indigenous practices, using river or lake water, and open-source wells controlled by the community (Quon and Jiang, 2023). Such localized practices may involve resource-sharing, and people engagement but these practices can be non-sustainable and uneconomical given the increasing trends of urbanization and population densities. On the contrary, the contemporary approaches seek to incorporate technology and science in water management which is characterized by better water structures like dams, treatment and distribution (Doost, Alsawaiyan and Yaseen, 2024). However, there are many difficulties connected with the realization of these active modern approaches, primarily in the sphere of rural development, the funds for which are generally very limited.

Approaches to sustainable water management in Nigeria are still very challenging to achieve. Among them, the problem of insufficient development of necessary facilities is a crucial one, as it prevents efficient water supply and purification (Saravanan et al., 2021). Some communities receive water in an interrupted manner or contaminated water, therefore alarming health repercussions and loss of confidence in water sources are observed. Also, governments of the nation fail to develop or implement proper regulatory instruments, leading to a bad state of water resources management. There is still poor knowledge and practice in the management of water use and other societal factors such as poverty which act as a barrier to proper management of water usage (Tseole et al., 2022). However, climate change increases these difficulties through changes in rainfall patterns, which causes more flooding and prolonged drought thus deepening the roles of the pyramid of water management challenges facing Nigeria. Coping with such issues involves a combination of social support, enhanced and appropriate policies, and finances put into structures organised to provide water for the whole community.

2.3 Regulatory Framework and Policies Supporting Sustainable Water Management in Nigeria

In Nigeria, the institutional factors for sustainable water management involve different laws, policies and institutional structures in addressing water deficit and its rational use. As inclined by Omokaro et al. (2024), the Nigerian National Water Policy (2004) is the major legislation for the development of integrated water resources management by advocating for public participation and sustainability of water resources. The policy also retains a view that water conservation should be subjected to various systems to enhance the quality of water and ecosystems as it encourages the state and local governments' decentralization of water supplies. Also, Adeoti (2020) stated that the Water Resources Act (2004) aims at the provision of welfare for the distribution, utilization and control of water, supporting the principles of sharing of water equitably and sparing water resources. These are supplemented by the National Environmental Policy which is directed towards sustainable nature resources and environmentalism, showing the link between water management and environmentalism.

However, there's still a problem with the implementation and the enforcement of these policies as well. Lack of coordination among institutions, inadequate funds and poor capacity among the existing regulatory agencies slow the attainment of sustainable water management objectives (Gany, Sharma and Singh, 2019). The Nigerian government has acknowledged these challenges and is in the process of working on ways to build and improve the necessary regulatory environment that would promote improved working collaboration or cooperation between the various relevant agencies as well as efforts aimed at building the capacity of such agencies. In addition, several state governments have formulated their water policies and laws to suit their state through the encouragement of sustainable use of water resources (Ngene et al., 2021). More and more engagement of the community and public and private partnerships for improvement and investment in water technologies. It has therefore become imperative for Nigeria to properly address issues surrounding water availability and management and the role that these policies and frameworks will play in facilitating sustainable use of this essential resource which supports development while at the same time conserving the environment.

2.4 Gaps in the existing literature

As the concern of sustainable water management for green building development has attracted increasing attention from scholars globally, there are still some research gaps in the current literature, especially in Nigeria. A lot of work has been done on practices and technologies of sustainable water management but few are specific to the socio-economic and environmental conditions of Nigeria. Furthermore, there is a lack of research concerning the integration of indigenous knowledge of water management and the current emergent sustainable technologies; hence, it is still unclear how cultural factors impact water consumption in green buildings. There is also very little published research on the current regulatory environment that governs water management in Nigeria or how such policies affect the effectiveness of sustainable strategies in construction. Additionally, very little empirical research has been done to compare the success of various water management techniques in real-world green building projects in Nigeria.

3.0 Methodology

3.1 Research Design

This study avails a secondary research design which looks at the collection, analysis, and interpretation of data and information that have been collected by other persons or organizations (Chong and Plonsky, 2024). This approach normally involves going through scholarly articles, government publications, industry publications and other publications to obtain information on a given sub-topic without having to embark on research to conduct surveys and interviews. Secondary research is especially useful for finding the gaps, trends, and practices within a given field to achieve a state of affairs of existing knowledge (Jerem and Mathews, 2021). It allows the researcher to harness findings from other completed research which in turn can be less time-consuming and expensive while the research also gets an opportunity to possibly expand on those findings.

3.2 Research Method

Quantitative research is an exploratory approach whose aim is to identify the reasons behind, the motives of, and the attitudes displayed by the participants towards a certain phenomenon. For this study, this method enables researchers to embrace extensive descriptions of the experiences and perceptions of the stakeholders such as the architects, builders, policymakers, and the members of the community. However, this study adopts previous academic research, industry articles and government publications to present relevant and dynamic trends which were considered concerning the difficulties and possibilities of sustainable water management. This approach not only enhances cultural, social and economic understanding of water management

practices in Nigeria, it also gets to the best practices and potential challenges of implementing sustainable practices in the Nigerian context (Guobadia, Mfon and Eduzor, 2024).

3.3 Data Collection Method

Secondary data will be sourced in this study through a process of literature review which involves a systematic search for scholarly articles, reports and government documents for literature related to sustainable water management practices in Green Building development in Nigeria (Van Dinter, Tekinerdogan and Catal, 2021). This approach affords the research a rich and diverse range of valid sources of information from peer-reviewed articles, industry, and grey literature including, governmental policies and non-governmental organisations' information bulletins. The systematic review will include a clear definition of inclusion and exclusion criteria, the use of academic databases, and the proper use of keywords. In marshalling this secondary data, the study will identify themes, trends and gaps within the existing literature which will enable a basis for the existing state of knowledge towards the conduct of the primary research instruments of the study (Fergnani, 2019).

3.4 Inclusion and Exclusion Criteria

The inclusion criteria in this study comprise articles from reputable and peer-reviewed journals, government publications and selected renowned publications that explore sustainable water management and green building development in Nigeria from 2014 to 2024 (Gessler and Siemer, 2021). It will incorporate keyword terms such as "Sustainable Water Management", "Green Building Development", and "Environmental Sustainability". Studies thus excluded will not discuss water management concerning green building development or the Nigerian environment or lack rigorous empirical data and methodology. This approach helps ensure that qualitative data is useful and relevant to the research objective and is well analyzed.

Table 3.1: The Data Search and Collection Process

Keywords	First Search	Refined Search	Further Refined Search	Adopted Themes
Sustainable Water Management	47,118	1,928	102	6
Green Building Development	36,291	1,027	86	8
Environmental Sustainability	41,827	991	129	9

3.5 Data Analysis Techniques

In this study, thematic analysis will be used to find the themes within the collected data on sustainable water management practices in green building development in Nigeria to report the patterns (Ahmad, Aibinu and Stephan, 2019). This approach entails coding the data where sections to sustainable water management regardless of their position in the data set, are considered and grouped into themes. The analysis will follow a six-phase process comprising familiarisation with the data, initial coding, theme search, theme review, theme definition and naming, and the creation of the final report (Jowsey, Deng and Weller, 2021). Thus, this particular method permits the timely detection of participants' views and the diversified and detailed identification of sustainable water management practices adopted among them. The thematic analysis will also enable the comparison of the themes that emerge with the literature proposing an assessment of the impact and the difficulties likely to be encountered when imposing such practices in the scenario of green building development in Nigeria (Ali, 2021).

4.0 Analysis of Findings

4.1 Findings from Adopted Studies

The issue of sustainable water management practices for green building development has generated attention from several authors, particularly as it affects sustainable water management, green building development, and environmental sustainability in the Nigerian Construction Industry. Wan Rosely and Voulvoulis (2024) reaffirm that sustainability processes can benefit from system thinking tools, for understanding the different dynamics that are at stake when addressing the issue of water management in complex systems. Thus, according to Srivastav et al. (2021), the strategies in water management are climate resilient and thus very useful for sustainable agriculture in water-scarce areas. According to Leigh and Lee (2019), decentralism and urban planning bring out robust water systems, a factor that should interest Nigerian cities due to the current urbanization. Writing in 2019, Hussain et al. explain that the efficient use of non-conventional water resources is essential to restore degraded land in arid and semi-arid environments. Eco-engineering decision scaling under future uncertainties relates to managing water, and the authors Poff et al. (2016) argue that ecological contexts should be addressed in the management of engineering solutions. Finally, Olley et al., (2024) provide a good example of a systematic literature review that outlines how such research can be used in policy development in sustainable water management – case studies from South Africa that have similar context to Nigeria's in its endeavours at sustainable water use. Cumulatively, these portfolios point to the fact that system thinking, decentralisation, climate change consideration and integrated innovative resource management are key to achieving sustainable water practices in Nigeria's green building.

Furthermore, Cao et al., (2022) recognize that while there has been progress in the Chinese building construction industry through green building, major problems apprehend the new construction, high initial cost, and low awareness among the population. Like Zhang et al. (2019), global green building initiatives suffer from limitations such as the presence of regulations and lack of knowledge, but there are various opportunities in the form of long-term financial returns and environmental conservation. However, Çiner and Doğan-Sağlamtimur (2019) note that green building offers environmental benefits, including improved carbon footprint, but there is limited understanding of how sustainability can be integrated into the strategies. According to Hanapiah et al. (2022) there is a low uptake of green buildings in Malaysia, owing to the simplicity involved in implementing green constructions from scratch, compared to the challenges whereby construction professionals are required to incorporate green specifications in existing structures. Agbajor and Mewomo, (2024) have established the same in South Africa which highlights the need to build domestic green building frameworks. According to Chen et al. (2024), the incorporation of renewable energy into construction is proposed to be relevant and this assertion tallies with that of Schäfer (2020) noting that green buildings provide value at the building and city levels. Darko et al. (2017) argue that government policy and public awareness are the major determinants explaining green technology in Ghana and other contexts by explaining that green building opportunities and policies are greatly supported by government-enforced regulatory requirements and strong financial incentives.

Tiza (2022) also discusses the rising trend of sustainability in the construction sector stating that the use of green construction materials and procedures is becoming popular. Ighalo and Adeniyi (2020) directly examine the cement industry where they explore the main environmental issue posed by the manufacture of cement and offer recommendations about the correct methods for disposal of waste and the use of energy. Wong and Zhou (2015) and Wang et al. (2019) analyze the integration of the BIM system with sustainability and proved that the application of green BIM over the life span of buildings and the incorporation of GIS systems can improve environmental sustainability in the construction domain. According to Francis and Thomas (2020), lean construction processes are revealed to positively engage with environmental sustainability by seeking to reduce and optimize waste. According to Riffat et al. (2016), there is a need to upgrade the upcoming cities, form and construction that would have low carbon footprint. Also, Badi and Murtagh (2019) based on this declare that green supply chain management should be adopted in constructions to enhance sustainability. Munaro et al. (2020) consider the circular economy in construction where the authors identify some benefits due to its implementation in construction projects. Finally, Balaguera et al. (2018) note that life cycle assessments in road construction are important and important when determining the sustainability of the material options. Altogether these studies present a vast and growing picture of sustainability in construction processes ranging from materials handling and disposal to technological innovation.

4.2 Analysis of Findings

The literature requires stress on the rise of the adoption of sustainable water management measures especially in green building development needs concerning environmentally sustainable development needs within the Nigerian construction industry. The literature identifies those systems thinking has gained importance as the process that enables the consideration of the multifaceted processes in sustainability (Wan Rosely and Voulvoulis, 2024). This is especially important for Nigeria considering the high levels of urbanization and lack of available water as defined by Leigh and Lee (2019). As rightly noted by Srivastav et al. (2021), decentralized water systems and climate change mitigation measures are essential for adapting to climate change and improving water management in industries, as well as in urban and rural regions. In addition, the following progressive points made by Hussain et al. (2019) regarding the efficient use of abnormal water sources are discussed; therefore, the problem of water scarcity addressed in several Nigerian cities and regions requires more innovative techniques. In this context, Nigeria can benefit from the eco-engineering decision scaling approaches mentioned by Poff et al. (2016) as well as the systematic literature reviews from Olley et al. (2024), which provide a model for policy development of sustainable water management.

Although the literature highlights various strategies for effective sustainable water management, issues where some challenges are identified; mainly the low rates of incorporating green building practices in Nigeria. Like Cao, Kamaruzzaman and Aziz (2022), Nigeria also has challenges including high initial costs of implementing sustainable buildings, low public awareness, and weak regulatory enforcement as the barriers to undertaking sustainable building practices as noted by Zhang et al. (2019). This concurs with Darko et al. (2017) whose findings suggest that policy support and increased public concern are critical for green building uptake. Although green building has financial payback that is realized in the long run and is environmentally friendly Çiner and Doğan-Sağlamtimur (2019), the major challenges are the understanding and complexities of retrofitting existing buildings (Hanapiah et al., 2022). The country should hence, devise a domestic green building framework as proposed by Agbajor and Mewomo (2024), that stems from its current urbanization and environmental sustainability challenges as a country. This would allow the country to realize the opportunities of incorporating renewable energy and green technology in construction as discussed by Chen et al in 2024 and Schäfer (2020).

Finally, the literature highlights the use of technological advancement and eco-friendly materials in green building construction. Tiza (2022), Wong and Zhou (2015) and Wang et al (2019) all point towards the benefits of technologies such as Building Information Modeling (BIM) and Geographical Information Systems (GIS) in improving the sustainability of buildings for their life cycle. All these tools enable the effective deployment of resources, increase on effectiveness of wastage minimization, and achieve an optimal use of water, which are paramount in effective construction in Nigeria. First, waste reduction also supports the environmental impacts as identified by Francis and Thomas (2020) based on lean construction practices. The call for a circular economy by Munaro et al. (2020) and using life cycle assessments by Balaguera et al. (2018) also winks at the need for sustainable material handling and disposal in Nigeria's construction industry. Hence, the idea of green supply chain management suggested by Badi and Murtagh (2019) could be beneficial for Nigeria's construction sector to enhance sustainably by improving water management in green building projects. Combined, the findings provide a framework for understanding how practice(s) of sustainable water management can support Nigeria's environmental and Urban development.

4.3 Discussion

From the literature on sustainable water management in green building development, several key observations can be made for the Nigerian construction industry. In their study, Wan Rosely and Voulvoulis (2024) agree with the claim that system thinking tools should be adopted for water management since the complexity of water systems can only be appreciated through the lens of system dynamics, as the application of the right preventive and corrective measures could bring out the right changes affecting water sustainability in the system. All these make this framework relevant for Nigeria given the fact that; Nigeria is a nation that has continued to undergo a process of urbanization and has been faced with several infrastructural development challenges which require a holistic approach in the provision of water management. Leigh and Lee (2019) have also made a similar and related call for decentralization and stronger water systems incorporated into Nigerian city planning since these Nigerian cities are now experiencing rapid urbanization and higher water demand. Likewise, Srivastav et al. (2021) examine climate adaptation approaches to water decentralisation, more relevant in Nigeria's water-stressed regions and where agriculture and resources integration occurs. The conclusions of Poff et al. (2016) on decision scaling in eco-engineering and the inclusion of ecological settings into engineered works still raise requirements of place-particular water management. From Olley et al. (2024), there are useful lessons from a systematic policy point of view in South Africa that can be prescribed for Nigeria given the similarities in the environments and infrastructure problems.

Extending the discourse of green building development, the combined application of water management into other sustainable construction processes becomes apparent throughout the literature. Cao et al. (2022) and Zhang et al. (2019) presented various factors inhibiting the deployment of green building practices around the world such as high initial costs and poor awareness, which are similar to the current green building sector in Nigeria. However, these barriers are realized while the long-term environmental and financial benefits of green building are endorsed as proposed by Çiner and Doğan-Sağlamtimur (2019) and Schäfer (2020) with sustainable water management as a significant factor towards managing the carbon footprint and enhancing the efficiency of buildings. The use of renewable energy, which Chen et al. (2024) consider, can be a part of the resource management paradigm in general and water usage in particular. According to Darko et al. (2017) therefore, government policy and public awareness is central to encouraging the use of green technology which is an area of concern especially in Nigeria given that the framework for green building and sustainable water management has not advanced far. Last but not least, findings from Tiza (2022), Ighalo, and Adeniyi (2020), and Francis and Thomas (2020) suggest that there is a need for the integration of water management and broader sustainability strategies for the advancement of green building development in Nigeria.

4.4 Comparison with Existing Literature

The results of this study on sustainable water management practices for green building development in Nigeria are consistent with prior research on sustainability in the construction industry, but some discrepancies are observed. Wan Rosely and Voulvoulis (2024) provide a sample of work that calls for a systems thinking perspective on water management and this study also reveals that integrated and climate-related water management approaches are important areas that should help in addressing water management challenges in Nigeria. Srivastav et al. (2021) also emphasize Climate-Resilient Water Management Practices, especially in arid zones which, is in harmony with this study as it revealed that there is the need for efficient and contextually appropriate solutions towards sustainable water management in the arid part of Nigeria. Furthermore, it is noteworthy that decentralisation and city planning are considered integral to fostering well-designed water systems by Leigh and Lee (2019); these viewpoints, unquestionably, corroborate a likely incubation environment for the sustainable water management Nigeria's rapidly urbanising cities can provide.

Nevertheless, the results of the present study are divergent from some of the emerging global issues acknowledged in the literature. For instance, Cao et al. (2022) and Zhang et al. (2019) argue that high upfront cost and low level of awareness are the significant impediments to green building implementation, especially in China and across the world, whereas this study, as a Nigerian context, postulates that lack of policies and bureaucratic norms for green building implementation exerts more pressure than financial challenges. In addition, though the study of global green building practices done by Çiner and Doğan-Sağlamtimur (2019) reveals that global green building initiatives are aimed at decreasing carbon footprints through the use of eco-friendly construction materials, they revealed more that the aspect of sustainable water management which is recognized globally as part of green building practices was not very much incorporated in the Nigeria green building index. Finally, this research departs from Balaguera et al. (2018) and Munaro et al. (2020) where significant concern is on life cycle assessment and circular economy models. The fact of the matter is that Nigeria is in the development stage and is still struggling to put in place water management systems as a start before the adoption of sloping large complex systems such as life cycle assessments. These differences explain why the construction industry in Nigeria has peculiar environmental, regulatory and infrastructure conditions which need specific solutions that may not conform to global best practices.

5.0 Conclusion

5.1 Summary of Key Findings

The main contributions of this study underscore the position of sustainable water management practices in the promotion of green buildings in Nigeria. Information was presented that indicated a need for incorporating next-generation decentralized water infrastructure systems, climate change and adaptation approaches, eco-engineering concepts for environmental conservation, and sustainable water resources development for combating recurrent water deficits and rapid urbanization. There is a concrete rationale concerning the utilization of system thinking tools in construction, which was discussed in the literature, and they help to analyse the water usage mystery. This research also identified Nigeria's particularly inept environmental regulation of sustainable water management that thwarts the expansion of green buildings. Also, generally, the international construction industry is limited by financial

restrictions and a low level of awareness, but in Nigeria, all potential problems are manifested in the fragmentation of policies and a lack of sufficient and comprehensive environmental planning (Guerra, B.C. and Leite, 2021; Asaju and Ayeni, 2021). Drawing these conclusions, it is necessary to stress the further development of efficiency-oriented policies, rising public awareness of water savings, the enhancement of resource management practices resulting in sustainability of water utilization, and the contribution to the creation of effective green building strategies in the country.

5.2 Recommendations

Based on the findings to enhance sustainable water management for green building development in Nigeria several recommendations should be put into practice. In more detail, the organizations and developers should encourage the usage of water-saving technologies including rainwater harvesting systems, the greywater recycling system and efficient water fixtures during new constructions and renovations (Almulhim and Abubakar, 2023). Besides the effectiveness of water conservation, these technologies are advantageous for future cost-reduction goals. There are also issues of eco-engineering and decentralized water systems which should be attended to by developers as pointed out by Leigh and Lee (2019) in regards to Nigeria's urbanization and overall scarcity of access to water across some regions. The government has a paramount responsibility to ensure that it sets legally binding policy measures that govern sustainable water management in construction. This could mean changing the regulations to make it compulsory for architects to incorporate the usage of water-efficient systems in their works or offering tax exemptions or rebates on developers who incorporate green systems by offering them a less dense fee per square footage than normal (Stoker et al., 2022). Furthermore, it is necessary to carry out government public awareness campaigns to inform both developers and communities of the role of water conservation in fulfilling broader environmental sustainability goals. There is also the involvement of the local people and organizations through implementable awareness programs and other community based organized water management programs like rain water harvesting and water conservation etc which will go a long way in creating a culture of sustainability.

Further studies should therefore pay attention to the formulation of regional-based sustainable water management practices that can be incorporated into the Nigerian green building initiative. Another area of interest is to assess the profitability of implementing water-efficient technologies in the unique economic setting of Nigeria to assist the developers gain a tiger sight of economic returns (Mojid and Mainuddin, 2021; Guobadia, Mfon and Eduzor, 2024). Furthermore, more investigations about the effects of decentralized water systems in urban centres can be useful for understanding better the challenges that Nigerian cities face in water management. Another possible line of research might concern applications of renewable energy for water sections, like the use of solar energy for the water treatment and pumping systems in green buildings which are discussed by Chen et al. (2024) as the area to increase resource efficiency. Lastly, other future studies should explore the perceived social and cultural factors that hinder sustainable water practices and usage as well as demographic predictors in various regions of Nigeria; this would assist policymakers and developers in knowing and addressing the cultural and economic, or even the local GDP constraints of appropriate utilization of sustainable water practices in different areas of Nigeria (Guobadia, Mfon and Eduzor, 2024; Guobadia, Etim and Mfon, 2024).

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