sustainability

MDPI

Article

Assessing the Adoption and Feasibility of Green Wall Systems in Construction Projects in Nigeria

Oluwayinka Seun Oke [1,*], John Ogbeleakhu Aliu [2,*], Damilola Ekundayo [3], Ayodeji Emmanuel Oke [4] and Nwabueze Kingsley Chukwuma [4]

[1] Department of Forestry and Wood Technology, Federal University of Technology Akure, Akure PMB 704, Nigeria
[2] Engineering Education Transformations Institute, College of Engineering, University of Georgia, Athens, GA 30602, USA
[3] Department School of Engineering and the Built Environment, Birmingham City University, Birmingham B4 7BD, UK; damilola.ekundayo@bcu.ac.uk
[4] Research Group on Sustainable Infrastructure Management Plus (RG-SIM+), Department of Quantity Surveying, Federal University of Technology Akure, Akure PMB 704, Nigeria; aeoke@futa.edu.ng (A.E.O.); chukwumaqsv148768@futa.edu.ng (N.K.C.)
* Correspondence: osoke@futa.edu.ng (O.S.O.); john.aliu@uga.edu (J.O.A.)

Abstract

This study aims to evaluate the level of awareness and practical adoption of green wall systems in the Nigerian construction industry. It seeks to examine the current state of green wall implementation and recommend strategies to enhance their integration into construction practices among Nigerian construction professionals. A thorough review of the existing literature was conducted to identify different types of green wall systems. Insights from this review informed the design of a structured questionnaire, which was distributed to construction professionals based in Lagos State. The data collected were analyzed using statistical tests. The study reveals that while there is generally high awareness of green wall systems among Nigerian construction professionals, the practical use remains low, with just 8 out of the 18 systems being actively implemented, eclipsing the mean value of 3.0. The findings underscore the need for targeted education, industry incentives, and increased advocacy to encourage the use of green wall systems in the Nigerian construction sector. The results have significant implications for the Nigerian construction industry. The limited awareness and adoption of green wall systems highlight the need for strategic actions from policymakers, industry leaders and educational institutions. Promoting the use of green walls could drive more sustainable building practices, improve environmental outcomes and support the broader goals of decarbonization and circularity in construction. This research adds to the body of knowledge on sustainable construction by offering a detailed evaluation of green wall awareness and adoption within the Nigerian context. While green wall systems have been studied globally, this research provides a regional perspective, which in this case focuses on Lagos State. The study's recognition of the gap between awareness and implementation highlights an important area for future research and industry development.

Keywords: construction projects; green infrastructure; green wall systems; sustainable construction; urban greening

check for updates

Academic Editor: Antonio Caggiano

Received: 3 April 2025
Revised: 13 May 2025
Accepted: 15 July 2025
Published: 6 August 2025

Citation: Oke, O.S.; Aliu, J.O.; Ekundayo, D.; Oke, A.E.; Chukwuma, N.K. Assessing the Adoption and Feasibility of Green Wall Systems in Construction Projects in Nigeria. *Sustainability* **2025**, *17*, 7126. https://doi.org/10.3390/su17157126

1. Introduction

Green infrastructure has emerged as a vital component of sustainable urban development, with green wall systems playing a significant role in improving environmental performance and enhancing urban aesthetics. According to [1], green walls, which involve the vertical cultivation of vegetation on building façades and interior surfaces, offer a multifunctional solution to several environmental challenges. These include improving air quality, enhancing thermal insulation, reducing noise pollution and increasing biodiversity [2]. Beyond these direct benefits, green wall systems have significant potential to contribute to sustainable decarbonization and circularity by reducing carbon emissions, promoting energy efficiency and fostering resource recovery and reuse in the construction sector [3]. Despite these advantages, the Nigerian construction industry has yet to fully capitalize on the potential of green wall systems, leaving a significant gap in the country's transition toward sustainable infrastructure.

Green wall systems can also play a critical role in decarbonization by acting as natural carbon sinks [4]. The vegetation used in green walls absorbs carbon dioxide (CO_2) from the atmosphere through photosynthesis, helping to offset emissions generated by urban activities and building operations [3]. Also, green walls enhance the thermal performance of buildings by providing a layer of insulation, which reduces the reliance on energy-intensive heating and cooling systems [5]. Research shows that green walls can lower building surface temperatures by up to 10 °C, reducing indoor cooling demand by as much as 30% [6]. This reduction in energy consumption translates directly into lower greenhouse gas (GHG) emissions, contributing to long-term decarbonization goals. Additionally, green walls mitigate the urban heat island (UHI) effect—a phenomenon where urban areas experience higher temperatures than surrounding rural areas due to heat retention from concrete and asphalt surfaces. By creating a cooling microclimate, green walls help to reduce the need for mechanical ventilation and air conditioning, further decreasing the carbon footprint of urban buildings [5]. The incorporation of green walls in both new and existing structures aligns with global efforts to reduce the carbon intensity of the built environment and improve urban resilience to climate change [3].

In addition to decarbonization, green wall systems promote circularity by integrating natural systems into the construction lifecycle [7]. The materials used in green wall construction, such as recycled plastics, organic substrates, and reclaimed water for irrigation, support resource efficiency and minimize waste [5]. Green walls enable nutrient cycling by capturing and reusing water runoff, reducing the strain on municipal drainage systems while simultaneously supporting plant health. Moreover, modular green wall systems can be dismantled, refurbished and reinstalled, aligning with circular economy principles of material reuse and extended product lifespans [7]. The plant species selected for green walls can further enhance circularity by improving soil quality and biodiversity [8]. Certain species have phytoremediation properties, which allow them to absorb pollutants and heavy metals from the air and soil, thereby restoring environmental health [7]. Additionally, green wall systems can be integrated with rainwater harvesting and greywater recycling systems, creating closed-loop water management processes that reduce dependency on freshwater resources [4].

Despite the environmental and economic benefits of green wall systems, their adoption within the Nigerian construction industry remains limited. One of the primary challenges is the lack of awareness and technical expertise among construction professionals regarding the installation and maintenance of green walls [9]. Moreover, high initial costs, inadequate policy support and the absence of standardized guidelines for green wall construction have hindered widespread adoption [10]. However, the increasing emphasis on sustainable urban development and climate resilience presents an opportunity to drive the adoption of green walls. While the performance of green wall systems may vary based on climatic conditions, particularly in regions with high humidity like Lagos, this study focuses specifically on the current level of awareness and adoption within the Nigerian construction industry. Specifically, the study will address the following research questions:

1. To what extent are construction professionals in Nigeria familiar with green wall application systems?
2. To what extent are construction professionals actually integrating these green wall systems into construction activities?
3. What strategies can be implemented to bridge the gap between awareness and practical adoption of green wall systems in the Nigerian construction industry?

The findings from this research will provide valuable insights for policymakers, construction professionals and industry stakeholders seeking to integrate green infrastructure into Nigeria's urban landscape. By highlighting the environmental and economic advantages of green walls, this study will contribute to the broader goal of achieving sustainable decarbonization and circularity within the Nigerian construction sector. Also, the proposed recommendations will help to shape informed strategies for promoting green wall adoption, thereby aligning Nigeria's construction practices with global sustainability targets.

Nigeria was selected as the focus of this study due to its rapidly urbanizing population, growing construction industry and pressing need for sustainable infrastructure solutions [11]. As the most populous country in Africa and one of the fastest-growing urban economies globally, Nigeria faces significant environmental challenges, including rising greenhouse gas emissions, urban heat island effects and deteriorating air and water quality in major cities such as Lagos, Abuja, and Port Harcourt [12]. Despite these challenges, the adoption of green infrastructure practices, such as green wall systems, remains limited within the Nigerian construction sector. Also, Nigeria's construction industry is poised for expansion as it responds to increasing demand for housing, commercial spaces and public infrastructure [11]. However, this growth has often been associated with resource-intensive practices and limited integration of sustainable technologies. By focusing on Nigeria, the study seeks to explore the gap between awareness and practical implementation of green wall systems in an emerging economy context, where the potential for positive environmental impact is substantial but underutilized.

2. Review of Existing Studies

2.1. Understanding the Concept of Green Wall Systems

Green wall systems, also referred to as living walls or vertical gardens, are innovative architectural elements that integrate vegetation into the vertical surfaces of buildings [13]. These systems are designed to enhance the aesthetic, environmental and functional performance of structures by incorporating plants and greenery into both interior and exterior walls. The concept of green wall systems is rooted in the broader principles of sustainable construction and biophilic design, which emphasize the importance of connecting built environments with natural elements to improve human well-being and environmental quality [14]. Green wall systems typically consist of a structural framework, a growing medium and an irrigation system that supports plant growth [7]. The structural framework provides stability and anchors the system to the building surface, while the growing medium, which can be soil-based or hydroponic, provides nutrients and support for the plants [2]. Advanced irrigation systems are often integrated to regulate water supply and maintain optimal growing conditions for the plants. The plants used in green wall systems are carefully selected based on factors such as climate, orientation and intended visual and functional outcomes [7].

There are two primary types of green wall systems: green façades and living walls. Green façades involve the use of climbing plants or vines that grow along a support structure, such as trellises, cables, or mesh, which are anchored to the building [14]. The plants in green façades typically grow from the ground or from planter boxes installed at different levels. In contrast, living walls are more complex and consist of pre-planted panels or modular units attached to the building surface [2]. Living walls can support a wider variety of plant species, including ferns, succulents and flowering plants, and they often require more sophisticated irrigation and nutrient delivery systems to maintain plant health [1]. The concept of green wall systems extends beyond their visual appeal. They are designed to create a more sustainable and comfortable environment by improving air quality, regulating building temperature and contributing to urban biodiversity [14]. The integration of vegetation into building façades helps to filter pollutants, increase oxygen levels, and reduce the urban heat island effect by cooling the surrounding environment [1]. Moreover, green wall systems enhance the acoustic performance of buildings by reducing noise transmission and creating a more peaceful atmosphere. Their incorporation into architectural design reflects a growing recognition of the importance of nature-based solutions in addressing environmental challenges and improving the quality of urban life [14]. Figure 1 provides a diagrammatic illustration of a typical green wall system showing key components, including vegetation, growth medium, support structure, irrigation system and drainage layer. This annotated illustration helps visualize how green wall systems are constructed and function within a building façade.

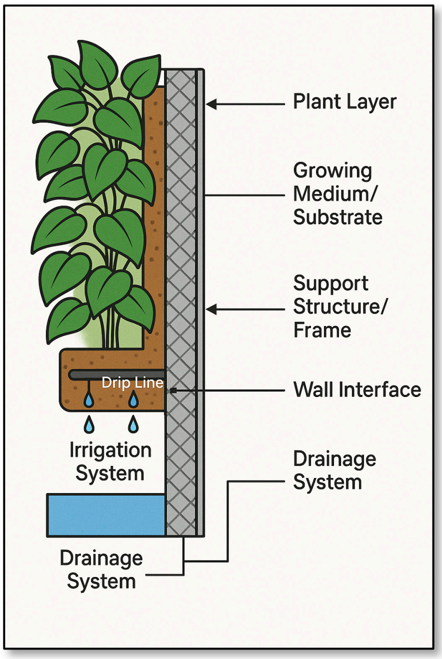

Figure 1. Diagrammatic illustration of typical green wall system showing key components.

2.2. *Overview of Green Wall Systems in Construction*

Green wall systems have become increasingly popular in modern construction, providing both environmental and aesthetic benefits. Their ability to improve air quality, reduce heat island effects and enhance the energy efficiency of buildings has made them a key element in sustainable construction. According to [1], green wall systems contribute to environmental performance by reducing surface temperatures, improving air quality and offering sound insulation benefits. Various types of green wall systems have been developed to meet different structural and environmental requirements, each with their own functional advantages and design considerations. External green walls are among the most common forms of green wall systems in construction. These walls consist of vegetation attached directly to the exterior façade of a building or supported by a framework. Research by [2] shows that external green walls can reduce surface temperatures by up to 15 °C, thereby enhancing the thermal comfort of buildings and lowering energy consumption for cooling. They also act as natural barriers to noise pollution, creating a quieter and more comfortable indoor environment.

Green roofs, while not technically vertical systems, complement green walls by providing similar environmental benefits. According to [15], green roofs improve insulation, reduce stormwater runoff and increase urban biodiversity. They regulate building temperatures by absorbing sunlight and creating a cooling effect, thereby reducing the urban heat island effect. Combined with green walls, green roofs form a comprehensive green envelope around a building, maximizing energy efficiency and environmental benefits [7]. Indoor green wall systems contribute significantly to indoor environmental quality and occupant well-being. Studies by [16] indicate that indoor plants improve air quality by filtering out toxins such as formaldehyde and benzene, increasing oxygen levels and enhancing cognitive performance. Indoor wall plants also contribute to humidity regulation and noise reduction, making them ideal for office spaces, healthcare facilities and residential buildings [17]. Their psychological benefits, including stress reduction and increased productivity, have been widely documented in environmental psychology literature.

A study by [16] found that green façades reduce building surface temperatures and provide natural shading, which lowers indoor cooling requirements. They are also effective in improving air quality and reducing carbon dioxide levels in urban areas. Green façades are often selected for their low maintenance requirements and ability to adapt to various climatic conditions. Green façades can offer significant potential to reduce energy consumption and carbon emissions in urban areas like Lagos, which faces high ambient temperatures and humidity [12]. As highlighted in studies from other tropical regions (e.g., Kuala Lumpur), the thermal performance of green façades can significantly reduce the need for air conditioning, which accounts for a major portion of energy demand in buildings [18]. The plants act as natural insulators, reducing building surface temperatures and mitigating the urban heat island effect. In Lagos, where electricity supply is erratic and costly, reducing energy demand for cooling can contribute to long-term cost savings and greater energy security. Moreover, green façades, by absorbing CO_2 from the atmosphere, can contribute to the city's decarbonization goals, helping offset emissions from urban activities and transport sectors [12]. While green façades provide cooling benefits in tropical climates, the results vary significantly depending on local humidity levels and the selected vegetation. In dry climates, evaporative cooling is highly effective, but in regions with high relative humidity, like Lagos and even Abuja, this effect is reduced, as the potential for moisture retention and excessive humidity could lead to building envelope issues, such as mold and deterioration of materials [11]. Studies from Kuala Lumpur and Accra, cities with similar climates, show that the cooling benefits of green façades are less pronounced during the rainy season, due to limited evaporation, and emphasize the importance of selecting plant species that are resistant to high humidity and rainfall. In terms of CO_2 reduction, a study by [19] suggested that green façades in humid climates still contribute to a reduction in overall CO_2 levels, but the magnitude of this effect is often lower than that observed in arid climates due to limited evapotranspiration capacity.

Climbing plants and vines are one of the simplest green wall solutions. They grow vertically along walls or trellises and require minimal structural support. Research by [20] shows that climbing plants are highly effective at reducing solar radiation and heat penetration into buildings. Their adaptability to different climates and ease of maintenance make them a popular choice for residential and commercial properties. Superficial vegetation coverings involve thin layers of plants attached to the exterior surface of a building. According to research by [7], these coverings enhance thermal performance by reducing heat absorption and providing sound insulation. Their lightweight design makes them suitable for retrofitting older buildings and for use in high-rise construction where additional structural load is a concern. Living walls are complex systems composed of pre-planted panels or modular units mounted on a vertical framework. These systems typically include integrated irrigation and nutrient delivery mechanisms to support plant growth. Studies by [21] highlight the effectiveness of living walls in reducing air pollutants and improving thermal regulation. Table 1 presents a summary of the selected green wall system that can be applied in construction.

Table 1. Summary of selected green wall system applications.

S/N	Green Wall System Applications	Literature Sources
1	Artistic green walls	[22]
2	Biodiverse green walls	[16]
3	Biofilteration green walls	[23]
4	Climbing plants vines	[20]
5	Edible green walls	[24]
6	External walls	[16]
7	Green curtain walls	[23]
8	Green façades	[14]
9	Green roofs	[24]
10	Green screens	[24]
11	Indoor wall plants	[25]
12	Integrated green system	[25]
13	Living walls	[24]
14	Modular green walls	[24]
15	Pocket gardens	[23]
16	Self-sustaining green walls	[25]
17	Superficial vegetation coverings	[23]
18	Vertical green system	[24]

(Table created by authors).

2.3. Limitations and Drawbacks of Green Wall Systems

While green wall systems offer numerous environmental and aesthetic benefits, it is important to acknowledge the limitations associated with their implementation, particularly in tropical and humid climates such as that of Nigeria. One of the key challenges is the effectiveness of evaporative cooling, which can be significantly reduced in regions with high relative humidity, potentially leading to moisture retention issues in the building envelope [26]. Inadequate maintenance, especially in the absence of automated irrigation systems, can result in plant decay, unpleasant odors and pest infestation [27]. Additionally, the structural load imposed by some green wall systems, especially living walls, may not be suitable for retrofitting on older buildings without reinforcement [26]. Cost is another critical barrier; the initial investment, including installation and long-term maintenance, can be prohibitively high for many developers in developing economies [3]. Moreover, a lack of local expertise and technical knowledge often hinders successful adoption [27]. These factors must be taken into account when considering the feasibility and sustainability of green wall systems within the Nigerian construction sector.

3. Research Methodology

The main goal of this research is to assess the level of awareness and practical use of green wall systems among construction professionals in Nigeria. The study seeks to investigate the industry's knowledge of green wall systems and the extent to which they are being incorporated into construction projects. This research was carried out in Lagos State, Nigeria, a rapidly growing urban center and the country's economic powerhouse. Lagos is located in the southwestern part of Nigeria, bordered by the Atlantic Ocean to the south and Ogun State to the north and east [28]. Despite being the smallest state in Nigeria, covering approximately 3577 square kilometers, Lagos is the most densely populated, with an estimated population exceeding 20 million. Lagos was selected as the study site due to its fast-paced urbanization, severe environmental challenges, and growing interest in sustainable construction practices [29]. The city faces critical issues such as urban heat islands, air pollution and a shortage of green spaces, making it a fitting case for the current study. The combination of environmental stressors and increased awareness of sustainable solutions highlights the relevance of studying green wall systems in this context.

The bibliography includes a wide range of studies that highlight the different types of green wall systems, their applications and the projects in which they have been implemented. A quantitative research approach was adopted for this study, utilizing a structured questionnaire survey as the primary data collection instrument [30]. This method was selected for its efficiency in gathering large volumes of data, which allowed for a thorough assessment of industry professionals' awareness and the extent of green wall system integration in Nigerian construction projects. To ensure the clarity and effectiveness of the survey, a pilot study was conducted with 15 experts, including environmental specialists, architects, urban planners and landscape architects. The purpose of this pilot study was to assess the questionnaire's relevance, clarity and overall structure, as well as to identify any potential issues that could affect the accuracy of the data. Feedback gathered from the pilot study led to several refinements in the questionnaire. For example, technical terms were rephrased to ensure that all respondents, regardless of their technical background, could understand the questions. Ambiguous questions were restructured for better clarity, and the Likert scale was adjusted to ensure consistent response options. These changes improved the overall reliability of the instrument, ensuring that the collected data would be both valid and comprehensible.

This study utilized purposive and snowball sampling techniques to identify and recruit participants with relevant expertise in the construction industry. Given the challenges posed by poor record-keeping practices in Lagos State, these sampling methods were particularly effective for the context of the study. Purposive sampling was employed to target professionals who possessed direct experience and knowledge of green wall systems, ensuring that the collected data directly aligned with the research objectives. In addition, snowball sampling complemented this approach by utilizing the professional networks of initial respondents to identify additional participants who met the inclusion criteria. This method helped address the challenge of incomplete or limited records. To ensure the credibility and reliability of the data, priority was given to professionals who were registered with the relevant regulatory bodies. As such, members of the Architects Registration Council of Nigeria (ARCON), the Council of Registered Builders of Nigeria (CORBON), the Council for the Regulation of Engineering in Nigeria (COREN), and the Quantity Surveyors Registration Board of Nigeria (QSRBN) were invited to participate. These regulatory bodies ensure that participants possess the necessary qualifications, industry experience and technical expertise relevant to green wall systems and sustainable construction practices.

For the survey administration, Google Forms was chosen as the platform due to its user-friendly interface, flexibility in designing questionnaires, and ease of data collection and analysis [31]. The online format allowed for wider distribution, convenience for participants, and real-time tracking of responses. Out of the 257 questionnaires distributed, 111 were successfully retrieved, resulting in a response rate of 43%. This rate was considered satisfactory, as similar studies often report comparable or even lower response rates when surveying professionals in regions facing challenges like poor record-keeping and limited access to comprehensive documentation. A five-point Likert scale was used to measure the significance of various green wall system applications. The scale included the following ratings: 5 = high significance, 4 = moderate significance, 3 = neutral significance, 2 = low significance and 1 = very low significance.

The data collected in this study were analyzed using the Statistical Package for the Social Sciences (SPSS version 26), a widely recognized tool for conducting quantitative data analysis. To assess the reliability of the survey instrument, Cronbach's alpha coefficient was used, providing a measure of internal consistency. This coefficient helped verify that the data collected accurately reflected the intended variables and ensured that the instrument was reliable. According to [32], a high Cronbach's alpha value suggests a strong internal consistency between the items in the measurement scale. For this study, the 18 green wall system applications yielded a Cronbach's alpha coefficient of 0.822, indicating a high level of internal consistency across the types of green wall system applications measured. To present the demographic characteristics of the participants, frequency and percentage distributions were used. In addition to assessing the reliability of the instrument, efforts were made to ensure its validity. The Shapiro–Wilk test was conducted to assess the normality of the data, determining whether the dataset followed a normal distribution. This is a critical step for ensuring the validity of various quantitative analyses. Additionally, to explore potential differences in responses across different groups of participants, the study employed the Kruskal–Wallis H-test. Prior to this analysis, the data were tested for normality using the Shapiro–Wilk test. The results confirmed that the data were not normally distributed, which justified the use of this non-parametric test. The Kruskal–Wallis H-test effectively identified whether statistically significant differences existed among the various respondent categories [33]. Furthermore, the study utilized mean values and standard deviations to rank and compare the collected data. By analyzing the mean values, the study was able to determine the average perceptions of construction professionals regarding the awareness and integration of green wall system applications. The standard deviations provided insight into the degree of variation in responses around the mean, indicating the level of consensus or disagreement among the participants.

4. Results

4.1. Background Details of Respondents

Figures 2–5 provides a summary of the respondents' background information, highlighting their academic qualifications, years of experience, professional qualifications and membership status. The majority of respondents (48.65%) hold a Bachelor's degree (B. Tech/B. Sc), followed by Master's degree holders at 34.23%. A smaller portion of respondents have a Higher National Diploma (HND) (7.21%) or a PhD (9.91%). In terms of professional experience, 40.54% of respondents have less than 5 years of experience, indicating a younger workforce, while 33.33% have 6 to 10 years of experience. Fewer respondents (8.11%) have 16 to 20 years of experience, and 5.41% have more than 21 years in the field. Regarding professional qualifications, the largest group of respondents are quantity surveyors (32.43%), followed by engineers (20.72%) and builders (18.92%). Smaller percentages of respondents are architects (15.32%) or project managers (12.61%). Finally, most respondents hold Corporate membership (59.46%) in their professional bodies, with 24.32% being Fellow members and 16.22% being Probationers. This distribution suggests a largely experienced group of professionals within established membership categories. These are all shown from Figures 2–5.

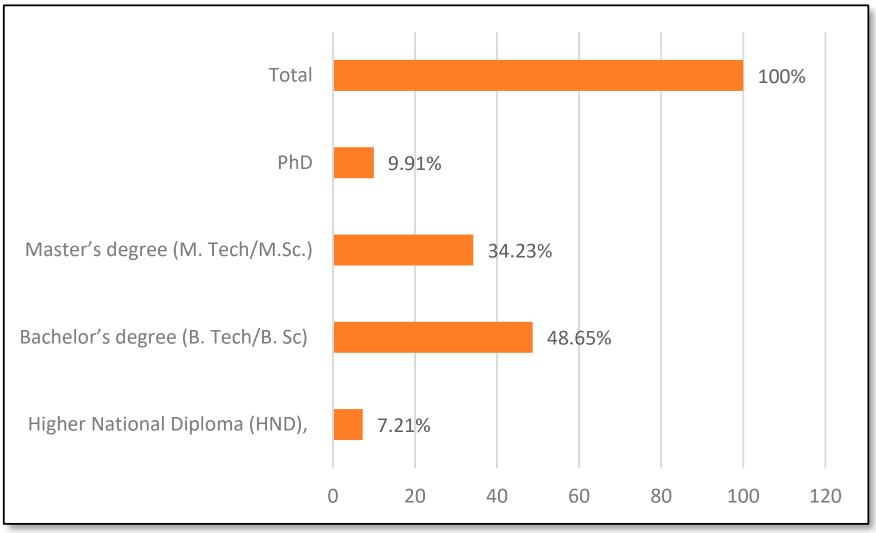

Figure 2. Academic qualifications of respondents.

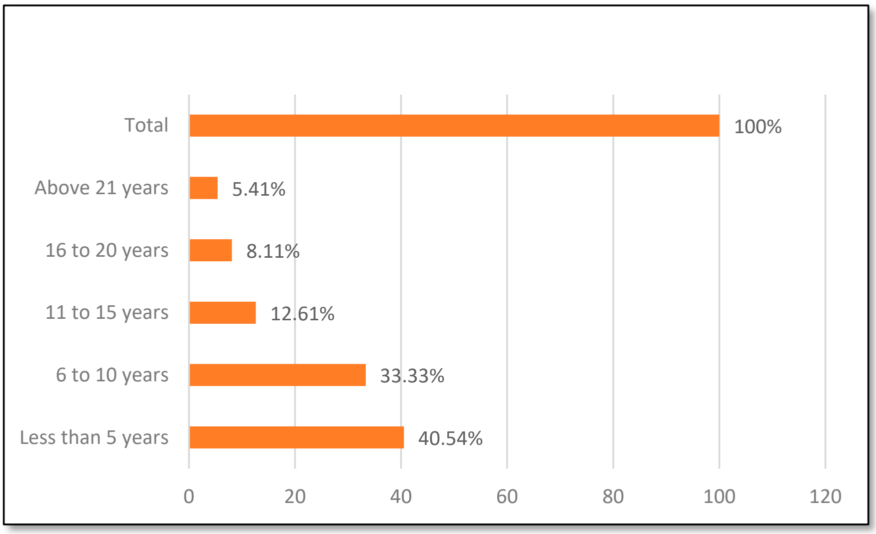

Figure 3. Years of experience of respondents.

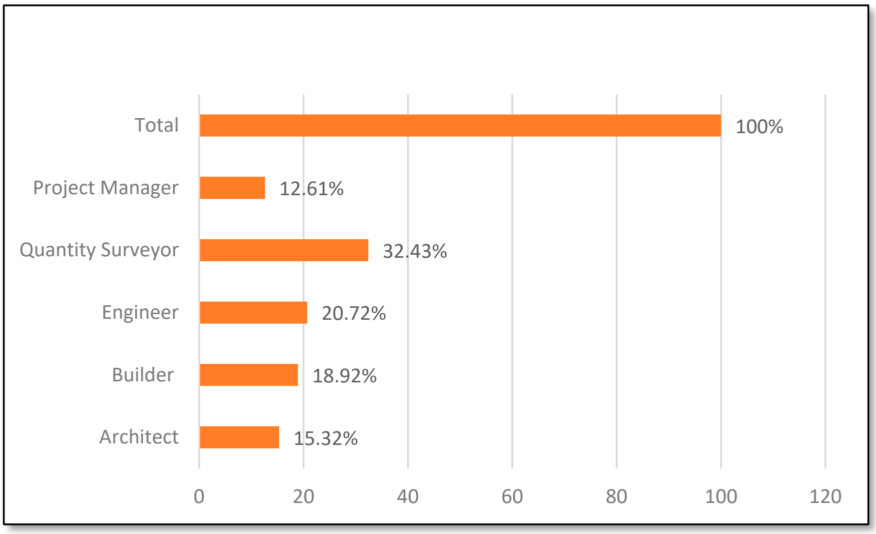

Figure 4. Professional qualifications of respondents.

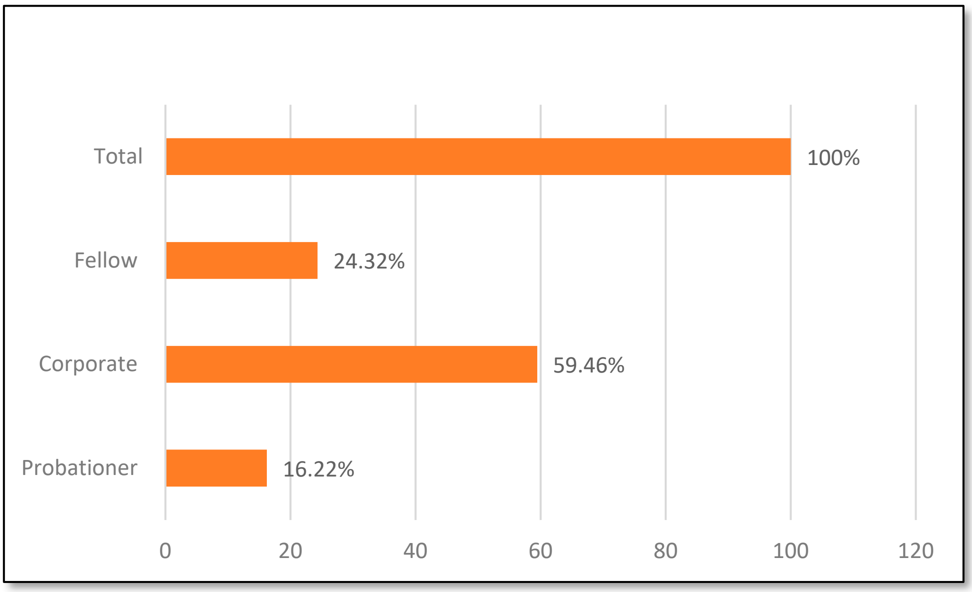

Figure 5. Professional membership of respondents.

4.2. Level of Awareness of Green Wall System Applications in the Construction Industry

Table 2 presents the findings on the level of awareness of green wall system applications among different professional groups. The Shapiro–Wilk normality test was used to evaluate whether the data followed a normal distribution. The non-significant *p*-values (greater than 0.05) across all green wall system applications indicate that the data did not meet the assumption of normality. Consequently, the Kruskal–Wallis H-test was conducted to determine whether there were statistically significant differences in the level of awareness among the different professional groups. The Kruskal–Wallis test results showed that none of the green wall system applications had a statistically significant *p*-value (all > 0.05). This implies that there were no significant differences in the level of awareness across the professional groups regarding green wall system applications.

Table 2. Level of awareness of green wall system applications in the construction industry.

Green Wall System Applications	Architects		Quantity Surveyors		Engineers		Builders		Project Managers		Overall		Kruskal–Wallis	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	χ^2	Sig.
External walls	4.24	1	3.86	1	3.74	1	4.13	1	4.33	1	3.97	1	2.731	0.582
Green roofs	3.29	6	3.56	2	3.65	2	3.77	6	3.67	12	3.59	2	6.112	0.137
Indoor wall plants	3.35	3	3.47	3	3.48	6	3.61	10	4.00	7	3.50	3	8.961	0.167
Green façades	3.47	2	3.44	4	3.17	15	3.84	5	3.67	9	3.49	4	14.225	0.096
Climbing plants vines	3.29	4	3.11	8	3.26	11	4.06	2	3.00	17	3.42	5	13.856	0.112
Superficial vegetation coverings	3.00	12	3.25	5	3.57	3	3.65	9	3.67	11	3.40	6	10.431	0.135
Living walls	2.94	13	3.14	7	3.48	5	3.74	7	4.00	2	3.36	7	9.218	0.148
Green curtain walls	3.00	11	2.94	12	3.35	8	3.94	3	3.33	15	3.31	8	8.452	0.085
Artistic green walls	3.12	9	3.19	6	3.17	13	3.65	8	4.00	3	3.31	9	5.472	0.256
Integrated green system	2.82	16	3.00	9	3.17	14	3.90	4	3.33	13	3.26	10	3.985	0.417
Vertical green system	3.12	8	3.00	11	3.26	11	3.55	11	4.00	6	3.23	11	4.915	0.328
Green screens	3.29	5	3.00	10	3.39	7	3.39	15	3.67	8	3.23	12	5.254	0.295
Pocket gardens	3.24	7	2.78	15	3.30	10	3.55	12	3.33	16	3.18	13	6.722	0.138
Self-sustaining green walls	2.94	14	2.89	13	3.30	9	3.42	14	4.00	4	3.16	14	4.310	0.366
Modular green walls	3.06	10	2.81	14	3.22	12	3.19	18	4.00	5	3.05	15	1.245	0.911
Edible green walls	2.71	18	2.72	16	3.52	4	3.29	17	3.67	10	3.05	16	6.523	0.195
Biodiverse green walls	2.88	15	2.69	18	3.13	18	3.32	16	3.33	14	3.00	17	7.349	0.095
Biofilteration green walls	2.76	17	2.69	17	3.13	17	3.45	13	3.00	18	3.00	18	6.199	0.162

Significant at $p < 0.05$; χ^2 = chi-square.

In terms of rankings, external walls emerged as the most recognized green wall system application across all professional groups, with an overall mean score of 3.97. Architects ranked external walls highest (mean = 4.24), which reflects their focus on building aesthetics and façade design, where external walls play a crucial role in the visual and functional aspects of green building design. Architects are typically more engaged with the external structure and aesthetics of a building, which may explain why their awareness of external walls is high [34]. The high ranking for green façades (mean = 3.47) among architects also aligns with this perspective, as façades are integral to architectural design and sustainable building envelopes. These findings align with previous studies that have reported higher awareness of external green wall applications among architects due to their influence on building design and energy efficiency (Aung et al., 2023) [14]. Quantity surveyors also ranked external walls highest (mean = 3.86), followed by green roofs (mean = 3.56) and Indoor wall plants (mean = 3.47). The high ranking of green roofs among quantity surveyors could be due to their understanding of the cost implications and economic benefits associated with green roof systems, such as reduced energy costs and stormwater management [35]. Quantity surveyors are typically involved in cost estimation and budgeting, and previous research suggests that financial considerations play a key role in shaping their awareness and acceptance of sustainable building practices [36].

Engineers demonstrated the highest awareness of external walls (mean = 3.74) and green roofs (mean = 3.65). Engineers' awareness of external walls could be linked to the structural and environmental benefits provided by green walls, including improved insulation, energy efficiency and stormwater management [8]. Builders ranked external walls as the most recognized green wall system application (mean = 4.13), followed by climbing plants and vines (mean = 4.06) and green curtain walls (mean = 3.94). Builders' high ranking of climbing plants and vines may be attributed to the practical ease of installation and maintenance, as well as the immediate visual and environmental benefits these systems offer. This pattern aligns with previous research, which has highlighted that builders tend to have a greater awareness of construction-friendly green wall applications that require less technical expertise and have immediate aesthetic value [37]. Project managers demonstrated the highest awareness of external walls (mean = 4.33), followed by living walls (mean = 4.00) and artistic green walls (mean = 4.00). The high ranking of living walls and artistic green walls among project managers suggests an appreciation for the functional and aesthetic value these systems bring to project execution and client satisfaction. Project managers are often focused on the overall project outcome, balancing technical feasibility, costs and design quality, which may explain why they value aesthetically pleasing and functionally beneficial green wall applications [8].

The consistently high ranking of external walls across all professional groups reflects a shared understanding of their importance in green building design and environmental performance. However, the variation in the ranking of other green wall applications among the professional groups reflects their different roles and priorities in the construction process. For instance, architects and project managers tend to prioritize aesthetic and functional aspects, while engineers and builders are more focused on structural and technical feasibility. Quantity surveyors' focus on cost implications and long-term financial benefits also shapes their perception of green wall applications.

4.3. Level of Practical Use of Green Wall System Applications in the Construction Industry

Table 2 presents the findings on the level of practical use of green wall system applications among different professional groups. Again, the Kruskal–Wallis H-test was conducted to determine whether there were statistically significant differences in the practical use of green wall systems across professional groups. The *p*-values from the Kruskal–Wallis test (all > 0.05) indicate that none of the differences in the practical use of green wall applications among the professional groups were statistically significant. This suggests that while variations in practical use exist, they are not substantial enough to establish a significant difference between professional groups.

External walls emerged as the most practically used green wall system application across all professional groups, with an overall mean score of 3.54. Architects (mean = 3.82), engineers (mean = 3.74), builders (mean = 3.68) and project managers (mean = 4.33) all ranked external walls highest. This consensus reflects the widespread adoption of external walls in green building projects, likely because they are relatively easy to integrate into existing building designs and provide multiple functional benefits, such as thermal insulation, energy efficiency and improved aesthetics [38]. Project managers' highest ranking of external walls (mean = 4.33) may be due to their focus on the overall performance and aesthetic value of green wall systems in enhancing project outcomes. These findings are consistent with previous studies that have highlighted the dominance of external walls as the most frequently used green wall system due to their ability to balance functional and aesthetic benefits [3]. Green roofs ranked second overall (mean = 3.21), with engineers (mean = 3.61) and architects (mean = 3.12) showing the highest levels of practical use. Engineers' higher ranking of green roofs reflects their technical knowledge of the structural and environmental benefits provided by green roofs, such as stormwater management, improved insulation and energy savings. Architects' relatively high ranking of green roofs aligns with their design-oriented perspective, as green roofs are often incorporated into sustainable building designs to enhance building aesthetics and environmental performance. However, builders ranked green roofs lower (mean = 3.32), which may reflect the technical challenges involved in installing and maintaining green roofs, such as structural load requirements and waterproofing concerns.

Climbing plants and vines ranked third overall (mean = 3.11) and were most highly ranked by builders (mean = 3.45) and project managers (mean = 4.00). Builders' higher ranking of climbing plants and vines suggests a preference for simpler, cost-effective green wall solutions that are easy to install and maintain. Climbing plants and vines require minimal structural modifications, making them more attractive to builders focused on reducing construction complexity [13]. Project managers' high ranking reflects an appreciation for the rapid visual transformation and environmental benefits offered by climbing plants and vines. Previous research has reported similar findings, noting that climbing plants and vines are favored in construction projects due to their low cost and immediate impact on building aesthetics and environmental performance [20]. Superficial vegetation coverings (mean = 3.06) and Green façades (mean = 3.06) ranked fourth and fifth overall, respectively. Engineers ranked superficial vegetation coverings higher (mean = 3.35), reflecting their understanding of the structural and environmental benefits of these systems, such as improved insulation and air purification. Project managers ranked green façades higher (mean = 4.00), suggesting that they value the aesthetic and environmental benefits of green façades in improving building performance and occupant satisfaction. The lower rankings among architects and quantity surveyors (mean = 3.00 and 2.83, respectively) may reflect the higher complexity and maintenance requirements associated with green façades, which could increase project costs and limit practical use. Living walls ranked seventh overall (mean = 3.02), with project managers (mean = 4.00) and engineers (mean = 3.30) showing the highest levels of practical use. The relatively high ranking by engineers reflects their understanding of the technical complexity involved in living wall installations, such as irrigation, structural support and plant selection. Project managers' high ranking of living walls suggests a growing recognition of their contribution to building performance and environmental quality. However, architects (mean = 2.71) and quantity surveyors (mean = 2.64) ranked living walls lower, likely due to concerns about cost, complexity, and maintenance requirements. Among the lower-ranked green wall system applications, edible green walls (mean = 2.80), biodiverse green walls (mean = 2.79) and modular green walls (mean = 2.76) showed relatively low levels of practical use. Engineers and project managers ranked these applications higher, reflecting their appreciation for the environmental and functional benefits they provide. However, the lower rankings among architects and quantity surveyors suggest that cost, maintenance, and structural integration challenges may limit the broader adoption of these systems.

4.4. Mean Gap Analysis for Awareness and Usage

The analysis of the mean gap between awareness and practical use of green wall system applications is shown in Table 3. External walls emerged as the most recognized green wall system, with the highest awareness score of 3.97 and the highest practical use score of 3.54, resulting in a moderate gap of 0.43. This indicates that while industry professionals are highly aware of the benefits and applications of external walls, certain barriers such as cost, technical complexity and maintenance demands may be limiting their full-scale adoption. The relatively high usage score suggests that external walls are more established and integrated into construction practice compared to other green wall systems. Interestingly, vertical green systems recorded one of the smallest gaps (0.22) between awareness (3.23) and practical use (3.01). This suggests that industry professionals are relatively comfortable with implementing vertical green systems, likely due to their adaptable design, ease of installation, and growing familiarity with the technology. The small gap implies that vertical green systems could serve as a model for increasing the adoption of other green wall systems through targeted education and support. The smallest gaps were recorded for biodiverse green walls (0.21) and biofiltration green walls (0.30). This indicates that once awareness is established, these systems are relatively easier to implement, possibly due to their straightforward design and clear environmental benefits. Their lower gap suggests that these systems could be scaled up more easily compared to others, especially with targeted technical guidance and policy incentives.

Table 3. Mean gap of awareness and practical use of green wall system applications in the construction industry.

Green Wall System Applications	Level of Awareness		Level of Practical Use		Mean Gap (Awareness—Usage)
	Mean	Rank	Mean	Rank	(Mean Gap)
External walls	3.97	1	3.54	1	0.43
Green roofs	3.59	2	3.21	2	0.38
Indoor wall plants	3.50	3	3.03	6	0.47
Green façades	3.49	4	3.06	5	0.43
Climbing plants vines	3.42	5	3.11	3	0.31
Superficial vegetation coverings	3.40	6	3.06	4	0.34
Living walls	3.36	7	3.02	7	0.34
Green curtain walls	3.31	8	2.97	9	0.34
Artistic green walls	3.31	9	2.96	10	0.35
Integrated green system	3.26	10	2.96	11	0.30
Vertical green system	3.23	11	3.01	8	0.22
Green screens	3.23	12	2.82	14	0.41
Pocket gardens	3.18	13	2.94	12	0.24
Self-sustaining green walls	3.16	14	2.84	13	0.32
Modular green walls	3.05	15	2.76	17	0.29
Edible green walls	3.05	16	2.80	15	0.25
Biodiverse green walls	3.00	17	2.79	16	0.21
Biofilteration green walls	3.00	18	2.70	18	0.30

The findings highlight a clear need to bridge the gap between awareness and usage through targeted industry interventions. Systems with high awareness but low usage (e.g., indoor wall plants, green façades) would benefit from enhanced technical training, cost-effective installation methods and maintenance support. Previous research suggests that training in the technical aspects of these systems can significantly enhance their adoption [24]. Moreover, policy incentives such as tax breaks, grants and regulatory support could encourage greater adoption of green wall systems. Studies have shown that financial incentives and supportive regulations play a key role in fostering green infrastructure adoption in urban areas [2]. The relatively small gap for vertical green systems and biofiltration walls suggests that scaling up these systems could provide immediate environmental and economic benefits, demonstrating their value to the construction industry. Evidence from existing studies indicates that these systems can result in measurable improvements in energy efficiency, air quality, and overall environmental sustainability [24]. By reinforcing industry confidence through training and support, the overall adoption of green wall systems could be significantly improved.

5. Discussions and Implications of the Above Findings

By evaluating the level of awareness and practical use of green wall systems within the Nigerian construction industry, this study provides valuable insights into the current state of green infrastructure adoption. The findings reveal varying levels of awareness and practical use across different green wall systems, highlighting external walls, green roofs and indoor wall plants as the most recognized and widely used systems, with mean awareness values above 3.5 (see Table 4). This suggests that more visible and functional green wall systems tend to have higher levels of both awareness and adoption, reflecting a growing understanding of the benefits of green infrastructure within the Nigerian construction sector. However, the mean gap between awareness and usage across most systems indicates that hile awareness is relatively high, practical implementation remains limited.

Table 4. Level of practical use of green wall system applications in the construction industry.

Green Wall System Applications	Architects		Quantity Surveyors		Engineers		Builders		Project Managers		Overall		Kruskal–Wallis	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	χ^2	Sig.
External walls	3.82	1	3.14	1	3.74	1	3.68	1	4.33	1	3.54	1	2.845	0.573
Green roofs	3.12	2	2.89	2	3.61	2	3.32	6	3.33	16	3.21	2	5.978	0.142
Climbing plants vines	2.76	9	2.78	5	3.35	3	3.45	2	4.00	4	3.11	3	8.732	0.172
Superficial vegetation coverings	3.00	5	2.81	4	3.35	4	3.23	10	3.00	18	3.06	4	14.552	0.101
Green façades	3.00	6	2.83	3	3.22	14	3.19	11	4.00	5	3.06	5	13.487	0.118
Indoor wall plants	3.06	4	2.69	6	3.22	15	3.23	9	3.67	9	3.03	6	10.215	0.128
Living walls	2.71	11	2.64	7	3.30	6	3.35	5	4.00	2	3.02	7	9.067	0.153
Vertical green system	3.06	3	2.58	9	3.30	8	3.26	7	3.33	15	3.01	8	8.627	0.089
Green curtain walls	2.71	12	2.58	8	3.26	10	3.35	4	3.33	11	2.97	9	5.319	0.248
Arstistic green walls	2.88	7	2.56	10	3.26	9	3.26	8	3.33	10	2.96	10	4.102	0.426
Integrated green system	2.59	14	2.53	11	3.22	16	3.42	3	4.00	3	2.96	11	4.832	0.321
Pocket gardens	2.82	8	2.50	13	3.35	5	3.19	12	3.33	12	2.94	12	5.367	0.287
Self-sustaining green walls	2.59	15	2.44	14	3.17	17	3.13	13	3.67	7	2.84	13	6.815	0.141
Green screens	2.53	17	2.50	12	3.22	13	3.03	16	3.33	13	2.82	14	4.225	0.359
Edible green walls	2.41	18	2.39	16	3.30	7	3.03	15	4.00	6	2.80	15	1.312	0.924
Biodiverse green walls	2.71	10	2.28	18	3.22	12	3.06	14	3.67	8	2.79	16	6.488	0.188
Modular green walls	2.53	16	2.39	15	3.26	11	2.90	17	3.33	14	2.76	17	7.521	0.099
Biofiltration walls	2.65	13	2.31	17	3.09	17	2.90	18	3.00	17	2.70	18	6.084	0.157

Significant at $p < 0.05$; χ^2 = chi-square.

The findings of this study align with several existing studies on the adoption of green wall systems in the construction industry. Ref. [37] emphasized the increasing global interest in green wall systems due to their environmental and aesthetic benefits, particularly in urban areas. The high level of awareness and practical use of external walls and green roofs in this study supports their conclusion that more functional and visually appealing green wall systems tend to have higher adoption rates. Similarly, ref. [39] examined the thermal performance and energy efficiency of green façades and living walls, concluding that increased awareness of these benefits directly influences practical use. The present study confirms this trend, as green façades and living walls show relatively high levels of awareness and moderate usage. However, the observed mean gap suggests that despite the perceived benefits, practical challenges such as cost and maintenance may be hindering full adoption in the Nigerian context.

Ref. [39] examined green wall adoption in tropical and subtropical climates, highlighting climate adaptability, maintenance needs, and cost as key factors influencing adoption. The current study supports this view, as external walls and green roofs– which are more adaptable to Nigeria's climate and require less maintenance—rank higher in both awareness and usage. The relatively lower adoption of more complex systems such as biofiltration and biodiverse green walls reflects the practical challenges associated with their maintenance and operational requirements. Ref. [17] explored the role of green wall systems in improving urban microclimates and energy efficiency, stressing the importance of government incentives and industry guidelines in promoting wider adoption. The present study supports this perspective, as the high awareness but moderate usage of green façades and living walls suggests that stronger policy support and financial incentives could drive greater practical implementation within the Nigerian construction sector.

While the study's findings largely align with existing research, some differences are notable. Unlike the findings of [15], which reported balanced levels of awareness and adoption in developed countries, this study reveals a more pronounced gap between awareness and practical use in Nigeria. This suggests that while the benefits of green wall systems are well understood, practical challenges such as financial limitations, technical capacity and lack of regulatory support are hindering full adoption [24]. Additionally, while [16] found that green façades and living walls had relatively high adoption rates in tropical regions, the current study indicates that despite high awareness, usage remains moderate in Nigeria. This difference highlights the need for targeted interventions to address the financial and technical barriers specific to the Nigerian construction industry. Another notable difference is the relatively high awareness but low practical use of more complex systems such as biofiltration and biodiverse green walls. This contrasts with studies in developed countries where higher levels of technical expertise and stronger financial backing have supported wider adoption of these systems. The gap observed in Nigeria points to the need for increased technical training and financial incentives to encourage greater use of advanced green wall systems.

The findings from this study have important implications for the Nigerian construction industry. The high level of awareness for systems such as external walls, green roofs and indoor wall plants indicates that stakeholders in the construction industry recognize the environmental and functional benefits of green wall systems. However, the gap between awareness and practical use suggests that financial constraints, technical challenges and regulatory gaps are limiting full adoption. To address this gap, targeted policy interventions such as tax incentives, subsidies for green construction materials and technical training for construction professionals are needed. Strengthening industry guidelines and providing financial support for the installation and maintenance of green wall systems could also help bridge this gap. Furthermore, increased collaboration between policymakers, industry stakeholders, and academic institutions could lead to the development of practical frameworks to promote the wider adoption of green wall systems in Nigeria. Improving the practical use of green wall systems could significantly enhance the environmental and economic benefits of green infrastructure, including improved thermal insulation, reduced urban heat, enhanced biodiversity and increased property value. Encouraging greater adoption of green wall systems will contribute to more sustainable and resilient urban environments in Nigeria, aligning with global trends toward environmentally conscious construction practices.

6. Conclusions and Areas for Future Research

This study aimed to assess the level of awareness and practical application of green wall systems within the Nigerian construction industry. The results show that awareness of green wall systems is high, with mean values for all green wall systems being above 3.0, indicating that construction professionals are generally familiar with these systems and their benefits. However, despite the high awareness, the practical adoption of green wall systems is relatively low. Out of the 18 systems considered, only 8 had mean adoption scores above 3.0, highlighting the significant gap between awareness and actual implementation. The research provides meaningful insights into the current state of green wall integration and highlights the discrepancies between awareness and actual implementation. However, beyond awareness and implementation, the desirability of these systems must also be critically considered, particularly in the context of Nigeria's humid climate, where such systems may not always offer the same benefits as in temperate regions.

To address these knowledge gaps, several strategic recommendations can be proposed. First, there is a need for structured training programs focused on the technical installation and maintenance of green walls to equip construction professionals with the necessary skills. Second, incentives such as tax breaks or subsidies for adopting green infrastructure could encourage more developers to incorporate green wall systems into their projects. Third, introducing green wall technology into the curriculum of architecture and construction programs could help increase future adoption. Fourth, establishing industry-wide guidelines and standards for green wall installations would provide a clearer framework for implementation. Fifth, partnerships between construction firms and environmental agencies could facilitate knowledge-sharing and create pilot projects to demonstrate the long-term benefits of green walls. Finally, increasing public and client awareness through targeted campaigns and stakeholder engagement could drive greater demand for green wall applications.

The findings underscore that despite high awareness levels, the limited adoption reflects a gap that could be closed with targeted policy interventions, better technical capacity and stronger industry commitment. Existing studies have similarly shown that green wall systems contribute to reduced energy consumption, noise reduction and psychological well-being, aligning with global sustainable development goals. Nevertheless, the suitability of green wall systems must be evaluated in relation to specific environmental conditions, as their performance and impact can vary significantly across different climates.

However, this study has certain limitations that should be noted. The sample size and geographical focus may restrict the broader applicability of the findings, as the study primarily reflects the experiences of professionals in Lagos State alone. As such, the extent to which the findings can be generalized to other regions of Nigeria, or internationally, should be approached with caution. Expanding future research to include more diverse geographical areas and a wider range of participants could provide deeper insights. Additionally, the reliance on survey-based (quantitative) data collection introduces the potential for response bias, as participants may have provided socially acceptable answers rather than reflecting actual practices. Future studies could incorporate interviews and field observations to gain deeper insights into real-world practices. Furthermore, the study mainly explored the perspectives of construction professionals, which may overlook the views of other stakeholders, such as property developers, government regulators and environmental groups. Future research should aim to include a wider range of stakeholders to develop a more complete understanding of the factors influencing green wall adoption.

Author Contributions: O.S.O.: Conceptualization, Methodology, Formal analysis, Writing—original draft. J.O.A.: Investigation, Data Curation, Writing—original draft, Visualization. D.E.: Methodology, Formal analysis, Writing—review & editing. A.E.O.: Validation, Conceptualization, Methodology, Investigation, Writing—review & editing, Supervision. N.K.C.: Software, validation, format analysis, resources, data curation, writing—original draft. All authors have read and agreed to the published version of the manuscript.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Institutional Review Board Statement: Ethical review and approval were waived for this study by the Ethics Committee of the Federal University of Technology, Akure, as the research involved minimal risk and was conducted anonymously. Informed consent was obtained from all participants.

Informed Consent Statement: All data or codes generated or used during the study are available from the corresponding author by request.

Data Availability Statement: All data or codes generated or used during the study are available from the corresponding author by request.

Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Manouchehri, M.; Santiago López, J.; Valiente López, M. Sustainable design of vertical greenery systems: A comprehensive framework. *Sustainability* **2024**, *16*, 3249. [CrossRef]
2. El Menshawy, A.S.; Mohamed, A.F.; Fathy, N.M. A comparative study on green wall construction systems, case study: South valley campus of AASTMT. *Case Stud. Constr. Mater.* **2022**, *16*, e00808. [CrossRef]
3. Ascione, F.; De Masi, R.F.; Mastellone, M.; Ruggiero, S.; Vanoli, G.P. Green walls, a critical review: Knowledge gaps, design parameters, thermal performances and multi-criteria design approaches. *Energies* **2020**, *13*, 2296. [CrossRef]
4. Dong, X.; He, B.J. A standardized assessment framework for green roof decarbonization: A review of embodied carbon, carbon sequestration, bioenergy supply, and operational carbon scenarios. *Renew. Sustain. Energy Rev.* **2023**, *182*, 113376. [CrossRef]
5. Freewan, A.A.; Jaradat, N.A.M.; Amaireh, I.A. Optimizing shading and thermal performances of vertical green wall on buildings in a hot arid region. *Buildings* **2022**, *12*, 216. [CrossRef]
6. Vox, G.; Blanco, I.; Schettini, E. Green façades to control wall surface temperature in buildings. *Build. Environ.* **2018**, *129*, 154–166. [CrossRef]
7. Calheiros, C.S.; Stefanakis, A.I. Green roofs towards circular and resilient cities. *Circ. Econ. Sustain.* **2021**, *1*, 395–411. [CrossRef] [PubMed]
8. Ogut, O.; Tzortzi, N.J.; Bertolin, C. Vertical green structures to establish sustainable built environment: A systematic market review. *Sustainability* **2022**, *14*, 12349. [CrossRef]
9. Ganiyu, A.Y.; Adebiyi, R.W.M.; Abdulraheem, R.T.; Orire, M.; Eluwa, I.S.; Stephen, E. Barrier Factors Affecting Adoption of Green Building Technologies in Nigeria. *Built Environ. J. (BEJ)* **2020**, *17*, 37–48. [CrossRef]
10. Nzegbule, E.; Obiajunwa, U. Barriers and Enablers for Effective Adoption of Nature-Based Solutions (NbS) in Climate Change Mitigation and Adaptation in Nigeria. In *Handbook of Nature-Based Solutions to Mitigation and Adaptation to Climate Change*; Springer International Publishing: Cham, Switzerland, 2024.
11. Jegede, F.O.; Adewale, B.A.; Ajonye, G.O.; Adebajo, T. Evaluation of the use of green façade in residential buildings in Kubwa, Abuja, Nigeria. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2021.

12. Ajibola, A.I.; Abiola, O.S.; Ruth, E.; Thomas, A.J.; George, O. Evaluation of sustainable climate-responsive façade in mixed-use high-rise development in Lagos, Nigeria: A study of Eko Atlantic City. *Int. J. Multidiscip. Res. Growth Eval.* **2024**, *5*, 336–341.
13. Wang, W.; Zhou, X.; Wu, S.; Zhao, M.; Jin, Z.; Bei, K.; Zheng, X.; Fan, C. Vertical Green Wall Systems for Rainwater and Sewage Treatment. *Sustainability* **2024**, *16*, 7593. [CrossRef]
14. Aung, T.; Liana, S.R.; Htet, A.; Bhaumik, A. Implementing green facades: A step towards sustainable smart buildings. *J. Smart Cities Soc.* **2023**, *2*, 41–51. [CrossRef]
15. Unegbu, H.C.O.; Yawas, D.S.; Dan-asabe, B.; Alabi, A.A. Evaluating the Effectiveness of Green Roofs and Walls in Nigeria's Urban Centers. *Res. Sq.* **2024**, 1–29. [CrossRef]
16. Radić, M.; Brković Dodig, M.; Auer, T. Green facades and living walls—A review establishing the classification of construction types and mapping the benefits. *Sustainability* **2019**, *11*, 4579. [CrossRef]
17. Susca, T.; Zanghirella, F.; Colasuonno, L.; Del Fatto, V. Effect of green wall installation on urban heat island and building energy use: A climate-informed systematic literature review. *Renew. Sustain. Energy Rev.* **2022**, *159*, 112100. [CrossRef]
18. Hasnan, M.T.I.M.T.; Yunus, J.; Radzun, K.A.; Zawawi, E.M.A.; Ramli, S.A. Unveiling the potential of green facade retrofit for commercial shopping malls in Kuala Lumpur, Malaysia. *J. Des. Built Environ.* **2024**, 1–26. [CrossRef]
19. Thomsit-Ireland, F. *Overcoming the Barriers to Green Walls in Urban Areas of the UK*; University of Reading: Reading, UK, 2019.
20. Rout, S.; Khare, P.K. Climbing Strategies: A Key to Understanding Liana Ecology in Tropical Forests. *J. Agric. Sci. Eng. Innov. (JASEI)* **2024**, *4*, 40–49.
21. Riley, B.; de Larrard, F.; Malécot, V.; Dubois-Brugger, I.; Lequay, H.; Lecomte, G. Living concrete: Democratizing living walls. *Sci. Total Environ.* **2019**, *673*, 281–295. [CrossRef] [PubMed]
22. Azkorra, Z.; Pérez, G.; Coma, J.; Cabeza, L.F.; Burés, S.; Álvaro, J.E.; Erkoreka, A.; Urrestarazu, M. Evaluation of green walls as a passive acoustic insulation system for buildings. *Appl. Acoust.* **2015**, *89*, 46–56. [CrossRef]
23. Abdo, P.; Huynh, B.P.; Irga, P.J.; Torpy, F.R. Evaluation of air flow through an active green wall biofilter. *Urban For. Urban Green.* **2019**, *41*, 75–84. [CrossRef]
24. Aghimien, D.O.; Aliu, J.; Aigbavboa, C. Exploring blue-green roof for a sustainable built environment in South Africa. *Smart Sustain. Built Environ.* **2024**. [CrossRef]
25. Liu, F.; Yan, L.; Meng, X.; Zhang, C. A review on indoor green plants employed to improve indoor environment. *J. Build. Eng.* **2022**, *53*, 104542. [CrossRef]
26. Mirrahimi, S.; Mohamed, M.F.; Haw, L.C.; Ibrahim, N.L.N.; Yusoff, W.F.M.; Aflaki, A. The effect of building envelope on the thermal comfort and energy saving for high-rise buildings in hot–humid climate. *Renew. Sustain. Energy Rev.* **2016**, *53*, 1508–1519. [CrossRef]
27. Sadeghian, M.M. A review on green wall, classification and function. *Int. J. Sci. Res. Sci. Technol.* **2016**, *2*, 47–51.
28. Moshood, A.W.B.; Orunbon, N.O. Politics of Identity and Democratic Consolidation in Nigeria: A Case Study of 2023 Presidential Election in Lagos State, Nigeria. *Soc. Sci. Humanit. Educ. J. (SHE J.)* **2024**, *5*, 197–210.
29. Enoh, M.A.; Njoku, R.E.; Okeke, U.C. Modeling and mapping the spatial–temporal changes in land use and land cover in Lagos: A dynamics for building a sustainable urban city. *Adv. Space Res.* **2023**, *72*, 694–710. [CrossRef]
30. Mehrad, A.; Zangeneh, M.H.T. Comparison between qualitative and quantitative research approaches: Social sciences. *Int. J. Res. Educ. Stud.* **2019**, *5*, 36–43.
31. Keadkraichaiwat, I.; Sitticharoon, C.; Lertsiripatarajit, V.; Maprapho, P. Effects of using audience response systems (Kahoot and Google Forms and Sheets) on learning of medical students in a large class: A questionnaire-based retrospective study. *Educ. Inf. Technol.* **2024**, *29*, 17539–17563. [CrossRef]
32. Haven, T.L.; Errington, T.M.; Gleditsch, K.S.; van Grootel, L.; Jacobs, A.M.; Kern, F.G.; Piñeiro, R.; Rosenblatt, F.; Mokkink, L.B. Preregistering qualitative research: A Delphi study. *Int. J. Qual. Methods* **2020**, *19*, 1609406920976417. [CrossRef]
33. Pallant, J. *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows (Version 12)*; Allen & Unwin: Crows Nest, Australia, 2005.
34. Nguyen, B.V.D.; Han, J.; Moere, A.V. Towards Responsive Architecture that Mediates Place: Recommendations on How and When an Autonomously Moving Robotic Wall Should Adapt a Spatial Layout. *Proc. ACM Hum. Comput. Interact.* **2022**, *6*, 1–27. [CrossRef]
35. Hamid, H.N.A.; Romali, N.S.; Rahman, R.A. Key barriers and feasibility of implementing green roofs on buildings in Malaysia. *Buildings* **2023**, *13*, 2233. [CrossRef]
36. Arowoiya, V.A.; Akinradewo, O.F.; Oke, A.E. Enhancing Competencies of Quantity Surveyors in Cost Management of Mechanical and Electrical Services. *J. Surv. Constr. Prop.* **2022**, *13*, 32–41. [CrossRef]
37. Liberalesso, T.; Cruz, C.O.; Silva, C.M.; Manso, M. Green infrastructure and public policies: An international review of green roofs and green walls incentives. *Land Use Policy* **2020**, *96*, 104693. [CrossRef]

38. Zhang, L. Analysis of energy saving effect of green building exterior wall structure based on ANSYS simulation analysis. *Environ. Technol. Innov.* **2021**, *23*, 101673. [CrossRef]
39. Thomas, G.; Thomas, J.; Mathews, G.M.; Alexander, S.P.; Jose, J. Assessment of the potential of green wall on modification of local urban microclimate in humid tropical climate using ENVI-met model. *Ecol. Eng.* **2023**, *187*, 106868. [CrossRef]