

Application of Sustainability on Construction Projects in Sudan “Case Study on Khartoum’s Construction Sector”

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Abstract: *The construction industry plays a vital role in economic development but is simultaneously one of the leading contributors to environmental degradation due to high consumption of resources and poor waste management. This study explores sustainability implementation in Sudan’s construction sector, using Khartoum as a focal case. A structured questionnaire was distributed among contractors and consultants, generating 115 valid responses. Statistical analysis using SPSS (Cronbach’s alpha = 0.79) confirmed the reliability of the data. Findings indicate that while over 70% of respondents demonstrate strong awareness of sustainable construction benefits, actual adoption remains limited. Resource reduction (38.2%) was the most widely implemented practice, while advanced measures such as on-site recycling (2.4%) and the use of recycled materials (0.8%) were rarely applied. Key barriers include limited policies, weak institutional frameworks, unstable construction costs, and lack of professional training. This study highlights the urgent need for regulatory reform, targeted training, and industry engagement to bridge the gap between awareness and practice. The results provide policymakers and industry stakeholders in developing countries with insights into advancing sustainable construction practices.*

Keywords: sustainable construction, Sudan, Khartoum, environmental awareness, implementation barriers

1. Introduction

Sustainability as a global concept emerged in the mid-20th century in response to mounting concerns over environmental degradation caused by excessive resource exploitation and mismanagement of waste. It extends beyond reducing consumption to fostering a balance between human development and environmental preservation to ensure intergenerational equity (Reijnders, 2022; Paziienza et al., 2022).[1], [2]

The construction industry is a major contributor to global environmental challenges. It is responsible for approximately 30 – 40% of global carbon emissions, consumes nearly 40% of raw materials such as gravel and sand, and accounts for 25% of annual timber usage (Ossio et al., 2023; Dsilva et al., 2024).[3] [4]

In developing countries such as Sudan, the challenge is further amplified by rapid urbanization, reliance on conventional construction methods, financial limitations, weak institutional systems, and social inequalities. Despite the global push for sustainable development, empirical studies on sustainability adoption within Sudan’s construction industry remain scarce (Opoku et al., 2019; Elshiakh & Mahmoud, 2020; Aghimien et al., 2019). This study therefore addresses a critical knowledge gap by assessing sustainability awareness, current practices, and barriers in Khartoum’s construction sector. [5], [6], [7]

This knowledge gap underscores the importance of assessing both the level of awareness and the barriers to implementation in Sudan’s construction sector.

The objectives of this study are:

- To evaluate the level of awareness of sustainability and sustainable construction among construction professionals in Khartoum.
- To examine the extent of sustainable practices applied in local projects.
- To identify barriers impeding the adoption of sustainable construction practices.

This study is particularly important as it provides localized evidence to inform Sudan’s policy and industry efforts in aligning construction practices with global sustainability goals.

2. Methodology

2.1 Research Design

A descriptive analytical approach was employed, combining primary and secondary data. Secondary data included journal articles and official reports, while primary data were obtained from a structured questionnaire survey.

2.2 Ethical Considerations

Participants were informed of the research objectives and assured of confidentiality and voluntary participation. Informed consent was secured from all respondents.

2.3 Questionnaire Development

The survey was divided into four sections: demographic information, awareness of sustainability, sustainable construction practices, and barriers to adoption. Content validity was assessed through expert review. Internal consistency was acceptable (Cronbach’s alpha = 0.79).

2.4 Sample

The population included licensed consultants and contractors in Khartoum. Using Cochran’s formula, a sample size of 99 was calculated; 115 valid responses were obtained, exceeding the minimum requirement.

2.5 Data Analysis

Data were analysed using SPSS, with descriptive statistics (frequency, percentages, means) and inferential methods such as chi-square tests and the Relative Importance Index.

3. Results & Discussion

3.1 Reliability and Validity of the Survey Instrument

The reliability of the questionnaire was evaluated using Cronbach’s alpha coefficient. The obtained value of 0.79 exceeds the acceptable threshold of 0.70, indicating

satisfactory internal consistency and confirming that the survey instrument reliably measures sustainability awareness, practices, and barriers within the construction sector. This level of reliability is consistent with similar sustainability studies conducted in developing-country contexts and supports the robustness of the collected data.

3.2 Respondents’ Professional Background

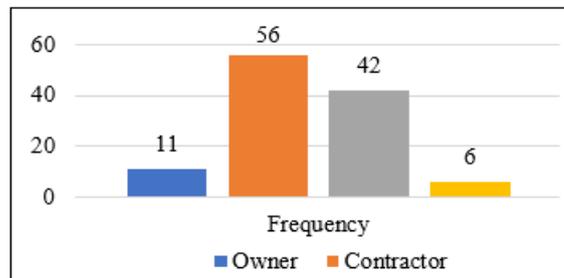


Figure 1: Nature of Work

The respondents’ professional distribution shows that contractors represent the largest group (48.7%), followed by consultants (36.5%), owners (9.6%), and other construction-related professionals (5.2%). This composition ensures that the findings reflect perspectives from key stakeholders directly involved in decision-making, project execution, and sustainability implementation within Khartoum’s construction industry.

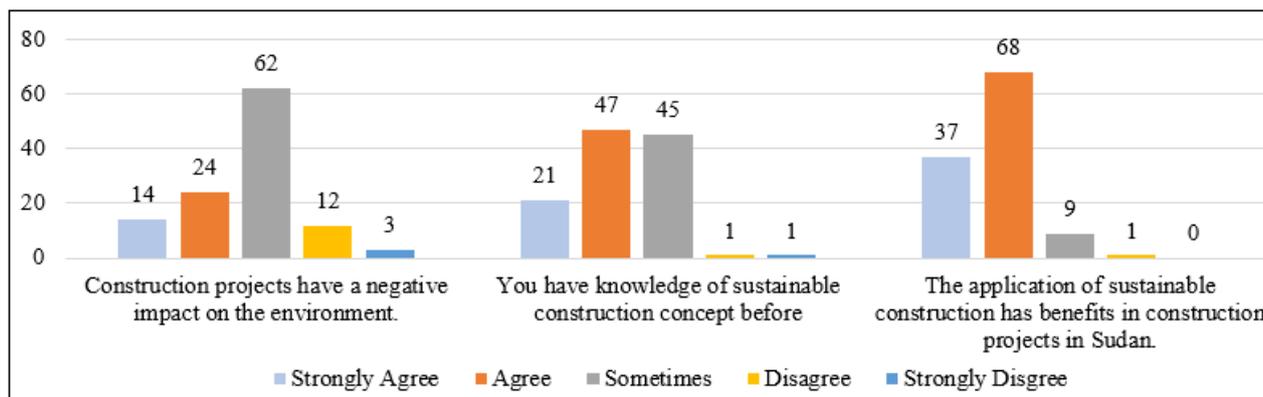


Figure 2: Awareness of Sustainability and Sustainable Construction

Figure 2 presents the results. The results indicate a high level of awareness of sustainability concepts among construction professionals. More than 70% of respondents agreed that sustainable construction contributes positively to environmental protection and project performance. The mean values for awareness-related statements ranged between 3.30 and 4.23, with statistically significant chi-square results (p <

0.05), demonstrating a strong and consistent agreement among respondents. These findings indicate that sustainability is conceptually understood in the industry, aligning with observations reported in other developing countries. (Simwero et al., 2024; Amuda-Yusuf et al., 2020). [8], [9]

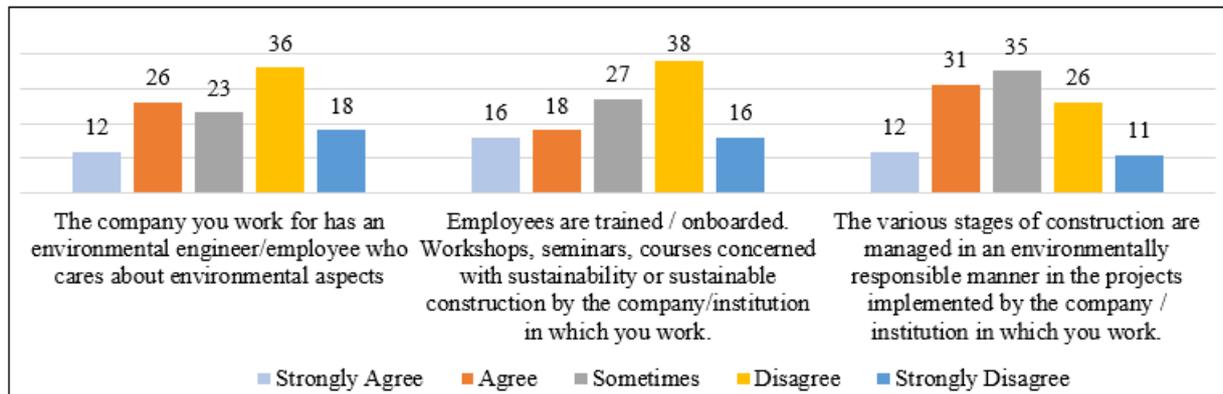


Figure 3: The Role of Companies in Promoting and Implementing Sustainability

Figure 3 illustrates that despite high awareness levels, the practical implementation of sustainable construction practices remains limited. Reducing resource consumption emerged as the most frequently applied practice (38.2%), followed by appropriate waste disposal (14.6%), quality follow-up during construction (13.8%), and environmental protection measures (13%). In contrast, advanced sustainability practices showed minimal adoption, including the use of renewable energy sources (4.1%), on-site recycling (2.4%), and recycled materials (0.8%). This disparity highlights a clear gap between awareness and practice, indicating that knowledge alone is insufficient to drive sustainability adoption without supportive institutional and economic conditions. These findings are consistent with studies in other developing regions, where financial constraints and lack of incentives hinder adoption (Osuizugbo et al., 2020; Mohamed et al., 2023). [10] [11] (Kiani Mavi R, 2021) This paper reviews sustainability research in construction projects using bibliometric and network analyses, identifying three main themes: evaluating sustainability, project management for sustainability, and drivers of sustainable construction.[12] Mohamed & Elshaikh (2022) found that although many sustainability indicators are recognized in Khartoum, their actual application during construction and operation stages remains inconsistent and limited.

(29%) and demolition stage (20%). However, sustainability considerations are significantly lower during the operation (6%) and maintenance (4%) phases. This uneven distribution suggests that sustainability is often addressed as an early-stage design concept rather than as a comprehensive life-cycle approach, limiting long-term environmental and economic benefits.

These findings are supported by local studies highlighting gaps in applying sustainability indicators during construction and operation stages in Khartoum (Mohamed & Elshaikh, 2022). [13]

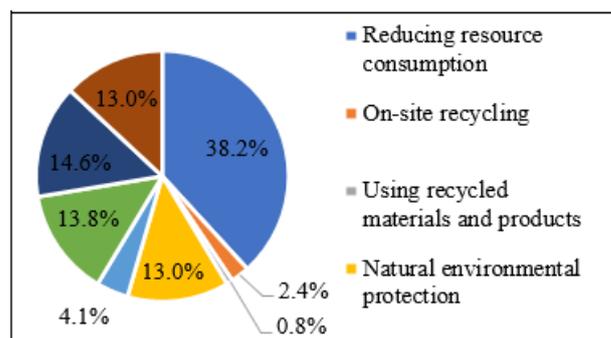


Figure 5: Sustainable Construction Practices

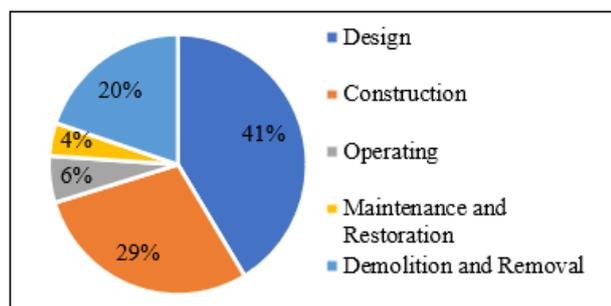


Figure 4: Application of Sustainability in Construction Phases.

Figure 4 reveals that sustainability is primarily applied during the design stage (41%), followed by the construction stage

The figure (5) shows that reducing resource consumption represented the highest percentage of sustainable construction practices implemented in the construction projects (38.2%), followed by appropriate waste disposal (14.6%), quality follow-up in the implementation of the built environment (13.8%), natural environmental protection and creating a healthy built environment (13%), use of alternative energy sources (4.1%), on-site recycling (2.4%), and the lowest percentage being the use of recycled materials and products (0.8%). These findings align with Sadar Din & Ishak (2024), who observed that in the UAE, sustainable construction practices are increasingly being integrated, with a focus on reducing resource consumption and improving environmental performance.[14]

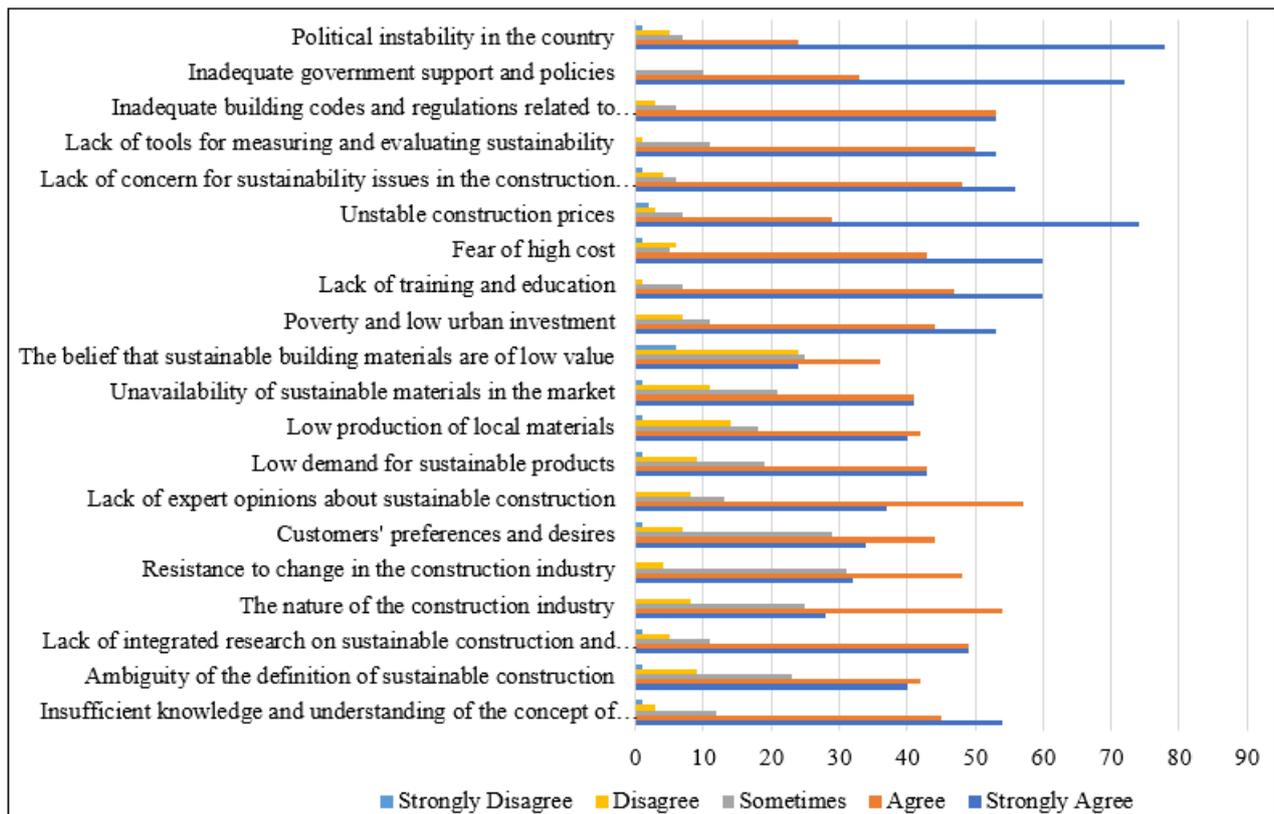


Figure 6: Obstacles to Applying Sustainability in Construction Projects.

The data confirm several major barriers obstructing sustainability practices in Khartoum’s construction sector, with an overall mean score of 4.16 out of 5, reflecting strong agreement among respondents regarding their severity. The most significant barriers include political instability, inadequate government support and policies, unstable construction prices, lack of training and education, and insufficient sustainability-related building codes. All barrier-related statements exhibited statistically significant chi-square values ($p < 0.05$), confirming that these obstacles are both prevalent and influential. Similar barriers have been highlighted across developing countries, where institutional weaknesses impede sustainable practice (Du Plessis, 2007). [15]

The study underscores Sudan’s need to align with global sustainability frameworks such as the United Nations Sustainable Development Goals (SDGs) and the Paris Climate Agreement. Policymakers should introduce

incentives for green construction, strengthen regulatory codes, and provide financial and technical support for the use of sustainable materials. Capacity-building programs for engineers, contractors, and regulators are critical to bridging the gap between awareness and implementation.

Overall, while Khartoum’s construction sector shows promising awareness levels, the low rate of actual practice highlights the urgent need for policy reforms, industry engagement, and integration of international best practices to accelerate the transition toward sustainable construction.

3.3 Test of Hypothesis

3.3.1 The first hypothesis:

There is no awareness of the concept of sustainability and sustainable construction among those working in the construction industry.

Table 1: Results of the First Hypothesis

Statements of the first hypothesis	Mean	Standard. Deviation	Phrase Scale		Chi-Square	Degree of Freedom	Asymp. Sig.
			Median	Interpret			
1. Construction projects have a negative impact on the environment	3.30	0.908	3	Sometimes	88.348	4	0.000
2. You have knowledge of sustainable construction concepts before.	3.75	0.793	4	Agree	96.304	3	0.000
3. The application of sustainable construction has benefits in construction projects in Sudan.	4.23	0.622	4	Agree	92.348	3	0.000
Total	3.76	0.529	4	Agree	18.070	2	0.000

3.3.2 The second hypothesis:

There are many challenges and obstacles facing the application of sustainability on construction projects in Khartoum.

Table 2: The Results of the Second Hypothesis

Statements of the first hypothesis	Mean	Standard. Deviation	Phrase Scale		Chi-Square	Degree of Freedom	Asymp. Sig.
			Median	Interpret			
1) Insufficient knowledge and understanding of the concept of sustainability	4.29	0.825	4	Agree	106.522	4	0.000
2) Ambiguity of the definition of sustainable construction.	3.97	0.973	4	Agree	57.826	4	0.000
3) Lack of integrated research on sustainable construction and sustainable materials.	4.22	0.856	4	Agree	100.174	4	0.000
4) The nature of the construction industry.	3.89	0.856	4	Agree	37.661	3	0.000
5) Resistance to change in the construction industry.	3.94	0.830	4	Agree	34.739	3	0.000
6) Customers' preferences and desires.	3.90	0.931	4	Agree	58.174	4	0.000
7) Lack of expert opinions about sustainable construction.	4.07	0.845	4	Agree	53.730	3	0.000
8) Low demand for sustainable products.	4.03	0.968	4	Agree	65.043	4	0.000
9) Low production of local materials.	3.92	1.036	4	Agree	53.913	4	0.000
10) Unavailability of sustainable materials in the market.	3.96	1.003	4	Agree	55.652	4	0.000
11) The belief that sustainable building materials are of low value.	3.42	1.185	4	Agree	20.174	4	0.000
12) Poverty and low urban investment	4.24	0.864	4	Agree	55.957	3	0.000
13) Lack of training and education.	4.44	0.651	5	Strongly Agree	88.791	3	0.000
14) Fear of high cost.	4.35	0.859	5	Strongly Agree	124.609	4	0.000
15) Unstable construction prices.	4.48	0.862	5	Strongly Agree	162.348	4	0.000
16) Lack of concern for sustainability issues in the construction industry.	4.34	0.804	4	Agree	123.826	4	0.000
17) Lack of tools for measuring and evaluating sustainability.	4.35	0.689	4	Agree	73.904	3	0.000
18) Inadequate building codes and regulations related to sustainability.	4.36	0.703	4	Agree	81.974	3	0.000
19) Inadequate government support and policies.	4.54	0.653	5	Strongly Agree	51.252	2	0.000
20) Political instability in the country.	4.50	0.862	5	Strongly Agree	177.826	4	0.000
Total	4.16	0.480	4	Agree	165.017	5	0.000

The first hypothesis, which assumed the absence of sustainability awareness among construction professionals, was statistically rejected. The significant chi-square values ($p < 0.05$) and high mean scores confirm that awareness of sustainability and sustainable construction concepts exists within the industry. In contrast, the second hypothesis, which proposed the presence of major challenges impeding sustainability implementation, was statistically supported. The consistently high mean values and significant test results validate the existence of serious institutional, economic, and technical barriers.

Overall, the results demonstrate that while sustainability awareness in Khartoum's construction sector is relatively strong, practical implementation remains constrained by systemic challenges. These findings emphasize the need for regulatory reform, capacity building, and the adoption of life-cycle-based sustainability strategies to enable effective and sustainable transformation within the construction industry.

4. Conclusion

This study assessed sustainability awareness and practices in Sudan's construction industry, with Khartoum as a case study. The findings revealed:

- The study demonstrates a high level of sustainability awareness among construction professionals in Khartoum State, with more than 70% of respondents acknowledging the environmental and economic benefits of sustainable construction; however, this awareness has not translated into effective practical implementation.

- Sustainable construction practices remain limited, with resource consumption reduction being the most applied practice (38.2%), while advanced practices such as on-site recycling (2.4%), use of recycled materials (0.8%), and renewable energy integration (4.1%) are rarely adopted.
- Sustainability integration is strongest during the design phase (41%), followed by the construction phase (29%), while application during demolition (20%), operation (6%), and maintenance (4%) stages remains weak, reducing overall life-cycle effectiveness.
- Key barriers to sustainability adoption include weak regulatory frameworks, political and economic instability, volatile construction prices, and lack of training, with these obstacles receiving high agreement levels from respondents (overall mean = 4.16 out of 5), confirming their significant impact on implementation.

5. Recommendations

- Establish and enforce clear sustainability-oriented building codes, regulations, and certification systems aligned with international frameworks.
- Strengthen capacity building through targeted training programs and integration of sustainability concepts into engineering and construction education.
- Introduce financial and institutional incentives to encourage the adoption of sustainable materials and construction practices.
- Promote organizational commitment by encouraging construction companies to embed sustainability indicators and environmental management systems within project delivery processes.

Future studies should examine the effects of policy implementation, compare Sudan with neighbouring African countries, and explore life cycle assessment approaches for evaluating sustainability in construction.

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