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Investigating The Role of Sustainable Practices in Construction Materials Handling: A Pathway Towards SDG Integration

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Abstract

This research explores the integration of sustainable practices in construction materials handling to enhance sustainability and support the achievement of Sustainable Development Goals (SDGs). The study aims to identify current barriers in construction materials handling practices to pinpoint inefficiencies and areas ripe for improvement in sustainability, determine the potential benefits of implementing sustainable practices in construction materials handling on the achievement of Sustainable Development Goals (SDGs) and propose strategies for integrating sustainable practices into construction materials handling processes effectively.. Using quantitative data collection and analysis, the study reveals that sustainable materials handling practices lead to cost savings (mean = 4.06) and that insufficient regulatory support is a major barrier (mean = 4.0). Enhanced reputation (mean = 4.15) and prioritizing green building certifications (mean = 4.19) are highlighted as key benefits and strategies, respectively. Reliability analysis shows Cronbach's Alpha values between 0.835 to 0.916, indicating good to excellent reliability, with an overall value of 0.888. These findings emphasize the need to address regulatory barriers and focus on green certifications to foster sustainable practices in construction materials handling, aligning the industry with SDGs.

1. Introduction

The construction industry is a cornerstone of global economic growth, yet it significantly impacts the environment and society. A critical aspect of the construction process, materials handling involves the movement, storage, and management of materials used in projects. Current practices, however, often fall short in sustainability, leading to inefficiencies, excessive resource use, waste generation, and environmental degradation. Sustainable materials handling practices—such as using renewable and recyclable materials, optimizing transportation, and reducing waste—offer opportunities to enhance environmental, social, and economic outcomes [6]. By adopting these practices, the construction industry can contribute meaningfully to the achievement of the Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production) [15]. Despite its potential, integrating sustainability into construction materials handling faces significant challenges. Barriers include a lack of awareness, resistance to change, inadequate financial resources, and limited regulatory support. Inefficient reliance on virgin materials, limited recycling initiatives, and improper waste management exacerbate the environmental and social costs of the industry. These challenges highlight the urgent need for actionable strategies that address inefficiencies, optimize resource use, and align practices with sustainable development principles. A multi-stakeholder approach involving governments, industry leaders, and civil society is essential to overcome these obstacles and drive sustainable transformation. This research aims to bridge the gap between conventional and sustainable construction materials handling practices. By examining existing practices, identifying inefficiencies, and assessing the impacts of sustainable alternatives, this study will propose practical strategies for integrating sustainability into construction processes. In doing so, it seeks to empower industry stakeholders with actionable recommendations for reducing environmental impacts, promoting social equity, and achieving long-term economic viability, thus contributing to global sustainability efforts aligned with the SDGs.

In Klang Valley, Malaysia, construction material handling practices involve a combination of traditional and modern approaches. Traditional methods, such as manual handling, cranes, hoists, forklifts, and basic mechanical equipment, continue to be widely used due to their low initial costs and familiarity within the industry [1]. However, these methods often lead to inefficiencies, including excessive material waste, high labor dependency, delays, and safety risks. In response to these challenges, more advanced techniques such as Industrialized Building Systems (IBS), Building Information Modeling (BIM), and Radio Frequency Identification (RFID) have been introduced to improve material tracking, reduce waste, and enhance efficiency [3]. Despite these technological advancements, inefficiencies persist due to poor planning, inaccurate material estimation, inadequate storage facilities, and reliance on outdated management practices [9]. Additionally, the lack of integration between digital technologies and on-site operations further exacerbates these inefficiencies, resulting in increased project costs and delays. The environmental impact of poor material handling, such as excessive waste generation and improper disposal practices, remains a major concern. Addressing these inefficiencies requires better regulatory enforcement, improved training programs, and wider adoption of sustainable material handling practices.

The construction industry, long criticized for its significant environmental impact through resource depletion and greenhouse gas emissions, plays a pivotal role in achieving the United Nations Sustainable Development Goals (SDGs) [15]. These goals, adopted in 2015, aim to address global challenges such as climate change, environmental degradation, and inequality by 2030. Sustainable construction practices, particularly in material handling, can mitigate environmental impacts, promote economic growth, and enhance social well-being. By aligning with SDGs, the construction sector can reduce waste, minimize emissions, and adopt resource-efficient processes, contributing to a sustainable future [8]. This study highlights the intersection of construction material handling and sustainability, critically assessing current inefficiencies and proposing strategies for integrating sustainable practices to transform the industry responsibly.

The adoption of sustainable practices in construction materials handling is hindered by several barriers, including technological, economic, and institutional challenges. Technological barriers include the limited availability and high costs of advanced tools like RFID and BIM for material tracking, the absence of standardized frameworks for assessing material sustainability, and challenges in recycling and ensuring the quality of reused construction materials [9]. Economically, higher upfront costs for green building materials and technologies, insufficient financial incentives, and uncertainty about long-term cost savings prevent many companies from embracing sustainable practices. While these approaches may lead to savings through waste reduction and energy efficiency, the delayed realization of benefits during operational phases makes justifying the initial investment difficult [16]. Institutional and regulatory barriers exacerbate the issue, including unclear or inconsistent policies, inadequate standards and certification systems such as LEED and BREEAM, and a lack of training and education for construction professionals. Many lack the knowledge and skills required to implement sustainable practices effectively, further limiting their adoption [4]. Overcoming these barriers requires a multi-faceted approach, including technological innovation, stronger economic incentives, clear regulatory frameworks, and comprehensive training programs.

The adoption of sustainable practices in construction materials handling yields significant environmental, economic, and social benefits. Environmentally, these practices reduce greenhouse gas emissions, conserve natural resources, enhance biodiversity, improve air and water quality, and foster resilience to environmental shocks [13]. Economically, they promote cost savings through resource efficiency and waste reduction, drive innovation, create job opportunities, attract investments through ESG-focused funding, and enhance regulatory compliance, ultimately contributing to long-term resilience and stability [2], [5]. Socially, sustainable practices improve health and wellbeing, enhance education access, reduce poverty and inequality, strengthen social cohesion, and uphold justice and human rights, supporting SDGs such as Good Health and Wellbeing (SDG 3), Quality Education (SDG 4), and Decent Work and Economic Growth (SDG 8) [13]. Together, these benefits demonstrate how sustainable practices advance the global agenda for achieving the Sustainable Development Goals [7].

2. Methodology

This research adopts a quantitative research method approach. The study progresses through several stages, each aimed at achieving specific objectives outlined in the research. Initially, a thorough review of existing literature on construction materials handling practices and sustainability is conducted, including academic journals, industry reports, case studies, and policy documents. The researcher then collects data on current construction materials handling practices through surveys distributed to construction companies and professionals. An in-depth quantitative analysis is then performed to pinpoint specific inefficiencies in the current materials handling processes using methods such as process mapping and statistical analysis. The potential impact of implementing sustainable practices is evaluated through quantitative case studies and simulation models predicting the outcomes of adopting these practices. The findings from the impact assessment are mapped against the 17 Sustainable Development Goals (SDGs) to identify how sustainable materials handling practices contribute to each goal. Based on this quantitative analysis, practical strategies and recommendations are developed to facilitate the integration of sustainable practices in construction materials handling, involving expert consultations and workshops with stakeholders to ensure practicality and feasibility.

2.1 Research Procedure

The research journey for "Investigating the Role of Sustainable Practices in Construction Materials Handling: A Pathway Towards SDG Integration" begins with a comprehensive literature review to establish a theoretical framework on sustainable practices in construction materials handling and their alignment with the Sustainable Development Goals (SDGs). This review will inform the identification of an appropriate survey instrument, focusing on awareness, current practices, and barriers to sustainable materials handling, targeting construction professionals such as project managers, engineers, and sustainability experts. A questionnaire is developed, validated through a pilot study, and distributed to a wider sample of stakeholders via in-person using Google-Form. Data collected is analysed using statistical software like SPSS, with descriptive statistics and reliability testing used to draw insights on the integration of SDGs. The findings are synthesized to highlight key discoveries, challenges, and opportunities for improvement in sustainable materials management, with practical recommendations for advancing SDG integration. The study recognizes its limitations, such as sample size and geographic constraints, and concludes with a structured report that includes future research directions, emphasizing the exploration of innovative technologies and regulations in sustainable materials handling.

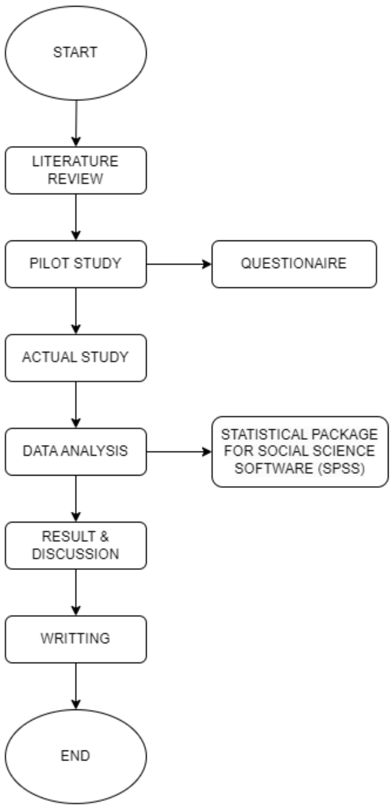

Fig. 1 *Methodology flowchart*

2.2 Research Instrument

Data collection methods are essential for obtaining precise and relevant information for research and can be categorized into primary and secondary data. Primary data, also known as field data, is gathered directly for a specific purpose through surveys, interviews, observations, and experiments. It is highly accurate and relevant, as it is tailored to meet the research's specific needs and is often more up-to-date. However, it is time-consuming and resource-intensive [13]. On the other hand, secondary data refers to information previously collected for a different context, sourced from books, peer-reviewed articles, government publications, or other printed or electronic media. It is cost-effective and readily available, making it convenient to use. However, it may lack relevance to the specific research question, require time for evaluation, and may be outdated or biased [10]. The sample size is determined using Cochran's formula, ensuring statistical reliability and accuracy in the findings. The formula used to calculate the sample size is based on Cochran (1977) [11]. This research need to conducted with 140 respondents. Then assume that *e*, acceptable sampling error in this research is 5%. The reliability level would be in 95% for this study. Making use of Cochran (1977) with these parameters, the calculated sample size was 138.3, which was rounded up to 140 participants for the survey.

The analysis method for this research involves utilizing Statistical Package for the Social Sciences (SPSS) software to analyze quantitative data collected through surveys and other instruments. SPSS is a robust tool that allows for statistical analysis, data manipulation, and presentation of results in a clear and interpretable format. The software is used to run descriptive statistics and reliability analyses to examine the barriers in construction materials handling practices, identifying inefficiencies and areas for improvement in sustainability. Additionally, the analyses will evaluate the potential benefits of implementing sustainable practices in construction materials handling and their contribution to the achievement of Sustainable Development Goals (SDGs). The assessments will also evaluate the possible advantages of integrating sustainable practices into construction materials handling processes by propose strategies for improvement sustainable practices into construction materials handling processes. Reliability and validity analysis are crucial components of the analysis process to ensure the accuracy and consistency of the data collected.

3. Results & Discussion

The findings of this study address the research objectives, focusing on identifying barriers to implementing sustainable construction materials handling practices, evaluating the potential benefits of these practices, and determining strategies for their integration. The data was analyzed using the Statistical Package for Social Sciences (SPSS) version 27, with preliminary sorting performed in Microsoft Excel. Data presentation was facilitated through relevant tables and illustrations to enhance clarity and interpretation. In 2023, Malaysia's construction sector employed approximately 1.26 million people [14]. For this study, 200 questionnaires were distributed via platforms such as Email, WhatsApp, and company query websites. Out of the 200, 167 responses were received, but 27 were excluded due to invalid feedback from respondents whose professional backgrounds were outside Malaysia or unrelated to the construction industry, including those in administrative roles, clerical positions, or internships. After filtering, 140 valid responses were retained, representing a 70% response rate from the total distributed questionnaires. A summary of the survey data is presented in Table 1.

Table 1 *Summary of survey data*

Data collection	Count	Percentage
Total questionnaires distributed	200	-
Total responses received	167	83.5%
Discarded responses	27	13.5%
Total valid responses	140	70%

3.1 Reliability Analysis

The reliability analysis for this study on sustainable practices in construction materials handling involved 140 respondents from Malaysia's construction sector. In this study, a total of 140 respondents, consisting of professionals in the construction industry, were surveyed. Reliability was evaluated using Cronbach's Alpha, with values for the key aspects, Current Practices in Construction Materials Handling, Barriers to Implementing Sustainable Practices, Potential Benefits of Sustainable Practices, and Strategies for Improvement, ranging from 0.835 to 0.916. Table 2 presents the detailed reliability test results for each variable.

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Table 2 *The result of reliability analysis*

No	Aspect	No of Item	Cronbach's Alpha Value	Strength of Association
1	Current Practices in Construction Materials Handling	5	0.857	Good
2	Barriers to Implementing Sustainable Practices	5	0.889	Good
3	Potential Benefits of Sustainable Practices	4	0.835	Good
4	Strategies for Improvement Sustainable Practices into Construction Materials Handling Processes	7	0.916	Excellent

The overall Cronbach's Alpha for the study was 0.888, indicating very good reliability. These results confirm that the measures employed in the study are consistent and dependable, ensuring the robustness and reliability of the findings. Based on the table for the actual study, the value of Cronbach's Alpha for the aspects Current Practices in Construction Materials Handling, Barriers to Implementing Sustainable Practices, Potential Benefits of Sustainable Practices, and Strategies for Improvement of Sustainable Practices in Construction Materials Handling Processes are 0.857, 0.889, 0.835, and 0.916 respectively. Meanwhile, the overall Cronbach's Alpha value for the study is 0.888. The results show that the reliability test for the actual study is very good, indicating that the study is reliable.

3.2 Demographic Analysis

A complete overview of the study respondents' positions as professionals, years of work experience, and educational backgrounds can be obtained from their demographic profile. From administrative jobs to engineering responsibilities and other associated designations, the data demonstrates the range of occupations within the construction sector. It also shows the range of professional experience, from individuals with minimal experience in the industry to those with considerable experience. Furthermore, the educational backgrounds of the respondents reflect a variety of academic accomplishments, including a mix of professionals with advanced degrees, certificate holders, and bachelor's degree grads. Table 3 shows demographic distribution provides a wide viewpoint on the subject being studied and provides insightful information about the respondents' background.

Table 3 *Demographic statistics*

Demographics	Items	Frequency (n=140)	Percentage (%)
Position	Project Manager	18	12.9
	Project Engineer	28	20
	Site Manager	35	25
	Site Engineer	39	27.9
	QAQC Engineer	15	10.7
	Others	5	3.5
Working experience	5 years and below	20	14.3
	6-10 years	38	27.1
	11-15 years	45	32.1
	16-20 years	35	25
	21 years and above	2	1.4
Education level	Diploma	13	9.3
	Bachelor's Degree	83	59.3
	Master	37	26.4
	Doctor of Philisophy (PhD)	7	5

3.3 Barriers to Implementing Sustainable Practices

Figure 2 illustrates the key barriers to implementing sustainable practices in the construction industry. The highest mean score of 4.04 for "Insufficient regulatory support or incentives" (BIS5) highlights the critical role that governmental policies and financial incentives play in driving sustainability efforts. Additionally, "Resistance to change within the organization" (mean = 4.01) and "Lack of access to sustainable materials" (mean = 3.96) further emphasize the industry's reluctance and structural challenges in adopting sustainable practices. The total average score of 3.97 suggests that these barriers are perceived as moderately high, indicating that overcoming these issues requires targeted interventions, such as regulatory reforms, financial incentives, improved supply chain access, and awareness programs.

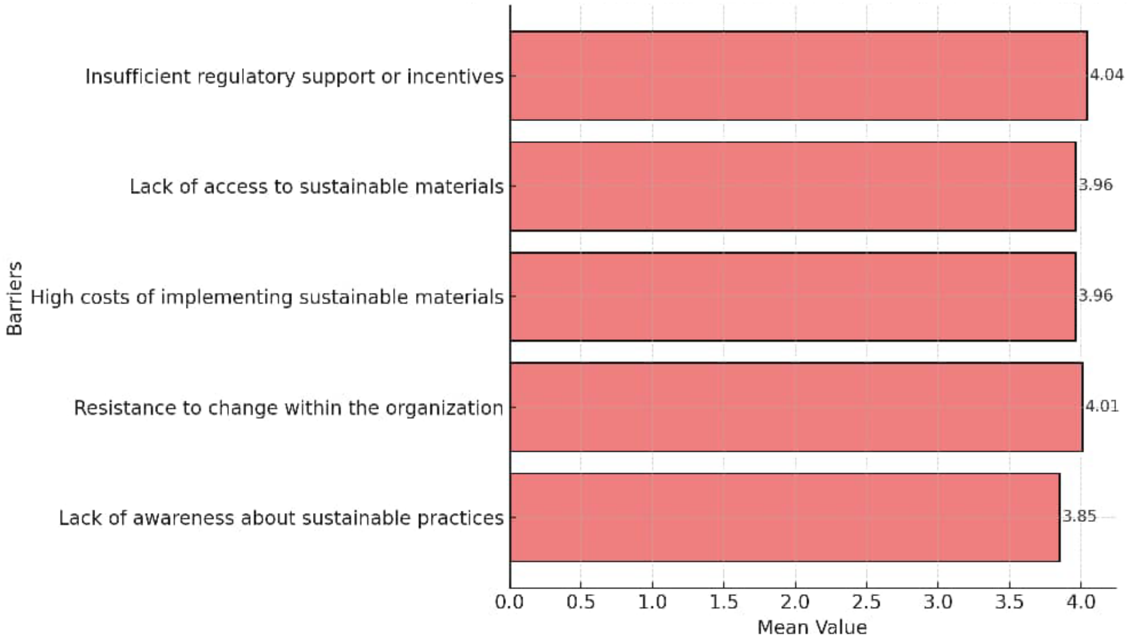

Fig. 2 *Bar chart of barriers to implementing sustainable practices*

3.4 Potential Benefits of Sustainable Practices

Figure 3 presents the benefits of implementing sustainable practices in the construction industry, with mean scores ranging from 4.04 to 4.15. The highest-rated benefit, "Enhanced reputation for sustainability" (mean = 4.15), highlights the industry's recognition of the positive image and competitive advantage gained through environmentally responsible practices. Other significant benefits include "Reduced environmental impact" (mean = 4.05), "Better compliance with local and global regulations" (mean = 4.04), and "Improved project efficiency and reduced costs" (mean = 4.04). The overall average score of 4.07 indicates that respondents highly value these advantages, reinforcing the importance of sustainable initiatives in construction projects. All benefits of sustainable practices haves mean scores ranging from 4.04 to 4.15. The total average score of 4.07 indicates that respondents highly value these benefits. Among the analyzed items, the highest-rated aspect was related to enhancing reputation for sustainability, indicating a strong acknowledgment of the value placed on adopting environmentally responsible practices

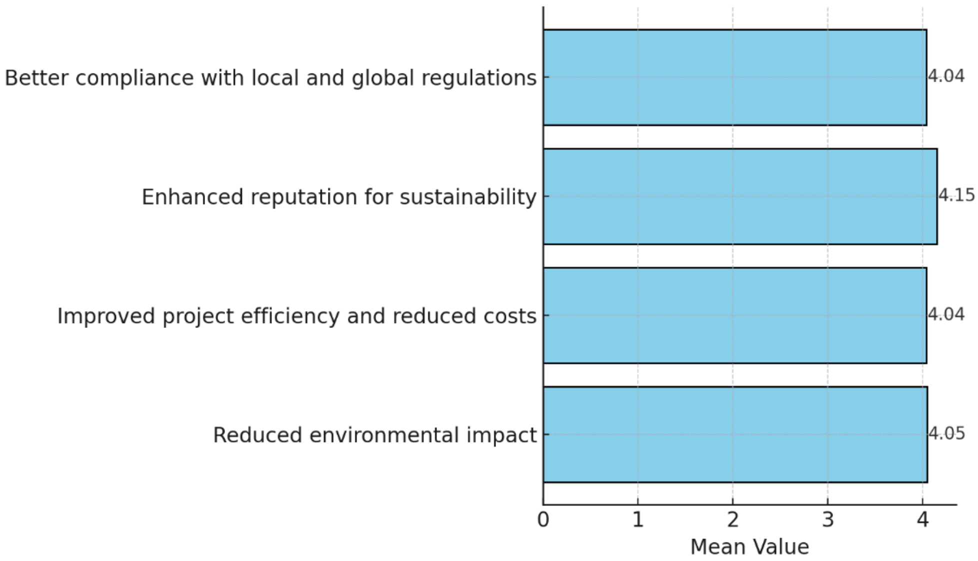

Fig. 3 *Bar chart of potential benefits of sustainable practices*

3.5 Strategies for Improvement Sustainable Practices into Construction Materials Handling Processes

The third objective aimed at proposing effective strategies for integrating sustainable practices into construction materials handling processes. This objective was successfully met through the identification and evaluation of key strategies. Figure 4 highlights the key strategies for integrating sustainable practices into construction material handling processes. The highest-rated strategy, "Achieving green building certifications should be a priority" (mean = 4.19), underscores the industry's recognition of the importance of adhering to sustainable building standards. Other significant strategies include "Low-emission machinery and equipment should be adopted" (mean = 4.16), "Strengthening regulations and enforcement" (mean = 4.12), and "Developing partnerships with suppliers for sustainable materials" (mean = 4.12). The overall mean score analysis confirms that these strategies are highly valued by industry stakeholders, indicating the need for proactive measures to support their implementation. Among the strategies, achieving green building certifications emerged best strategy, reflecting a high level of importance based on the mean analysis.

Fig. 4 *Bar chart of strategies for improvement sustainable practices into construction materials handling processes*

4. Conclusion

This study successfully achieved its objectives by identifying barriers, exploring benefits, and proposing strategies for integrating sustainable practices in construction materials handling, with a focus on aligning with Sustainable Development Goals (SDGs). Key barriers, such as insufficient regulatory support and organizational resistance, were identified, highlighting the need for stronger policies and cultural shifts. The study demonstrated that sustainable practices can reduce environmental impact, enhance project efficiency, and achieve cost savings, while strategies like promoting training, fostering partnerships with sustainable suppliers, and adopting technologies like Building Information Modeling (BIM) were emphasized as critical for implementation. Despite limitations such as limited respondent reach and time constraints, the findings provide actionable insights for the construction industry to advance sustainability. Future research should explore global best practices, consumer behavior, and emerging technologies like Artificial Intelligence (AI) and the Internet of Things (IoT) to further drive sustainable materials handling and contribute to a greener, more sustainable future.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting

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