MANAGING BARRIERS AFFECTING TO IMPLEMENT SUSTAINABLE CONSTRUCTION WOOD WASTE MANAGEMENT IN SRI LANKA

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Abstract. The increasing use of wood in the construction industry in developing countries has led to significant environmental, economic, and health related challenges, thereby highlighting the need for sustainable construction wood waste management. In developing countries, sustainable construction wood waste management cannot be implemented effectively due to different barriers such as financial barriers, technical barriers, knowledge barriers, institutional barriers, and socio-cultural barriers. This study aimed to identify and address the key barriers to implementing sustainable construction wood waste management in Sri Lanka and to propose suitable strategies for overcoming these challenges. The study used a qualitative approach, and the required data was collected through semi-structured interviews. The findings were revealed that three main conventional practices used in Sri Lankan construction industry to manage wood waste such as open dumping, landfilling, and incineration, whereas there are few sustainable practices also used in Sri Lankan construction industry to manage wood waste based on the findings such as recycling, reuse, use as by-product, and use for energy recovering. Overall applicability of sustainable practices to manage construction wood waste is very low rate in Sri Lanka due to existing barriers as financial barriers, technical barriers, knowledge barriers, institutional barriers, and socio-cultural barriers. The study findings revealed five barriers in Sri Lanka under each type of barrier, except socio-cultural barriers. Financial barrier is identified as a major barrier affecting to implementation of sustainable construction wood waste management in Sri Lanka, and it leads to the emergence of other types of barriers. Therefore, this study proposed suitable effective strategies to manage each type of barrier affecting to implementation of sustainable construction wood waste management in Sri Lanka.

Keywords: Wood Waste Management, Sustainability, Construction Industry, Types of Barriers, Effective Strategies

1. Introduction

Nowadays, sustainable practices have become an essential requirement for disposing of construction and demolition waste (Sivashanmugam, et al., 2024). This is because construction and demolition waste contribute to numerous adverse impacts on the environment, such as increased greenhouse gas emissions, high energy consumption, increased public issues and the release of various harmful contaminants into the environment (Chen, et al., 2021). Among different types of construction and demolition waste, wood waste has emerged as a major category that requires sustainable management and disposal due to its adverse impacts on the environment and the high volume generated in the construction industry (Jahan, et al., 2022). Sustainable construction wood waste management offers both environmental and economic benefits, including reduced greenhouse gas emissions, enhanced environmental sustainability, compliance with environmental regulations, improved corporate image, and the potential for electricity generation, so on (Zhu & Feng, 2024).

Nevertheless, the implementation of sustainable practices in construction wood waste management is a significant challenge in developing countries such as Sri Lanka, due to the presence of different barriers (Kozlovská & Spišáková, 2013; Victar & Waidyasekara, 2023). These barriers can be categorised into several categories, such as technical barriers, political or legal barriers, knowledge/ awareness barriers, financial barriers, managerial barriers, and social and cultural barriers (Al-Otaibi, et al., 2022; Kozlovská & Spišáková, 2013). Failure to address these barriers can lead to substantial economic, environmental and public health challenges within the country (Adhikari & Ozarska, 2018).

As a developing country, Sri Lankan construction industry has not given adequate attention to sustainable practices in managing construction wood waste (Victar & Waidyasekara, 2023). Most existing wood waste management practices are based on conventional methods, which include open dumping, landfilling, and incineration (Bimsara, et al., 2024). These practices have led to increased costs in waste management and greater land area requirements for landfilling. Consequently, professionals involved in managing construction and demolition waste face significant challenges in effectively handling wood waste. The implementation of sustainable construction wood waste management has been identified in global studies as an effective solution to mitigate such issues (Zhu & Feng, 2024). However, in the Sri Lankan context, the adoption of these sustainable practices remains a challenge due to the presence of various barriers. Furthermore, studies, Bimsara, et al., (2024) and Victor and Waidyasekara (2023) carried out in the Sri Lankan context also only focused on other types of construction and demolition wastes, not focused on construction wood waste management. Thus, to manage the barriers to implementing sustainable construction wood waste management, the investigation of suitable strategies will be essential in the Sri Lankan context. Therefore, the aim of this study was to manage barriers to implementing sustainable wood waste management in Sri Lanka by proposing suitable strategies.

2. Literature Review

2.1 OVERVIEW OF CONSTRUCTION WOOD WASTE

Wood waste can be generated from different sources, including municipal, commercial, industrial and construction sectors (Somer & Alkhayat, 2024). Amongst, construction sector is placed in a significant position in generating wood waste as the wood waste has become the second largest component of construction and demolition waste, which contributes approximately 20%-30% of total construction and demolition waste (Jahan, et al., 2022). Usually, construction wood waste refers to wood materials discarded during the construction and demolition of the building (Somer & Alkhayat, 2024). The authors further stated that construction wood waste includes offcuts, sawdust, pallets, packaging, and wood from demolished structures. However, most of the wood waste is mixed with many other construction materials, which makes the separation of them more time consuming and intensive tasks (Kern, et al., 2018).

Improper construction wood waste disposal contributes to create adverse impacts on the environment, economy and human health. When improperly managed, construction wood waste often ends up in landfills, leading to methane emissions as it decomposes, a potent greenhouse gas that exacerbates climate change (Chen, et al., 2021). Furthermore, improper construction and wood waste management lead to landfill overcrowding and deforestation (Adhikari & Ozarska, 2018). Economically, the inefficient use of wood materials increases construction costs and squanders valuable resources that could be repurposed (Bimsara, et al., 2024). Furthermore, treated or painted wood waste may leach toxic chemicals into soil and water, posing risks to ecosystems and human health (Al-Otaibi, et al., 2022). Hence, addressing these adverse impacts requires ithe ntegration of sustainable practices with construction wood waste management.

2.2 INTEGRATION OF SUSTAINABLE PRACTICES WITH CONSTRUCTION WOOD WASTE MANAGEMENT

Integrating sustainable practices into the construction wood waste management is essential for mitigating adverse environmental impacts and improving resource efficiency (Al-Otaibi, et al., 2022). This can be approached through waste reduction, recycling and reuse of waste during the construction and demolition process (Yuan & Shen, 2011). Strategies including designing for deconstruction, using modular construction methods, and ensuring accurate material estimation can significantly lower wood waste production (Hossain & Poon, 2018). Additionally, sorting wood

waste on-site makes it easier to recycle or repurpose, turning scraps into mulch, bioenergy, or composite wood products (Adhikari & Ozarska, 2018). Utilizing reclaimed wood in new construction not only reduces the need for new materials but also preserves the embodied energy of previously used wood (Jahan, et al., 2022). Government and organizations can also help by executing effective policies, providing incentives, and creating recycling facilities for construction wood waste management. By adopting these sustainable practices, the construction industry can significantly contribute to environmental conservation, resource management, and the development of a circular economy through sustainable construction wood waste management (Jahan, et al., 2022). However, it is not an easy achievement in developing countries like Sri Lanka due to different types of barriers. Thus, identification of barriers to implement sustainable construction wood waste management is essential to achieve its success.

2.3 BARRIERS TO IMPLEMENTING SUSTAINABLE CONSTRUCTION WOOD WASTE MANAGEMENT

The review of literature indicates that there are five main types of barriers affecting to implementation of sustainable construction wood waste management as follows;

Financial Barriers: When implementing sustainable construction wood waste management, it usually incurs additional financial costs to the project. Furthermore, fear of higher investment costs, longer payback period, client worries about profitability, ignorance of life-cycle cost, and lack of financial resources can be determined as main financial barriers to implementing sustainable construction wood waste management (Agyemang, et al., 2024; Munaro & Tavares, 2023).

Technical Barriers: Review of previous studies indicates a lack of sustainable materials in waste management, a lack of sustainable measurement tools, a lack of demonstration projects, a lack of technical guidance, and a shortage of technical tools and equipment (Al-Otaibi, et al., 2022; Zhu & Feng, 2024).

Knowledge Barriers: Knowledge barriers refer to a lack of professionals with expertise skills, a lack of client awareness, a lack of awareness on benefits, negligence of sustainability and sustainable development, and a lack of education and knowledge on sustainable construction designs (Pandey, 2022; Zhu & Feng, 2024).

Political and Legal Barriers: Political and legal barriers include the absence of adequate support and guidance from government and local authorities, lack of management and leadership, lack of motivation and appreciation process for sustainable wood waste management, lack of policies, rules and regulations on construction wood waste management, and delay in decision making process due to rigid organization structures of relevant authorities (Al-Otaibi, et al., 2022; Olofinnade, et al., 2021).

Socio-cultural Barriers: Social and cultural factors can significantly impact sustainable wood waste management in the construction industry. However, a lack of demand for sustainable products and cultural change resistance are the main socio-cultural barriers in sustainable construction wood waste management (Munaro & Tavares, 2023). Furthermore, the absence of efforts and support from developers and clients also negatively impacts on sustainable construction wood waste management (Victar & Waidyasekara, 2023).

Therefore, these barriers should be managed effectively to implement sustainable wood waste management in the construction industry, especially in developing countries like Sri Lanka. Successful sustainable construction wood waste management would offer numerous environmental, economic, and human health benefits, such as reducing long-term construction costs and time, conserving natural resources, reducing environmental pollution, and supporting the transition to a circular economy in the construction industry.

3. Research Methodology

This study used a qualitative research approach to collect the required data through semi-structured interviews conducted among professionals who are involved in managing construction wood waste in Sri Lanka. Interview participants were selected through purposive sampling based on their expertise, which included over 10 years of experience in construction wood waste management in Sri Lanka, their availability and willingness to participate in face-to-face interviews lasting 70-90 minutes, and their ability to communicate effectively. The interview guideline was prepared based on findings from the literature. Table I presents the details of the interviewees. The collected data were analysed using manual content analysis, as manual coding enhances focus on the data sets, minimises variation in the contextual meanings of data, and strengthens the analytical process.

Table 1: Details of interviewees

Interviewee Code	Designation	Experience (yrs.)	Project Sector
R-01	Chartered Architect	16	Government
R-02	Architect	11	Private
R-03	Chartered Architect	15	Private
R-04	Chief Engineer (Civil)	29	Government
R-05	Site Engineer	19	Government
R-06	Design Manager	20	Private
R-07	Chartered Architect	17	Private
R-08	Civil Engineer	10	Government
R-09	Facilities Engineer	18	Private
R-10	Design Manager	11	Private

4. Research Findings and Discussion

The research findings are discussed under the following four main sections: conventional construction wood waste management practices in Sri Lanka, existing sustainable construction wood waste management practices in Sri Lanka, barriers affecting to implementation of sustainable construction wood waste management in Sri Lanka, and strategies to manage them.

4.1 CONVENTIONAL CONSTRUCTION WOOD WASTE MANAGEMENT PRACTICES IN SRI LANKA

In Sri Lankan construction industry, three main conventional wood waste management practices are used as presented in Table 2;

Table 2: Applicability of conventional wood waste management practices in Sri Lanka

Conventional wood waste management practices	Responses on the applicability of conventional construction wood waste management practices in Sri Lanka									
	R-01	***R-02***	***R-03***	***R-04***	***R-05***	***R-06***	***R-07***	***R-08***	***R-09***	***R-10***
Landfilling	✓			✓	✓	✓		✓	✓	✓
Open dumping	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Incineration		✓		✓					✓	✓

According to findings from semi-structured interviews, landfilling, open dumping, and incineration are conventional practices used in Sri Lanka to manage construction wood waste. Among these practices, open dumping is the most common practice, and it has resulted in an adverse impact on the environment. Apart from the above conventional practices, some of the construction wood waste is managed by selling it for other works or purposes. However, it would not be much applicable in every construction project, as most of the wood waste is mixed with

another construction materials. Adverse impacts of conventional wood waste management practices including greenhouse gas emission, over crowd landfilling requirements, and cost inefficiency, so on lead to find out sustainable ways to manage construction wood waste.

4.2 EXISTING SUSTAINABLE CONSTRUCTION WOOD WASTE MANAGEMENT PRACTICES IN SRI LANKA

As per the interviewees, there are four main sustainable construction wood waste management practices that are exercised by the companies. Table 3 presents the distribution of responses in relation to different types of practices used.

Table 3: Applicability of existing sustainable construction wood waste management practices in Sri Lanka

Existing sustainable construction wood waste management practices	**Responses on applicability of existing sustainable construction wood waste management practices in Sri Lanka**									
	R-01	***R-02***	***R-03***	***R-04***	***R-05***	***R-06***	***R-07***	***R-08***	***R-09***	***R-10***
Recycling	✓			✓						✓
Reuse	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Use as by-products	✓	✓							✓	✓
Use for energy recovery	✓	✓								

Among existing sustainable construction wood waste management practices, reuse is identified as the most common practice. For example, wood waste from the packing activities of construction materials is reused for temporary construction works at the site. However, recycling, use as a by-product, and use for energy recovery are not frequent construction wood waste management practices in Sri Lanka due to different challenges such as lack of recycling facilities, lack of investment cost, lack of skills and knowledge, and lack of awareness, so on. As a conclusion, there are no adequate existing sustainable construction wood waste management practices in Sri Lankan construction industry, and available practices also are not applicable in Sri Lanka due to different barriers affecting implementation.

4.3 BARRIERS TO IMPLEMENTING SUSTAINABLE CONSTRUCTION WOOD WASTE MANAGEMENT PRACTICES IN SRI LANKA

Barriers to implementing sustainable construction wood waste management practices were determined under five main categories as shown in Table 4.

Table 4: Barriers to implementing sustainable construction wood waste management in Sri Lanka

Types of barriers	**Barriers**	**Responses on the applicability of barriers affecting to implementation of sustainable construction wood waste management in Sri Lanka**									
		R-01	***R-02***	***R-03***	***R-04***	***R-05***	***R-06***	***R-07***	***R-08***	***R-09***	***R-10***
Financial	Additional cost to the project	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Fear of higher investment cost	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Longer payback period	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Ignorance of the life cycle cost	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

	Lack of financial resources	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Technical	Lack of sustainable materials in waste management	✓	✓	✓		✓	✓	✓		✓	✓	
	Lack of sustainable measurement tools	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Lack of demonstration projects	✓		✓				✓	✓	✓		
	Lack of technical guidance	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Shortage of technical tools and equipment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Knowledge	Lack of professionals with expertise and skills		✓		✓				✓	✓	✓	
	Lack of client awareness	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Lack of awareness of the benefits		✓	✓			✓		✓	✓	✓	
	Negligence of sustainability and sustainable development	✓	✓						✓	✓	✓	
	Lack of education and knowledge on sustainable construction designs	✓	✓		✓		✓	✓		✓	✓	
Political and legal	Absence of adequate support and guidance from the government and local authorities	✓	✓		✓		✓	✓		✓	✓	
	Lack of management and leadership,		✓	✓	✓					✓	✓	
	Lack of motivation and an appreciation process for sustainable wood waste management	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Lack of policies, rules and regulations on construction wood waste management	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Delay in decision-making process due to the rigid organization structures of the relevant authorities	✓	✓	✓			✓	✓	✓			
Socio-cultural	Lack of demand for sustainable products	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Cultural change resistance	✓	✓		✓	✓		✓			✓	
	Absence of efforts and support from developers and clients	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

According to Table IV, financial barriers are the main barriers to implementing sustainable construction wood waste management practices in Sri Lanka. Literature findings also highlighted that financial barriers become the main challenge when implementing sustainable wood waste management practices in developing countries, especially in the construction industry, due to their dynamic nature. In Sri Lanka, technical feasibility is also to be improved to implement sustainable construction wood waste management. Research findings revealed that a lack of sustainable measurement tools, a lack of technical guidance, and a shortage of tools and equipment are the main technical barriers to implement sustainable construction wood waste management in Sri Lanka. The interviewees stated that those technical barriers mainly occurred as a result of financial barriers and challenges. Knowledge and political and legal barriers are also similarly affecting to implementation of sustainable construction wood waste management in Sri Lanka. Especially, the lack of client awareness in Sri Lanka hinders to achievement of sustainable goals in the construction industry. This may be a result due to lack of education and knowledge on sustainable construction designs and their benefits. Furthermore, Sri Lankan government and other institutions also need to improve their involvement in implementing sustainable construction wood waste management practices. The research findings revealed that existing motivation and appreciation for sustainable practices, policies, rules and regulations, and decision-making processes were not effectively facilitated to implement sustainable construction wood waste management in Sri Lanka. Lack of demand for sustainable products in Sri Lanka and the absence of efforts and support from developers and clients can be determined as the main socio-cultural barriers to implementing sustainable construction wood waste management in Sri Lanka. These barriers may also result from to cost aspects of sustainable practices. Hence, financial barriers are connected with other barriers and require effective strategies to manage all barriers to implement sustainable construction wood waste management in Sri Lanka.

4.4 STRATEGIES TO MANAGE BARRIERS TO IMPLEMENT SUSTAINABLE CONSTRUCTION WOOD WASTE MANAGEMENT IN SRI LANKA

Research findings identified the following strategies, as mentioned in Table 5 to manage barriers to implementing sustainable construction wood waste management in Sri Lanka.

Table 5: Strategies to manage barriers to implement sustainable construction wood waste management in Sri Lanka

Types of barriers	**Strategies**
Financial barriers	• Allocation of adequate financial resources • Make awareness on financial benefits of sustainable construction wood waste management • Make awareness on payback period • Provide financial funding sources to implement sustainable construction wood waste management • Make decision based on life-cycle cost
Technical barriers	• Adapt new technologies • Conduct professional courses on sustainable wood waste management practices to obtain technical skills • Provide information about demonstration projects in a global context • Use high-tech machinery for wood processing activities in Sri Lankan construction industry by promoting sustainable practices • Provide sustainable measurement tools and other equipment to implement sustainable wood waste management practices
Knowledge barriers	• Conduct a training program on sustainable wood waste management • Make awareness on sustainable construction wood waste management for all project stakeholders

Political and legal barriers	• Establish policies, rules and regulations on sustainable construction wood waste management • Improve government and other authorities' involvement to implement sustainable construction wood waste management • Establish an appreciation and reward process to encourage sustainable construction wood waste management practices
Socio-cultural barriers	• Promote sustainable products in the markets • Encourage to adapt of sustainable designs to construction projects • Improve attitude to promote the source separation of waste • Promote 3R concepts and other sustainable concepts

Except from the above strategies, research findings revealed the following common strategies to implement sustainable construction wood waste management in Sri Lanka effectively.

- Encourage research on sustainable practices used in wood waste management in Sri Lankan construction industry.
- Finalize the design of the construction project with minimum wood waste generation at the construction stage.
- Encourage to planting of trees or arrange the planting of trees proportionately to meet the usage and wastage of wood in Sri Lankan construction industry. It helps offset the environmental impact of deforestation caused by high wood consumption, thereby promoting ecological balance and biodiversity and reducing the overall carbon footprint of the construction sector. Moreover, it ensures the long-term availability of wood resources, promoting a circular approach to resource use.
- Introduce the system to charge fines or penalties from construction projects that do not use sustainable practices in wood waste management in Sri Lankan construction industry.
- Introduce and promote by-products that can be produced by using construction wood waste.

Accordingly, findings were accomplished the aim of this study by proposing above strategies to manage barriers affecting to implement sustainable construction wood waste management in Sri Lanka.

5. Conclusion

Nowadays, the necessity of sustainable construction wood waste management practices in developing countries like Sri Lanka is rapidly increasing due to high usage of wood in the construction industry and their adverse impacts on the environment, economy, and human health. In Sri Lanka, sustainable construction wood waste management is not a familiar concept at present due to different reasons. As a result of that, this study found out three main conventional practices used in Sri Lankan construction industry to manage wood waste, such as open dumping, landfilling, and incineration. Among them, open dumping is frequently used to manage wood waste in Sri Lankan construction industry than other conventional practices. Nevertheless, there are few sustainable practices used in the Sri Lankan construction industry to manage wood waste based on the findings, such as recycling, reuse, use as a by-product, and use for energy recovery. The reason behind the limited applicability of sustainable construction wood waste management practices in Sri Lanka was found to as different types of barriers affecting to implement of sustainable construction wood waste management, including financial barriers, technical barriers, knowledge barriers, political and legal barriers, and socio-cultural barriers. This study revealed five barriers under each type of barrier except socio-cultural

barriers (refer Table IV). Furthermore, financial barriers can be identified as a major barrier to implementing sustainable construction wood waste management in Sri Lanka, and they also lead to the emergence of other types of barriers. Eventually, this study proposed effective strategies to manage each type of barrier to implement sustainable construction wood waste management in Sri Lanka. Furthermore, this study recommended strategies in general to promote and encourage sustainable construction wood waste management in Sri Lanka while accomplishing the aim of the study.

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