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TOWARDS A CIRCULAR ECONOMY: EVALUATING EFFECTIVE IMPLEMENTATION STRATEGIES FOR RECYCLING AND REUSE PROGRAMMES IN SRI LANKA'S CONSTRUCTION INDUSTRY

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ABSTRACT

Construction waste accounts for a significant portion of the total waste generated in Sri Lanka. To promote a Circular Economy (CE) in the construction industry, it is essential to adopt building procedures that minimize waste, increase the use of recycled materials in new construction, and create markets for recycled and reused materials. However, the lack of modern recycling facilities and technologies hampers the effective processing and reuse of construction materials. Additionally, there is limited market demand for recycled construction materials, primarily due to concerns about product quality and the absence of standardized products. In order to promote sustainability and reduce the industry's reliance on new materials, it is crucial to implement recycling and reuse programs. Therefore, this research aims to evaluate the effective implementation strategies for recycling and reuse programs in Sri Lanka's construction industry. The literature review highlighted these existing programs and identified the challenges and opportunities for implementing recycling and reuse initiatives in Sri Lanka's construction industry. Additionally, semi-structured interviews were conducted with 9 experts, and a questionnaire survey was administered to 48 participants to gather data. The interviews revealed strategies to address the challenges, while thematic analysis was employed to analyze the interview data, and the Relative Importance Index (RII) method was used to evaluate the effectiveness of the identified strategies. A total of 9 strategies were identified for integrating recycling and reuse programs into Sri Lanka's construction industry. The findings of this study may enable to enhance the sustainability in the construction sector by minimizing waste and promoting sustainability goals.

Keywords: *Construction Waste; Recycling and Reuse; Sustainable.*

1. INTRODUCTION

As a major global economic sector, the construction industry significantly contributes to environmental degradation through high resource consumption and waste generation.

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Globally, construction and demolition waste (CDW) accounts for 25% to 30% of all solid waste generated (Soto-Paz et al., 2023). In alignment with the UN's Sustainable Development Goals 2030, Sri Lanka aims to achieve a sustainable and prosperous nation by 2030. Sri Lanka generates (Mannamarakkalage, 2025). Sri Lanka generates 0.43 kg of waste per capita each year, which hinders the country's economic potential and its ability to achieve a sustainable future. This issue jeopardizes the nation's resources for future generations (Agarwal & Bimpli, 2025).

The global construction industry faces increasing pressure to address environmental challenges such as resource depletion, pollution, and climate change (Nilimaa, 2023; Srour et al., 2012). As construction activities intensify, so does the industry's contribution to carbon emissions and waste generation (Nilimaa, 2023). The construction industry is one of the largest emitters of greenhouse gases, accounting for 36% of global energy consumption and 37% of energy-related carbon emissions (Kalu Arachchi et al., 2025).

The construction sector's growth in developing countries is likely to increase construction and demolition waste, including concrete, wood, metal, and plastic, leading to potential environmental pollution if not managed properly (Gálvez et al., 2018). According to Kourmpanis et al. (2008), construction waste constitutes a significant portion of the total waste generated in Sri Lanka. Dumping these materials in landfills or using illegal disposal techniques generates major problems that negatively impact soil, water, and air quality (Kourmpanis et al., 2008).

Adopting building procedures that minimize waste creation in the construction industry, increasing the use of recycled materials in new construction, and finding markets for recycled and reused materials can all contribute to a CE in construction (Liyanage et al., 2022). The existing solid waste management systems in Sri Lanka are inadequate, with most construction and demolition waste being disposed of in landfills or illegal dumps (Karunasena & Amaratunga, 2016). The primary challenge of the built environment is managing construction and demolition waste that has not been disposed of properly, leading to severe environmental consequences (Agarwal & Bimpli, 2025). While Sri Lanka, particularly the Colombo Municipal Council, has initiated commendable programs recycling, these efforts are not fully effective or scalable due to systemic challenges in public participation, infrastructure, incentives, workforce management (Kaida, 2025).

There is an urgent need to learn how to reuse and recycle C&D waste, which can generate commercial opportunities, jobs, and, most importantly, promote environmental sustainability (Bansal et al., 2016). The construction industry can reduce waste and improve resource recovery by designing buildings and infrastructure for their entire life cycle, from material selection to disposal (Mollaei et al., 2023). The lack of modern recycling facilities and technologies limits the ability to effectively process and reuse construction materials (Crawford et al., 2017). Furthermore, there is little market demand for recycled construction materials due to concerns about product quality and the lack of standardized products (Geng et al., 2023).

This research aims to evaluate the effective implementation strategies for recycling and reuse programs in Sri Lanka's construction industry. Therefore, the study's aim will be achieved by accomplishing four objectives: identifying current recycling and reuse programs, assessing challenges and opportunities for implementing these programs, strategizing on overcoming challenges in implementation, and ultimately evaluating the

effectiveness of the identified strategies for implementing recycling and reuse programs in Sri Lanka's construction industry.

2. LITERATURE REVIEW

2.1 CONSTRUCTION AND DEMOLITION WASTE

The construction sector stands as one of the largest and most vital industries, being the primary user of natural resources and the leading contributor to pollution (Elgizawy et al., 2016). Construction and demolition waste encompasses materials discarded during new construction, refurbishment, and demolition processes of various structures, including buildings, roads, bridges, flyovers, and subways (Yuan et al., 2011). Beyond the direct environmental impact associated with landfilling, the creation of construction and demolition waste is tied to the depletion of natural resources and increased energy consumption (Marzouk & Azab, 2014). Hazardous substances such as asbestos, lead, and mercury, commonly present in older buildings, pose significant health risks if not managed correctly during demolition or renovation (Manoharan et al., 2021). Automated material recovery facilities have been developed to effectively sort and process construction and demolition waste. These facilities enable the reclamation of valuable materials while reducing the volume of waste directed to landfills (Mashudi et al., 2023). The average waste percentages of various materials throughout construction stages are 6.3% for the substructure, 4.8% for the superstructure, and 5.6% for finishes. In terms of concrete waste, the figures differ by building type, with high-rise structures generating 8.2%, low-rise at 5.2%, and medium-rise at 4.0% (Rathnayake et al., 2024). Globally, the construction industry is responsible for producing nearly ten billion tons of (CDW) each year, resulting in considerable financial burdens for contractors and contributing significantly to environmental degradation (Zhu & Feng, 2025).

2.2 GLOBAL PRACTICES IN CONSTRUCTION WASTE MANAGEMENT

Countries such as Germany, the Netherlands, and Denmark have been particularly successful in achieving these targets, recycling approximately 70% of all construction waste (Dytianquin et al., 2021). Germany's success can largely be attributed to its well-developed infrastructure, strong regulatory framework, and involvement of both public and private sector stakeholders (Iqbal et al., 2023). The Netherlands is implementing programs such as the use of recycled materials for road construction and modular building components that can be easily removed and reused (Van et al., 2021). Japan has effectively managed construction waste by utilizing modern material sorting and processing technologies while maintaining close coordination between government agencies, construction companies, and recycling firms (Menegaki & Damigos, 2018). The construction industry in the European Union generates 531 million tonnes of construction and demolition waste per year, accounting for around a quarter of the world's total waste. Approximately 46% of this waste is recycled across the 27 member states of the European Union (Junak & Sicakova, 2017). In countries such as the USA, Canada, Europe, Australia, India, Japan, Hong Kong, and Taiwan, several recycling projects related to construction and demolition waste have been implemented. Before the recycling of this waste, the generator must perform waste sorting (Liyanage et al., 2022).

2.3 RECYCLING AND REUSE OF CONSTRUCTION MATERIALS

Recycling involves managing waste and converting it into new products, whereas reuse refers to the practice of repurposing resources for similar or different uses without significant alterations (Minunno et al., 2020). Reusing and recycling, waste from construction and demolition can reduce the need for new materials, enabling the construction sector to contribute significantly to climate change mitigation and support sustainable development (Kourmpanis et al., 2008). These methods offer numerous environmental and economic advantages, including resource conservation, energy savings, waste reduction, and cost-effectiveness (Abera, 2023). Nevertheless, to fully realize these benefits, the construction industry must tackle issues related to material quality, infrastructure, and market demand (Storey, 2014).

2.4 CURRENT RECYCLING AND REUSE PRACTICES IN SRI LANKAN CONSTRUCTION INDUSTRY

Current practices mostly involve recycling construction and demolition waste into materials like aggregates and reusing structural components such as steel and concrete (Karunasena & Amaratunga, 2016). Concrete, for instance, is often demolished but not widely recycled, and this trend highlights the limited focus on reuse and recycling in the country's construction industry (Wimalarathna et al., 2023). Some construction companies have implemented basic waste separation programs, sorting materials such as metals, wood, and concrete for reuse or recycling (Kumarasinghe & Sylva, 2024). However, wood is frequently burned, and landfills, often filled with construction waste, continue to be heavily utilized in Sri Lanka (Ramos & Martinho, 2023).

The application of CE principles can help address these issues by promoting the reduction, reuse, and recycling of construction materials, which can extend the lifespan of products (Ghufran et al., 2022). CE strategies also have the potential to reduce raw material usage, preserve material resources, and lower the carbon footprint of construction projects (Adekunle et al., 2023). Additionally, digital tools improve record-keeping and coordination between stakeholders, leading to better material management (Liyanage et al., 2022).

Furthermore, construction projects that adopt circular techniques, such as wastewater reuse and rainwater collection, can significantly reduce the demand for freshwater, thus enhancing overall environmental sustainability (Wimalasena et al., 2025). A significant example of sustainable building practices in Sri Lanka is the "Jetwing Lighthouse Hotel," which incorporates passive cooling, solar energy utilization, and water reuse systems, demonstrating how CE principles can be effectively integrated into building design (Kalu Arachchi et al., 2025). The use of modular building methods and prefabrication can also optimize resource consumption by reducing offcuts and construction waste, leading to budgetary savings (Wimalasena et al., 2025). Bansal et al., (2016) highlights global technologies for recycling construction and demolition waste, focusing on separation techniques such as eddy current magnetic separation, air shifting, dry density separation, and spiral separation to eliminate contaminants like wood, gypsum, and plastics. These processes yield high-quality recycled materials, while rock breakers and mechanical hammers further reduce debris for use in non-structural applications like kerb stones, paving blocks, and tiles.

2.5 OPPORTUNITIES TO IMPLEMENT RECYCLING AND REUSE PROGRAMMES IN SRI LANKA

2.5.1 Environmental

Recycling one ton of concrete waste can save approximately 900 kg of CO2 emissions, contributing to more sustainable construction practices (Al-Sharif et al., 2024). Recycling materials in construction can significantly lower its carbon footprint, supporting global climate change efforts (Labaran et al., 2022). Research suggests that recycling CDW could cut the carbon footprint of building operations by up to 50% (Wimalasena et al., 2025). Additionally, recycling CDW can alleviate the environmental burden of landfilling and generate economic returns by producing goods that are in demand (Liyanage et al., 2022).

2.5.2 Economic

One of the most apparent benefits is the financial savings derived from using recycled and reused materials (Wimalasena et al., 2025). By incorporating these materials, construction organizations can reduce procurement costs and decrease dependence on expensive virgin materials for new projects (Amarasinghe et al., 2024). Furthermore, the demand for sustainable building materials rises, industries focusing on recycling, processing, and selling repurposed building materials have significant growth potential (Knoth et al., 2022).

According to the literature review findings, identified opportunities are given in Table 1.

Table 1: Opportunities to implement recycling and reuse programmes

Opportunities	Reference
Reduction of CO_2 emissions	(Al-Sharif et al., 2024)
Lower demand for virgin materials, conserving natural resources	(Knoth et al., 2022; Rathnayake et al., 2024; Wimalasena et al., 2025)
Cost savings	(Wimalasena et al., 2025)
Growth of the recycled material market, creating business opportunities	(Knoth et al., 2022)
Decreased environmental pollution	(Lamma & Waleed, 2021; Liyanage et al., 2022)
Improved air and water quality, reducing health risks	(Hajam et al., 2023)

2.6 CHALLENGES TO IMPLEMENTING RECYCLING AND REUSE PROGRAMMES IN SRI LANKA

Implementing recycling and reuse programmes in Sri Lanka faces several challenges (Victar & Waidyasekara, 2024). Addressing these challenges requires strategic investments in technology, financial support, and awareness initiatives to promote sustainable construction practices (Rathnayake et al., 2024; Victar & Waidyasekara, 2024). According to the literature review, identified challenges are given in Table 2.

Table 2: Challenges to implement recycling and reuse programmes

Challenges	Reference
Lack of advanced technology and knowledge	(Karunasena & Amaratunga, 2016; Rathnayake et al., 2024; Victar & Waidyasekara, 2024)
Significant initial investment in technology, equipment, and training	(Athapaththu & Karunasena, 2016; Coelho & De Brito, 2013)
High costs of building recycling facilities	(Coelho & De Brito, 2013; Liyanage et al., 2022)
Lack of knowledge and understanding of recycling and reuse benefits	(Al-Raqeb et al., 2023; Liyanage et al., 2022)
Difficulty in adopting new practices due to workflow changes	(Al-Raqeb et al., 2023; Ghufran et al., 2022)
Limited market demand for recycled materials	(Geng et al., 2023)
Limited infrastructure and resources for waste segregation, collection, and processing	(Rathnayake et al., 2024; Victar & Waidyasekara, 2024)
Fluctuating raw material prices	(Ghufran et al., 2022)

3. METHODOLOGY

3.1 RESEARCH PROCESS

Given the complexity of the subject, a mixed-methods approach was adopted, combining qualitative exploration and quantitative evaluation to ensure a holistic understanding of the research problem (Williams, 2007). This methodological framework enhances data collection and analysis, capturing both numerical trends and in-depth contextual insights (Dawadi et al., 2021). It also helps to validate and enrich findings by integrating multiple data sources, leading to more reliable and well-rounded conclusions (Dawadi et al., 2021). Pragmatic research philosophy was chosen, allowing the integration of quantitative methods, such as surveys, to measure industry challenges, alongside qualitative methods, such as interviews, to explore practical barriers (Khatri, 2020). The study employed a deductive approach, enabling statistical analysis of industry trends while incorporating qualitative insights.

The study commenced with an extensive literature review, which identified research gaps, defined the problem, and established key objectives. The review examined existing recycling practices, industry challenges, and potential opportunities. To refine and validate these findings, semi-structured interviews were conducted with key stakeholders, providing deeper insights into the practical barriers and opportunities within the sector. Subsequently, a questionnaire survey was administered to a broader group of industry professionals to collect quantitative data. The final phase involved statistical and thematic analysis of the collected data, ensuring a comprehensive evaluation of industry trends and stakeholder perspectives.

3.2 DATA ANALYSIS

3.2.1 Qualitative Data Analysis

The first phase involved conducting semi-structured interviews with a purposively selected sample in Sri Lanka's construction industry. Semi-structured interviews provide a balance of consistency and adaptability, while unstructured interviews offer greater depth and openness but less control and comparability (Ruslin et al., 2022). These interviews aimed to gather data on the existing recycling and reuse programmes, challenges to implementation, and strategies for improvement. Responses from the interviews were analysed using thematic analysis to identify key themes and patterns related to recycling and reuse programmes.

3.2.2 Expertise Core Data Analysis

The semi-structured interview was conducted with nine experts, and Table 3 represents the professional experience of the respondents who participated in the interviews.

Table 3: Expert core data analysis

Years of Experience	Professions	No. of Experts
5 - 10 years	Project Quantity Surveyor	1
	Planning Engineer	1
	Senior Civil Engineer	1
10 - 20 years	Project Manager	1
	Chartered Quantity Surveyor	1
20- 30 years	Senior Quantity Surveyor	1
	General Manager - MEP Services	1
More than 30 years	Chartered Quantity Surveyor	1
	Chartered Civil Engineer	1

3.2.3 Quantitative Data Analysis

The questionnaire survey was collected from a total of 48 participants. It is commonly used in research to collect information through structured or semi-structured questions, ensuring consistency in analysis (Kuphanga, 2024). This survey employed a non-probability sampling method. Non-probability sampling involves selecting participants based on specific criteria or relevance, not random selection, with the aim of gaining deeper insights rather than broad generalizations (Taherdoost, 2016). In this study, a five-point Likert scale was used. RII values were used to rank the effectiveness of identified strategies. RII provides a clear indication of the priority or significance of different variables, making it useful in analysing survey or questionnaire data (Tarek et al., 2022). The formula for finding RII for each factor is as follows:

$$RII = \frac{\sum w}{A \; x \; N} \qquad Equation\,(1)$$

Where, w = Weighting for each factor by the respondent (No. of responses x weight), A = Highest weight, and N = Total number of respondents

3.2.4 Demographic Survey Data Analysis

Out of 48 respondents to the questionnaire survey, 64% were from construction companies, 34% from consultancy firms, and 2% from the activated carbon industry. The demographic survey data analysis is represented in Figure 1.

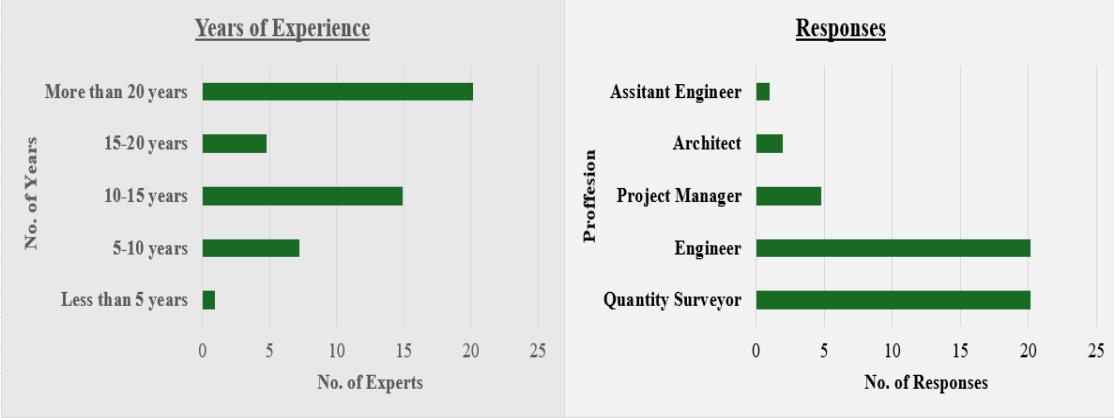

Figure 1: Demographic data analysis

4. RESEARCH FINDINGS

4.1 MATERIAL POTENTIAL AND INDUSTRY SUPPORT FOR RECYCLING AND REUSE IN THE SRI LANKAN CONSTRUCTION INDUSTRY

Participants indicated that while small-scale recycling efforts exist, they are not widely integrated into project workflows. A key challenge emphasized by all participants is the absence of a comprehensive recycling and reuse system in the industry. Insights gathered from interviews are represented in Table 4.

Table 4: Material potential for recycling and reuse

Material	Insights gathered from interviews	No. of responses	Literature review
Steel	Considered a suitable material for recycling.	9	✓
Timber	Can be effectively recycled and reused.	9	✓
Roof Tiles	Have the potential to be recycled.	2	
Concrete	Primarily repurposed for backfilling rather than being recycled.	2	✓

All interviewees highlighted steel and timber as the most commonly recycled materials, a finding also supported by the literature review. Two interviewees noted that concrete is rarely fully recycled and is mainly used for backfilling, while another two identified roof tiles as a commonly reused material, particularly in renovations.

However, one interviewee noted that the growing adoption of BIM (Building Information Modelling) could improve material management and support future recycling initiatives. Another interviewee highlighted that the GBCSL (Green Building Council of Sri Lanka) has introduced a certification system to promote the use of recycled materials in construction projects.

4.2 OPPORTUNITIES AND CHALLENGES IN IMPLEMENTING RECYCLING AND REUSE PROGRAMMES IN SRI LANKA'S CONSTRUCTION INDUSTRY

Insights gathered from both interviews and the literature review highlight key challenges and opportunities in implementing recycling and reuse programs represented in Table 5.

Table 5: Opportunities and challenges for recycling and reuse programmes

Considered key criteria	Insights gathered from the interviews	Interviews										Literature review
		R1	R2	R3	R4	R5	R6	R7	R8	R9	Total	
Opportunities	Environmental and economic benefits	✓		✓	✓	✓		✓			5	✓
	Green certification and market differentiation				✓		✓	✓			3	
	Job creation				✓						1	✓
Challenges	Lack of technology			✓	✓	✓		✓	✓	✓	6	✓
	Financial constraints	✓		✓		✓		✓	✓		6	✓
	Regulatory and governmental barriers	✓	✓	✓		✓	✓				5	
	Lack of public awareness		✓	✓				✓			3	✓
	Insufficient infrastructure		✓			✓			✓		3	✓

Key challenges identified include a lack of advanced recycling technology, noted by five interviewees. Financial constraints were mentioned by four, citing high initial investments for facilities and transportation. Two highlighted public awareness gaps, while regulatory barriers were noted by two, including a lack of government incentives and weak frameworks, as mentioned by four. Insufficient infrastructure, such as inadequate waste collection, was a concern for three interviewees, and one interviewee mentioned that tight project timelines hinder recycling integration. These findings echo the literature review, which identifies these obstacles as critical limitations.

The interviews and literature review highlight key opportunities, including reduced costs, enhanced sustainability through lower carbon emissions, and decreased landfill waste. Additionally, recycling practices can create jobs in waste management and processing, and help companies attain green building certifications, attracting eco-conscious clients. Addressing challenges related to technology, finance, regulation, and awareness can further boost recycling adoption in the sector.

4.3 STRATEGIES FOR OVERCOMING RECYCLING AND REUSE CHALLENGES

Interviewees suggested strategies to tackle challenges in recycling and reuse programs, which were then distributed via a questionnaire survey. Data from the survey were analysed using the RII method to rank the effectiveness of these strategies in the Sri Lankan construction industry.

This analysis included a comparison of each strategy's RII with the mean RII ($\bar{X}$ = 0.7955), indicated by the (X-$\bar{X}$) column, which shows how each strategy's score deviates from the average significance level. A total of 9 strategies with average RII values above 0.7955 were identified as the most effective strategies, as illustrated in Table 6.

Table 6: Proposed strategies

	Strategies	Semi-Structured interviews										Questionnaire survey		
		R1	R2	R3	R4	R5	R6	R7	R8	R9	Total	RII	Rank	(X-$\bar{X}$)
S1	Training and education	✓		✓				✓	✓		4	0.8667	1	0.0711
S2	Investment in technology and infrastructure	✓		✓		✓		✓		✓	5	0.8208	2	0.0253
S3	Development of Recycling Infrastructure						✓			✓	2	0.8208	2	0.0253
S4	Government support for companies	✓	✓	✓	✓	✓	✓	✓	✓	✓	9	0.8167	3	0.0211
S5	Partnering with investors who are interested in green technologies.	✓									1	0.8083	4	0.0128
S6	Establishing clear quality control standards for recycled materials	✓	✓	✓	✓	✓	✓	✓	✓	✓	9	0.8042	5	0.0086
S7	Public-Private Partnerships to fund recycling initiatives	✓	✓	✓	✓	✓	✓	✓	✓	✓	9	0.7958	6	0.0003
S8	Setting green certification standards	✓	✓	✓	✓	✓		✓	✓		7	0.7958	6	0.0003
S9	Creating a Recycling and Reuse Department								✓		1	0.7958	6	0.0003

	Strategies	Semi-Structured interviews										Questionnaire survey		
		R1	R2	R3	R4	R5	R6	R7	R8	R9	Total	RII	Rank	(X-$\bar{X}$)
S10	Encourage companies to adopt circular economy practices						✓				1	0.7875	7	-0.008
S11	Hiring experts						✓				1	0.7833	8	-0.012
S12	Demonstrating the long-term cost savings							✓			1	0.7792	9	-0.016
S13	Attracting foreign investments and partnerships with international firms				✓		✓				2	0.7708	10	-0.025
S14	Reduced landfill fees for companies				✓						1	0.7458	11	-0.05
S15	Incorporation of Modular Construction Methods				✓	✓					2	0.7417	12	-0.054

According to the analysis, the most effective strategies for advancing recycling and reuse in Sri Lanka's construction industry focus on education, investment, regulation, and collaboration. Training and educational programs can raise awareness among industry professionals about the benefits and best practices of recycling. Investing in technology and developing recycling infrastructure will enhance the efficiency and feasibility of waste processing.

Government support for companies that produce high-quality recycled materials, along with clear quality control standards, can boost confidence in using these materials. Encouraging public-private partnerships and collaborating with green investors can provide the necessary funding and expertise to expand recycling initiatives.

Additionally, implementing green certification standards that promote recycling will incentivize companies to adopt sustainable practices. Establishing an internal Recycling and Reuse Department within companies can ensure a structured approach to sustainability efforts. By collectively implementing these strategies, the construction industry can drive long-term progress in sustainability.

5. CONCLUSIONS

This research emphasizes the urgent need for systematic recycling and reuse initiatives within Sri Lanka's construction industry. The study shows that despite increasing awareness, the adoption of these practices is still impeded by technological, financial, regulatory, and infrastructural challenges. However, there are promising opportunities available, including economic benefits, job creation, and green certifications, which could motivate companies to invest in recycling efforts. To address these challenges, the study identifies nine strategies. The construction industry must prioritize strategic investments in technology, enhance public-private partnerships, and implement clear policies to support sustainable waste management. Additionally, government incentives and regulatory frameworks should be strengthened to encourage companies to incorporate recycling practices into their operations. Furthermore, increasing awareness and providing technical training will facilitate the transition toward a more sustainable construction sector. By tackling these obstacles and capitalizing on available opportunities, Sri Lanka can progress towards a more sustainable and environmentally responsible construction industry.

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