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CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT ISSUES IN BUILDING PROJECT LIFE CYCLE STAGES: A CASE OF SRI LANKA

H.C. Victar[1] and K.G.A.S. Waidyasekara[2]

ABSTRACT

The construction industry is rapidly growing in Sri Lanka, leading to an increase in the amount of waste generated from building projects. This waste often ends up in landfills or is disposed of in an unorganised manner, causing environmental and health hazards. While there is a growing body of research on Construction & Demolition (C&D) Waste Management (WM) including Zero waste, there is lack of studies available on the management of WM issues according to the life cycle of building projects in Sri Lanka. Hence, this study aims to investigate the C&D WM issues in Sri Lanka according to the life cycle of building projects. The study adopts a qualitative approach that involves conducting two rounds of expert interviews following the Delphi method and using manual content analysis to analyse the collected data. According to building life cycle, WM issues are categorised as Preconstruction; Construction and Building Renovation; Use and Operate; Demolitions and Repurpose and Material Recovery and Production. The research is significant as it provides insight into the current issues of C&D WM in Sri Lanka and offers recommendations for improvement. By categorising the issues based on the different stages of the project life cycle, it becomes easier to identify where in the process the C&D WM issues are most prevalent and to develop targeted solutions to address them.

Keywords: *Building Project; Construction and Demolition (C&D); Life Cycle Stages; Waste Management (WM).*

1. INTRODUCTION

The building construction consumes up to 40% of global raw materials (Darko & Chan, 2016), generates about 40% of waste (Nasir et al., 2017), and emits about 25% of carbon dioxide (Mahpour, 2018). Hence, it implies the construction industry is one of the highest waste generators globally (Bilal et al., 2020), a sign of unsustainability of the sector (Núñez-Cacho et al., 2018). These issues could be traced to the unsustainable economic approach of "take, make, dispose", otherwise known as linear economy, entrenched in the building construction industry (Bilal et al., 2020). Construction waste generation has been identified as a major issue due to its direct impacts on the environment as well as

[1] Postgraduate, Department of Building Economics, University of Moratuwa, Sri Lanka, victarhc.22@uom.lk
[2] Senior Lecturer, Department of Building Economics, University of Moratuwa, Sri Lanka, anuradha@uom.lk

the efficiency of the construction industry (Formoso et al., 2002). A study conducted by Ameh et al. (2013) found that on average 21–30% of cost overruns occurred in construction projects due to material wastage (Udawatta et al., 2015). Currently, the European construction sector produces 820 million tonnes of C&D every year, which is around 46% of the amount of total waste generated.

Furthermore, WM issues have also been increasingly advocated in dealing with C&D waste generated from construction due to global urbanisation and urban renewal. This is particularly urgent in emerging countries where economic development must be sustained by construction activities, while the massive amount of C&D waste generated and accumulated as a grand challenge that the economies have not experienced before. Their capability for waste treatment is meagre given the huge amount of waste generated by the construction sector. The key to tackling the issues arising from C&D waste is to integrally apply the building life cycle (Bao et al., 2019). Moreover, WM issues handling is a significant consideration in sustainable construction (Park & Tucker, 2017).

There is a lack of WM issue categorisation in the life cycle of building projects, despite several studies that have focused on circular economy (CE) and Zero Waste concepts to reduce WM issues. While CE and Zero waste approaches have gained significant attention, there is a gap in understanding how WM issues vary across different stages of a building project's life cycle, which is critical to develop targeted and effective WM strategies. This research aims to address this gap and provide a comprehensive understanding of WM issues in the context of life cycle of building projects in Sri Lanka. This paper is structured as follows. First, it provides a comprehensive literature review on C&D waste management and issues. Next, the research method, comprising data collection and data analysis is elaborated. This is followed by the findings and conclusions.

2. LITERATURE REVIEW

2.1 CONSTRUCTION AND DEMOLITION WASTE

The production and manufacture of building components, along with the construction process itself, involves the extraction and movement of 6 billion tons of basic materials annually, or 40% of extracted materials in the US (Kibert & Kibert, 2008). In addition, the US construction industry contributes to a large amount of waste to the municipal solid waste stream (Yuan et al., 2012). Building related C&D waste in US was estimated to be 143 million metric tons. As a result of waste generation, contractors have to bear loss of profit due to the involvement of additional overhead costs and delays, loss of productivity due to additional time involvement for cleaning and considerable waste disposal costs. Construction waste generation not only has cost implications for handling processes but also consumes valuable land due to disposal activities (Hao et al., 2007). Furthermore, the industry cannot continue to practice if the environmental resources on which it depends are depleted. Thus, the significance of WM needs to be understood in order to encourage stakeholders to achieve goals related to WM (Manowong, 2012).

2.2 CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN CONSTRUCTION INDUSTRY

C&D WM have become one of the major environmental problems in both developed and developing countries. It has been a pressing issue in Hong Kong since the late 1990s.

Tremendous amounts of C&D waste have been generated from ongoing new construction works, as well as renovation and demolition work (Hao et al., 2007). The C&D waste has been increased which has been resulted from the extensive building and infrastructure development projects as well as redevelopment of old districts. The quantity of construction waste has increased from 8,000 tonnes in 1991 to 20,000 in 2004 (Hao et al., 2008).

On the other hand, management measures to reduce C&D waste at the project level have also attracted widespread attention (Bao et al., 2019). Previous studies have suggested some major variables affecting the overall effect of C&D waste reduction, including design change, investment of C&D WM, government regulations, site space for performing WM, low-waste construction technology, and WM culture within an organisation. Particularly, Yuan et al. (2012) described the design change occurring during construction is perceived as one of the most significant sources resulting in C&D waste because Osmani et al. (2008) estimated that around 33% of on-site waste is related to project design. Government regulations also play a critical role in C&D waste reduction by developing and fostering the regulatory environment for waste reduction (Karavezyris, 2007). Site space for performing WM activities is regarded as a significant variable by (Wang et al., 2010) as without a space layout pre-planned, the temporary placement of sorting facilities and implementation of WM activities might disarrange other construction activities.

2.3 ISSUES IN ACHIEVING SUSTAINABLE CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT

Execution of WM in attaining sustainable construction still does not assist the stakeholder practices in the construction. It is also supported by Shafii et al. (2006) who stated that the lack of demonstration of tools and approaches made it difficult for stakeholders to deal with the waste created during construction. It might be caused by several complicated activities in construction associated with aspect planning, which probably reflect three main important elements in construction: which are time, money and material (Ismam & Ismail, 2014).

Regulatory practices related to issues in each area, lack of waste treatment methods, lack of coordination, poor performance of stakeholders, lack of eco-friendly awareness and information campaigns, and problems enforcing WM in C&D policies. Besides sound administrative management, progressive activities are also required (Crawford et al., 2017). In the absence of government policies, there are no incentives for support or local government interests where the old construction methods are being utilised (Liu et al., 2020). Actions of stakeholders, lack of actual financial subsidies, and lack of reward and penalty schemes can be destructive for WM in C&D operations (Chen et al., 2002). Improper C&D waste disposal has also been recognised as a factor. Due to these factors just stated, illegal dumping reached nearly 60% (Chen et al., 2021). Also, contributing to this there is a deficiency in research and development practices and a lack of extensive skills and special training among people who are working in this field. To see improvement in the area of WM in C&D, there is a need for effective professional practices from all C&D practitioners. Other issues that China is facing with regards to WM in C&D are incomplete policies and standards, lack of market acceptance and inadequate off-site construction development conditions (Yuan, 2013). As depicted in literature, previous researchers have classified waste management issues into several

categories, which include managerial, financial, educational and environmental, socio-cultural, technical, government, economic, and market issues. The research findings section provides detailed information on the relevant waste management issues within each of these categories, taking into account the Sri Lankan context.

2.4 LIFE CYCLE OF A BUILDING PROJECT

The focus on a building's life cycle should guide decision-making in selecting the most appropriate technology and minimising the environmental impact of structures through thoughtful design or renovation. Buildings that appear to be cost-effective in the short term may have significant maintenance or waste management expenses, and elevated items may have extraordinarily high production costs never get recovered (Esa et al., 2017). Although different life cycle stages have been identified by many authors, this paper adopted five life cycle stages, Preconstruction; Construction and Building Renovation; Use and Operate; Demolitions and Repurpose; and Material Recovery and Production based on the categorisation done by Akanbi et al. in 2018, Esa et al. in 2017, and Yeheyis et al. in 2013.

3. METHODOLOGY

The Delphi technique is the well-received method of getting expert opinions on a certain knowledge area (Mansour et al., 2022). It aims to obtain a consensus among a panel of experts on real-world issues that are often intangible (Gad & Shane, 2012). The Delphi qualitative method was chosen as the research approach for this study. For this investigation, fifteen (15) interviews as Delphi round 1, ten (10) interviews as Delphi round 2 of expert interviews were conducted for about seventy to eighty minutes per each round with experts in the built environment and analysed them according to the experts' opinions through manual content analysis. These experts are selected based on the purposive sampling method.

According to Coy (2019), judgment sampling is used in the purposive sampling technique. It is commonly used in Delphi qualitative research to discover and pick the most information-rich examples in order to make the most use of available resources of C&D WM issues in Sri Lankan construction industry. The researcher determines what information is required and sets out to discover people who can and will offer it based on their knowledge or experience. Thus, the sample is purposefully determined and based on the researcher's judgment in relation to the research aim. Purposive sampling allows the selection of interviewees who are knowledgeable and interested in the selected area of study (Rai & Thapa, 2015). According to Grime and Wright (2016), a Delphi qualitative survey establishes the relevant diversity within that population. A review of the collected papers shown in Table 1 shows the existing issues in C&D WM.

Table 1: Expert profiles

Coding for Panel Experts	Designation	Delphi Rounds		Years of Experience	Criteria						Accessibility
					Compulsory Qualification		Additional qualifications (Satisfy at least three of the following criteria)				
		Round 1	Round 2		C1	C2	A1	A2	A3	A4	
I.01	Managing Director	✓	✓	25 years	✓	✓	✓	✓	✓	✓	✓
I.02	Senior Professor	✓	✓	20 years	✓	✓	✓	✓	✓	✓	✓
I.03	Senior Lecturer	✓	✓	19 years	✓	✓	✓	✓	✓	✓	✓
I.04	Contract Administrator	✓	✓	20 years	✓	✓	✓		✓	✓	✓
I.05	Environmentalist	✓	✓	10 years	✓	✓	✓		✓	✓	✓
I.06	Senior Quantity Surveyor	✓	✓	16 years	✓	✓	✓	✓	✓	✓	✓
I.07	Director	✓	✓	24 years	✓	✓	✓	✓	✓	✓	✓
I.08	Construction Engineer	✓	✓	22 years	✓	✓	✓	✓	✓	✓	✓
I.09	Project Manager	✓	✓	18 years	✓	✓	✓	✓	✓	✓	✓
I.10	Planning Engineer	✓	✓	12 years	✓	✓	✓	✓	✓	✓	✓
I.11	Senior Civil Engineer	✓		18 years	✓	✓	✓	✓	✓	✓	✓
I.12	Supervisor	✓		11 years	✓	✓	✓	✓	✓	✓	✓
I.13	Senior Architecture	✓		21 years	✓	✓	✓	✓	✓	✓	✓
I.14	Senior Facility Manager	✓		14 years	✓	✓	✓	✓	✓	✓	✓
I.15	Quality Controller	✓		17 years	✓	✓	✓		✓	✓	✓

C1: Knowledge and a better understanding of construction WM and CBE practices
C2: More than 10 years of experience in the C&D industry
A1: Graduate in a construction-related discipline
A2: A Postgraduate degree related to Construction Management or WM
A3: Corporate Member of a Professional Institution
A4: Practical Experience/ Research Experience in WM and CBE

As per the criteria given in Table 1, every expert had to fulfil the above compulsory qualifications, and at least three additional qualifications must be fulfilled. A wide range of information from different perspectives could only be achieved if the sample of building experts was selected from different professions. Furthermore, selecting professionals having more than 10 years of industrial experience in C&D industry specially in building projects.

4. RESEARCH FINDINGS

4.1 DELPHI ROUND 1 – CURRENT ISSUES OF CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN SRI LANKA

During Delphi round 1, experts were asked to identify current applicable WM issues of C&D in Sri Lanka especially considering building projects. At the end of the Delphi round 1, six (6) managerial issues, five (5) educational and environmental issues, seven (7) financial issues, three (3) market issues, five (5) government issues, five (5) cultural issues, five (5) economic issues and three (3) technical issues were identified out of literature findings. In addition, four (4) managerial issues, three (3) educational and environmental issues, two (2) financial issues, two (2) market issues, two (2) government issues, one (1) socio-cultural issue and one (1) economic issue were suggested by the interviewees as WM issues and are indicated in bold letters. Hence, applicable WM issues in the Sri Lankan construction industry were listed and carried forward to the second round of the interview. Table 2 indicates the current C&D issues of WM in Sri Lanka.

Table 2: Construction and demolition issues of waste management in Sri Lanka

WM Issues Type	WM Issue
Managerial Issues	Weak waste characterisation
	Insufficient resources
	Inconsistency in making policies
	Lack of communication among participants
	Delay of material delivery
	Poor management of materials
	Unawareness of software usage
	Lack of supervision
	Incorrect decisions
	Improper energy management
Educational and Environmental Issues	Inadequate training for workers
	Attention on housing deficit than environmental impact
	Limited knowledge of designers
	Lack of healthcare waste handling training
	Lack of education in waste management
	Not producing waste management specialists
	Lake of environmental policies, acts, standards
	Lack of environmental impact assessment practices
Financial Issues	Cost of project
	Absence of economic penalisation
	Lack of recycling market
	Unsafe market and inflation of prices
	Finding financing in start-ups is difficult
	Need for investors
	Lack of financing from the government
	Financial market instability

WM Issues Type	WM Issue
	Insufficient financial resources
Market Issues	Rapid changes in markets, e.g., restrictions on exports or costs for recovering wood waste
	Business secrecy can hinder development projects
	Business competition in developing new waste-based products who gets the materials
	The biogas market's dependency on energy markets
	Unclear if waste materials will be available if legislation changes (e.g., division of responsibilities)
Government Issues	Negligence attitude of the government
	Inconsistent in making policies
	Public procurement lacks circular requirements
	Secondary material markets lack support from the government
	Lack of policy
	Political instability
Socio-cultural Issues	Lack of communication between designers and clients
	Insufficient gender equality in construction projects
	Perception that waste will never be eliminated
	In developing new products and services, forecasting consumer behaviour is difficult
	Remote locations prove challenging for networking
	Inadequate health on construction sites
Economic Issues	Economic savings and revenue models are difficult to assess because of the lack of data on access to and availability of waste
	Long distances and efficiency of logistics in waste collection
	Incineration is cheaper for companies than recycling
	Lack of processors/refiners of waste-based materials
	Schedules in business are tight, which hinders cooperation
	Virgin materials are cheap compared to recycled materials
Technical Issues	Lack of waste disposal charge
	Incomplete design
	Poor performance strategies

Some of the administrative issues impeding successful C&DW administration were weak waste characterisation, insufficient resources, and delayed material supply. According to **I.02** *"Waste characterisation information assists in planning how to decrease waste, set up recycling programmes, and preserve money and resources according to managerial decisions"*. Furthermore, **I.08** explained, *"Waste characterisation tools on this site may be used by local government planners, transporters, and recyclers to estimate the quantity of certain items in their waste stream".* Although, the majority of the interviewees agreed for this software unawareness is considered as the main issue of WM. **I.07** mentioned, *"Lack of supervision can negatively impact construction waste management by leading to poor waste sorting, inadequate storage and disposal practices, and a lack of adherence to regulations".* **I.03**, **I.06,** and **I.12** conferred, a corresponding idea of supervision, and it mitigates these effects, it is important to establish clear

guidelines and procedures for WM, as well as regular monitoring and enforcement to ensure compliance. Additionally, providing education and training for construction workers on proper WM practices can help to promote responsible behaviour.

Furthermore, the rise in waste material prices as a result of unstable market conditions reduces workers' motivation to separate garbage for recycling and reuse. **I.02** deliberated, that the absence of economic penalisation in Sri Lanka for WM refers to the lack of financial penalties or disincentives for individuals or organisations that do not properly manage their waste. This means there is no cost for improper disposal of waste and as a result, WM practices may be neglectful or inadequate. **I.06**, **I.09, and I.14** proclaimed, in Sri Lanka for WM signifies the situation where the WM industry operates in an unregulated manner and the prices for WM services are artificially increased. According to the majority of interviewees' explanation, market issues in construction WM indicate challenges faced by the industry in properly managing and disposing of construction waste. These issues can result in environmental problems and inefficiencies, making it difficult for the construction WM industry to effectively serve its customers. **I.04**, **I.05**, **I.08**, and **I.09** established, changes can lead to changes in the demand for waste materials, which can affect the waste collection, processing, and disposal. These fluctuations in market conditions can challenge WM operations, making it difficult to maintain consistent and effective WM practices. According to **I.10** stated, *"the competition to obtain waste materials for these products can have an impact on construction waste management in Sri Lanka, as businesses may prioritise acquiring waste materials over disposing of them properly".* This can result in increased waste generation, illegal dumping, and other environmental issues if waste materials are not managed properly in the country.

In Sri Lanka, secondary material markets for construction WM are hindered by a lack of government support. This includes insufficient funding, regulations, and infrastructure, leading to challenges in managing and disposing of construction waste. As a result, these markets struggle to develop and contribute to sustainable WM practices. **I.06** stated, *"The government can address these challenges by providing support and resources to these markets, promoting sustainable Waste Management practices and a healthy environment".* Socio-cultural issues have a significant impact on WM and construction in Sri Lanka. **I.03**, **I.05,** and **I.09** emphasised, one major issue is the lack of proper waste disposal habits among the population, leading to littering and illegal dumping in urban and rural areas. This results in environmental degradation, and health hazards and it also affects tourism. Another issue is the inadequate infrastructure for WM, leading to the absence of organised collection, transportation and disposal of waste. There is also a lack of education and awareness among the public regarding the importance of WM and its impact on the environment. These socio-cultural issues, if not addressed, will continue to pose challenges in implementing effective WM and construction practices in Sri Lanka.

Furthermore, the absence of refiners and processors of construction waste also means that valuable resources are being wasted and not utilised to their full potential. According to **I.15** stated, *"Poor performance strategies in construction waste management can lead to negative outcomes for both the environment and the economy. One of the main issues is the lack of proper planning and coordination, resulting in ineffective waste management practices".* This leads to waste being generated unnecessarily, leading to increased costs for waste disposal and increased environmental degradation. Further, most of the interviewees argued, another issue is the lack of incentives for waste reduction, reuse, and

recycling, resulting in waste being treated as a low priority by construction companies. Additionally, there is often a lack of investment in WM infrastructure and technology, resulting in a limited capacity for processing and recycling waste materials.

4.2 DELPHI ROUND 2 - CURRENT C&D WASTE MANAGEMENT ISSUES ACCORDING TO THE LIFE CYCLE OF BUILDING PROJECTS IN SRI LANKA

During Delphi round 2, experts were asked to classify current applicable important WM issues according to the life cycle of building projects. At the end of the Delphi round 2, eighteen (18) WM issues as Preconstruction, twenty (20) issues as Construction and Building Renovation, eight (8) issues as Use and Operate, nineteen (19) issues as Demolition and Repurpose and thirteen (13) issues as Material Recovery and Production stage were identified out of the applicable current C&D WM issues. Table 3 indicates the current C&D WM issues in building life cycle stages.

WM issues can arise due to a number of factors, including the generation of significant amounts of construction waste, the absence of proper sorting and disposal methods, a lack of recycling facilities and programs, non-compliance with WM regulations, improper storage and handling of hazardous waste, a lack of accountability among contractors and stakeholders, and limited awareness of sustainable WM practices. These issues can have negative impacts on the environment and public health, and it is important for all parties involved in a building project to work together to address and mitigate WM issues. By categorising the issues based on the different stages of the project life cycle, it becomes easier to identify where in the process the WM issues are most prevalent, and to develop targeted solutions to address them. This approach can also help stakeholders to better understand the interdependencies between different stages of the project, and to identify opportunities to optimise WM issues throughout the entire project life cycle.

WM issues at the Preconstruction stage of the building can have significant impacts on the environment and public health. One major issue is the lack of proper planning and implementation of WM strategies during the early stages of a building project. This can result in the generation of excessive waste and poor WM practices throughout the construction process. Another issue is the absence of waste segregation and sorting at the source, which makes it difficult to effectively manage and dispose of waste. There is also a need for greater awareness of the dangers of hazardous waste and proper handling and disposal methods. Additionally, limited regulations and enforcement of WM policies can result in inadequate WM practices and the risk of environmental degradation. Furthermore, limited public awareness and education on WM practices can also contribute to poor WM practices at the Preconstruction stage. Addressing these WM issues is crucial for promoting sustainability and safety in the building industry.

I.12 stated, *"Insufficient resources allocated to the construction industry in Sri Lanka can have a significant impact on waste management during the Construction and Building Renovation stage".* This can include a lack of access to proper waste disposal facilities and services, as well as limited investment in new technologies and methods for managing and disposing of waste. Additionally, **I.04**, **I.05,** and **I.14** asserted, insufficient resources can result in limited enforcement of regulations and standards, making it challenging to hold stakeholders accountable for their WM practices. This can also lead to inadequate WM practices, such as the improper handling and disposal of hazardous

waste, limited waste segregation and sorting at the source, and increased waste generation. Further **I.01** stated, *"To address these issues, it is crucial for the Sri Lankan government to allocate sufficient resources to the construction industry to support effective and efficient waste management practices"*. By ensuring that WM is a priority and that adequate resources are available, the building industry can work towards reducing waste generation, promoting sustainability, and ensuring the safe disposal of waste.

Construction WM during the Use and Operate stage of a building refers to the challenges and problems faced in managing the waste generated after the building is completed and in use. This stage can produce waste from a variety of sources, including maintenance activities, renovations, and daily operations. **I.14** especially highlighted, *"The improper storage and disposal of waste during this stage can lead to environmental pollution, health hazards, and increased waste disposal costs. Additionally, the lack of designated waste storage areas and management systems can result in unsightly waste accumulation and potential health and safety risks".* To address these issues, it is important for buildings to implement proper WM practices and systems, including designating areas for waste storage and collection, establishing procedures for separating and disposing of waste, implementing recycling programs, and educating building occupants on the importance of WM and proper disposal methods. By doing so, buildings can reduce the amount of waste generated, promote environmental sustainability, and ensure the health and safety of building occupants.

I.01 thoroughly highlighted that, *"In Sri Lanka's construction industry, there is a lack of economic penalties for waste management issues during the Demolition and Repurpose stage. This means that companies and contractors are not incentivised to properly dispose of waste and can often leave it in an inappropriate manner, leading to environmental and health hazards".* The absence of economic penalties also allows for these practices to continue without consequences, contributing to the overall poor WM culture in the industry. Further, **I.12** and **I.14** articulated that, effective WM practices are crucial for the preservation of the environment and the safety of local communities. The implementation of economic penalties could help encourage better WM practices and improve overall sustainability in the construction industry in Sri Lanka. In the construction industry in Sri Lanka, there is a perception that waste will never be fully eliminated during the Demolition and Repurpose stage. This mindset results in a lack of effort to properly manage waste and can lead to environmental and health hazards. **I.05** highlighted that, *"The belief that waste will always be present contributes to the ongoing issue of poor WM practices and further perpetuates the problem".*

5. DISCUSSION

C&D WM is a critical issue in Sri Lanka as the country experiences a growing construction sector. In recent years, the amount of C&D waste generated in Sri Lanka has increased significantly, creating a strain on the country's WM system and its environment. The literature review found that there is a lack of proper WM policies and practices in the country, which has led to a high level of waste generation and limited recycling. Additionally, the study found that there is a lack of awareness among construction professionals and the general public about the importance of WM and limited financial incentives for sustainable practices (Begum et al., 2006). **I.08** highlighted that "*This growth has led to an increase in the amount of waste generated from construction and*

demolition activities, which often end up in open landfills, riverbeds, and other sensitive ecosystems". To address this issue, this study aims to investigate the C&D WM issues in Sri Lanka according to the life cycle of building projects. Further, Hassan et al. (2012) confirmed that, less encouragement from related agencies is the only issue that has the mean response of importance. In addition, **I.12** confirmed that one of the main challenges in managing C&D waste in Sri Lanka is the lack of proper WM infrastructure. Many areas lack designated waste dispute sites, and there is a shortage of vehicles and equipment needed for the collection and transportation of waste.

During the preconstruction stage, decisions are made that can have a significant impact on the amount of waste generated during C&D. Further, **I.13** stated that *"This includes the choice of materials, design, and the construction method. It is important to consider the environmental impact of these decisions and to adopt waste reduction strategies from the outset".* Ismam and Ismail (2014) supported that design stage is crucial for the management of C&D waste, as decisions made at this stage can greatly impact the amount and type of waste generated. Architects and engineers should consider the life cycle of materials, the recyclability of products, and the feasibility of incorporating waste reduction and recycling into the design.

According to interviewees' arguments, at the demolition stage, a large amount of waste is generated. This waste includes concrete, wood, metal, and other materials that are often mixed together and difficult to recycle. Proper demolition and deconstruction practices, such as separating materials, can greatly improve the recyclability of the waste and reduce its impact on the environment (Hao et al., 2007). This finding supports the study done by Begum et al. (2006) that the average maximum willingness to pay to improve construction waste collection and disposal services is higher for large contractors as compared to the medium and small contractors. This finding is very critical because most contractors in Malaysia are medium and small-class ones. Contractors need to change their attitude in order to achieve our country's project goals and reduce construction site waste. In conclusion, managing C&D waste is a complex issue that needs to be addressed throughout the life cycle of a building. Effective WM practices, along with regulations and education, can help to reduce the environmental impact of C&D activities in Sri Lanka.

6. CONCLUSIONS AND RECOMMENDATIONS

The aim of the research was accomplished through a gradual method that included a review of the available literature and a two-stage Delphi survey. The research was carried out incrementally by first conducting a literature review, followed by Delphi Round 1, and finally Delphi Round 2, which involved interviews with experts. The conclusion of a study on C&D WM issues in Sri Lanka could summarise the key findings related to the management of waste during the different stages of the building project life cycle. Finally, eighteen (18) WM issues as Preconstruction, twenty (20) issues as Construction and Building Renovation, eight (8) issues as Use and Operate, nineteen (19) issues as Demolition and Repurpose and thirteen (13) issues as Material Recovery and Production stage were identified out of the applicable current C&D WM issues in Sri Lanka.

The study could suggest specific measures to improve C&D WM in Sri Lanka. These recommendations could be based on best practices from other countries, as well as on the results of the study. Some possible recommendations include:

1. Implementing a comprehensive WM plan for all C&D projects, which includes the segregation, collection, transportation, and disposal of waste,
2. Encouraging the use of recycled materials in construction projects, can reduce the amount of waste generated and promote sustainable development,
3. Promoting awareness and education about the proper disposal of C&D waste, as well as the benefits of recycling and reusing materials, and
4. Improving the infrastructure for WM, including the development of WM facilities and the upgrading of existing facilities.

These recommendations can be modified and refined based on the specific findings and context of the study, but they provide a general framework for improving C&D WM in Sri Lanka.

Table 3: Current Construction and Demolition Waste Management Issues during Life Cycle Stages of a Building Project in Sri Lanka

Preconstruction	Construction and Building Renovation	Use and Operate	Demolitions and Repurpose	Material Recovery and Production
Weak waste characterisation	Insufficient resources	Insufficient resources	Lack of supervision	Inconsistency in making policies
Unawareness of software usage	Poor management of materials	Inconsistency in making policies	Absence of economic penalisation	Lack of recycling market
Cost of project	Lack of communication among participants	Lack of communication among participants	Lack of recycling market	Unsafe market and inflation of prices
Absence of economic penalisation	Lack of supervision	Absence of environmental awareness	Lack of financing from the government	Lack of financing from the government
Unsafe market and inflation of prices	Incorrect decisions	Not producing waste management specialists	Inadequate training to workers	Absence of environment awareness
Clients' unawareness	Unsafe market and inflation of prices	Remote locations prove challenging for networking	Absence of environmental awareness	In developing new products and services, forecasting consumer behaviour is difficult
Absence of environment awareness	Absence of environmental awareness	Lack of waste disposal charge	Lack of education in waste management	Remote locations prove challenging for networking
Lack of environment policies acts, standards	Not producing waste management specialists	Unawareness of software usage	Perception that waste will never be eliminated	Public procurement lacks circular requirements
Lack of environment impact assessment practices	Lack of waste disposal charge		Lack of waste disposal charge	Secondary material markets lack support from government
Not producing waste management specialists	Incomplete design		Negligence attitude of the government	Economic savings and revenue models are difficult to assess because of the lack of data on access to and availability of waste
In developing new products and services, forecasting consumer behaviour is difficult	Poor performance strategies		Public procurement lacks circular requirements	Rapid changes in markets, e.g., restrictions on exports or costs for recovering wood waste
Incomplete design	Negligence attitude of the government		Secondary material markets lack support from the government	Business competition in developing new waste-based products who gets the materials
Poor performance strategies	Inconsistent in making policies		Long distances and efficiency of logistics in waste collection	The biogas market's dependency on energy markets
Lack of integrity	Economic savings and revenue models are difficult to assess because of the lack of data on access to and availability of waste		Lack of processors/refiners of waste-based materials	
Negligence attitude of the government	Virgin materials are cheap compared to recycled materials		Unawareness of advanced technology usage	
Inconsistent in making policies	The biogas market's dependency on energy markets			
Virgin materials are cheap compared to recycled materials				
Unawareness of technological software usage				

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