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Article

PLS-SEM Analysis of Efficient Waste Management Practices for Green Building Status

Mal Kong Sia[1]*, Wong Chin Yew[2*], Bing Ning Tan[1] & Hong Lee Yong[1]

[1]Faculty of Built Environment, Tunku Abdul Rahman University of Management and Technology, Jalan Genting Kelang, Setapak, 53300 Kuala Lumpur, Malaysia
[2]Faculty of Social Science and Humanities, Tunku Abdul Rahman University of Management and Technology, Jalan Genting Kelang, Setapak, 53300 Kuala Lumpur, Malaysia
[2]American University of Sovereign Nations, USA

*Corresponding Authors: siamk@tarc.edu.my, vivienyew1963@gmail.com

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Abstract: This study investigates the effectiveness of nine different construction and demolition waste (CDW) management practices in the context of achieving green building status. A total of 93 completed questionnaires were received from the targeted respondents in Kuala Lumpur and Penang, out of which 67 were filtered for Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS 4. Eight CDW management practices and 49 indicators for seven categories of factors causing waste were finally identified to establish discriminant validity between the constructs in the model. There was a strong correlation between waste causes and satisfaction with CDW management practices, with a path coefficient of 0.328 ($p<0.01$). The Q^2 predicted values for both the CDW Management Practices and Satisfaction are above zero, indicating their predictive relevance. All the 67 selected respondents (100%) agreed that effective CDW management practices could assist in achieving green building status. The results are relevant to those stakeholders who wish to construct green buildings because Green Building Index certification requires effective CDW management practices to be integrated into the design and construction phases to ensure waste is disposed properly to reduce its adverse impacts to the environment.

Keywords: Circular economy; construction and demolition waste; green building index; Malaysia; PLS-SEM; waste management practices

Introduction

Developing infrastructure is crucial for the people's well-being as it affects their living conditions, social welfare and health (Rawshan et al., 2010). Urbanisation and population growth in Malaysia have led to an increase in the standard of living but also a rise in waste production, and the need to manage the environmental burden (Nurzalikha et al., 2016). Therefore, assessing the effectiveness of current CDW management practices in the Malaysian construction industry is critical, as it can help to achieve green building status, benefiting society and the environment. In Malaysia, a green building is one that uses ecologically friendly elements and operations throughout its lifecycle (Li et al., 2020). Green building status assesses a building's sustainability and environmental friendliness based on criteria set by a government-certified green building rating system. The Green Building Index (GBI) is one of the recognized standards Malaysia. It comprises six essential criteria, namely energy efficacy, indoor environmental quality, sustainable site, material and resources, water efficiency and innovation (Nasim et al., 2016).

CDW management practices and green building criteria are interconnected. The study by (Lu et al., 2019) emphasized the importance of effective CDW management in achieving green building status. Green building criteria intend to promote sustainability and reduce the environmental impact of buildings, whereas CDW management practices focuses on minimising waste generation and disposing these wastes in an eco-friendly way (Kabirifar et al., 2021). The GBI certification scheme requires construction wastes to be discarded in an eco-friendly way, such as using certified waste management facilities and recycling (Pervez Hameed et al., 2017). According to (Zhang et al., 2019), effective CDW management practices must be integrated into the design and construction process in order to achieve green building status. This may involve implementing a waste management plan that outlines procedures to minimize waste generation and dispose the wastes produced in an environmentally responsible way. The process may also include the use of specific systems and sustainable materials that help cut down on wastes and promote sustainability at the same time.

The Malaysian building industry is grappling with a significant challenge: the escalating volume of construction waste generated during building phases. Improper management of this waste has severe repercussions, leading to environmental pollution and health hazards that directly diminish the quality of life (Aguirre, 2019). A critical barrier to adopting sustainable waste management practices in Malaysia is the inadequate knowledge among industry experts and workers (Debrah et al., 2021). While the necessity for effective waste management is acknowledged, there's a clear need to not only identify and address specific implementation barriers but also to ensure robust waste management practices are intrinsically woven into existing green building criteria. Currently, this critical integration is not sufficiently robust, impeding the holistic adoption of sustainable construction practices among stakeholders, including contractors and developers (Ahn et al., 2016). Therefore, this study aims to bridge this gap by integrating comprehensive and effective waste management practices into the green building criteria, thereby minimizing the overall construction waste produced.

Conceptual Framework

The conceptual framework shown in Figure 1 is used to explore the relationship between the causes of construction and demolitions wastes and the CDW management practices implemented. The causes of construction and demolition wastes are conceptualized as a higher-order construct (HOC) comprises 7 lower-order constructs (LOCs) whereas the CDW management practices are conceptualized as a construct with 9 indicators. Satisfaction is conceptualized as a construct with a single indicator to measure the satisfaction with the current CDW management practices implemented.

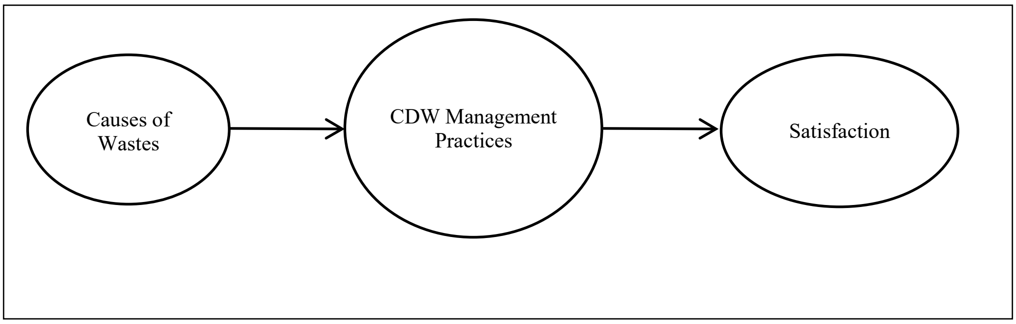

Figure 1. Conceptual model

Literature Review

1. Causes of Wastes

Construction and demolition wastes are defined as wastes produced during construction activities, e.g. concrete, steel and debris (Kabirifar et al., 2020). According to Sasitharan et al. (2012a), construction wastes can be divided into two categories, namely physical and non-physical wastes. Physical wastes include timber, brick and broken concrete while non-physical wastes comprise cost overruns and construction delays

(Omotayo et al., 2020). Concrete, wood and bricks are the most common types of physical wastes found on construction sites. Despite promoting material reuse, the volume of construction wastes continues to grow. Effective CDW management practices help reduce costs and diminish negative environmental impacts linked to construction activities. Construction wastes in Malaysia can arise from a variety of sources. One of the main causes of construction waste is the poor design and planning of a project (Luangcharoenrat et al., 2019). This issue could be due to the unprofessional conduct of the workers, who pay little attention to the drawing details or to a sophisticated project design. Mistakes in manufacturing the wrong size of a component would happen during the construction period and eventually lead to massive material waste and rework since the construction workers may not fully understand the design due to a lack of information or complicated instructions. According to (Sasitharan et al., 2011), construction wastes are mainly caused the following variables, namely design and documentation (Alias Imran Latif et al., 2020), handling (Roseline Ikau et al., 2016), management (Othuman Mydin et al., 2014a), procurement (Polat et al., 2017), external factors (Satupa & Rimpi, 2017), worker conditions (Narcis et al., 2019) and site conditions (Othuman et al., 2014b).

2. Waste Management Practices

Site Waste Management Plan

A Site Waste Management Plan (SWMP) is a useful tool for the contractors and project managers to estimate and keep track of the amount and types of construction wastes likely to be generated during a project. It also helps to establish appropriate management strategies that can reduce the amount of waste sent to landfills (Shahid et al., 2022). SWMP outlines a detailed plan for on-site waste management which specifies measures for waste reduction, materials segregation and recycling (Marinelli et al., 2014; Er and Karudan, 2016).

Prevention

Preventing waste is the most effective strategy in managing construction wastes. This entails better planning, design, procurement processes and the sustainable materials or prefabrication techniques (Suresh Kumar Lachimpadi et al., 2012). Emad Kasra Kermanshahi et al. (2015) stated that modular construction can also reduce the generation of CDW while increasing project efficiency and cost-effectiveness. Cradle-to-Cradle (C2C) approaches prevent waste generation by creating closed-loop product cycles, converting waste into resources for new materials.

Reduce

Adopting reduction strategy during planning stage and persistently implementing it throughout construction reduces waste production (Li et al., 2022). Efforts are made to decrease construction wastes resulting from influencing factors like design changes and inadequate material handling (Sasitharan Nagapan et al., 2012a). By practising the waste reduction method, it also helps to reduce the cost of transportation, waste disposal and waste recycling (Lu and Yuan, 2011). Improved design, planning and material use further minimize construction waste.

Reuse/Recycle

Reuse and recycling are critical techniques for sustainable construction waste management, as they attempt to reduce the environmental and economic implications of building activities. Reuse is the direct re-use of materials for their original purpose in different projects, such as repurposing formwork from a previous site (Suresh Kumar Lachimpadi et al., 2012). This method is highly preferred because to its low processing and energy needs, which allow contractors to avoid costly waste disposal and save significantly. Complementing this, recycling converts building waste materials into new goods by collecting, separating, and processing them (Yuan et al., 2011). This strategy successfully decreases landfill waste, conserves natural resources, and lowers the total environmental impact of building. On-site recycling is gaining popularity in Malaysia since it decreases carbon emissions and transportation costs while increasing overall efficiency (Bao et al., 2020). Both solutions contribute to a more circular economy in the building sector by conserving valuable resources and reducing environmental impact.

Recovery

Recovery is a waste management technique that involves extracting materials or components from the waste stream in a way that preserves their original form, making them reusable in the same way they were created (Zuhairi Abd Hamid et al., 2016). The use of waste materials for energy generation or fuel production is a popular form of recovery in Malaysia, as it provides a renewable and sustainable alternative energy source. The adoption of recovery methods can significantly reduce the volume of waste ending up in landfills.

Landfill

Landfilling is the final strategy in the waste management hierarchy and involves the disposal of waste in landfills (Sasitharan et al., 2012b). While this strategy is necessary for managing wastes that cannot be prevented, reduced, reused, recycled, or recovered, it is the least preferred option due to its negative impacts on the environment and human health (Kabirifar et al., 2020). However,landfills are considered a significant contributor to negative environmental impacts in thecountry.

Buy-back/Drop-off Centre

Buy-back centres and drop-off centres are effective methods of construction waste management, particularly for promoting the reuse and recycling of construction waste (Sabeen et al., 2016). A buy-back centre has been established for purchasing recyclable waste materials such as metals under the municipal council at market price from contractors who act as collectors (Ng et al., 2015). Contrastingly, drop-off centres provide a convenient location for contractors and individuals to drop off their construction waste for proper disposal and recycling (Mwanza et al., 2018).

Circular Economy Principles

The circular economy (CE) is an emerging concept that aims to address the issue of wastemanagement and is receiving attention from various countries including Malaysia (Normalisa Md Isa et al., 2021). According to Spisakova et al. (2022), the CE approach emphasises a closed material lifecycle through recycling and reuse and goes beyond the 3R principles of reduce, reuse and recycle to include reimagine and redesign in order to maximise resource efficiency by rethinking processes and designing out waste.

Methodology

Table 1 summarises the references and the indicators for the constructs in this study. Figure 2 is the initial reflective-reflective model with the indicators for the constructs shown in Table 1. The ‘causes of wastes’ were measured on a scale from ‘1 = strong disagree’, ‘2 = disagree’, ‘3 = neutral’, ‘4 = agree’, and ‘5 = strongly agree’. However, ‘CDW Management Practices’ were measured on a scale from ‘1 = neutral’, ‘2 = ineffective’, ‘3 = moderately effective’, ‘4 = highly effective’, and ‘5 = extremely effective’. Satisfaction was measured on a scale from ‘1 = strong dissatisfy’, ‘2 = dissatisfy’, ‘3 = neutral’, ‘4 = satisfy’, and ‘5 = strongly satisfy’.

Table 1. Indicators for LOC and references

LOC	Indicator	Code	References
Design and Documentation	Frequent design change	DD1	[15], [16], [32], [40], [68], [69], [70], [71], [72]
	Inadequate/Incorrect specification	DD10	[68], [69], [70], [71], [72]
	Design errors	DD2	[15], [16], [32], [40], [68], [69], [70], [71], [72]
	Insufficient design information	DD3	[16], [40], [68], [71], [73]
	Slow drawing revision and distribution	DD4	[16], [40], [68], [69], [72]
	Incomplete contract document	DD5	[16], [40], [69], [71], [72]
	Complicated design	DD6	[15], [16], [32], [40], [69], [72]
	Inexperience designer	DD7	[15], [16], [40], [71], [73]

	Contract documentation error	DD8	[15], [16], [32], [40], [68], [69], [72]
	Poor coordination of parties	DD9	[16], [40], [70], [71], [73]
Handling	Wrong material storage	Handling1	[15], [16], [32], [40], [69], [71], [72], [73]
	Inefficient method of unloading	Handling10	[40], [69], [72]
	Poor material handling	Handling2	[15], [16], [32], [40], [69]
	Damage during transport	Handling3	[15], [16], [32], [40], [69], [72]
	Poor quality of materials	Handling4	[15], [16], [32], [40], [71], [73]
	Equipment failure	Handling5	[16], [40], [70], [72]
	Material ordering problems	Handling6	[15], [40], [69]
	Over allowances	Handling7	[32], [40], [69], [71], [72], [73]
	Materials supplied in loose form	Handling8	[32], [40], [69], [72]
	Item non-compliance to specification	Handling9	[32], [40], [69], [71]
Worker	Worker's mistakes	Worker1	[16], [40], [69], [71]
	Too much overtime for workers	Worker10	[16], [32], [40], [71]
	Incompetent workers	Worker2	[15], [16], [40], [70], [73]
	Damage caused by workers	Worker3	[16], [32], [40], [71]
	Insufficient training for workers	Worker4	[16], [40], [68], [71], [73]
	Lack of experience	Worker5	[16], [32], [40], [70], [71]
	Shortage of skilled workers	Worker6	[16], [40], [70], [73]
	Inappropriate use of materials	Worker7	[16], [32], [40], [69], [71]
	Poor workmanship	Worker8	[16], [32], [40], [69], [72]
	Worker's lack of enthusiasm	Worker9	[15], [16], [40], [70]
Management	Poor planning	Management1	[15], [16], [40], [70], [71], [73]
	Lack environmental awareness	Management10	[16], [32], [40], [71], [73]
	Poor site management	Management2	[16], [40], [69], [70], [73]
	Poor controlling	Management3	[15], [16], [32], [40], [70], [71], [72], [73]
	Poor supervision	Management4	[15], [16], [32], [40], [69], [70], [72], [73]
	Inappropriate construction method	Management5	[15], [16], [32], [40], [73]
	Lack of coordination among parties	Management6	[15], [16], [40], [70], [71]
	Lack of information flow among parties	Management7	[16], [69], [32], [40], [70], [71], [72]
	Scarcity of equipment	Management8	[16], [69], [32], [40], [70]
	Lack of waste management plans	Management9	[15], [16], [32], [40], [69], [72], [73]
Site Condition	Leftover materials on site	SiteCondition1	[16], [32], [40], [68]
	Lack of legislative enforcement	SiteCondition10	[16], [40]
	Poor site condition	SiteCondition2	[16], [40], [71]
	Packaging wastes	SiteCondition3	[16], [40], [72]
	Site Congestion	SiteCondition4	[16], [32], [40]
	Lighting problem	SiteCondition5	[16], [32], [40], [71]
	Crews' interference	SiteCondition6	[16], [40]
	Improper planning for required quantity	SiteCondition7	[69], [72], [73]
	Difficulties accessing construction	SiteCondition8	[40], [69], [72]
	Extended project duration	SiteCondition9	[40]
Procurement	Ordering errors	Procurement1	[16], [40]
	Error in shipping/ Supplier error	Procurement2	[16], [32], [71], [72]
	Mistakes in quantity surveys	Procurement3	[16], [32], [71]
	Ignorance of specifications	Procurement4	[16]
	Waiting for replacement	Procurement5	[16], [40]
	Lack early stakeholders' involvement	Procurement6	[69]
External Factor	Effect of weather	ExtFactor1	[16], [32], [40], [69], [70], [71], [72]
	Accidents	ExtFactor2	[16], [40], [72]
	Theft	ExtFactor3	[16], [32], [40], [69], [71], [72]
	Vandalism	ExtFactor4	[16], [32], [40], [69], [72]
	Third party damages	ExtFactor5	[16], [32], [40]
	Festivities celebration	ExtFactor6	[16], [40]
	Unpredictable local condition	ExtFactor7	[16], [32], [40], [71]
	Unforeseen ground conditions	ExtFactor8	[40]
	Political reason	ExtFactor9	[71]
CDW Management Practices	Rate Buy-back/Drop-off Centre	RateBuyBack/DropoffCentre	[58], [59], [60], [61], [62]
	Rate CE Principles	RateCEPrinciple	[57], [63], [64], [65], [66]

Rate Landfill	RateLandfill	[12], [38], [53], [58]
Rate Preventing	RatePreventing	[46], [47], [48]
Rate Recovery	RateRecovery	[38], [56], [57]
Rate Recycle	RateRecycle	[52], [53], [54], [55]
Rate Reduce	RateReduce	[13], [50], [51]
Rate Reuse	RateReuse	[46]
Rate SWMP	RateSWMP	[12], [42], [43], [44], [45]

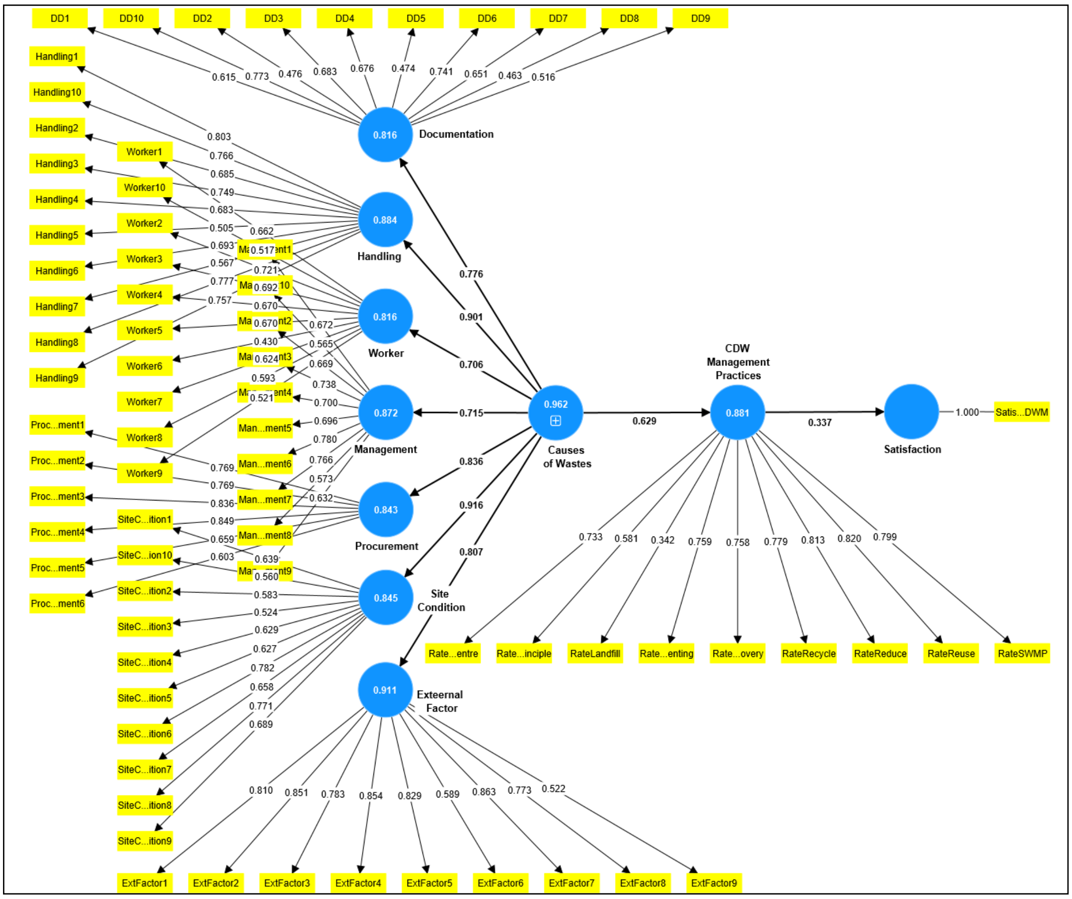

Figure 2. Constructs and indicators for the initial model

A survey questionnaire, constructed based on the indicators identified for each of the constructs shown in Table 1, was developed to collect the data for this study. A total of 250 questionnaires in Google Forms were distributed through emails from 2 June 2023 to 24 July 2023 to the targeted stakeholders in Kuala Lumpur and Penang working in the construction industry. A total of 93 responses were received. The questionnaires received were further screened. Those respondents who were from unrelated profession, unrelated organization and unfamiliar with CDW management practices were disqualified for further analysis. The number of questionnaires distributed and received as well as the valid responses used for analysis is shown in Table 2. The sample size of 67 meets the 10 times rule (Hair et al., 2017) for PLS-SEM using SmartPLS 4 (Sia et al., 2024). According to Azlan Shah Ali et al. (2009), Malaysia's construction industry has historically had a low response rate. In order to encourage participation, a follow-up mechanism was implemented. Additionally, the researchers point out that, while the sample size (n=67) is suitable for PLS-SEM, it might limit the generalizability of the results and suggest larger sample sizes for future studies.

In terms of ethical considerations, the university's ethics council waived ethical approval for this study because data was collected exclusively through an online questionnaire. Participants can choose whether or not to answer. If choose to respond, there is informed consent to provide. Prior to the study's implementation, subject matter experts thoroughly reviewed the questionnaire. Their suggestions were carefully implemented to improve question wording, maintain logical flow, and confirm topic validity.

Table 2. Summary of questionnaires distributed and received

Location	Distributed	Received	Questionnaires Not Responded	Disqualified Respondents	Valid Responses	Response Rate
Kuala Lumpur	125	52	73	20	32	25.6%
Penang	125	41	84	6	35	28.0%

The Findings

1. Respondents' Demographic Information

Table 3 shows the respondents' professions in their organizations. Of the 67 respondents, 7 of them are developers, 14 respondents are contractors, 2 respondents are managers, 4 respondents are engineers and 28 respondents are quantity surveyors. The remainders comprise of 8 sub-contractors and 4 site supervisors. Thus it can be concluded that 55 respondents (82.1%) who actively participated in this survey hold high positions in their respective organizations, namely from quantity surveyors to developers.

Table 3. Profession of respondents in the organization

Location	Profession	Organization				Frequency
		Sub-contractor Firm	Contractor Firm	Consultant Firm	Developer Firm	
Kuala Lumpur and Penang	Developer	0	0	0	7	7
	Contractor	0	14	0	0	14
	Manager	0	2	0	0	2
	Engineer	0	1	3	0	4
	Quantity Surveyor	6	13	9	0	28
	Sub-contractor	8	0	0	0	8
	Site Supervisor	1	3	0	0	4

Table 4 shows the frequency distribution of the respondents' total years of experience in the Malaysian construction industry. It is noteworthy to mention that 49 respondents (73.1%) have more than 5 years or more of working experience. Of the 67 respondents, 48 respondents (71.6%) are 31 years old and above. The results in Table 3 and Table 4 show that majority of the respondents are professionals with adequate knowledge and experience about waste management.

In Table 5, 59 of the respondents indicated they either agreed or strongly agreed that it is importance to identify the causes of construction and demolition wastes, with a mean value of 4.493. Additionally in Table 6, all the 67 respondents mentioned that they were aware of CDW management, and they agreed that effective CDW management practices could help in attaining green building status. 60 of the respondents mentioned that CDW management were practised by the companies they worked in, with 7 respondents indicated otherwise. These 7 respondents were neutral in their answers on the importance of identifying the causes of construction and demolition wastes as shown in Table 5.

2. Descriptive Statistics of Indicators

Table 7 shows the descriptive statistics for all the indicators shown in Figure 2. Except for the indicators 'Handling 2' and 'Worker 8', all the other indicators are within the normality range because kurtosis values with skewness values between -2.0 and +2.0 are considered as acceptable (George and Mallery, 2019). However, these two indicators were retained for further analysis because their skewness values are close to -2.0.

Table 4. Working experience and age range of respondents

Location	Working Experience	Age							Frequency
		25 and Below	26-30	31-35	36-40	40-45	46-50	Above 50	
Kuala Lumpur and Penang	Below 5 years	9	5	1	3	0	0	0	18
	5-10 years	0	5	10	6	4	1	0	26
	11-20 years	0	0	1	2	5	1	0	9
	Above 20 years	0	0	0	0	1	2	11	14

Table 5. Importance of identifying the causes of construction and demolition wastes

Profession	Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)	Mean Value	Standard Deviation
Developer	5	2	0	0	0	4.493	0.741
Contractor	6	5	3	0	0		
Manager	2	0	0	0	0		
Engineer	3	0	1	0	0		
Quantity Surveyor	20	6	2	0	0		
Sub-contractor	4	2	1	1	0		
Site Supervisor	2	2	0	0	0		

Table 6. Respondents' perception about CDW management practices

Item		Response		Total
		Yes	No	
Respondents' Awareness Toward CDW Management		67	0	67
Effective CDW Management Practices Help in Attaining Green Building Status		67	0	67
Adoption Status of CDW Management Practices in Organization	Developer firm	7	0	7
	Consultant firm	7	5	12
	Contractor firm	32	1	33
	Sub-contractor firm	14	1	15

Table **7.** Skewness and Kurtosis of indicators

LOC	Description	Code	Overall Mean	Mean	SD	Excess Kurtosis	Skewness
Design and Documentation	Frequent design change	DD1	3.930	4.284	0.708	1.502	-0.994
	Inadequate/Incorrect specification	DD10		4.194	0.738	0.702	-0.788
	Design errors	DD2		4.015	0.855	2.036	-1.202
	Insufficient design information	DD3		4.075	0.779	-0.144	-0.521
	Slow drawing revision and distribution	DD4		4.134	0.790	-0.112	-0.620
	Incomplete contract document	DD5		3.149	1.319	-1.100	-0.322
	Complicated design	DD6		4.075	0.951	0.710	-1.004
	Inexperience designer	DD7		4.030	0.772	-0.754	-0.251
	Contract documentation error	DD8		3.149	1.352	-1.031	-0.315
	Poor coordination of parties	DD9		4.194	0.934	2.403	-1.414
Handling	Wrong material storage	Handling1	4.133	4.433	0.796	3.803	-1.682
	Inefficient method of unloading	Handling10		4.104	0.883	1.597	-1.140
	Poor material handling	Handling2		4.493	0.677	8.928	-2.183
	Damage during transport	Handling3		4.388	0.791	3.580	-1.565
	Poor quality of materials	Handling4		4.269	0.857	2.591	-1.431
	Equipment failure	Handling5		3.806	1.026	0.205	-0.785
	Material ordering problems	Handling6		4.030	0.977	1.314	-1.142
	Over allowances	Handling7		3.627	1.182	-0.728	-0.560
	Materials supplied in loose form	Handling8		4.060	0.862	1.767	-1.119
	Item non-compliance to specification	Handling9		4.119	0.856	1.775	-1.114
Worker	Worker's mistakes	Worker1	4.309	4.463	0.676	-0.356	-0.897
	Too much overtime for workers	Worker10		3.507	1.084	-0.153	-0.487
	Incompetent workers	Worker2		4.507	0.529	-1.233	-0.340
	Damage caused by workers	Worker3		4.388	0.645	-0.597	-0.591
	Insufficient training for workers	Worker4		4.478	0.556	-0.837	-0.443
	Lack of experience	Worker5		4.478	0.556	-0.837	-0.443
	Shortage of skilled workers	Worker6		4.358	0.942	3.754	-1.882
	Inappropriate use of materials	Worker7		4.373	0.709	1.935	-1.207
	Poor workmanship	Worker8		4.388	0.977	4.734	-2.136
	Worker's no enthusiasm	Worker9		4.149	0.833	2.401	-1.242
Management	Poor planning	Management1	4.463	4.433	0.738	0.624	-1.133
	Lack environmental awareness	Management10		4.597	0.575	0.303	-1.117
	Poor site management	Management2		4.567	0.579	0.002	-0.978
	Poor controlling	Management3		4.493	0.608	-0.328	-0.787
	Poor supervision	Management4		4.672	0.470	-1.486	-0.748
	Inappropriate construction method	Management5		4.388	0.690	0.858	-0.979

	Lack coordination among parties	Management6		4.493	0.632	-0.237	-0.879
	Lack information flow among parties	Management7		4.463	0.740	0.787	-1.227
	Scarcity of equipment	Management8		3.955	0.905	0.595	-0.775
	Lack waste management plans	Management9		4.567	0.628	2.981	-1.553
	Leftover materials on site	SiteCondition1		4.343	0.890	1.240	-1.394
	Lack of legislative enforcement	SiteCondition10		4.328	0.871	0.891	-1.259
	Poor site condition	SiteCondition2		4.433	0.652	1.522	-1.069
	Packaging wastes	SiteCondition3		4.537	0.631	2.601	-1.421
	Site Congestion	SiteCondition4		3.701	1.106	0.210	-0.865
Site Condition	Lighting problem	SiteCondition5	4.016	3.463	1.124	-0.482	-0.421
	Crews' interference	SiteCondition6		3.791	0.986	-0.519	-0.329
	Improper planning for required quantity	SiteCondition7		4.433	0.738	1.842	-1.361
	Difficulties accessing construction	SiteCondition8		3.672	1.138	-0.473	-0.561
	Extended project duration	SiteCondition9		3.463	1.238	-1.179	-0.226
	Ordering errors	Procurement1		4.239	0.948	1.565	-1.364
	Error in shipping/ Supplier error	Procurement2		4.075	0.852	0.047	-0.739
	Mistakes in quantity surveys	Procurement3		4.030	0.846	-0.431	-0.512
Procurement	Ignorance of specifications	Procurement4	3.941	4.194	0.885	0.542	-1.058
	Waiting for replacement	Procurement5		3.493	1.214	-0.890	-0.417
	Lack early stakeholders' involvement	Procurement6		3.612	1.145	-0.590	-0.526
	Effect of weather	ExtFactor1		4.388	0.828	1.167	-1.329
	Accidents	ExtFactor2		4.299	0.847	0.458	-1.077
	Theft	ExtFactor3		4.343	0.838	0.775	-1.197
	Vandalism	ExtFactor4		4.254	0.920	0.389	-1.123
External Factor	Third party damages	ExtFactor5	4.085	4.403	0.754	1.399	-1.262
	Festivities celebration	ExtFactor6		3.493	1.309	-0.992	-0.372
	Unpredictable local condition	ExtFactor7		4.179	0.929	-0.026	-0.941
	Unforeseen ground conditions	ExtFactor8		4.299	0.847	1.059	-1.228
	Political reason	ExtFactor9		3.104	1.247	-0.951	-0.061
	Rate Buy-back/Drop-off Centre	RateBuyBack/ DropoffCentre		3.896	1.426	-0.303	-1.043
	Rate CE Principles	RateCEPrinciple		3.433	1.595	-1.278	-0.609
	Rate Landfill	RateLandfill		3.090	1.443	-1.323	-0.282
	Rate Preventing	RatePreventing		3.672	1.480	-0.724	-0.853
	Rate Recovery	RateRecovery	3.667	3.328	1.587	-1.368	-0.514
	Rate Recycle	RateRecycle		3.716	1.358	-0.128	-1.074
	Rate Reduce	RateReduce		3.716	1.464	-0.510	-0.979
	Rate Reuse	RateReuse		3.836	1.192	1.032	-1.351
	Rate SWMP	RateSWMP		4.313	1.136	3.145	-1.963
Satisfaction	**Satisfaction with the current practice of CDW Management**	**SatisfactionCDWM**	**3.672**	**3.672**	**0.998**	**-0.026**	**-0.489**

Note: Excess kurtosis = kurtosis – 3. If excess kurtosis = 2.601, kurtosis = 5.601

3. Assessment of Model Using PLS-SEM

According to the embedded two-stage approach (Sarstedt et al., 2019), the lower-order constructs connected directly to 'Causes of Wastes' are analysed first. After lower-order construct reliability and composite validity are established in the first stage, the next stage is to create higher-order construct using their respective latent variable scores.

First Stage: Assessment Of Lower Order Constructs

Table 8 shows that the Cronbach's alpha values and construct reliability and validity for the LOCs in the initial model are higher than the threshold of 0.700 and 0.700 respectively. However, as shown in Figure 2, the outer loading of the indicator RateLandfill is 0.342. This indicator was dropped for further analysis.

In addition, Table 9 shows that there is one HTMT value which is greater than 0.900, indicating there is no discriminant validity between the constructs 'Handling and 'Site Condition'. Moreover, the Fornell-Larcker criterion in Table 10 shows that there is discriminant validity between the constructs 'Handling' and 'Documentation'; 'Procurement' and 'Handling'; 'Site Condition' with 'Documentation', 'External Factor', 'Handling' and 'Procurement'; and between 'Worker' and 'Site Condition'.

Table 11 summarises the cross-loadings of all the indicators for the LOCs. A few indicators in Table 11 with cross loadings < 0.100 have been found to cause noncompliance of the initial model with the Fornell-Larcker criterion and the HTMT requirements. Good discriminant validity is shown by cross-loadings that are less than 0.100, which often show that the indicator is not highly correlated with other constructs. It indicates that the specific question is effectively assessing just its intended theme and avoiding confusion with additional questions.

Table 8. Construct reliability and validity (initial model)

Construct	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
CDW Management Practices	0.881	0.913	0.905	0.525
Documentation	0.816	0.839	0.856	0.381
External Factor	0.911	0.918	0.929	0.597
Handling	0.884	0.891	0.906	0.496
Management	0.872	0.878	0.896	0.466
Procurement	0.843	0.854	0.886	0.567
Site Condition	0.845	0.850	0.879	0.424
Worker	0.816	0.830	0.857	0.380

Table 9. HTMT (initial model)

	CDW Management Practices	Documentation	External Factor	Handling	Management	Procurement	Satisfaction	Site Condition
Documentation	0.463							
External Factor	0.680	0.586						
Handling	0.580	0.778	0.767					
Management	0.559	0.661	0.443	0.580				
Procurement	0.569	0.691	0.742	0.815	0.635			
Satisfaction	0.310	0.245	0.521	0.289	0.150	0.251		
Site Condition	0.630	0.847	0.801	0.914	0.717	0.859	0.334	
Worker	0.518	0.589	0.498	0.732	0.486	0.641	0.299	0.742

Table 10. Fornell-Larcker Crirterion (Initial Model)

	CDW Management Practices	Documentation	External Factor	Handling	Management	Procurement	Satisfaction	Site Condition	Worker
CDW Management Practices	0.724								
Documentation	0.349	0.617							
External Factor	0.638	0.510	0.773						
Handling	0.519	0.675	0.694	0.704					
Management	0.487	0.578	0.416	0.520	0.683				
Procurement	0.516	0.585	0.656	0.709	0.563	0.753			
Satisfaction	0.337	0.226	0.502	0.277	0.027	0.238	1.000		
Site Condition	0.546	0.683	0.710	0.794	0.623	0.725	0.316	0.651	
Worker	0.444	0.433	0.444	0.643	0.418	0.541	0.285	0.631	0.616

Table 11. Cross Loadings (Initial Model)

Indicator	CDW Management Practices	Documentation	External Factor	Handling	Management	Procurement	Satisfaction	Site Condition	Worker
DD1	0.110	**0.615**	0.301	0.410	0.388	0.362	0.153	0.443	0.084
DD10	0.248	**0.773**	0.425	0.558	0.480	0.422	0.208	0.500	0.288
DD2	0.158	**0.476**	0.150	0.280	0.147	0.172	0.076	0.317	-0.066
DD3	0.271	**0.683**	0.310	0.384	0.412	0.356	0.185	0.435	0.179
DD4	0.313	**0.676**	0.400	0.526	0.522	0.424	0.056	0.472	0.287
DD5	-0.078	**0.474**	0.105	0.262	0.106	0.215	0.139	0.347	0.425
DD6	0.462	**0.741**	0.534	0.549	0.440	0.530	0.246	0.577	0.359
DD7	0.220	**0.651**	0.266	0.421	0.365	0.332	0.051	0.401	0.304
DD8	-0.084	**0.463**	0.095	0.239	0.056	0.166	0.125	0.343	0.393

DD9	0.228	**0.516**	0.286	0.359	0.356	0.437	0.116	0.300	0.409
ExtFactor1	0.602	0.309	**0.810**	0.516	0.224	0.423	0.461	0.481	0.31
ExtFactor2	0.548	0.308	**0.851**	0.530	0.209	0.463	0.451	0.504	0.315
ExtFactor3	0.563	0.338	**0.783**	0.567	0.314	0.502	0.420	0.480	0.308
ExtFactor4	0.560	0.377	**0.854**	0.637	0.379	0.571	0.497	0.556	0.307
ExtFactor5	0.520	0.401	**0.829**	0.554	0.376	0.478	0.374	0.568	0.383
ExtFactor6	0.227	0.544	**0.589**	0.420	0.342	0.520	0.238	0.586	0.319
ExtFactor7	0.527	0.430	**0.863**	0.565	0.392	0.584	0.546	0.605	0.418
ExtFactor8	0.609	0.409	**0.773**	0.604	0.388	0.529	0.275	0.615	0.395
ExtFactor9	0.195	0.424	**0.522**	0.369	0.212	0.450	0.159	0.514	0.305
Handling1	0.468	0.550	0.573	**0.803**	0.465	0.504	0.254	0.649	0.493
Handling10	0.535	0.461	0.642	**0.766**	0.386	0.546	0.276	0.589	0.420
Handling2	0.397	0.496	0.346	**0.685**	0.430	0.423	0.129	0.536	0.394
Handling3	0.282	0.466	0.434	**0.749**	0.326	0.446	0.105	0.542	0.488
Handling4	0.329	0.524	0.392	**0.683**	0.385	0.469	0.068	0.501	0.447
Handling5	0.124	0.406	0.437	**0.505**	0.320	0.423	0.098	0.498	0.327
Handling6	0.350	0.487	0.554	**0.693**	0.349	0.627	0.255	0.600	0.566
Handling7	0.081	0.414	0.348	**0.567**	0.260	0.461	0.174	0.472	0.412
Handling8	0.411	0.459	0.540	**0.777**	0.261	0.535	0.283	0.582	0.500
Handling9	0.550	0.482	0.553	**0.757**	0.454	0.530	0.256	0.595	0.450
Management1	0.191	0.325	0.114	0.230	**0.672**	0.299	-0.172	0.420	0.140
Management10	0.437	0.307	0.344	0.363	**0.565**	0.419	0.186	0.370	0.313
Management2	0.220	0.341	0.131	0.273	**0.669**	0.213	-0.013	0.450	0.206
Management3	0.210	0.352	0.147	0.315	**0.738**	0.277	-0.078	0.470	0.330
Management4	0.398	0.289	0.230	0.297	**0.700**	0.371	0.057	0.378	0.295
Management5	0.469	0.340	0.312	0.395	**0.696**	0.390	-0.010	0.355	0.158
Management6	0.341	0.515	0.290	0.366	**0.780**	0.511	-0.122	0.437	0.294
Management7	0.369	0.541	0.450	0.486	**0.766**	0.474	0.064	0.52	0.439
Management8	0.280	0.483	0.416	0.420	**0.573**	0.452	0.050	0.495	0.345
Management9	0.361	0.319	0.253	0.292	**0.632**	0.308	0.202	0.291	0.218
Procurement1	0.521	0.431	0.521	0.534	0.401	**0.769**	0.272	0.501	0.438
Procurement2	0.523	0.355	0.577	0.618	0.482	**0.769**	0.169	0.513	0.428
Procurement3	0.341	0.442	0.485	0.537	0.384	**0.836**	0.188	0.538	0.424
Procurement4	0.483	0.504	0.574	0.67	0.493	**0.849**	0.241	0.616	0.44
Procurement5	0.248	0.509	0.498	0.397	0.417	**0.659**	0.146	0.604	0.287
Procurement6	0.143	0.409	0.256	0.397	0.348	**0.603**	0.019	0.506	0.428
SiteCondition1	0.424	0.495	0.554	0.551	0.527	0.512	0.295	**0.639**	0.286
SiteCondition10	0.450	0.343	0.490	0.628	0.439	0.476	0.158	**0.560**	0.510
SiteCondition2	0.455	0.431	0.269	0.477	0.553	0.387	0.035	**0.583**	0.269
SiteCondition3	**0.617**	0.357	0.469	0.563	0.415	0.454	0.114	**0.524**	0.421
SiteCondition4	0.175	0.414	0.356	0.347	0.275	0.411	0.073	**0.629**	0.319
SiteCondition5	0.202	0.388	0.329	0.385	0.322	0.411	0.242	**0.627**	0.596
SiteCondition6	0.404	0.552	0.556	0.569	0.403	0.582	0.188	**0.782**	0.530
SiteCondition7	0.397	0.448	0.546	0.665	0.367	0.519	0.457	**0.658**	0.363
SiteCondition8	0.270	0.535	0.526	0.464	0.377	0.468	0.194	**0.771**	0.394
SiteCondition9	0.088	0.436	0.428	0.433	0.347	0.435	0.232	**0.689**	0.391
Worker1	0.197	0.272	0.355	0.498	0.165	0.309	0.225	0.459	**0.662**
Worker10	0.174	0.255	0.262	0.284	0.155	0.298	0.182	0.387	**0.517**
Worker2	0.288	0.242	0.297	0.517	0.175	0.353	0.146	0.421	**0.721**
Worker3	0.325	0.246	0.220	0.492	0.268	0.413	0.036	0.386	**0.692**
Worker4	0.377	0.258	0.240	0.359	0.310	0.284	0.121	0.394	**0.67**
Worker5	0.241	0.333	0.224	0.337	0.297	0.318	0.121	0.370	**0.67**
Worker6	0.263	0.215	0.175	0.175	0.110	0.228	0.220	0.201	**0.43**
Worker7	0.368	0.394	0.494	0.547	0.401	0.535	0.426	0.543	**0.624**
Worker8	0.315	0.111	0.216	0.262	0.266	0.240	0.177	0.27	**0.593**
Worker9	0.144	0.269	0.093	0.283	0.367	0.208	0.005	0.307	**0.521**
RateBuyback/ DropoffCentre	**0.733**	0.350	0.606	0.398	0.365	0.419	0.416	0.478	0.413
RateCEprinciple	**0.581**	-0.034	0.255	0.239	0.159	0.173	0.061	0.100	0.141

RateLandfill	**0.342**	0.293	0.233	0.233	0.330	0.258	0.114	0.300	0.281
RatePreventing	**0.759**	0.155	0.384	0.372	0.460	0.411	0.129	0.296	0.238
RateRecovery	**0.758**	0.195	0.363	0.335	0.428	0.354	0.191	0.294	0.318
RateRecycle	**0.779**	0.194	0.395	0.336	0.241	0.270	0.151	0.332	0.295
RateReduce	**0.813**	0.185	0.420	0.376	0.388	0.312	0.151	0.348	0.272
RateReuse	**0.82**	0.331	0.481	0.393	0.440	0.413	0.231	0.486	0.358
RateSWMP	**0.799**	0.349	0.686	0.528	0.302	0.526	0.433	0.591	0.399
Satisfaction	**0.337**	**0.226**	**0.502**	**0.277**	**0.027**	**0.238**	**1.000**	**0.316**	**0.285**

Assessment of Final Model

To comply with the Fornell-Larcker criterion as well as the HTMT requirements, the following indicators have to be dropped, namely DD5, DD8, DD9, ExtFactor6, ExtFactor9, Handling5, Handling6, Management8, Procurement5, SiteCondition1, SiteCondition2, SiteCondition3, SiteCondition5, SiteCondition7 and SiteCondition10 and Worker 7. The final model is given in Figure 3.

Table 12 shows that the Cronbach's alpha values and composite reliability and validity values are higher than the recommended value of 0.700. The Fornell-Larcker criterion in Table 13 shows that the square root of the AVE for each of the construct is more than its correlation with the other construct, indicating there is discriminant validity between the constructs.

Table 14 shows that all the HTMT values are now less than 0.900, indicating there is indeed discriminant validity between all the LOCs.

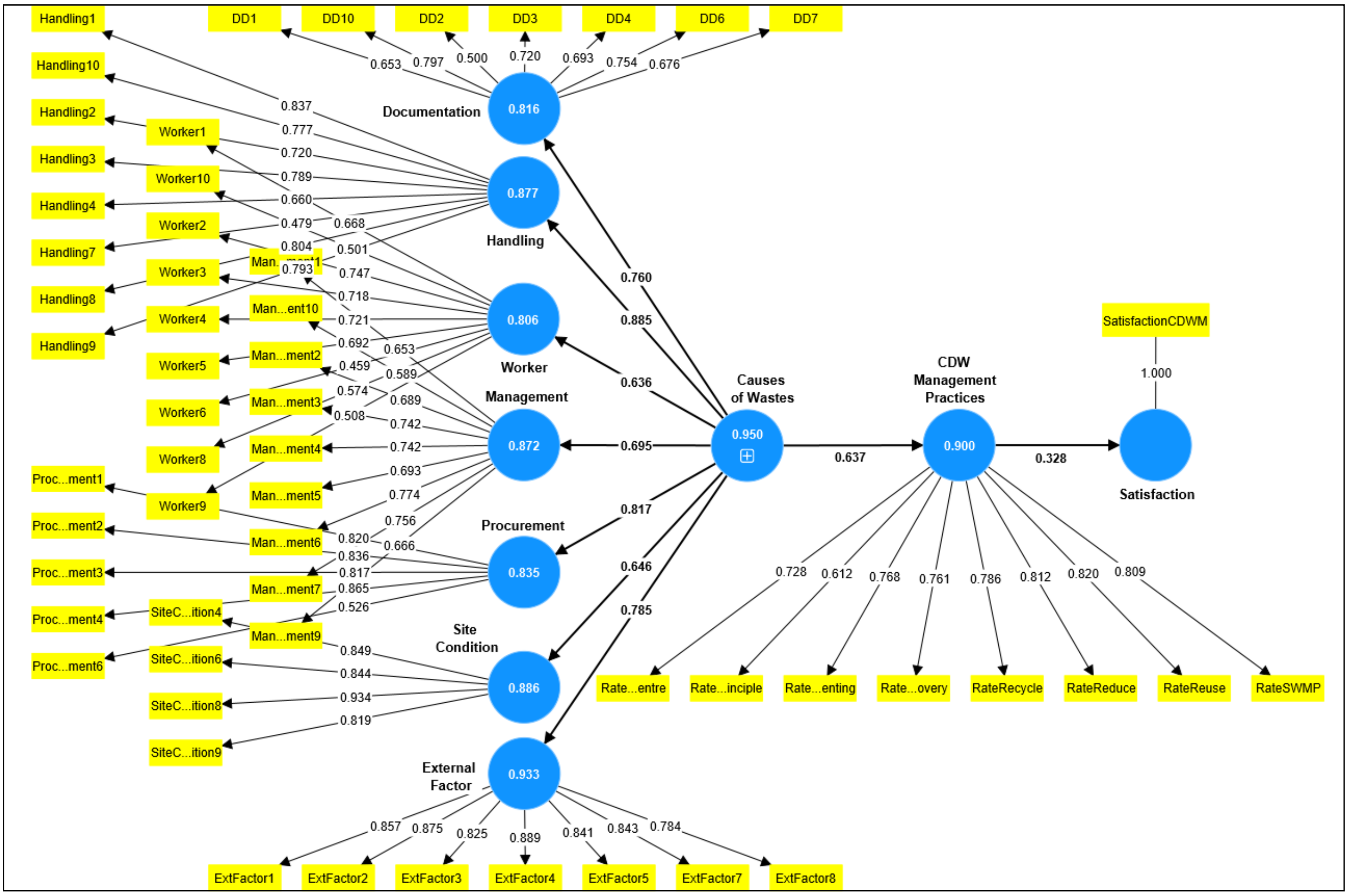

Figure 3. Final model (first stage)

Table 12. Construct Reliability and Validity

	Cronbach's alpha	**Composite reliability (rho_a)**	**Composite reliability (rho_c)**	**AVE**
CDW Management Practices	0.900	0.921	0.918	0.585
Causes of Wastes	0.950	0.958	0.954	0.310
Documentation	0.816	0.837	0.862	0.477
External Factor	0.933	0.934	0.946	0.715
Handling	0.877	0.889	0.905	0.548
Management	0.872	0.879	0.897	0.494
Procurement	0.835	0.861	0.885	0.613
Site Condition	0.886	0.906	0.921	0.744
Worker	0.806	0.827	0.852	0.396

Table 13. Fornell-Larcker criterion

	CDW Management Practices	**Documentation**	**External Factor**	**Handling**	**Management**	**Procurement**	**Satisfaction**	**Site Condition**	**Worker**
CDW Management Practices	**0.765**								
Documentation	0.367	**0.690**							
External Factor	0.664	0.479	**0.845**						
Handling	0.527	0.665	0.660	**0.740**					
Management	0.468	0.565	0.375	0.492	**0.703**				
Procurement	0.526	0.527	0.606	0.684	0.526	**0.783**			
Satisfaction	0.328	0.212	0.511	0.266	0.025	0.240	**1.000**		
Site Condition	0.258	0.498	0.437	0.458	0.344	0.470	0.204	**0.863**	
Worker	0.389	0.288	0.349	0.568	0.352	0.481	0.208	0.442	**0.630**

Table 14. HTMT (=< 0.900)

	CDW Management Practices	**Documentation**	**External Factor**	**Handling**	**Management**	**Procurement**	**Satisfaction**	**Site Condition**	**Worker**
CDW Management Practices									
Documentation	0.385								
External Factor	0.692	0.515							
Handling	0.577	0.766	0.716						
Management	0.517	0.632	0.390	0.548					
Procurement	0.566	0.609	0.657	0.795	0.594				
Satisfaction	0.303	0.224	0.529	0.281	0.153	0.251			
Site Condition	0.291	0.567	0.459	0.522	0.386	0.553	0.212		
Worker	0.458	0.383	0.394	0.652	0.430	0.606	0.243	0.518	

Second Stage: Assessment of Higher-order Construct

Figure 4 shows the structural model with the latent variable scores for the HOC 'Causes of Wastes'. It is used to establish the quality criteria for the structural model.

Table 15 shows that the composite reliability values for the structural model are higher than the recommended value of 0.700. Similarly, average variance extracted values surpassed the threshold of 0.500. The Fornell-Larcker criterion in Table 16 shows that the square root of the AVE for each of the construct in the structural model is more than its correlation with the other construct, indicating there is discriminant validity. The HTMT values in Table 17 confirm that there is discriminant validity between the constructs.

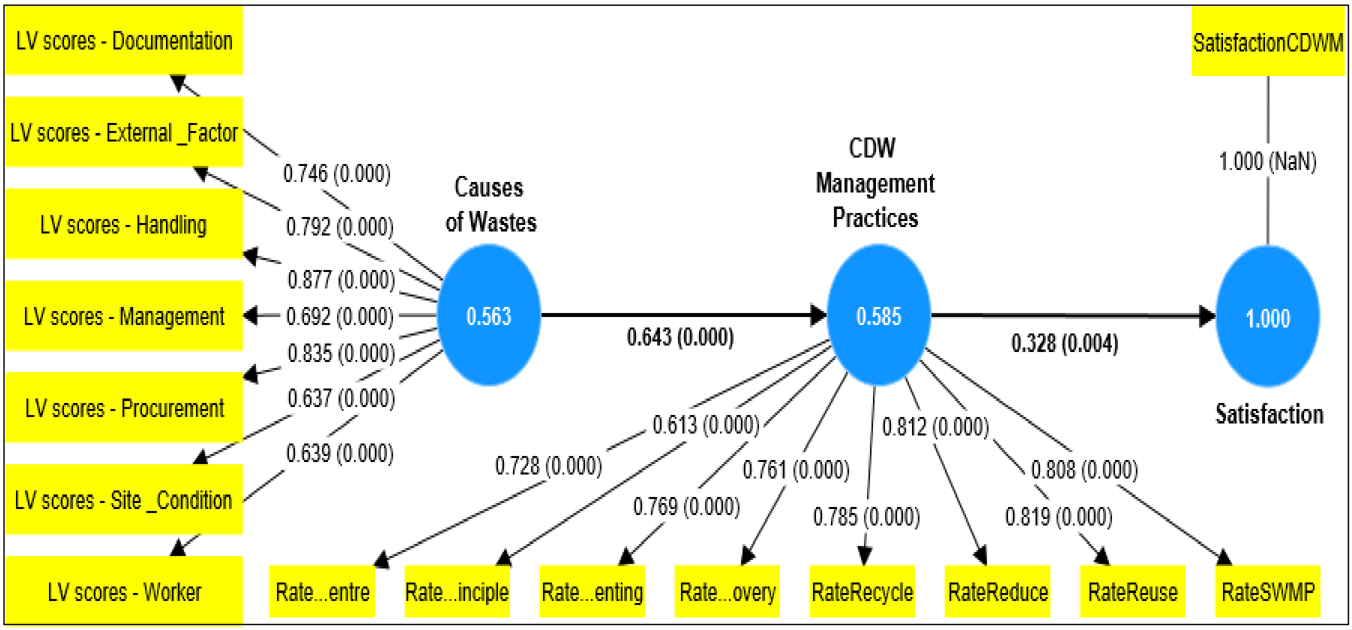

Figure 4. Final model (second stage)

Table 15. Construct reliability and validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	AVE	R-Square (R^2)
Causes of Wastes	0.870	0.898	0.899	0.563	---
CDW Management Practices	0.900	0.921	0.918	0.585	0.413
Satisfaction	---	---	---	---	0.108

Table 16. Fornell-Larcker criterion

	CDW Management Practices	Causes of Wastes	Satisfaction
CDW Management Practices	0.765		
Causes of Wastes	0.643	0.751	
Satisfaction	0.328	0.340	1.000

Table 17. HTMT (=< 0.900)

	CDW Management Practices	Causes of Wastes	Satisfaction
CDW Management Practices			
Causes of Wastes	0.662		
Satisfaction	0.303	0.341	

Table 18 shows the total effects in the structural model. There is a significant relationship between ‘Causes of Wastes’ and ‘CDW Management Practices’ ($p<0.001$). Similarly, there be is a significant relationship between ‘CDW Management Practices’ and ‘Satisfaction’ ($p<0.01$). Table 19 shows the effect size f-square for the structural model. The model fit for the structural model is given in Table 20. The results from Cross-Validated Predictive Ability Test for Q^2predict values are given in Table 21.

Table 18. Total effects

	Original sample	Sample mean	Standard deviation	T statistics	p Values
Causes of Wastes → CDW Management Practices	0.643	0.664	0.047	13.786	0.000
CDW Management Practices → Satisfaction	0.328	0.330	0.113	2.914	0.004
Causes of Wastes → Satisfaction	0.211	0.220	0.077	2.751	0.006

Table 19. f-Square

	Causes of Wastes	CDW Management Practices	Satisfaction
Causes of Wastes		0.703	
CDW Management Practices			0.121
Satisfaction			

Table 20. Model fit

	Saturated Model	Estimated Model
SRMR	0.108	0.109
d_ULS	1.574	1.624
d_G	0.756	0.762
Chi-square	239.662	241.808
NFI	0.667	0.664

Table 21. Q^2Predict - LV prediction summary

	Q^2Predict	RMSE	MAE
CDW Management Practices	0.358	0.835	0.685
Satisfaction	0.083	0.983	0.795

From the initial results presented in Table 7, the effectiveness of CDW management practices in descending order based on mean values as rated by the respondents is SWMP, buy-back/drop-off centre, reuse, recycle, reduce, preventing, CE principles, recovery and landfill. Reuse and recycle have been rated with the same mean value of 3.716. Landfilling was rated as the least effective option by the respondents with a mean value of 3.090. The reason could be due to its negative impacts on the environment and human health as explained by Kabirifar et al. (2020). On the other hand, SWMP has been identified as the most effective CDW management practice with a mean value of 4.313, where '4 = highly effective'. Overall, the overall effectiveness for all the 9 CDW management practices is 3.667.

The initial results presented in Table 7 for the causes of wastes show that management category has been identified as the main cause of wastes with an overall mean value of 4.463. The second main cause of wastes is the worker category, with an overall mean value of 4.309. The order for the other categories is 'handling' = 4.133, 'external factor' = 4.085, 'site condition' = 4.016, 'procurement' = 3.941 and 'design and documentation' = 3.930.

Further analyses through PLS-SEM for internal consistency, construct reliability and validity as well as discriminant validity revealed that landfilling had to be dropped due to its low loading as well as cross loadings < 0.10 with the other CDW management practices. In addition, 16 indicators or causes of wastes had to be dropped due to cross loadings < 0.10 with the other indicators, namely 3 indicators (DD5, DD8 and DD9) from the design and documentation category, 2 indicators (Handling and Handling6) from the handling category, 1 indicator (Worker 7) from the worker category, 1 indicator (Management8) from the management category, 6 indicators (SiteCondition1, SiteCondition2, SiteCondition3, SiteCondition5, SiteCondition7 and SiteCondition10) from the site condition category, 1 indicator (Procurement5) from the procurement category, and 2 indicators (ExtFactor6 and ExtFactor9) from the external category. The final model shown in Figure 3 comprising 7 categories of factors causing wastes with 49 indicators and 8 CDW management practices has a model fit close to 0.108 as shown in Table 20, which is close to good (= 0.100).

The results in Table 18 show that causes of wastes have a significant total effect of 0.643 ($p<0.001$) on CDW management practices, and CDW management practices have a significant total effect of 0.328 ($p<0.01$) on satisfaction of respondents with the current practice of CDW management implemented. It is thus important to identify the causes of wastes in order to evaluate the effectiveness of CDW management practices, and the respondents in this study gave a mean value of 4.493 as shown in Table 5. These findings provide critical empirical support and provide the justification for the research purpose. The strong, significant effect (0.643 and 4.493) demonstrates that understanding what generates waste is an effective tool for improving waste management. As a result, a substantial impact size of 0.328 suggests that the identified CDW management practices are regarded to be more easily adopted and sustained by the industry.

Discussion

The Green Building Index (GBI) is a certification system in Malaysia that assesses the sustainability of a building based on various green building criteria (Shraddha Pandey, 2018). Materials and resources (MR) is a category in the GBI rating system which consists of several sub-criteria related to this study, namely reused and recycled materials, sustainable resources, waste management and green products (Green Building Index, 2022; Chandratilake & Dias, 2015).

This study's finding that "causes of wastes have a significant total effect of 0.643 ($p<0.001$) on CDW management practices" provides strong empirical evidence for a vital relationship that is frequently discussed conceptually. It goes beyond a broad understanding to measure the significant impact of addressing waste origins on management effectiveness. This validates the theoretical idea that upstream interventions (identifying and mitigating causes) are more effective than downstream efforts (controlling waste after it has been generated). It implies that any complete theoretical model of effective CDW management must clearly incorporate and prioritise the control of waste causes.

The components under waste management are ‘storage, collection and disposal of recyclables’ and ‘construction waste management’. Under this category, in order to achieve a higher score for storage, collection and disposal of recyclables, proper collection and disposal of recyclable materials should be implemented on-site or off-site in order to reduce wastes and prevent pollution (Saleh & Faieza, 2016; Mwanza et al., 2018; Sasitharan et al., 2013).

MR in the GBI certification system focuses on environmentally friendly materials acquired from sustainable sources, as well as recycling, which indicates that contractors should prioritise effective construction waste management by storing, collecting and reusing recyclables as well as building formwork and debris (Illankoon et al., 2017). Effective waste management also reduces the amount of wastes sent to landfills, which helps conserve the environment and achieve the MR criteria (Liu et al., 2020). Waste reduction practices also help to optimise resource use and reduce the carbon footprint of the construction process (Kumar Raja et al., 2021).

The research objective to "integrate comprehensive and effective waste management practices into the green building criteria" (GBI in Malaysia) is a straightforward theoretical premise. The study's finding that "CDW management practices have a significant total effect of 0.328 ($p<0.01$) on satisfaction of respondents" establishes a fresh theoretical relationship. It implies that, in addition to the immediate environmental advantages, successful CDW practices help to foster a favourable impression and experience among industry stakeholders. This suggests that stakeholder satisfaction can be viewed as a beneficial consequence or a reinforcing mechanism in green building adoption theory.

Conclusion

As a conclusion of this study, the direct link formed between identifying waste causes and gaining GBI certification provides a practical layer to the literature on CDW management, particularly in Malaysia. It emphasises how strong waste management practices are not just an environmental goal, but also a requirement for meeting sustainability criteria in various regulatory regimes. The study highlights the need for effective policy interventions in Malaysia to manage construction and demolition waste. The high f^2 value for "Causes of Wastes with CDW Management Practices" indicates that existing waste management practices may not be adequately addressing the main causes of waste. Malaysian government, perhaps through the Ministry of Natural Resources and Environmental Sustainability or relevant local authorities, could enact policies requiring detailed waste audits during the design and construction phases of all building projects, particularly those seeking Green Building Index certification. This would provide specific data on waste sources, allowing for targeted solutions. To learn more about the precise "causes of wastes" that stakeholders have highlighted, further study could use qualitative techniques (such as focus groups and in-depth interviews). Rich, complex insights about human behaviour, poor project management, design defects, and waste-causing material procurement problems would result from this.

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