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The Mediating Role of Policy-Related Factors in the Relationship between Practice of Waste Generation and Sustainable Construction Waste Minimisation: PLS-SEM

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Abstract: As the construction industry grows, it produces large volumes of construction waste, which has a tremendous environmental impact and generates public concern in the neighbouring towns. The construction industry generates a significant volume of waste and faces a challenge with poor construction waste minimisation in order to prevent adverse environmental and dumping impacts worldwide. In developing countries, regional waste management systems have increased problems. Environmental pollution (air, water, and soil) and human health issues are caused by waste produced in a country as a result of different cultural, social, and religious activities. Prior studies were reviewed to choose dimensions and items for the data gathering instrument. A pilot test was conducted to identify potential questionnaire adjustments, and hypotheses were tested using structural equation modelling (SEM). A total of 220 Malaysian construction professionals answered the survey, which yielded the results. Five hypotheses have direct correlations based on the findings, three of which have a significant effect. Furthermore, the findings reveal that policy-related factors mediate the relationship between improving factors and sustainable construction waste minimisation. In contrast, they did not mediate the relationship between current practices/generation and sustainable construction waste management. The established framework can help improve construction waste management and help achieve global sustainable development goals. The data reveal that adopting preventive plans to reduce construction waste is one of the most important aspects of enhancing profitability. This study could aid construction industry players in evaluating waste management components during the construction and design stages of a building project.

Keywords: effective construction; current practices of waste generation; sustainable construction waste minimisation; policy-related factors; partial least squares-structural equation modelling (PLS-SEM)

1. Introduction

In 2015, the construction industry significantly impacted the natural and built environment. In 2019, 16.6 million tonnes of waste were produced, constituting 38% of destruction, with 43% of those wastes ending up in landfills [1,2]. In the construction and demolition procedures, massive amounts of waste are generated. Practitioners and scholars have become deeply concerned about the difficulties interconnected with construction and demolition waste [3,4]. Furthermore, C&D waste is rapidly increasing and, in most nations, is not completely managed [5]. Therefore, the architectural, engineering, and construction (AEC) industry should seek to minimize and recover C&D waste as part of construction waste management strategies: a green grading system, a circular economy, and zero waste [6,7]. Many reports in the early literature have recommended reusing and recycling C&D waste to reduce it [8]. The first step in lowering C&D waste is to reduce construction waste. This is addressed by eliminating the waste's causative factors [9,10]. Improper designs and expected design changes have been identified as sources of the primary volume of waste in the construction industry [11,12]. Poor design has resulted in a 33% increase in overall construction waste volume [13]. The sources of construction waste can be managed and prevented where appropriate, resulting in a reduction in waste generation. The causes of construction waste can be mitigated and avoided where necessary using integrated building design and design enhancements [14].

In developing countries, the current practice of construction waste management (CWM) has resulted in a tremendous increase in the amount of waste produced. First, much more waste (including C & C&D) is generated in metropolitan areas due to continuing population growth and fast urbanisation, particularly in developing countries [14]. UN research predicts that the global population will grow dramatically over the next 30 years, reaching 8.5 billion people, with 7.1 billion living in poorer countries [15]. Subsequently, many people migrate to cities and towns due to these countries' high economic development rates; more waste (including C&D) is generated in the metropolitan regions due to ongoing population growth and fast urbanization, particularly in developing countries. By 2025, the proportion of people living in cities is expected to increase from 33% to 55% [16]. As a result, the number of newly constructed buildings and infrastructure amenities will increase, resulting in increased construction waste.

In compliance with policy-related factors, various policy instruments for controlling construction waste for sustainable urban growth have been developed worldwide [17]. The effective execution of such policy instruments depends on a broad range of outcomes. One important consideration is the requirement to estimate the waste generated by construction projects accurately. Government agencies set the CWM policy for effective monitoring to ensure that the waste collector handles it efficiently [18]. Governments are taking steps to resolve these issues, such as enforcing a policy requiring the implementation of waste management incentives to promote on-site collection and ensure proper reuse, recycling, or disposal of all types of waste, and enforcing a travel ticketing scheme to regulate the movement of waste to a public construction contract [19]. The policy also promotes the usage of recycled waste aggregates from building waste for use in development projects. In 2006, the volume of building waste disposed of in landfills was reduced by about 30%.

To sustainably minimise construction waste, one of the most significant tools driving long-term sustainability is waste management strategy. Waste management has a link to public health and environmental destruction. Therefore, it is critical to analyse how resources and generated waste are managed to build a sustainable waste management system. Due to increased construction activities, manufactured goods are transported worldwide, resulting in waste. Consequently, if they are not handled properly, they have negative consequences for the natural environment. The Environmental Protection Agency (EPA) designated construction and demolition waste as waste materials generated during the design, renovation, or demolition of structures and roads. This includes products produced as a result of natural disasters [20,21]. Sustainable construction is another important tool for long-term development that involves deliberating on environmental, social, economic, and cultural issues. Establishing a relationship between the economic, environmental, and social aspects of building design, construction, and use is essential for sustainable construction. Indeed, environmentally friendly construction is important for achieving sustainable development [22].

In Malaysia, previous studies on construction projects have investigated many factors such as ineffective C&DW management and the lack of well-organised and systematic categorisation with clients, designers, and subcontractors [23,24]. Milios [25] has addressed many factors such as fundamental obstacles, determining the material choice, communication complexity, and coordination. Other studies have focused on enhancing CWM reuse and recycling [26], the inability of contractors to follow exact and thorough CWM regulations [27], the state of CDW treatment and its shortcomings [22,23], and industry guides for material reuse and recycling in a sustainable environment [28]. Although these factors were necessary, the impact of the current practice of waste generation on sustainable construction waste and the mechanism of how policy-elated factors mediate this relationship have been neglected. In Malaysia, there are currently no legal or economic mechanisms to assist construction professionals in reducing the amount of trash generated. Therefore, there is a pressing need to address how the current practice of waste generation impacts sustainable construction waste minimisation and how policy-related factors moderate the relationship between them.

Consequently, the study examines the mediating impact of policy-related factors on the relationship between the practice of waste generation and sustainable construction waste minimisation. Thus, the fundamental research question is: what is the mediating effect of policy-related factors on the relationship between the practice of waste generation and sustainable construction waste minimisation among Malaysian construction professionals? This study will give empirical evidence for project managers in the construction industry in Malaysia specially to ensure that waste is minimised by incorporating waste material reduction, reuse, and recycling. As a result, by extracting valuable goods from construction waste, effective construction waste management will aid in the achievement of sustainable development goals in various parts of the world, including Malaysia [29].

2. Literature Review and Hypotheses Development

This section comprises a review of relevant studies in the literature to develop the conceptual framework, discuss the relationships, and formulate the hypotheses as provided below.

2.1. Sustainable Construction Waste Management

Considering the alarming rate at which waste is generated and abandoned, C&DW's economic impact is significant. Construction materials account for over 40% of the world economy's material flow [30]. Moreover, a significant percentage of the overall cost of construction projects is accounted for by the price of the various materials, which further implies that any drop in the volume of waste produced will result in considerable project savings [31]. A few studies have looked at the increase in the number of jobs and sales of recycled materials due to increased waste diversion from landfills, using both direct and indirect data [31]. Aside from other environmental issues, this action helps mitigate the depletion of resources and diverts them from landfills [32]. Waste is produced as a result of projects, which must account for employee turnover as a result of delays and higher costs, as well as reduce which must account for turnover because of delays and the burden of additional costs, reduced productivity, and high waste disposal costs [32]. The concept of social impact can be defined as the practice of understanding, monitoring, and handling the wide range of social impacts generated from a variety of planned and unplanned endeavours, ranging from both negative and positive influences [32].

The readiness of people to improve their behaviours and attitudes when it comes to C&DW generation, collection, and disposal is addressed as social impact in C&DW management. From a sociological perspective, it is regarded that construction stakeholders' participation and commitment are significant C&DW management drivers [33,34]. It is worth emphasising that social and human capital is concerned with societal sustainability.

Human capital focuses on the skills and loyalty of employees. While social capital consists of elements such as the quality of life and social standards socially constructed in each society, social capital comprises various social constructs such as how people view their roles and status [35]. Kabirifar [36] notes that it is challenging to meet the expectations of all stakeholders while considering the limits of their time and resources, and trade-offs are inevitable. Thus, as explained above, the following description emerged: communities derive their values from sustainability, which is socially implemented through the development of human resources and the advancement of social capital. It is critical to efficiently manage social capital for stakeholders to appreciate and recognise the value of organisation engagement in the system. To the above advantages, we may further add the improved economic, environmental, and social aids that can be increased from waste management implementation. The values shown in Table 1 represent the different factors that contribute to a sustainable C&D energy strategy.

Table 1. The sustainable management contributing factors.

Sustainable Construction Waste Management	Factors	References
Environmental	Pollution and deterioration of the environment (water, soil, air, and noise), global warming problems, impediments to green development, greenhouse gas emissions, fossil fuel emissions, resource and raw material depletion, and the effects of unlawful dumping in the neighbourhood, among other issues	[34,37,38]
Economic	Materials, energy, water, labour, and equipment expenses, waste transportation costs, disposal costs, costs of precious lands filled with C&DW, reuse and recycling costs, etc.	[39–42]
Social	Short- and long-term health and safety impacts of C&DW collection, sorting, and disposal, project stakeholders' attitudes toward C&DW management, public perception and awareness shifts toward C&DW direction, incentive role in preventing illegal C&DW dumping, aesthetic impacts of recycling plants and material stockpiled, etc.	[43,44]

2.2. Current Practices/Generation

The construction industry has grown rapidly as people's living standards have improved. Increased demand for infrastructure projects, variations in usage patterns, and population growth contribute to waste [45]. Construction waste consists of building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials resulting from different construction activities. In addition, construction trash, such as asbestos produced during the demolition of existing structures, can be problematic Kabir [46]. As a result, it is critical to have a comprehensive and well-defined strategy and technology to manage waste generated by building operations to minimise the negative impact on environmental, social, and economic factors.

Regarding waste management technologies, Kabir [46] has indicated that waste minimisation, reuse, recycling, and composting should be the most environmentally friendly measures in the waste management hierarchy. Malaysia implements the industrial building system (IBS), a waste-controlling and ecologically friendly construction method [47]. A prefabricated component-based construction system is referred to as an IBS [48]. However, according to Bajjou and Chafi [49], greater initial expenses deter construction professionals from adopting this strategy even though IBS could be one of the most effective strategies to reduce on-site waste.

2.3. Factors Driving Improvement

These factors improve waste management to ease the shortcomings of CWM. Table 2 illustrates some of the most critical variables that go into the management of C&D waste.

Table 2. Factors for Improving Waste Management (CWM).

Group	Factors for Improving Waste Management (CWM)	References
Construction Factors	Segregation of waste and collection in dedicated bins	[50,51]
	Green buildings that minimise the emission of toxic substances throughout their life cycle	
	Green building practices	
	Industrial building system (IBS)	
	Design management to prevent the over-specification of materials	
	Building information modelling (BIM)	
	Stock control measures to avoid the over-ordering of materials	
Manpower Factors	The pledge of the contractor's representative at the site	[52,53]
	Contribution and cooperation of subcontractor	
	Organisation breakdown structures involved in waste management	
Management Factors	Cost estimation for waste treatment bills required	[54,55]
	Studies on the feasibility of waste estimating methodologies	
	Adequate training to develop the necessary skills and experience	
	Additional tender premiums where waste initiatives are to be implemented	

2.4. Mediating Policy-Related Factors

The Malaysian government is taking steps to resolve these issues, such as enforcing a policy requiring the implementation of waste management incentives to promote the on-site collection and ensure proper reuse, recycling, or disposal of all types of waste, and enforcing a travel ticketing scheme to regulate the movement of waste to a public construction contract. The policy also promotes the usage of recycled waste aggregates from building waste for use in development projects. The appropriate measurement of construction waste at the project level, which is an experiential level of both the government and the construction sector to take adequate measures, is critical to successfully implementing this policy. In 2021, the regulations were formulated to produce an interconnected and comparatively successful system. Hong Kong's policy structure for managing CWM resulted in a 30 percent reduction in building waste disposal volume in landfills. The construction waste disposal fee plan has already produced around HK 55 million (USD 7 million) [56]. Furthermore, policymakers in developing countries such as the United States of America, Korea, Japan, China, and Vietnam appear to be concerned about construction waste minimisation policies. Kabir [46] revealed that construction waste minimisation policies are conveyed as fundamental waste management strategies and a powerful tool for achieving synergistic effects with national approaches for prevention, resource procurement, and emission reduction [57].

2.4.1. Construction Waste Management Policy

Due to the development of sustainable improvements as a new standard, the building industry has begun to recognise the negative effects on the environment [46]. On the other hand, construction is not a sustainable and environmental activity by definition. Scholars have cited a series of negative construction impacts, including waste generation, resource depletion, land deterioration, and harmful emissions [58]. Waste makes up a large amount of municipal waste. Thus, it is critical to have a proper policy dealing with the building industry if you want to live in a pollution-free environment. As a result, Malaysia's government established the Construction Industry Development Board (CIDB) to reform the industry and enhance environmental performance and awareness among its key players [59]. The Malaysian government has also established Standard Building Works Specifications (SBW) overseen by the Ministry of Works. All government policies and procedures reflect a desire to manage construction waste effectively. Although construction professionals do not comply with all policies, a more holistic approach is necessary to preserve economic, social, and environmental factors. Policy-related factors are shown in Table 3.

Table 3. Policy-related factors.

Industry Policy Factor	Cost Estimation for the Quantity of Waste Treatment: a Bill Is Required	References
	Studies on the feasibility of waste estimating techniques	[54,55]
	Adequate training to develop the necessary skills and experience	
	Where waste activities are to be implemented, there will be additional tender premiums.	
	A residential officer is in charge of waste management.	
	Optimizing legal procedures for the installation of waste treatment equipment	

2.4.2. Summary of Literature Review

For the conceptual framework of this research, six models of the construction waste management approach were established. First, the framework in construction projects was reviewed [60]. At this stage, the focus was to determine the components of the critical elements of construction waste management in every aspect. The selection and adoption of each component were made based on the following criteria: the component's suitability for construction waste management through the application of the three Rs (reduce, reuse, recycle) in a construction project, and the suitability for integrating construction waste management through application of the three Rs for each component.

The relevance and approach for explaining the construction sector in Malaysia are discussed in the conceptual framework of this research given in Figure 1. The approach to waste management (reduce, reuse, and recycle) is mainly applicable in many developing nations. Waste management in numerous countries is complex and can be influenced by numerous considerations, such as population growth, transportation infrastructure, geographical area, and environmental regulations [57]. It has also been noted that waste management in developing countries is different from that in developed countries. Another important technique for the sustainable construction process involving environmental, social, economic, and cultural concerns is sustainable construction. It is more necessary for sustainable construction to evaluate the relationship between the economic, environmental, and social aspects of building design, construction, and use. Long-term sustainability necessitates sustainable construction [61,62]. For example, Umar [63] emphasises the advantages of high-performance C&D waste management for a smooth construction process while reducing environmental effects. It adheres to the two pillars of sustainable construction: resource-saving and pollution reduction [64]. As indicated in Figure 1, waste management is critical to sustainable construction [65]; the evaluation of CWM performance is influenced by sustainable construction. Environmental, social, and economic sustainability elements are all thought to impact CWM outcomes [66–68]. The relationship between current practices/generation and policy-related factors has not been significant [69]. However, current practices/generation was found to affect sustainable construction waste management significantly. Additionally, significantly increasing key drivers have a statistically significant positive mediating impact on policy-related variables of sustainable construction waste management. On the other hand, improved factors have had little impact on sustainable construction waste management. Furthermore, policy-related factors have been established to significantly impact sustainable construction waste management [70,71]. Thus, it can be concluded from the above literature review that there are seven hypotheses of this study that need to be investigated among Malaysian construction projects, as shown in Figure 1.

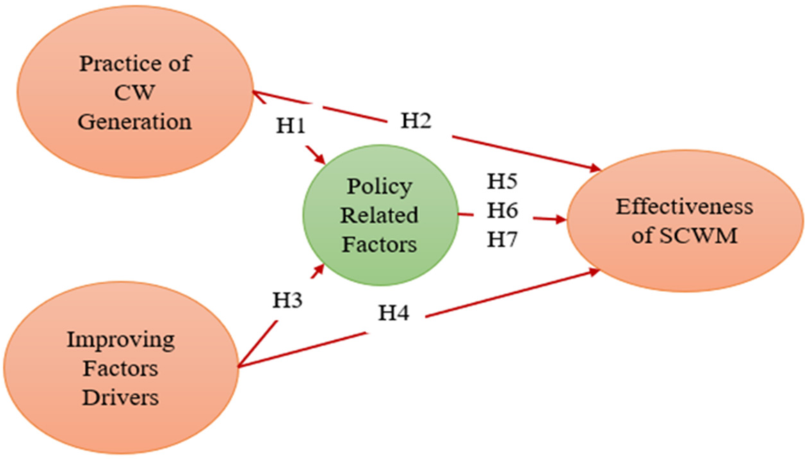

Figure 1. Novel model for sustainable CWM.

3. Methodology

The research approach was developed using a conceptual model. This method is based on a three-step process that includes identifying model constructs, (ii) categorising construction, and (iii) specifying relationships between these constructs [72]. The study adopted the questions from previous studies to measure the study's variables, such as existing waste generation techniques, enhancing factors, policy-related factors, and sustainable construction waste management. Validation of the instrument of this study (survey) has been conducted in two stages—first, the face and content validity of this survey by experts. The second phase consisted of the pilot study, which had to assess the instrument's reliability before the main study [73–75]. Thus, after the validation stage, the survey was ready to collect the data to test the hypotheses of this study. This questionnaire was divided into two sections. Part one contained demographic information about the respondents, and part two included items to measure variables of this study as shown in Tables 1–3 using a five-point Likert scale ranging from "never" to "always" [76,77].

Subsequently, based on a random stratified sampling technique, 220 survey responses were collected from Malaysian construction professionals working in various regions throughout the country. According to Kline [78], a complex path model requires about 200 sample sizes or larger to analyse. At the same time, Yin [79] recommended that for SEM, it is appropriate for the sample size to exceed 100. The survey was administered in person (self-administered) and received a high response rate of 85.9% [80]. The data were filtered and loaded into SPSS statistical software to conduct data screening checks before submission to the model test by PLS-SEM.

Structural Equation Modelling (SEM)

Three techniques from the literature review were evaluated to investigate the current study model: (i) multiple linear regression (MLR), (ii) system dynamics (SD), and (iii) structural equation modelling (SEM). First, the regression equation was not used because the link between variables was not considered, which is a fundamental limiting condition for implementing the regression equation. Second, due to the nature of the data (for example, data that are independent of time), the system dynamics technique could not be used. Finally, the structural equation modelling (SEM) method describes the link between various observable and non-observable factors; therefore, it was appropriate for the study's needs. The PLS-SEM is a handy tool for dealing with variable faults [81]. In this study, the SEM technique was utilised to establish the link between modelling the relationship between current waste generation practices and sustainable construction waste minimisation and to investigate the mediating role of policy-related factors on the relationship between the current practice of waste generation and sustainable construction waste. According to Nayernia [82], structural equation modelling has developed into a non-experimental research tool with previously unknown procedures for hypothesis testing. In social science research, according to Yuan [83], structural equation modelling is a prevalent and well-known approach to data analysis. In previous studies, the PLS-SEM analysis method has been used in many sectors such as the building sector [84–86], transportation sector [87–89], construction waste generation [90,91], and assessment of the environmental and economic impacts of construction and demolition waste [92]. In addition, according to Hair et al. [93], partial least square (PLS) methods are now well-known as an alternative to the SEM method. The PLS-SEM, along with other programmes such as AMOS and LISREL, is a versatile and effective method for building and predicting statistical models [94]. Therefore, PLS-SEM has been employed to test the hypotheses of this study as below:

Hypothesis 1 (H1). *There is a significant impact of current practices/generation on policy-related factors.*

Hypothesis 2 (H2). *There is a significant impact of current practices/generation on sustainable construction waste management.*

Hypothesis 3 (H3). *There is a significant impact of improving factors on policy-related factors.*

Hypothesis 4 (H4). *There is a significant impact of improving factors on sustainable construction waste management.*

Hypothesis 5 (H5). *There is a mediating role of policy-related factors in the relationship between the current practices/generation and sustainable construction waste management.*

Hypothesis 6 (H6). *There is a mediating role of policy-related factors in the relationship between the improving factors and sustainable construction waste management.*

4. Results

4.1. Assessing the Measurement Model

The SEM is depicted in Figure 1 as well as the study's conceptual model. According to Henseler [95], indicator reliability involves (i) evaluating a measurement model that entails estimating, (ii) composite reliability, (iii) average variance extracted (AVE), and (iv) validity discrimination. In general, outside load indications in the range of 0,40 to 0,70 must be removed only if doing so results in a significant increase in AVE and composite reliability, but if the range is less than 0.40, they should be removed directly [93]. Table 4 and Figure 2 reveal that all outside loading values in the measurement model were more than 0.7. The results of Table 4 show that the model's structures passed this test. In the supplementary file, there is a table called Item Loading.

Table 4. Internal reliability and convergent validity.

Construct	Cronbach's Alpha	Rho_A	CR	AVE
Design Factors	0.790	0.793	0.845	0.537
Design Development Stages/Lean Construction	0.831	0.834	0.869	0.579
Construction and Site Management	0.783	0.790	0.844	0.539
External and Workers/Handling Factors	0.792	0.794	0.846	0.531
Planning and Design Factors	0.820	0.821	0.864	0.537
Management Practices	0.762	0.763	0.830	0.563
Construction Factors	0.816	0.820	0.860	0.500
	0.843	0.847	0.878	0.627
Waste Minimisation Measures	0.846	0.848	0.878	0.522
Effective to Improve CWM	0.854	0.855	0.886	0.574
Waste Management Policy Factors	0.764	0.764	0.832	0.672
Industry Factors	0.814	0.816	0.858	0.562
Factors in the Environment	0.725	0.727	0.814	0.504
Economic Constraints	0.891	0.894	0.913	0.567

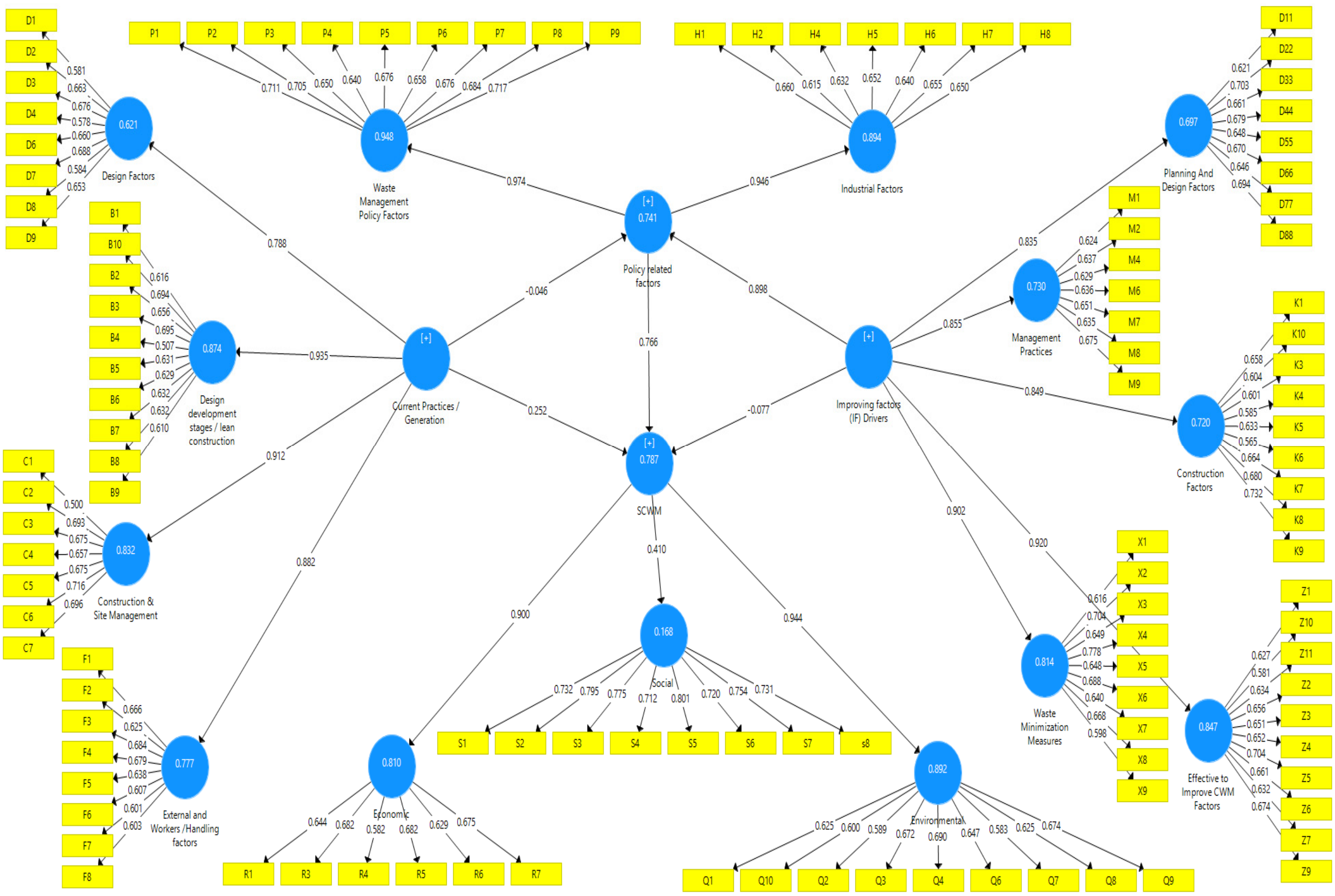

Figure 2. Output loading of factors.

Values greater than 0.70 are recommended for further investigation [95]. For all outside loads greater than 0.7, the internal consistency of composite reliability (CR) was evaluated [96]. Table 4 shows that all of the model's variables passed the CR > 0.70 test and were thus accepted. AVE is a standard metric used to measure the model's constructs' convergent validity, with values greater than 0.50 indicating an acceptable convergent value, as indicated by [97].

4.2. Goodness of Fit of Model

According to Henseler and Sarstedt [98], the geometric mean of both the average R^2 and the average variance extracted from endogenous variables was proposed as the goodness of fit (GoF). Simultaneously, the AVE (community) considers the quality of the index's measurement models. If the numbers are 0.1, 0.25, or 0.36, the GoF index is termed small, medium, or big, respectively [99]. The equation can be used to compute the GoF index:

$$\mathrm{GOF} = \sqrt{\overline{\mathrm{R}^2} \times \overline{\mathrm{AVE}}} = \sqrt{0.764 \times 0.4319} = 0.574$$

The GoF criteria determine if GoF values are not acceptable (less than 0.1), low-slung (0.1 to 0.25), moderate (0.25–0.36), or high (beyond 0.36) in order to be accepted as a globally acceptable PLS model. As a result, based on these requirements and the Gof value of (0.574), the GoF model is likely to be significant enough to be designated as a worldwide PLS-SEM model. Based on Adabre [100], the model's GoF of 0.39 is relatively high. As a result, the research model is correct.

4.3. Discriminant Validity

By the norms observed, discrimination validity is defined as a concept that appropriately differs from the other constructs. The model's discriminative validity thus means that it captures things that are not properly reflected in the model by other constructs [101]. The discriminant validity was evaluated by the cross loading criterion. In assessing discriminating validity, the square AVE roots of each construct can be compared to the correlations between them. According to Ab Hamid [102], the AVE's square root is greater than the correlation between latent variables. The results show that the measuring model in Table 5 had a discriminating value for sustainable construction waste management (SCWM).

Table 5. Fornell-Larcker criterion.

	m1	**m2**	**x11**	**x12**	**x13**	**x14**	**x21**	**x22**	**x23**	**x24**	**x25**	**y1**	**y2**	**y3**
m1	0.68													
m2	0.50	0.644												
x11	0.525	0.477	0.637											
x12	0.592	0.565	0.602	0.632										
x13	0.611	0.59	0.599	0.601	0.662									
x14	0.616	0.639	0.574	0.552	0.553	0.639								
x21	0.615	0.638	0.489	0.582	0.561	0.594	0.666							
x22	0.630	0.551	0.485	0.597	0.607	0.557	0.643	0.641						
x23	0.601	0.521	0.523	0.585	0.601	0.621	0.605	0.611	0.638					
x24	0.562	0.563	0.492	0.563	0.602	0.588	0.642	0.631	0.60	0.667				
x25	0.593	0.509	0.518	0.579	0.592	0.615	0.61	0.601	0.610	0.650	0.648			
y1	0.594	0.551	0.549	0.613	0.630	0.578	0.598	0.606	0.510	0.640	0.59	0.635		
y2	0.305	0.587	0.477	0.546	0.582	0.599	0.563	0.539	0.608	0.601	0.525	0.517	0.65	
y3	0.147	0.128	0.255	0.237	0.158	0.202	0.127	0.1	0.137	0.109	0.139	0.185	0.147	0.753

4.4. Assessing the Structural Model

It is time to assess the structural model after establishing measurement model reliability and validity. Collinearity, path coefficients, coefficient of determination (R^2), and effect size are all terms that are used to describe the relationship between two variables (f^2);

these and predictive significance were all discussed in the literature as recommendations for evaluating and presenting the structural model (Q^2).

4.4.1. Path Coefficients

The estimations of the relationships between the model's constructs are referred to as path coefficients [103]. The coefficients range from +1 to −1, with +1 indicating a strong positive association, 0 indicating a weak or non-existent relationship, and −1 indicating a strong negative relationship. PLS bootstrapping, a statistical approach for obtaining many simulated samples from a single dataset, was used to test the hypotheses. This programme calculates standard errors and provides confidence intervals for various sample statistics when performing hypothesis testing [93]. Table 6 displays the estimated model together with the estimated path coefficients and *p*-values for the leading hypotheses.

Table 6. Hypothesis testing.

Path Direct Effect	β	*t*-Value	*p*-Value
H1: Current Practices/Generation -> Policy-Related Factors	−0.046	0.619	0.537 ^{NS}
H2: Current Practices/Generation -> Sustainable Construction Waste Management	0.252	4.878	0.000 ***
H3: Improving Factor Drivers -> Policy-Related Factors	0.898	14.39	0.000 ***
H4: Improving Factor Drivers -> Sustainable Construction Waste Management	−0.077	1.043	0.3 ^{NS}
H5: Policy-Related Factors -> Sustainable Construction Waste Management	0.766	12.133	0.000 ***

*** $p < 0.001$; ^{NS} Not significant.

Since (=−0.046, $t = 0.619$, $p > 0.05$), H1 current practices/generation has no statistically significant effect on policy-related factors. As a result, H1 was rejected. However, since (=0.252, $t = 4.878$, $p > 0.000$), current practices/generation has a statistically significant positive effect on sustainable construction waste management in H2. As a result, H2 is acceptable. In H3, (=0.898, $t = 14.39$, $p > 0.001$), improving factor drivers have a statistically significant positive effect on policy-related factors. As a result, H3 is accepted. In H4 (=−0.077, $t = 1.043$, $p > 0.05$,) improving factors have no statistically significant effect on sustainable construction waste management. As a result, H4 is rejected. Finally, in H5 (=0.766, $t = 12.133$, $p > 0.001$), H5 is accepted because policy-related factors have a statistically significant beneficial impact on sustainable construction waste management.

According to the mediation analysis, in H6 Policy-related factors did not mediate the relationship between current practice/generation and sustainable construction waste management ($\beta = -0.035$, $t = 0.584$, $p > 0.05$). While in H7, the mediation results showed that policy-related factors have a strong indirect positive effect on the relationship between improving factors and sustainable construction waste management ($\beta = 0.688$, $t = 8.254$, $p < 0.001$),as shown in Table 7. All these hypotheses have been shown in Figure 3.

Table 7. Indirect Effects.

Relationship		Indirect Effect		Bootstrapped Confidence Interval			Decision
		Path Coeff	*t*-Value	*t*-Value	95% LL	95% UL	
H6	CPG-PRF-SCWM	−0.035	0.584	0.561	−0.188	0.05	No mediation
H7	IFD-PRF-SCWM	0.688	8.254	0.000 ***	0.536	0.866	Full mediation

Note: *** = *** $p < 0.001$, LL: Lower level, UL: Upper level.

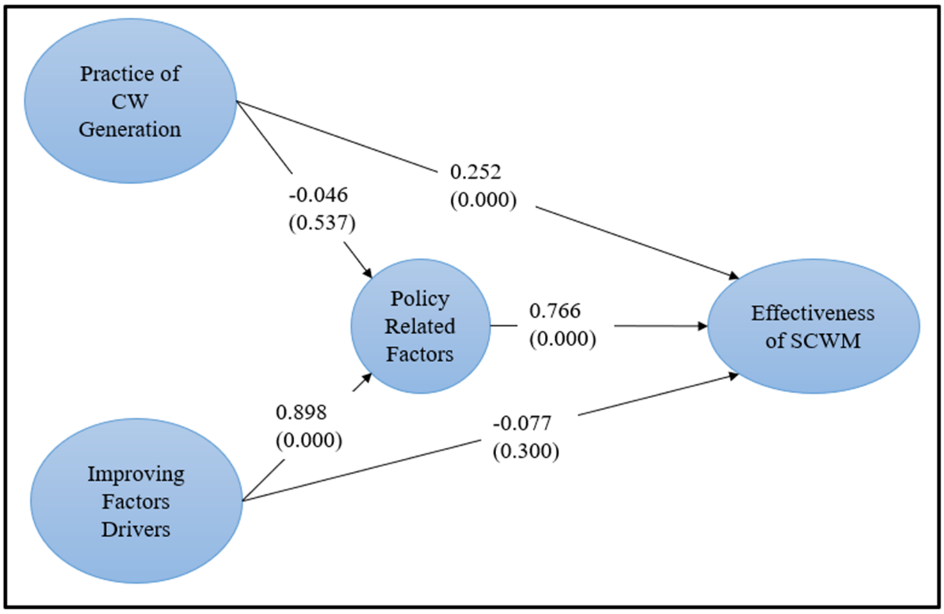

Figure 3. A structural equation modelling the main hypothesis.

4.4.2. Power of Exploratory of Model

The coefficient of determination (R^2), the impact of independent variables on latent dependent variables, was measured using one of the structural model parameters [103]. Hair Jr [104] indicated that resulting R^2 values of 0.19, 0.33, or 0.67 are considered low, moderate, or high, respectively. Furthermore, the adjusted R^2 values can be used to evaluate the quality of different models or to compare them in different scenarios. Table 8 shows the results, which reveal that the exogenous factors have much variety, whereas the endogenous variables have much variation. Which show that exogenous factors have a lot of diversity, but endogenous variables have a lot of variability.

Table 8. Associated *R* Square Adjusted and *R* Square.

Construct	*R* Square	*R* Square Adjusted	Variance Explained
Policy Related Factors	0.741	0.739	High
Sustainable Construction Waste Management	0.787	0.785	High

4.5. Effect Size (f^2)

The f^2 effect size measures the strength of each exogenous variable in explaining endogenous variables. If the f^2 value of a construct is between 0.02 and 0.14, it is considered to have a small effect; if the f^2 value is between 0.15 and 0.34, it is considered to have a medium effect; and if the f^2 value is greater than 0.35, it is considered to have a large effect. An f^2 value of less than 0.02 indicates that the construct has no impact on the endogenous construct [105]. The f^2 effect size of the constructs is shown in Table 9. The findings show that current practices/generation has little impact on policy-related factors but significantly impacts sustainable construction waste management. Improving variables have a tremendous impact on policy-related factors but have no effect on sustainable construction waste management. Finally, policy-related factors significantly impact the long-term management of construction waste.

Table 9. Predictive Relevance.

Construct	SSO	SSE	Q^2 (=1-SSE/SSO)
Policy Related Factors	4320	3031.281	0.298
Sustainable Construction Waste Management	6210	4985.28	0.197

5. Discussion

The sustainable construction waste factors were drawn from a variety of field-specific literature. Seven hypotheses were explored in this research, five of which showed significant correlations, though the rest used policy-related factors as a mediating input. However, Table 5 shows that the structure of current practices/generation constructs failed to predict the policy-related factors. Additionally, improving-factor constructs failed to predict sustainable construction waste management. With three directly statistically significant hypotheses (H2, H3, and H5), then, the results of this study revealed statistically insignificant direct hypotheses (H1 and H4). Construction waste management has measured current waste generation practices in Malaysia in terms of present practices and issues with disposal and monitoring, including a lack of competent employees to perform efficient trash collection and disposal procedures and the estimation of Malaysia's construction waste generation. The majority of contractors do not consistently use separation and recycling, waste recycling, reuse, or disposal. At all stages of construction, the sector is under increasing pressure to develop good working procedures. Based on the abovementioned findings, this study classifies effective contributing factors that affect C&DW management into four groups: a legislative framework for or sustainable C&DW management [106,107]; waste management Policy, industry policy, environmental, economic, and social factors; the C&DW project life cycle; and C&DW management tools that influence the C&DW stakeholder climate and project working environment. The attitudes of project stakeholders toward C&DW management have social, short-term, and long-term impacts on health and safety. Incentives to prevent illegal C&DW dumping significantly impact recycling plants and material inventories.

This study found that in H1, current practices/generation do not affect policy-elated factors ($\beta = -0.046$, $t = 0.619$, $p < 0.573$). This result is in line with the findings of earlier studies [108–110]. All of these studies reported that current practices/generation do not affect policy-related factors. Otherwise, according to hypothesis H2, current practises/generation have an impact on sustainable construction waste management ($\beta = 0.252$, $t = 4.878$, $p < 0.000$). This result is in line with prior research findings from various studies [111] that current waste generating practices significantly impact sustainable construction waste management. This finding also agrees with the findings by [39,112,113].

Improving factors have been assessed by proposing and investigating factors for improving waste management to mitigate the shortcomings of the waste management program. In hypothesis H3, according to the findings of this study, improving factors affect policy-related factors ($\beta = 0.898$, $t = 14.39$, $p < 0.000$). This result is consistent with previous findings reported in several prior studies [22,114]. All of these studies reported that improving factors have a significant impact on policy-related factors. Otherwise, this study found that in H4, policy-related factors do not affect sustainable construction waste management ($\beta = -0.077$, $t = 1.043$, $p < 0.3$). This finding is aligned with prior results reported in a previous study [115,116]. Therefore, all of these studies reported that improving factors do not affect sustainable construction waste management. The results of a previous study [117] support this result.

Policy-related factors are the most successful in stimulating sustainable construction. In addition, even when planning new construction waste management systems, sustainable construction waste management techniques are more results-oriented than ways that can drive progress. Further, the adoption of sustainable construction waste management can be aided by government policy in various ways, according to Shafii [118]. Research by Bamgbade [119] noted that several policies, such as government assistance, regulation, and standards, as well as the implementation of energy-efficiency labels in the construction industry in Malaysia, all help to broaden the industry. These policies and procedures can be utilised to create a waste management program These policies and approaches can be used to develop a waste management system that includes reduction, minimisation, reuse, recycling, recovery, and construction waste disposal. Several researchers have reported similar results [39,120–123], noting the influence of various sustainable waste management steps on government policy-related factors. Furthermore, ongoing study will help to establish sustainable construction waste reduction strategies and government regulations that support sustainable development goals. The community and nature can also be supported in various ways.

The importance of waste reduction has drawn the attention of many scientists and professionals, resulting in numerous research efforts. As a result, the integration of all C&DW tool contributions has been found important in reducing C&DW. This study divides C&DW management tools into three categories: information technology tools for C&DW management, C&DW management approaches, and C&DW management technologies [124]. For hypothesis H5, this study discovered that policy-related factors affect sustainable construction waste management ($\beta = 0.766$, $t = 12.133$, $p < 0.000$). These findings are consistent with research findings from several previous studies [22]. According to all of these studies, policy-related factors have a major impact on sustainable construction waste management. The outcome of [125,126] supported this finding. In the case of H6, there is an indirect effect; Preacher and Hayes [127] indicated that percent boot CI: (LL = −0.188, UL = 0.05) does straddle a 0 in between, which indicates there is no mediation. The statistical findings indicate that PRFs do not significantly mediate between factors. Besides, there is a statistically significant direct effect between CPG (IV) and SCWM (DV) ($\beta = 0.252$, $t = 4.878$, $p < 0.000$), as shown in Table 4.

Accordingly, policy-related factors do not mediate the relationship between CPG and SCWM; therefore, H6 is rejected. The study showed that policy-related Factors do not mediate the relationships between CPG (IV) and SCWM (DV) in Malaysia because having such a strategy minimises the pressures of governmental policies, and the factors are positively correlated. Government policies, such as regulatory and fiscal tools and plans and programs, have been proven to be the most important antecedents for encouraging enterprises to eco-innovate. This result is the same as the result of [128,129].

Likewise, in (H7), Preacher and Hayes [127] imply that percent boot CI: (LL = 0.536, UL = 0.866) There is no 0 between the two numbers, indicating a mediation. The statistical data show that PRFs have a significant moderating impact between factors. Additionally, nearby remains a statistically insignificant direct effect between IFD (IV) and SCWM (DV) ($\beta = -0.077$, $t = 1.043$, $p < 0.3$), as shown in Table 7. Accordingly, CPG mediates the relationship between IFD and SCWM, thus indicating that H7 is supported. According to the findings, policy-related factors mediate the relationships between work activities and driving performance amongst Malaysians by boosting plan reliability, reducing the number of stacks, and panelling the material handling distance. Contractors are discouraged from actively engaging because of their relationships with employees and unions, suppliers, and environmentally responsible construction procedures. According to Samari [130], government funding is the most successful in improving green construction because it is more results-oriented than other strategies for promoting sustainable construction waste management. Governments can also encourage the use of environmentally friendly construction waste management in a number of different ways. The research by Bamgbade [119] indicated that the Malaysian government might advance sustainable construction waste agendas through several policies, including cash rewards, law and standards, and building labelling with an energy efficiency rating. This process can develop into a waste management system that includes waste reduction, minimisation, reuse, recycling, recovery, and construction waste disposal. The aforementioned result has been reported by a number of researchers [39,120–123]. Government policy can help at many stages of sustainable waste management.

6. Conclusions

CWM generates more than 100 tonnes of construction material every year in Malaysia, causing significant environmental and social problems. Particularly since 2020, the amount has continued to rise at a rapid rate. According to the findings and discussion above, this paper looked at the mediating role of policy-related factors in the relationship between current practices/generation, improving factors, and sustainable construction waste management. The findings show that there is no significant relationship between current practices/generation and policy-related factors. However, current practices/generation was found to affect sustainable construction waste management significantly. Furthermore, improving factor drivers have been proven to significantly impact policy-related factors. However, improving factor drivers have not significantly affected sustainable construction waste management. Besides that, policy-related factors have been shown to meaningfully impact sustainable construction waste management. Moreover, this study established the mediating role of policy-related factors as an instrument that highlights the relationships among improving factors and sustainable construction waste Management. The study showed that policy-related factors have almost no influence on the relationship between current waste generation practises and sustainable construction waste management.

- This study offers a theoretical contribution by examining the significant positive mediating role of improving factors on policy-related factors that significantly affect sustainable construction waste management, thus enhancing the existing body of knowledge. It also makes a practical contribution by providing a strategic methodological approach to help management strengthen the performance of small businesses and ensure their long-term effectiveness.
- The model shows that the study findings reveal that exploratory power is considered sustainable, with R^2 values of 0.83 percent. Based on Figure 2 and Table 5 results, the findings of this investigation proved that all hypotheses were supported.
- According to the model, the CDW management model components may indicate ways to deal with construction waste more sustainably. Future research should focus on worldwide construction industry norms, waste management, and construction demolition trash.

6.1. Theoretical Contribution

This study will add to the amount of knowledge in the construction industry about waste management measures. One of the major impediments to developing efficient construction waste management strategies in Malaysia's metropolis was the lack of attention to waste management in the existing policy. Buildings are not designed to meet waste management needs due to a lack of attention, and contractors lack awareness of waste management. Due to the similarity of reduced reuse and recycling measures, stakeholders do not understand 3R CW management strategies. The issue in current systems has been identified. As a result, the only way construction sites can effectively deal with the large amount of trash generated is for clients and construction experts to be more effective and efficient in SCWM. This finding contributes to the body of knowledge in the literature to be a foundation for future researchers interested in construction waste management strategies to investigate how other possible variables impact construction waste management strategies.

6.2. Practical Contribution

Those components of the model are considered as a basis for guiding better sustainable construction. First, the model could assist owners and construction professionals in reducing the waste backlog and improving the environmental safety of workers and construction infrastructure. These findings may also allow building owners and building experts to minimise the future issue of non-materials and high costs. Second, the CWM model could serve as a reference for contractors, managers, and other construction professionals on how to collect, handle, and integrate key waste management processes into residential construction projects. The findings may benefit many construction industries, particularly those in developing countries with extensive manufacturing waste but very limited knowledge. They could help small and medium-sized construction companies become more environmentally conscious and develop practical and sustainable solutions. Third, the findings enable project leadership teams to prioritise their construction projects' workforce, materials, equipment, and time during the planning phase, reducing waste and boosting efficiency and sustainability. Finally, this study has set the groundwork for better standards, which could be important for evaluating and reducing waste. Construction waste prevention is critical, as it avoids design flaws that contribute to waste production. Construction waste is primarily detected through traditional construction techniques.

Despite the study's achievements, the limitations associated with the data collection approach are well-acknowledged. The data for this study were gathered from worker construction professionals to understand their perspectives on the study variables. However, this did not replicate a deep understanding of the study issues from all parties involved. Hence, we recommend that a qualitative method be applied to categorise additional elements linking to sustainable construction waste management from supervisors' and administrators' perspectives in Malaysian construction projects to generate valuable results. Furthermore, the data for this study were collected in Malaysia and may have limited generalizability; consequently, it is preferred that data collection be expanded to include numerous nations.

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References

1. Singh, S.; Rekha, P.; Surya, M. Utilization of Linz–Donawitz slag from steel industry for waste minimization. *J. Mater. Cycles Waste Manag.* **2020**, *22*, 611–627. [CrossRef]
2. Yaseen, Z.M.; Ali, Z.H.; Salih, S.Q.; Al-Ansari, N.J.S. Prediction of risk delay in construction projects using a hybrid artificial intelligence model. *Sustainability* **2020**, *12*, 1514. [CrossRef]
3. Ghisellini, P.; Ji, X.; Liu, G.; Ulgiati, S. Evaluating the transition towards cleaner production in the construction and demolition sector of China: A review. *J. Clean. Prod.* **2018**, *195*, 418–434. [CrossRef]
4. Maceika, A.; Bugajev, A.; Šostak, O.R. The Modelling of Roof Installation Projects Using Decision Trees and the AHP Method. *Sustainability* **2020**, *12*, 59. [CrossRef]

5. Akhtar, A.; Sarmah, A.K. Construction and demolition waste generation and properties of recycled aggregate concrete: A global perspective. *J. Clean. Prod.* **2018**, *186*, 262–281. [CrossRef]
6. Bao, Z.; Lu, W.; Chi, B.; Yuan, H.; Hao, J. Procurement innovation for a circular economy of construction and demolition waste: Lessons learnt from Suzhou, China. *Waste Manag.* **2019**, *99*, 12–21. [CrossRef] [PubMed]
7. Alattyih, W.; Haider, H.; Boussabaine, H. Development of Value Creation Drivers for Sustainable Design of Green Buildings in Saudi Arabia. *Sustainability* **2019**, *11*, 5867. [CrossRef]
8. Wong, K.D.; Fan, Q. Building information modelling (BIM) for sustainable building design. *Facilities* **2013**, *31*, 138–157. [CrossRef]
9. Wang, J.; Yu, B.; Tam, V.W.; Li, J.; Xu, X. Critical factors affecting willingness of design units towards construction waste minimization: An empirical study in Shenzhen, China. *J. Clean. Prod.* **2019**, *221*, 526–535. [CrossRef]
10. Bakchan, A.; Faust, K.M. Construction waste generation estimates of institutional building projects: Leveraging waste hauling tickets. *Waste Manag.* **2019**, *87*, 301–312. [CrossRef]
11. Won, J.; Cheng, J.C.; Lee, G. Quantification of construction waste prevented by BIM-based design validation: Case studies in South Korea. *Waste Manag.* **2016**, *49*, 170–180. [CrossRef]
12. Won, J.; Cheng, J.C. Identifying potential opportunities of building information modeling for construction and demolition waste management and minimization. *Autom. Constr.* **2017**, *79*, 3–18. [CrossRef]
13. Kareem, J.A.H. The impact of intelligent manufacturing elements on product design towards reducing production waste. *Int. J. Eng. Bus. Manag.* **2019**, *11*, 1847979019863955.
14. Tetali, S. Assessment of cool roof technology for its energy performance in buildings. *Int. Inst. Inf. Technol.* **2011**. Available online: https://www.semanticscholar.org/paper/Assessment-of-cool-roof-technology-for-its-energyTetali/5596f8ac0258fabc62c939343dd964da6fcc6262 (accessed on 29 November 2021).
15. Jain, K.N.; Tirupathi, R.; Palabindala, V. Coronavirus: Managing a Resource Crunch and Ethical Challenges. 2020. Available online: https://cdn.mdedge.com/files/s3fs-public/hosp_may2020_lores_digital_0.pdf (accessed on 29 November 2021).
16. Cohen, B. Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technol. Soc.* **2006**, *28*, 63–80. [CrossRef]
17. McMichael, A.J. The urban environment and health in a world of increasing globalization: Issues for developing countries. *Bull. World Heal. Organ.* **2000**, *78*, 1117–1126.
18. Kneifel, J. Buildings, Beyond the code: Energy, carbon, and cost savings using conventional technologies. *Energy Build.* **2011**, *43*, 951–959. [CrossRef]
19. Loonen, R.; de Klijn-Chevalerias, M.; Hensen, J. Opportunities and pitfalls of using building performance simulation in explorative R&D contexts. *J. Build. Perform. Simul.* **2019**, *12*, 272–288.
20. Kartam, N.; Al-Mutairi, N.; Al-Ghusain, I.; Al-Humoud, J. Environmental management of construction and demolition waste in Kuwait. *Waste Manag.* **2004**, *24*, 1049–1059. [CrossRef] [PubMed]
21. Zhao, W.; Leeftink, R.; Rotter, V. Evaluation of the economic feasibility for the recycling of construction and demolition waste in China—The case of Chongqing. *Resour. Conserv. Recycl.* **2010**, *54*, 377–389. [CrossRef]
22. Mohammed, M.; Shafiq, N.; Elmansoury, A.; Muhammad, A. A Confirmatory Framework PLS-SEM for Construction Waste Reduction as Part of Achieving Sustainable Development Goals of a Building. 2021. Available online: https://www.preprints.org/manuscript/202107.0409/v1 (accessed on 20 July 2021).
23. Huang, B.; Wang, X.; Kua, H.; Geng, Y.; Bleischwitz, R.; Ren, J. Construction and demolition waste management in China through the 3R principle. *Resour. Conserv. Recycl.* **2018**, *129*, 36–44. [CrossRef]
24. Foster, G. Conservation and Recycling, Circular economy strategies for adaptive reuse of cultural heritage buildings to reduce environmental impacts. *Resour. Conserv. Recycl.* **2020**, *152*, 104507. [CrossRef]
25. Milios, L.; Beqiri, B.; Whalen, K.A.; Jelonek, S.H. Sailing towards a circular economy: Conditions for increased reuse and remanufacturing in the Scandinavian maritime sector. *J. Clean. Prod.* **2019**, *225*, 227–235. [CrossRef]
26. Liu, H.; Long, H.; Li, X. Identification of critical factors in construction and demolition waste recycling by the grey-DEMATEL approach: A Chinese perspective. *Environ. Sci. Pollut. Res.* **2020**, *27*, 8507–8525. [CrossRef] [PubMed]
27. Yuan, H. A SWOT analysis of successful construction waste management. *J. Clean. Prod.* **2013**, *39*, 1–8. [CrossRef]
28. Umar, U.A.; Shafiq, N.; Ahmad, F.A. A case study on the effective implementation of the reuse and recycling of construction & demolition waste management practices in Malaysia. *Ain Shams Eng. J.* **2021**, *12*, 283–291.
29. Ferronato, N.; Rada, E.C.; Portillo, M.A.G.; Cioca, L.I.; Ragazzi, M.; Torretta, V. Introduction of the circular economy within developing regions: A comparative analysis of advantages and opportunities for waste valorization. *J. Environ. Manag.* **2019**, *230*, 366–378. [CrossRef] [PubMed]
30. Kovanda, J. Conservation and Recycling, Incorporation of recycling flows into economy-wide material flow accounting and analysis: A case study for the Czech Republic. *Resour. Conserv. Recycl.* **2014**, *92*, 78–84. [CrossRef]
31. Forbes, H.L.; Ahmed, S.M. *Modern Construction: Lean Project Delivery and Integrated Practices*; CRC press, Taylor & Francis group: Boca Raton, FL, USA, 2010.
32. Bradford-Hartke, Z.; Lane, J.; Lant, P.; Leslie, G. Environmental benefits and burdens of phosphorus recovery from municipal wastewater. *Environ. Sci. Technol.* **2015**, *49*, 8611–8622. [CrossRef]
33. Mellado, F.; Lou, E.C.W. Building information modelling, lean and sustainability: An integration framework to promote performance improvements in the construction industry. *Sustain. Cities Soc.* **2020**, *61*, 102355. [CrossRef]

34. Pheng, L.S.; Chuan, Q.T. Environmental factors and work performance of project managers in the construction industry. *Int. J. Proj. Manag.* **2006**, *24*, 24–37. [CrossRef]
35. Kaasa, A. Effects of different dimensions of social capital on innovative activity: Evidence from Europe at the regional level. *Technovation* **2009**, *29*, 218–233. [CrossRef]
36. Kabirifar, K.; Mojtahedi, M.; Wang, C.; Tam, V.W. Construction and demolition waste management contributing factors coupled with reduce, reuse, and recycle strategies for effective waste management: A review. *J. Clean. Prod.* **2020**, *263*, 121265. [CrossRef]
37. Ogunsanmi, O. Management, Effects of procurement related factors on construction project performance in Nigeria. *Ethiop. J. Environ. Stud. Manag.* **2013**, *6*, 215–222.
38. Oke, A.E.; Kineber, A.F.; Albukhari, I.; Othman, I.; Kingsley, C. Assessment of Cloud Computing Success Factors for Sustainable Construction Industry: The Case of Nigeria. *Buildings* **2021**, *11*, 36. [CrossRef]
39. Nagapan, S.; Rahman, I.A.; Asmi, A.; Memon, A.H.; Latif, I. Issues on construction waste: The need for sustainable waste management. In Proceedings of the 2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER), Kota Kinabalu, Malaysia, 3–4 December 2012.
40. Li, R.Y.M.; Du, H. *Sustainable Construction Waste Management in Australia: A Motivation Perspective, in Construction Safety and Waste Management*; Springer: Berlin/Heidelberg, Germany, 2015; pp. 1–30.
41. Ouda, O.; Peterson, H.; Rehan, M.; Sadef, Y.; Alghazo, J.; Nizami, A.J.W.; Valorization, B. A case study of sustainable construction waste management in Saudi Arabia. *Waste Biomass-Valorization* **2018**, *9*, 2541–2555. [CrossRef]
42. Sfakianaki, E. Critical success factors for sustainable construction: A literature review. *Manag. Environ. Qual. Int. J.* **2019**, *30*, 176–196. [CrossRef]
43. Herbsman, Z.; Ellis, R. Research of factors influencing construction productivity. *Constr. Manag. Econ.* **1990**, *8*, 49–61. [CrossRef]
44. Kometa, S.; Olomolaiye, P.O. Evaluation of factors influencing construction clients' decision to build. *J. Manag. Eng.* **1997**, *13*, 77–86. [CrossRef]
45. Bernardini, O.; Galli, R. Dematerialization: Long-term trends in the intensity of use of materials and energy. *Futures* **1993**, *25*, 431–448. [CrossRef]
46. Kabir, Z.; Khan, I. Environmental impact assessment of waste to energy projects in developing countries: General guidelines in the context of Bangladesh. *Assessments* **2020**, *37*, 100619. [CrossRef]
47. Esa, M.R.; Halog, A.; Rigamonti, L. Strategies for minimizing construction and demolition wastes in Malaysia. *Resour. Conserv. Recycl.* **2017**, *120*, 219–229. [CrossRef]
48. Saad, S.; Alaloul, W.S.; Ammad, S.; Altaf, M.; Qureshi, A.H. Identification of critical success factors for the adoption of Industrialized Building System (IBS) in Malaysian construction industry. *Ain Shams Eng. J.* **2021**, *13*, 1–13. [CrossRef]
49. Bajjou, M.S.; Chafi, A. Identifying and managing critical waste factors for lean construction projects. *Eng. Manag. J.* **2020**, *32*, 2–13. [CrossRef]
50. Liu, J.; Yi, Y.; Wang, X. Exploring factors influencing construction waste reduction: A structural equation modeling approach. *J. Clean. Prod.* **2020**, *276*, 123185. [CrossRef]
51. Nagapan, S.; Rahman, I.A.; Asmi, A. A review of construction waste cause factors. In Proceedings of the Asian Conference on Real Estate: Sustainable Growth Managing Challenges (ACRE), Johor Bahru, Malaysia, 3–5 October 2011; Available online: https://www.researchgate.net/publication/258224434_A_Review_of_Construction_Waste_Cause_Factors (accessed on 29 November 2021).
52. Umeokafor, N. An investigation into public and private clients' attitudes, commitment and impact on construction health and safety in Nigeria. *Eng. Constr. Archit. Manag.* **2018**, *25*, 798–815. [CrossRef]
53. Senaratne, S.; Hewamanage, P.R. The role of team leadership in achieving LEED certification in a green building project. *Built Environ. Proj. Asset Manag.* **2015**, *5*, 170–183. [CrossRef]
54. Bostan, I. Considerations on insufficient legal regulation of special allocations made by the central executive authority. *J. Public Adm. Financ. Law* **2016**, *9*, 119–124.
55. Saleem, A.; Bekele, A.; Fitzpatrick, M.B.; Mahmoud, E.A.; Lin, A.W.; Velasco, H.E.; Rashed, M. Knowledge and awareness of cervical cancer in Southwestern Ethiopia is lacking: A descriptive analysis. *PLoS ONE* **2019**, *14*, e0215117. [CrossRef]
56. Ann, T.; Poon, C.; Wong, A.; Yip, R.; Jaillon, L. Impact of construction waste disposal charging scheme on work practices at construction sites in Hong Kong. *Waste Manag.* **2013**, *33*, 138–146.
57. Marshall, R.E.; Farahbakhsh, K. Systems approaches to integrated solid waste management in developing countries. *Waste Manag.* **2013**, *33*, 988–1003. [CrossRef]
58. Sekhar, P.R.; Reddy, E.S.; Anjireddy, M. Environmental Impacts on Soil Quality with Special Reference to Pharma Industry Using Remote Sensing and GIS. *CAFET-INNOVA. Tech. Soc.* **2010**, *3*, 389–397.
59. Bamgbade, J.A.; Kamaruddeen, A.M.; Nawi, M. Malaysian construction firms' social sustainability via organizational innovativeness and government support: The mediating role of market culture. *J. Clean. Prod.* **2017**, *154*, 114–124. [CrossRef]
60. Fapohunda, J.A. *Operational Framework for Optimal Utilisation of Construction Resources during the Production Process*; Sheffield Hallam University: Sheffield, UK, 2009.
61. Chen, Y.; Okudan, G.E.; Riley, D.R. Sustainable performance criteria for construction method selection in concrete buildings. *Autom. Constr.* **2010**, *19*, 235–244. [CrossRef]

62. Sepasgozar, S.M.; Hui, F.K.P.; Shirowzhan, S.; Foroozanfar, M.; Yang, L.; Aye, L. Lean practices using building information modeling (Bim) and digital twinning for sustainable construction. *Sustainability* **2021**, *13*, 161. [CrossRef]
63. Umar, U.A.; Shafiq, N.; Malakahmad, A.; Nuruddin, M.F.; Khamidi, M.F. A review on adoption of novel techniques in construction waste management and policy. *Cycles Waste Manag.* **2017**, *19*, 1361–1373. [CrossRef]
64. Duić, N.; Urbaniec, K.; Huisingh, D. Components and structures of the pillars of sustainability. *J. Clean. Prod.* **2015**, *88*, 1–12. [CrossRef]
65. Ali, A. Development of a Framework for Sustainable Construction Waste Management. A Case Study of Three Major Libyan Cities. Ph.D. Thesis, University of Wolverhampton, Wolverhampton, UK, 2018.
66. Grosz, M. *Addressing the Waste Trade in the Context Of Sustainability, in Sustainable Waste Trade under WTO Law*; Brill Nijhoff: Leiden, Belgium, 2011; pp. 277–327.
67. Gregersen, H.M.; Ffolliott, P.F.; Brooks, K.N. *Integrated Watershed Management: Connecting People to Their Land and Water*; CABI: Oxfordshire, UK, 2007.
68. Freda, I. Chapter ten ecopolitical action on the desert of the real. In *Culture, Environment and Ecopolitics*; Cambridge scholars publishing: Cambridge, UK, 2020.
69. Kot, S.; Haque, A.U.; Kozlovski, E. Strategic SCM's mediating effect on the sustainable operations: Multinational perspective. *Organizacija* **2019**, *52*, 219–235. [CrossRef]
70. Mohammed, M.; Shafiq, N.; Elmansoury, A.; Al-Mekhlafi, A.-B.A.; Rached, E.F.; Zawawi, N.A.; Haruna, A.; Rafindadi, A.D.; Ibrahim, M.B. Modeling of 3R (Reduce, Reuse and Recycle) for Sustainable Construction Waste Reduction: A Partial Least Squares Structural Equation Modeling (PLS-SEM). *Sustainability* **2021**, *13*, 10660. [CrossRef]
71. Ghafourian, K.; Kabirifar, K.; Mahdiyar, A.; Yazdani, M.; Ismail, S.; Tam, V.W. A Synthesis of Express Analytic Hierarchy Process (EAHP) and Partial Least Squares-Structural Equations Modeling (PLS-SEM) for Sustainable Construction and Demolition Waste Management Assessment: The Case of Malaysia. *Recycling* **2021**, *6*, 73. [CrossRef]
72. Sekaran, U.; Bougie, R. *Research Methods for Business: A Skill Building Approach*; John Wiley & Sons: Hoboken, NJ, USA, 2016.
73. Ngai, E.; Cheng, T.; Ho, S.S. Critical success factors of web-based supply-chain management systems: An exploratory study. *Prod. Plan. Control.* **2004**, *15*, 622–630. [CrossRef]
74. Al-Mekhlafi, A.-B.A.; Isha, A.S.N.; Naji, G.M.A. The relationship between fatigue and driving performance: A review and directions for future research. *J. Crit. Rev.* **2020**, *7*, 134–141.
75. Al-Mekhlafi, A.-B.A.; Isha, A.S.N.; Sabir, A.A.; Naji, G.M.A.; Ajmal, M.; Al-Harasi, A.H. Fatigue Assessment of Oil and Gas Tanker Drivers: Psychomotor Vigilance Test (PVT-192). *Solid State Technol.* **2020**, *63*, 4256–4262.
76. Mangione, S.; Chakraborti, C.; Staltari, G.; Harrison, R.; Tunkel, A.R.; Liou, K.T.; Cerceo, E.; Voeller, M.; Bedwell, W.L.; Fletcher, K. Medical students' exposure to the humanities correlates with positive personal qualities and reduced burnout: A multi-institutional US survey. *J. Gen. Intern. Med.* **2018**, *33*, 628–634. [CrossRef]
77. Kucukvar, M.; Egilmez, G.; Tatari, O. Life cycle assessment and optimization-based decision analysis of construction waste recycling for a LEED-certified university building. *Sustainability* **2016**, *8*, 89. [CrossRef]
78. Kline, R.B. *Principles and Practice of Structural Equation Modeling*; Guilford publications: New York, NY, USA, 2015.
79. Yin, R.K. *Case Study Research: Design and Methods*, 4th ed.; Sage Publications: Thousand Oaks, CA, USA, 2009.
80. Patricia Suriakumari, F.A.D. *Factors Influencing the Perceived Timeline to Adopt XBRL Amongst Public Listed Companies in Malaysia*; Universiti Utara Malaysia: Kedah, Malaysia, 2018.
81. Nachtigall, C.; Kroehne, U.; Funke, F.; Steyer, R. Pros and cons of structural equation modeling. *Methods Psychol. Res. Online* **2003**, *8*, 1–22.
82. Nayernia, A. A Review of Structural Equation Modeling (SEM) and its Application in Language Education Research. *Mod. J. Appl. Linguist.* **2013**, *5*, 172–179.
83. Yuan, K.H.; Chan, W.; Bentler, P.M. Robust transformation with applications to structural equation modelling. *Br. J. Math. Stat. Psychol.* **2000**, *53*, 31–50. [CrossRef] [PubMed]
84. Singh, V.; Kumar, A.; Singh, T. Impact of TQM on organisational performance: The case of Indian manufacturing and service industry. *Oper. Res. Perspect.* **2018**, *5*, 199–217. [CrossRef]
85. Ali, B.; Zahoor, H.; Nasir, A.R.; Maqsoom, A.; Khan, R.W.A.; Mazher, K.M. BIM-based claims management system: A centralized information repository for extension of time claims. *Autom. Constr.* **2020**, *110*, 102937. [CrossRef]
86. Chileshe, N.; Hosseini, M.R.; Jepson, J. Critical barriers to implementing risk assessment and management practices (RAMP) in the Iranian construction sector. *J. Constr. Dev. Ctries.* **2016**, *21*, 81. [CrossRef]
87. Lahiri, K.; Stekler, H.O.; Young, P. Monthly output index for the US transportation sector. *J. Transp. Stat.* **2002**, *6*, 1–27.
88. Al-Mekhlafi, A.-B.A.; Isha, A.S.N.; Chileshe, N.; Abdulrab, M.; Kineber, A.F.; Ajmal, M. Impact of Safety Culture Implementation on Driving Performance among Oil and Gas Tanker Drivers: A Partial Least Squares Structural Equation Modelling (PLS-SEM) Approach. *Sustainability* **2021**, *13*, 8886. [CrossRef]
89. Al-Mekhlafi, A.-B.A.; Isha, A.S.N.; Chileshe, N.; Abdulrab, M.; Saeed, A.A.H.; Kineber, A.F. Modelling the Relationship between the Nature of Work Factors and Driving Performance Mediating by Role of Fatigue. *Int. J. Environ. Res. Public Health* **2021**, *18*, 6752. [CrossRef] [PubMed]
90. Li, J.; Ding, Z.; Mi, X.; Wang, J. Conservation, and Recycling, A model for estimating construction waste generation index for building project in China. *Resour. Conserv. Recycl.* **2013**, *74*, 20–26. [CrossRef]

91. Khahro, S.H.; Memon, A.H.; Memon, N.A.; Arsal, A.; Ali, T.H. Modeling the Factors Enhancing the Implementation of Green Procurement in the Pakistani Construction Industry. *Sustainability* **2021**, *13*, 7248. [CrossRef]
92. Marzouk, M.; Azab, S. conservation, and recycling, Environmental and economic impact assessment of construction and demolition waste disposal using system dynamics. *Resour. Conserv. Recycl.* **2014**, *82*, 41–49. [CrossRef]
93. Hair, J.F.; Anderson, R.E.; Babin, B.J.; Black, W.C. *Multivariate Data Analysis: A Global Perspective*; Pearson: Upper Saddle River, NJ, USA, 2010; Volume 7.
94. Ringle, C.M.; Sarstedt, M.; Straub, D.W. Editor's comments: A critical look at the use of PLS-SEM in "MIS Quarterly". *MIS Q.* **2012**, *36*, 3–14. [CrossRef]
95. Henseler, J. Bridging design and behavioral research with variance-based structural equation modeling. *J. Advert.* **2017**, *46*, 178–192. [CrossRef]
96. Davadas, S.D.; Lay, Y.F. Factors affecting students' attitude toward mathematics: A structural equation modeling approach. *Eurasia J. Math. Sci. Technol. Educ.* **2017**, *14*, 517–529.
97. Wong, K.K.-K. Mediation analysis, categorical moderation analysis, and higher-order constructs modeling in Partial Least Squares Structural Equation Modeling (PLS-SEM): A B2B Example using SmartPLS. *Mark. Bull.* **2016**, *26*, 1–22.
98. Henseler, J.; Sarstedt, M. Goodness-of-fit indices for partial least squares path modeling. *Comput. Stat.* **2013**, *28*, 565–580. [CrossRef]
99. Al Mansoori, F.T.; Rahman, I.A.; Kasim, R. Structural Relationship of Factors Affecting the Performance of Oil & Gas Company: Case Study of Adnoc. *Int. J. Sustain. Constr. Eng. Technol.* **2020**, *11*, 140–149.
100. Adabre, M.A.; Chan, A.P.C. Modeling the impact of barriers on sustainable housing in developing countries. *J. Urban Plan. Dev.* **2021**, *147*, 05020032. [CrossRef]
101. Epure, E.V.; Compagno, D.; Salinesi, C.; Deneckere, R.; Bajec, M.; Žitnik, S. Process models of interrelated speech intentions from online health-related conversations. *Artif. Intell. Med.* **2018**, *91*, 23–38. [CrossRef]
102. Ab Hamid, M.; Sami, W.; Sidek, M.M. Discriminant validity assessment: Use of Fornell & Larcker criterion versus HTMT criterion. *J. Phys. Conf. Ser.* **2017**, *890*, 120–163.
103. Hair, J.F., Jr.; Sarstedt, M.; Hopkins, L.; Kuppelwieser, V.G. Partial least squares structural equation modeling (PLS-SEM): An emerging tool in business research. *Eur. Bus. Rev.* **2014**, *26*, 106–121. [CrossRef]
104. Hair, J.F., Jr.; Matthews, L.M.; Matthews, R.L.; Sarstedt, M. PLS-SEM or CB-SEM: Updated guidelines on which method to use. *Int. J. Multivar. Data Anal.* **2017**, *1*, 107–123. [CrossRef]
105. Janadari, M.; Ramalu, S.S.; Wei, C. Evaluation of measurment and structural model of the reflective model constructs in PLS–SEM. In Proceedings of the Conference: The Sixth (6th) International Symposium of South Eastern University of Sri LankaAt: South Eastern University of Sri Lanka, Oluvil, Sri Lanka, 20–21 December 2016.
106. Nikmehr, B.; Hosseini, M.R.; Rameezdeen, R.; Chileshe, N.; Ghoddousi, P.; Arashpour, M. An integrated model for factors affecting construction and demolition waste management in Iran. *Eng. Constr. Arch. Manag.* **2017**, *24*, 1246–1268. [CrossRef]
107. Estokova, A.; Samesova, D. Sustainable Building Materials and Life Cycle Assessment. *Sustainability.* **2021**, *13*, 2012. [CrossRef]
108. Bhatt, G.; Emdad, A.; Roberts, N.; Grover, V. Building and leveraging information in dynamic environments: The role of IT infrastructure flexibility as enabler of organizational responsiveness and competitive advantage. *Inf. Manag.* **2010**, *47*, 341–349. [CrossRef]
109. Mohammadi, M.; Jolai, F.; Tavakkoli-Moghaddam, R. Solving a new stochastic multi-mode p-hub covering location problem considering risk by a novel multi-objective algorithm. *Appl. Math. Model.* **2013**, *37*, 10053–10073. [CrossRef]
110. Ramli, A.; Zain, R.M.; Zain, M.Z.M.; Rahman, A.A.A. Environmental Factors and Academic Performance: The Mediating Effect of Quality of Life, in The Importance of New Technologies and Entrepreneurship in Business Development. In *The Context of Economic Diversity in Developing Countries*; Springer: New York, NY, USA, 2021; pp. 2082–2105.
111. Chan, Y.E.; Sabherwal, R.; Thatcher, J. Antecedents and outcomes of strategic IS alignment: An empirical investigation. *IEEE Trans. Eng. Manag.* **2006**, *53*, 27–47. [CrossRef]
112. Hoang, N.H.; Ishigaki, T.; Kubota, R.; Yamada, M.; Kawamoto, K.K. A review of construction and demolition waste management in Southeast Asia. *J. Mater. Cycles Waste Manag.* **2020**, *22*, 315–325. [CrossRef]
113. Sebastian, R.; Louis, J.J.R.; Reviews, S.E. Understanding waste management at airports: A study on current practices and challenges based on literature review. *Renew. Sustain. Energy Rev.* **2021**, *147*, 111229. [CrossRef]
114. Al-Tit, A.A. E-commerce drivers and barriers and their impact on e-customer loyalty in small and medium-sized enterprises (SMES). *Verslas Teor. Ir Prakt.* **2020**, *21*, 146–157. [CrossRef]
115. Kumar, A.; Moktadir, M.A.; Khan, S.A.R.; Garza-Reyes, J.A.; Tyagi, M.; Kazançoğlu, Y. Conservation, and Recycling, Behavioral factors on the adoption of sustainable supply chain practices. *Resour. Conserv. Recycl.* **2020**, *158*, 104818. [CrossRef]
116. Yadav, H.; Soni, U.; Kumar, G. Analysing Challenges to Smart Waste Management for a Sustainable Circular Economy in Developing Countries: A Fuzzy Dematel Study. Available online: https://assets.researchsquare.com/files/rs-263855/v1_covered.pdf?c=1636611444 (accessed on 29 November 2021).
117. Chua, M.H. Home renovation waste upon change of ownership: A Coasian way of addressing an urban externality. *Waste Manag.* **2021**, *119*, 145–151. [CrossRef]

118. Shafii, F.; Ali, Z.A.; Othman, M.Z. Achieving sustainable construction in the developing countries of Southeast Asia. In Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006), Kuala Lumpur, Malaysia, 5–6 September 2006.
119. Bamgbade, J.A.; Kamaruddeen, A.M.; Nawi, M.N. Factors influencing sustainable construction among construction firms in Malaysia: A preliminary study using PLS-SEM. *Rev. Tec. De La Fac. De Ing. Univ. Del Zulia* **2015**, *38*, 132–142.
120. Jingkuang, L.; Yousong, W. Establishment and application of performance assessment model of waste management in architectural engineering projects in China. *Syst. Eng. Procedia* **2011**, *1*, 147–155. [CrossRef]
121. Manowong, E. Investigating factors influencing construction waste management efforts in developing countries: An experience from Thailand. *Waste Manag. Res.* **2012**, *30*, 56–71. [CrossRef] [PubMed]
122. Akadiri, P.O.; Fadiya, O.O. Empirical analysis of the determinants of environmentally sustainable practices in the UK construction industry. *Constr. Innov.* **2013**, *13*, 352–373. [CrossRef]
123. Yeheyis, M.; Hewage, K.; Alam, M.S.; Eskicioglu, C.; Sadiq, R. An overview of construction and demolition waste management in Canada: A lifecycle analysis approach to sustainability. *Clean Technol. Environ. Policy* **2013**, *15*, 81–91. [CrossRef]
124. Onubi, H.O.; Yusof, N.A.; Hassan, A.S. Design, and Technology, Adopting green construction practices: Health and safety implications. *J. Eng. Des. Technol.* **2019**, *18*, 635–652.
125. Colangelo, F.; Forcina, A.; Farina, I.; Petrillo, A. Life cycle assessment (LCA) of different kinds of concrete containing waste for sustainable construction. *Buildings* **2018**, *8*, 70. [CrossRef]
126. Spišáková, M.; Mésároš, P.; Mandičák, T. Construction Waste Audit in the Framework of Sustainable Waste Management in Construction Projects—Case Study. *Buildings* **2021**, *11*, 61. [CrossRef]
127. Preacher, K.J.; Hayes, A.F. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behav. Res. Methods* **2008**, *40*, 879–891. [CrossRef] [PubMed]
128. Paillé, P.; Boiral, O.; Chen, Y. Linking environmental management practices and organizational citizenship behaviour for the environment: A social exchange perspective. *Int. J. Hum. Resour. Manag.* **2013**, *24*, 3552–3575. [CrossRef]
129. Hazarika, N.; Zhang, X. Factors that drive and sustain eco-innovation in the construction industry: The case of Hong Kong. *J. Clean. Prod.* **2019**, *238*, 117816. [CrossRef]
130. Samari, M.; Godrati, N.; Esmaeilifar, R.; Olfat, P.; Shafiei, M.W.M. The investigation of the barriers in developing green building in Malaysia. *Mod. Appl. Sci.* **2013**, *7*, 1–10. [CrossRef]