sustainability

Article

Analysis of the Underlying Causes of Waste Generation in Indonesia's Construction Industry

Heni Fitriani [1,*], Saheed Ajayi [2] and Sunkuk Kim [3]

[1] Department of Civil Engineering, Faculty of Engineering, Universitas Sriwijaya, Inderalaya, Ogan Ilir 30662, Indonesia
[2] School of Built Environment, Engineering and Computing, Leeds Beckett University, Leeds LS2 8AG, UK
[3] Department of Architectural Engineering, Kyung Hee University, Yongin-si 17104, Gyeonggi-do, Republic of Korea
* Correspondence: heni.fitriani@unsri.ac.id; Tel.: +62-711-580-139

Abstract: The construction industry produces enormous volumes of construction waste that have a negative influence on the environment. This study examines the underlying causes of waste generation in the Indonesian construction industry based on professional perspectives. This study used a questionnaire as a research instrument and examined the data with reliability and exploratory factor analysis. Based on the analysis, there are eight underlying causes that contribute to the generation of construction waste in the Indonesian construction sector. The five most significant underlying causes of waste generation that obstruct sustainable practices include waste-inducing site and human resource management approaches, inadequate collaboration and support among stakeholders, equipment management, material logistics management, and poor working environments. As a result, it is crucial for Indonesian experts to pay attention to the factors that contribute to waste generation in order to lessen its negative effects on the environment and promote sustainable practices.

Keywords: causes of waste; construction waste; Indonesia; environment; factor analysis

check for updates

Citation: Fitriani, H.; Ajayi, S.; Kim, S. Analysis of the Underlying Causes of Waste Generation in Indonesia's Construction Industry. *Sustainability* **2023**, *15*, 409. https://doi.org/10.3390/su15010409

Academic Editor: Antonio Caggiano

Received: 30 October 2022
Revised: 19 December 2022
Accepted: 22 December 2022
Published: 27 December 2022

1. Introduction

Notwithstanding that the construction industry plays a significant role in global development through infrastructural development, there are also some negative aspects to the role of the construction industry, such as consuming a lot of resources [1] and engendering a great deal of waste, thus causing environmental degradation [2]. The rapid growth of infrastructure has led to a boom in construction activities, consequently resulting in the generation of a huge volume of waste. Construction waste has become a major global challenge to sustainable development. In Ireland, the C&D industry produced 8.2 million tonnes of waste in 2020 [3]. Likewise, the volume of waste generated by construction and demolition in the USA was approximately 600 million tons in 2018, which increased significantly by 342% from 1999 to 2018, and it is projected to reach a total of 2.2 billion tons by 2025 [4]. Similarly, construction projects in Malaysia generated approximately 271,948 tons of construction and demolition waste from all states in this country [5]. The statistics across many nations show similar trends, suggesting negative environmental activities associated with the growth of the global construction sector.

Construction and demolition waste refers to leftover materials at the construction site, leftover resources produced as a result of construction activities, or debris removed to pave the way for construction activities that are discarded. While waste is supposed to be material with no remaining value, as opined by Nagapan et al. [6], poor waste management approaches imply that even materials with some residual value sometimes end up in landfills. According to Phillips [7], approximately 30% of materials at construction sites often end up as waste. This has huge environmental and financial implications, especially since up to 50% of the total project cost is associated with material costs [8].

There have been a large number of studies related to identifying the construction waste generated through activities at different stages of construction processes. For example, Khanh and Kim [9] reported that construction waste is caused by non-value-adding activities during construction, which was mostly caused by employees' lack of skills, competency, and management-related factors, among others. Olanrewaju and Ogunmakinde [10] investigated the causes, barriers, and strategies for waste minimization at the design stage based on architects' perspectives. The study found that the most essential causes of waste and barriers to waste management were last minutes changes in design by the client and lack of training in waste management. Nagapan et al. [6] argued that construction waste was caused by poor site management and supervision, lack of experience, inadequate planning and scheduling, and mistakes and errors during construction. Ajayi et al. [11] also identified major factors responsible for waste generation, such as material damage on-site and double material handling, among others. The literature shows that many scholars have studied diverse strategies for managing construction waste throughout the lifecycle of a project, including the planning, design, procurement, and construction stages, adopting the concept of the 3Rs (reduce, reuse, and recycle) [2,12,13].

According to PBC Today [14], Indonesia will be one of the biggest players in the global construction market after China, the US, and India by 2030, indicating that construction waste will grow significantly if not adequately managed. As stated by Statista.com [15], approximately 4.32 million metric tons of waste were managed in Indonesia in 2020 with targets of 30% waste reduction and 70% handling of solid waste by 2025, following Presidential Regulation No. 97 in 2017. This shows that there is an urgency to conduct waste management to achieve sustainable construction. Therefore, there is a need to minimize the construction waste generated from construction activities, thereby benefiting economic, social, and environmental aspects of residents' lives. Whilst many scholars have studied the importance of construction waste management in developed countries and studies focusing on developing nations are emerging, limited studies have been conducted concerning construction waste in Indonesia, indicating that it is not yet a primary concern in Indonesia. As waste minimization and its management is influenced by culture, as opined by Teo and Loosemore [16] and Ajayi et al. [17], the implementation of waste management practices in one country may differ from that in other countries since adoption is context-based. This is especially true since sustainability in general and aspects of sustainable construction practices are influenced by a nation's unique social, economic, cultural, and legislative environment [18].

Thus, this study examined the underlying causes of waste generation in the construction industry based on the perspectives of Indonesian construction professionals. The findings could help stakeholders better understand the causes of waste generation within the construction industry, especially from construction experts' point of view, enabling them to provide strategies to cope with construction waste more effectively and efficiently. By identifying the key causes of waste, construction waste can be controlled during project lifecycles, especially in the design and construction stages, thus enabling stakeholders to reduce waste. Hence, this study is anticipated to fill information gaps and offer a framework for policymakers and building industry actors in Indonesia in terms of construction waste generation. This study also provides practical and theoretical knowledge for construction players in identifying construction waste generation, not only for the Indonesian context but also for that of other developing nations, particularly those in the Asia-Pacific region. Additionally, studies in other countries may employ the current study's findings as a foundation for their model conceptualization and data collection methods.

The rest of this paper is organized as follows. Section 2 presents the extant literature review of construction waste within the construction industry, which is then followed by the research methodology and results and discussion in Sections 3 and 4, respectively. In the end, conclusions and limitations are presented in Section 5.

2. Construction Waste

Construction waste is generated by activities and decisions taken at different stages of the project lifecycle, including the planning, design, procurement, and actual construction stages [19]. It is estimated that approximately 10–30% of total waste is generated by the construction, demolition, and renovation of buildings and other facilities [20]. In the UK, waste from construction sites is mostly generated from construction and demolition [21], which is similar to the results of the study by Luangcharoenrat et al. [1] in Thailand. Construction waste can be categorized as inert waste, which is neither chemically nor biologically reactive, such as soil, asphalt, and concrete, and non-inert construction waste such as wood, bamboo, plants, and so on. Shen et al. [22] describes waste as any construction-related materials, such as concrete, wood, steel, and other materials. In addition, according to Wrap [23], waste is defined as objects that have been damaged during building activities such as remodeling, demolition, and construction. Thus, when new buildings and civil engineering structures are constructed or when older buildings are demolished, construction and demolition materials are produced. Numerous studies, as reviewed in the subsequent section, suggest that construction waste is caused by activities and decisions made at different stages of project delivery processes, including the planning, design, procurement, and construction stages.

Causes of Construction Waste

The growth of construction activities has led to a huge volume of construction waste generation across the globe, putting immense pressure on the environment and depleting natural resources. Studies on waste management, especially those relating to the causes of construction waste, have been emerging. According to Berk [24], the major causes of construction waste generation are frequently design changes and reworks, resulting in around 15–20% wastage of total materials used in construction sites. It is known that design decisions play an important role in initiating waste generation, as seen by the large percentage of waste caused by activities and decisions made at the pre-construction stage, for instance, decisions on the use of material choice, size of materials, contract documents and drawings, among others [19]. To reduce the effect of design changes and minimize waste, Akinade et al. [25] highlighted the need to use building information modeling (BIM) for designing construction and demolition waste (CDW).

Apart from individual commitments to building synergy in waste management programs by project stakeholders, collaboration and support among stakeholders is essential to achieve sustainable practices in the construction industry. The study by Fitri et al. [26] determined that the best practices from developed countries can be implemented in developing countries, suggesting the need for stakeholders' involvement and strong regulation and law enforcement toward waste minimization. The study also stated that most developed countries have significantly implemented waste management through the 3R principles (reduce, reuse, and recycle) and only a limited amount of waste is dumped in landfills due to the economic and environmental benefits of diverting waste from landfills. It is believed that efforts to reduce the volume of construction waste will give significant benefits in terms of natural resource conservation, material cost reductions, and reductions in waste disposal expense. Thus, problems associated with rising construction waste need to be solved.

Poor management at the project site is key to construction waste generation, leading to unsustainable practices within the construction industry. In line with this, the study by Ajayi et al. [11] highlighted that poor management can be one of the most significant contributing factors to waste generation. Similarly, Nagapan et al. [6] determined that insufficient site management and supervision were the most significant causes of construction waste in Malaysia. The success or failure of a project highly depends on the top practices of project management at the project site and can significantly affect not only waste generation, but also project productivity in terms of cost, quality, and duration [27]. Hence, there is a need to implement sustainable project management at the site to reduce construction waste growth and enhance overall project productivity. Enhancing on-site management systems is encouraged to minimize waste generation [28], for example, by reusing construction materials during the construction process.

The study by Wang et al. [28] discovered that the biggest proportion of total waste was dominated by concrete waste, which accounted for approximately 80–90% of total waste and was mainly caused by plastering flow, damaged concrete, large order, and so on. This implied that poor material handling and poor availability of proper equipment could also cause waste generation. The use of old construction machinery and technologies could also contribute to waste generation. Thus, the application of modern techniques and approaches, such as the use of prefabricated slabs, drywalls, and modular materials, to improve working methods could have a positive impact on waste generation. Prefabricated materials can reportedly reduce waste generation rate by approximately 52% [29] or even up to 84.7% [30]. Hence, the practice of modular buildings or precast concrete manufactured offsite can significantly reduce construction waste on projects.

While other studies have stressed the importance of equipment management as a major cause of waste generation, material management also has a role to play [19]. The substantial use of raw materials and improper material handling during construction activities requires the need for efficient material management, such as choosing the appropriate materials that generate less waste and are reusable and recyclable [13]. Damaged materials and cutovers are mostly affected by the incorrect use of operating machines and cutting materials, which can generate more waste. For example, steel waste produced by steel bars cut from pile works is an incorrect working method at construction sites that can generate waste. The need to prepare a systematic and efficient approach for handling and storing materials to minimize waste generation is therefore essential to mitigating construction waste generation. Effective material procurement can also diminish waste generation, such as conducting effective purchase management and partnership with suppliers [8]. Proposing the use of advanced technologies for waste management is also key to meeting the goal of a waste minimization program.

The urgency to enhance workers' competency is also considered a key challenge to implementing waste mitigation in the construction industry. It is argued that incompetency can trigger mistakes by workers due to lack of training [20,31]. The incompetency of workers is one of the human resource problems of construction waste generation. Therefore, there is a need to improve competency and education among workers related to waste management [32]. Summarily, many factors are responsible for construction waste generation, which are due to activities and decisions made at any stage of project delivery processes. Table 1 summarizes the factors that can contribute to construction waste generation.

Table 1. Causes of construction waste based on previous studies.

No	Causes of Construction Waste	References
1	Improper material handling	[1]
2	Use of incorrect material	[27]
3	Poor site layout and work condition	[9,27]
4	Poor site safety and security	[33]
5	Lack of proper site documentation	[9,27]
6	Inadequate tools and equipment	[1,9,27]
7	Poor equipment choice or ineffective equipment	[9]
8	Over-allocated/unnecessary equipment on site	[9]
9	Unavailability of heavy equipment (crane, forklift etc.)	[34]
10	Inadequate instruction on detailed working method	[34]

Table 1. *Cont.*

No	Causes of Construction Waste	References
11	Inefficiencies associated with personnel turnover	[34]
12	Language barrier among workers	[33,34]
13	Shortage of site workers	[9]
14	Poor distribution of personnel	[33]
15	Careless working attitudes and behaviors	[1,27]
16	Low morale and lack of workers' motivation	[33–35]
17	Lack of workers' awareness	[35]
18	Socializing (talking with fellow workers)	[34]
19	Absenteeism	[34]
20	People arriving late or leaving early because of illness, injury	[34]
21	Getting moved to another job/task before ongoing task is completed	[34]
22	Wrong teams /incompetent subcontractors	[1,6,33]
23	Lack of employee experience	[6]
24	Lack of training for employees	[27]
25	Inadequate instruction from supervisor	[34]
26	Shortage of supervisors/foreman	[9]
27	Poor communication skills of foreman	[34]
28	Lack of communication between the client and the main contractor	[19]
29	Lack of coordination among project stakeholders	[6,9]
30	Incorrect information and decision making	[9,33]
31	Unfairness in tendering or method of contractor choice	[33]
32	Poor site management and supervision	[6,9]
33	Lack of commitment from top management	[19]
34	Lack of support from the company managers	[35]
35	Lack of collective planning and scheduling	[9]
36	Insufficient project financing	[33]
37	Late payment	[33]
38	Lack of contractual incentives	[35]
39	Slow information flow between parties	[6]
40	Effect of inclement weather	[6,35,36]
41	Theft and vandalism	[27,36]
42	Natural catastrophes	[27]
43	Topography	[27]
44	Lack of penalties for poor waste management	[26]
45	Lack of training and guidance on waste management strategies	[31]
46	No incentive for waste minimization	[37]
47	Delay of regulatory reporting	[38]

3. Research Method

As the study aimed to establish a generalization through quantifiable data, quantitative methods of data collection and analysis were employed as recommended by Creswell [39]. With this approach, it is possible to establish the key causes of waste in the Indonesian construction industry based on the experience and perception of the experts within the industry. The study commenced with a review of extant literature to establish the likely causes of waste as suggested in similar studies, which then served as input for further studies. Using the findings from the literature review as presented in Table 1, which were in line with the practices across numerous waste management studies [11,13,25] and as recommended by Field [40], a questionnaire was designed as an instrument for data collection. The refined list of factors, phrased to fit rating scales as recommended by Field [40], served as input for the research instrument. The use of a questionnaire enabled the researchers to reach a larger audience across the nation within a reasonable time frame and with no significant cost implications [41].

3.1. Data Collection

Due to its wider benefits, including ease of reaching the audience, an online questionnaire through Google Form was adopted for the study from November 2021 to March 2022. The questionnaire contained three sections, including background and consent information, participants' demographics (summarized in Table 2), and the list of the potential causes of waste on a five-point Likert scale. The use of the Likert scale ensured that the relative significance of the variables could be easily established, with the participants' information summarized [42]. With the research population being Indonesian construction professionals, a list-based random sampling approach was adopted, as described by Fricker [43]. The sampling frame included the databases of various construction professional bodies in Indonesia. This included: (i) Ikatan Arsitek Indonesia (IAI)—Indonesian Architects Association, (ii) Asosiasi Kontraktor Indonesia (AKI)—Indonesian Contractors Association, (iii) Indonesian Construction Safety Expert Association (PAKKI), (iv) Ikatan Ahli Manajemen Proyek Indonesia (IAMPI)—Indonesian Association of Project Management Experts, (v) Lean Construction Institute Indonesia (LCII), and (vi) Ikatan Ahli Bangunan Hijau Indonesia (IABHI)—Indonesian Green Building Experts Association.

Table 2. Overview of the respondents.

Job Roles	Number of Respondents	Percentage (%)
Architect	26	5.6
Civil/structural engineer	98	20.9
Construction manager	14	3.0
Mechanical and Electrical engineer	11	2.4
Project manager	65	13.9
Quantity surveyor	20	4.3
Site Manager	19	4.1
Material supplier	2	0.4
Subcontractor	3	0.6
Staff officer	65	13.9
Faculty/Professor	42	9.0
Environmental engineer	15	3.2
Operation Staff	8	1.7
Consultant	49	10.5
Health and Safety Specialist	10	2.1
Others	21	4.5
Total	468	100.0

With Indonesia having approximately 1.21 million permanent construction workers and a further 9.5 million other temporary jobs across the construction industry [44], 1.21 million was considered as the target population, requiring a sample size of 385 at a 95%

confidence level. To ensure up to the targeted 385 responses, considering a potential 40% response rate as evident in many studies, approximately 1000 potential participants from within the targeted population were invited through messaging services such as email, WhatsApp, and LinkedIn. Overall, a total of 471 responses were received, with three of the responses removed due to their significant level of missing data. Table 2 provides the demographic information of the remaining 468 participants whose responses were used for the study.

3.2. Data Screening and Reliability Analysis

Apart from the removal of three responses due to their significant level of missing data, a reliability analysis was carried out to determine the extent to which the variables were related. According to Yockey [45], this helps in eliminating factors that may not contribute to the internal consistency of the data collected through the questionnaire. In addition, establishing such a relationship is a significant step in exploratory factor analysis [40], which was used in this study. Using SPSS 26, the Cronbach Alpha coefficient of the data, which is a measure of its internal consistency, was found to be 0.893. With this being above the recommended threshold of 0.7 [40], the data was confirmed to have excellent internal consistency. A further test, known as Cronbach Alpha If Item Deleted, was also carried out, as recommended by Field [40] and Nunnally and Bernstein [42]. With the test suggesting that any item with a coefficient above the original Cronbach Alpha value of 0.893 be deleted [40], none of the factors were removed as they had coefficients below the threshold. This suggested that all factors contributed to the overall internal consistency of the variables.

3.3. Exploratory Factor Analysis

To determine the underlying factors responsible for waste generation in the Indonesian construction industry, exploratory factor analysis was carried out as a dimension reduction approach. This helped in removing redundant attributes and replacing a large number of variables with a fewer number of uncorrelated factors, while also retaining a significant percentage of the original information [46]. With this approach, the latent underlying factors could be established [40].

Meanwhile, exploratory factor analysis is carried out in three stages, which included the evaluation of data suitability, factor extraction, and factor rotation [40]. To determine the suitability of the data for factor analysis, the Kaiser–Meyer–Olkins test (KMO), Bartlett test of sphericity, and determinant of coefficient matrix were carried out, requiring thresholds of $\geq$0.5, $<$0.05, and $>$0.00001, respectively [40]. The KMO and Bartlett test coefficients were 0.93 and 0.0001, respectively, putting the values of the initial exploratory factor analysis within the required thresholds. However, the initial value for the determinant of coefficient matrix of 1.581×10^{-13} suggested that the data failed to meet the requirements of the third test, requiring further evaluation. In line with Field, the diagonal of the anti-image correlation matrix and determinant of the correlation matrix were checked to eliminate variables with values below 0.5. Through this procedure, 12 variables were eliminated, achieving a determinant of coefficient matrix of 1.221×10^{-5}, which fell within the required threshold.

Using the reduced data containing 55 variables, factor extraction and rotation were carried out through Principal Component Analysis (PCA) and Varimax with Kaiser Normalization, respectively. According to Field [40], this required that a minimum Eigen value of 1 be retained. The resulting rotation suggested that there were eight underlying factors, representing 71.759% of the total variance, that were responsible for waste generation in the Indonesian construction industry. The total variance extracted was considered adequate, as it was above the threshold of 60% that Hair et al. [47] suggested as the minimum percentage of variance that must be explained by the extracted factors. As further detailed in Table 3, the factors were then labelled as follows, based on their component variables:

(i) Waste-inducing site and human resource management approaches (14.248% of variance)
(ii) Inadequate collaboration and support among stakeholders (13.192% of variance)
(iii) Equipment management approach (9.981% of variance)
(iv) Material logistics management (8.965% of variance)
(v) Poor working environment (7.012% of variance)
(vi) Poor communication on construction site (6.768% of variance)
(vii) Incompetency and waste behavior (6.725% of variance)
(viii) Lack of training and experience (4.869% of variance)

Table 3. Results from Factor Analysis.

NO.	Extracted and Rotated Components	Eigen Value	% of Variance	Factor Loading
Group 1	**Waste-inducing site and human resource management approaches**	7.979	14.248	
	Poor site safety and security			0.538
	Lack of proper site documentation			0.734
	Delay of regulatory reporting			0.553
	Language barrier among workers			0.708
	Shortage of site workers			0.712
	Poor distribution of personnel			0.568
	Socializing (talking with fellow workers)			0.538
	Absenteeism			0.632
	Arriving late or leaving early because of illness, injury			0.755
	Getting moved to another job/task before completed			0.680
	Unfairness in tendering or method of contractor choice			0.504
Group 2	**Inadequate collaboration and support among stakeholders**	7.387	13.192	
	Lack of communication between the client and the main contractor			0.580
	Lack of coordination among project stakeholders			0.673
	Incorrect information and decision making			0.612
	Lack of commitment from top management			0.655
	Lack of support from the company managers			0.677
	Lack of collective planning and scheduling			0.568
	Insufficient project financing			0.562
	Late payment			0.655
	Lack of contractual incentives			0.584
	Slow information flow between parties			0.588
Group 3	**Equipment management approach**	5.589	9.981	
	Poor site layout and work condition			0.507
	Inadequate tools and equipment			0.677
	Poor equipment choice or ineffective equipment			0.668
	Over-allocated/unnecessary equipment on site			0.643
	Unavailability of heavy equipment (crane, forklift etc)			0.665
	Inadequate instruction on the detailed working method			0.525
	Inefficiencies associated with personnel turnover			0.506
Group 4	**Material logistics management**	5.020	8.965	
	Improper material handling			0.573
	Use of incorrect material			0.572
	Poor site management and supervision			0.573
	Lack of penalties for poor waste management			0.747
	Lack of training and guidance on waste management strategies			0.744
	No incentive for waste minimization			0.591

Table 3. *Cont.*

NO.	Extracted and Rotated Components	Eigen Value	% of Variance	Factor Loading
Group 5	**Poor working environment**	3.927	7.012	
	Effect of inclement weather			0.768
	Theft and vandalism			0.668
	Natural catastrophes			0.523
	Topography			0.659
Group 6	**Poor communication on the construction site**	3.790	6.768	
	Inadequate instruction from supervisor			0.589
	Shortage of supervisors/foreman			0.592
	Poor communication skills of foreman			0.643
Group 7	**Incompetency and waste behavior**	3.766	6.725	
	Careless working attitudes and behaviors			0.699
	Low morale and lack of workers' motivation			0.605
	Lack of workers' awareness			0.635
	Wrong teams/incompetent subcontractors			0.508
Group 8	**Lack of training and experience**	2.727	4.869	
	Lack of employee experience			0.708
	Lack of training for employees			0.667

4. Results and Discussion

Based on the above findings, this section presents the underlying causes of construction waste in the Indonesian construction industry in eight groups.

4.1. Waste-Inducing Site and Human Resource Management Approaches

Based on the factor analysis, the first component, named 'waste-inducing site and human resource management approaches,' had a total variance of 14.248% and consisted of 11 variables associated mostly with site and people management. This implied that Indonesian construction professionals acknowledge that there is a lack of adequate site and human resource management (HRM), which becomes a major cause of construction waste generation within the Indonesian construction industry. As the leading cause of waste with the highest total variance, these behavioral issues could be termed as waste behavior, and it points to the need to raise awareness through education, and introduction of standardized benchmarks for the Indonesian Construction industry, as advocated by Fitriani and Ajayi [48]. A similar study carried out in the United Kingdom [17] and earlier study by Theo and Loosemore [16] on the theory of waste behavior in Australia further reinforced that waste behavior and associated professional cultural issues could be an intercontinental issue in the construction industry. However, recent studies in the UK suggest that this culture of waste behavior has been largely addressed by stringent legal requirements, such as landfill taxes, site waste management plans, and aggregate taxes, among others [49].

Site management is an important key element of project management, ensuring that the project team members collaborate to achieve goals within time and budget constraints, thereby enabling effective mitigation of waste generation [50]. As such, the functions of site management in a construction project are, for example, to control workforce distribution, coordinate safety and security among project members, and receive material deliveries [27]. To keep a project on time and within budget, there is a need to maintain proper site management, which in turn enables reliable planning and scheduling and requires extensive technical knowledge of site managers, as well as team leadership and management. This confirms that addressing the key causes of waste could have positive implications for project success.

As a labor-intensive industry, the approach to human resource management (HRM) in construction projects could also trigger waste generation. HRM plays a significant role in building effective and efficient management of employees within an organization or a company while running the business to obtain a competitive advantage [51]. Furthermore, Anwar and Abdullah [51] argued that HRM of employees is considerably influenced by skills, behavior, attitudes, abilities, and knowledge, which can affect organization performance. The absence of proper HRM directly impacts employees, resulting in dissatisfaction, poor motivation, lack of productivity, and poor performance that will ultimately cause waste generation in construction projects. This could directly contribute to deliberate waste generation and a care-free attitude, as espoused by Teo and Loosemore's [16] theory of waste behavior. The significance of workers' management was supported by the study by Luangcharoenrat et al. [1] in which human resources were argued to be a major cause of construction waste generation in Thailand, indicating the need for managing attitudes and behaviors of workers in order to achieve good quality of work and prevent reworks. Therefore, it is important to improve site and human resource management for construction waste mitigation.

4.2. Inadequate Collaboration and Support among Stakeholders

Component 2, named 'inadequate collaboration and support among stakeholders,' had a total variance of 13.192% and consisted of 10 variables. This factor suggested the urgency of having collaboration and support among stakeholders throughout the project lifecycle to achieve excellent waste management among other project success indicators. Stakeholders' collaboration and supports are vital for companies' value creation, which ensures deliverables meet the customers' needs, enhance project quality, and decrease project costs [52]. The need for stakeholders' engagement through a collaborative process is a key driver of project performance, which can significantly improve mutual understanding and efforts toward waste reduction [53]. According to Aghania et al. [54], there is a positive relationship between collaboration and project performance in which better collaboration will result in better project performance, reduce disputes, and enhance participation among project members.

In the case of Indonesia, it was found that collaboration and support among stakeholders were lacking, as evidenced in the study by Nursin et al. [55] in which a model for enhanced collaboration was proposed. Although this may have similarities with other nations, especially as the industry is characterized by fragmentation and over the wall syndrome [16], Indonesia-focused studies suggest that t enhanced collaboration is requisite to sustainable construction practices in the nation [18,56].

To improve project performance, several requisite measures were proposed, including support and collaboration. The need for collaboration and support among stakeholders can help mitigate waste generation, as noted by Vasconcelos et al. [53] who proposed the significance of collaborative development design for waste minimization. Sei Slehkie and Dongjie [56] also stressed the importance of stakeholders' collaboration to show a degree of contact and dynamic relationship among actors, the decision-making process, and strong policy enhancement. Thus, it is important to increase trust and collaboration through participatory methods associated with environmental issues in order to achieve sustainable practices.

4.3. Equipment Management Approach

Construction equipment management is essential for successfully running a project since selecting proper equipment can contribute to safety, quality, and timely project completion [57]. The significance of equipment management in construction projects is echoed by the third component of this study, named 'equipment management approach' with a total variance of 9.981%. While previous studies have suggested the significance of construction equipment for project productivity [58], its direct contribution to waste generation is a unique finding for the Indonesian construction industry. It is argued that construction equipment is responsible for approximately 25–40% of total project costs [58], suggesting the need to have an equipment policy and equipment management approach that could significantly affect the profitability of a company [59]. Thus, improving the equipment production rate is necessary for increasing the overall productivity of project performance [58] and designating efforts towards waste mitigation in projects.

Proposing the use of advanced technologies for waste management is also the main measure for driving construction waste minimization. In order to minimize construction waste, Fikri Hasmori et al. [32] suggested the use of mechanical handling to decrease material damage so that the material can be properly managed. The lack of proper equipment and the use of outdated construction technologies and equipment could also generate a huge amount of construction waste [1]. Thus, waste-minimizing construction machinery and technologies, such as the use of prefabricated slabs, drywalls, and modular materials, should be used to improve working methods in the Indonesian construction industry and address the specific issue of equipment as a key factor responsible for waste generation.

4.4. Material Logistics Management

The fourth component, named 'material logistics management,' had a total variance of 8.965%, suggesting the need for a proper material logistics management approach, which remains a challenge in the Indonesian construction industry. Material logistics management is defined as the process of planning, implementing, and controlling various activities related to material issues in construction projects [60]. Effective material logistics management plays a significant role in improving productivity, project profitability, and cost efficiency [61]. The material management at construction sites, which includes material planning, procurement, purchasing, and material delivery [62], should be accurately planned and executed to prevent productivity and financial losses [61].

Proper material logistics management might include proper material handling and storage, the use of correct materials, and effective material delivery, which could help reduce and mitigate construction waste by preventing double handling and breakage, which are some of the key causes of waste [8]. Moreover, spacing of material delivery in line with the construction project plan, as well as building component sizes that are influenced by actual design, could also become effective strategies to tackle material waste generation [63]. To achieve this, collaboration with product suppliers is an important strategy. Unlike in developed nations, this level of collaboration is currently lacking in the Indonesian construction industry, and it is essential for enhancing sustainable practices within the construction industry [48]. In line with this finding, such collaboration is also essential for construction waste minimization.

4.5. Poor Working Environment

Working conditions are an essential measure for enhancing employee productivity and boosting the workforce's morale. It was found to be one of the main factors responsible for waste generation in the Indonesian construction industry. This was evident by its total variance of 7.012% in this study, suggesting the need to have a working environment that can facilitate waste minimization. Within a construction site, factors that contribute to the proper working conditions may include cleanliness, good lighting, favorable temperature, good site layout, and implementation of fall prevention measures. Maintaining a favorable work environment is beneficial for employees to minimize errors and mistakes that could have implications for cost time, quality, as well as health and safety. A dangerous working environment lacking adequate space and with poor lighting and non-ergonomic employee amenities could influence long-term health and equally contribute to construction waste generation [27]. It is evident that factors contributing to construction waste could also have impacts on project cost, schedule, and quality [64]. Consequently, enhancing the construction site working environment would ensure comfortable working conditions that support tradespeople's performance and address factors that could contribute to waste generation.

Inclement weather and natural catastrophes associated with external factors are also supporting factors of a poor working environment that contribute to the generation of construction waste [6]. Building a safer and tidier working environment could help minimize construction waste generated during construction activities. Good housekeeping and careful handling of material storage will also create a healthy working environment [19].

4.6. Poor Communication on the Construction Site

As communication is important in transferring information between parties and achieving project success throughout the project's lifecycle, enhancing communication among construction workers could be a way to achieve effective waste management [65]. Project failure can be significantly triggered by inadequate communication among the project team. For example, lack of communication between design and construction parties may contribute to design changes both from design teams and clients, opening an opportunity for generating a significant volume of waste. Communication plays a vital role in supporting project success by bridging the gap associated with different values, cultures, education levels, and standards [66]. To achieve an effective level of communication, construction workers are required to enhance their communication skills. Fitriani and Ajayi [67] highlighted the importance of communication and collaboration among construction players to minimize waste generation and help achieve sustainable construction. A lack of communication at the construction site could also lead to both cost and time overruns.

To improve communication and collaboration among stakeholders, construction personnel need to organize regular meetings in order to coordinate work and increase productivity [68]. Improving communication among parties within organizations is necessary to decrease conflicts, especially if there are many parties involved in one project, thereby contributing to waste generation. Giving full responsibility for waste management to all employees with sufficient supervision and clear instructions as part of the communication plan can also successfully reduce waste generation. In addition, clear and effective communication among parties, such as contractors and subcontractors, can help reduce construction conflicts.

4.7. Incompetency and Waste Behaviur

The seventh variable with a total variance of 6.725% was named 'incompetency and waste behavior' and it further highlighted behavioral issues as a key factor contributing to waste generation. People's attitudes play an important role in controlling waste generation within the construction industry [69]. As in the theory of waste behavior, attitudes and behaviors among local contractors are influenced by the perception of whether clients will pay for waste management, resulting in a tendency for contractors to ignore waste mitigation. Thus, deliberate attitudes and behaviors are mostly determined by direct economic concerns [70]. Consequently, there is a need to change people's wasteful behavior and develop operatives' attitudes toward waste minimization [16].

Whilst humans have a significant role to play in mitigating construction waste, which requires positive waste management behaviors and attitudes [69], their competency is essential to enabling construction waste reduction. This was supported by the study by Ajayi et al. [11] and Jain [20], which indicated that incompetency could trigger workers' mistakes due to lack of training. The incompetency of workers is one of the human resource problems of construction waste generation. Therefore, there is a need to improve competency and education relating to site waste management [32]. Udawatta et al. [71] suggested effective approaches for reducing waste generation in Australia through strengthening team building and supervision, as well as developing strategic procedures for waste management. These efforts will minimize the total project costs that burden not only contractors but also clients.

Ajayi et al. [31] proposed the need for design competency for waste mitigation and argued that the design stage is the most critical phase during the project lifecycle, enabling the team to tackle construction waste generation before construction starts. This will allow the architects to design out waste through the use of innovative materials and standardization, among others, while also collaborating with contractors at an early stage to support error-free design. This is especially important since design variations and errors made in design are the main sources of waste generation [28]. Following the need for designing out waste, designers are anticipated to have specific competencies, such as waste behavioral competency, knowledge about construction, and teamwork skills, since design decisions significantly influence waste generation [25]. This is also applicable to other stakeholders involved in project delivery processes, especially operatives on the construction site, to mitigate errors and reworks that could ultimately result in waste generation.

4.8. Lack of Training and Experience

Training and education programs are effective ways to expand knowledge, develop skill sets, develop attitudes, and enhance individual performance [72]. The benefits of enhancing training and experience within organizations also include improved technical and problem-solving abilities, self-management abilities, decision-making speed, motivation, and performance consistency [73], which could ultimately support waste minimization. For instance, training associated with construction technologies development is important, as shown by the study by Akinade et al. [25] in which experience and knowledge in using technology such as building information modeling (BIM) was urgently recommended. The use of BIM for waste minimization could help architects design out waste efficiently. Training and education for all levels of the workforce about waste minimization and its impacts on the environment are necessary to increase environmental awareness [74]. Hence, it is important to provide training, education, and seminars to construction workers to minimize waste generation [28].

Similar to the study by Jain [20] in India and Wang et al. [28] in China, lack of training and experience remains a major challenge for construction waste minimization in Indonesia. One example was the poor experience of designers with construction techniques and methods in the design stage, which can result in the generation of construction waste. Due to a lack of knowledge about the impacts of design on construction waste generation, architects were less involved in waste minimization and mostly believed that contractors were more responsible for waste minimization according to the study by Osmani et al. [75]. The engagement of professional bodies in building capacity for the members of their associations is important to help achieve a waste minimization program. This was suggested in the study by Fitriani and Ajayi [18], which stressed the need to promote the involvement of professional bodies to actively conduct capacity development programs and training to increase the level of sustainability awareness among project teams. Thus, participation and commitment from all stakeholders within the construction industry are essentially required to minimize waste towards achieving zero waste, as the construction industry is expected to reduce the volume of construction waste generation.

4.9. Implications of Findings for Construction Waste Mitigation

The significance of construction waste mitigation in achieving sustainable construction and, by extension, the global sustainability agenda is well established. While studies have investigated the causes of waste in different countries, there is currently no study that has specifically focused on the Indonesian construction industry. Thus, investigating the causes of waste based on the perceptions and lived experience of Indonesian construction stakeholders uncovered some underlying causes, some of which shared similarities with that of other nations, with others showed issues that are specifically responsible for waste generation in the Indonesian construction industry. For instance, the identification of human resource management and waste management behavior, with the highest Eigen values in this study, suggests that while many nations have been able to put sustainability at the core of their construction practices, more could be done to entrench waste management practices into Indonesian construction processes. Learning from developed countries, as suggested by Ajayi et al. [2] who explained the significance of a site waste management plan (SWMP) in decreasing the volume of construction waste generated, is requisite to mitigating waste in the Indonesian construction industry. A SWMP, as previously used in managing construction waste in the UK, concerns the volume and types of waste anticipated at the construction and provides a detailed plan of how the waste could be managed [2]. This program also guarantees that the materials are managed efficiently to minimize the volume of waste generated. Such a detailed approach to waste mitigation, if adequately supported and implemented by all stakeholders within the Indonesian construction industry, could address the poor site management practice that contribute to waste generation. On-site waste management, as an integral part of SWMP, could also help reduce waste generation by providing sufficient space for allocating waste storage, waste management equipment, and space for processing materials [76].

Another significant theme underpinning the findings of this study, with significant implications for the Indonesian construction industry, is the need for enhanced stakeholder engagement at internal and external levels of project implementation. This is especially true at the internal stakeholder management level, since inadequate collaboration and support among stakeholders (13.192% of total variance) and poor communication on the construction site (6.768% of total variance) were identified as leading causes of waste, pointing to the need for enhanced collaboration among stakeholders. Similarly, the identification of inadequate material logistics management (8.965% of total variance) as a cause of waste calls for enhanced collaboration, communication, and coordination with external stakeholders, such as material and equipment suppliers. As proposed by Ajayi and Oyedele [8], coordinating with material suppliers as well as suppliers' commitment to waste mitigation through pre-cut materials, efficient packaging, and take back schemes, among others, would facilitate waste minimization. With material costs responsible for a significant proportion of the total project cost, efficient material logistics management would not only reduce waste generation but would also reduce costs associated with material over-ordering, delay, and breakage, among others. Such coordination would not only be essential for material suppliers in the Indonesian construction industry, but adequate coordination with equipment suppliers would also be requisite for mitigating construction waste. This is especially true since insufficient equipment management approaches explained 9.981% of the total variance.

Although some issues relating to skills, competencies, and training were established as factors contributing to waste generation in the Indonesian construction industry, the factors were generally ranked low considering their percentage of variance explained. The implication of this finding is that while professionals have knowledge of waste mitigation, its practice is largely hindered by inadequate commitment, as evident by the factor with the largest percentage of variance, and poor collaboration among the stakeholders. This is atypical of studies in developing countries, which often attribute poor sustainability practices to inadequate knowledge [77,78]. While the findings of this study do not exclude knowledge and awareness as key issues contributing to waste generation, they show that inadequate knowledge is not the main problem. Thus, enhanced collaboration and behavioral change towards waste mitigation are requisite for mitigating construction waste, especially since Indonesia is forecasted to become a big player in the global construction market by 2030, following China, the US, and India. As suggested by numerous studies [18,49,78], this would require enabling a legal framework to shift practices towards waste minimization and broader sustainability practices.

5. Conclusions

The size of the construction sector of the global economy has increased dramatically as a result of the continued growth of infrastructure, consequently creating massive amounts of construction waste with negative impacts on the environment. Construction waste issues have drawn the attention of researchers from all around the world due to their potentially dangerous consequences on the environment. Given that Indonesia is a nation with enormous potential for expanding construction activities and negatively impacting global warming as a result of waste generation, this study investigates the underlying causes of waste in the construction industry based on the perspectives of Indonesian professionals. This study used a questionnaire as a research instrument and examined the data with reliability and exploratory factor analysis.

The findings suggested that there are eight underlying causes of waste responsible for construction waste generation in the Indonesian construction industry. The five most significant underlying causes of waste generation that impede sustainability practices include waste-inducing site and human resource management approaches, inadequate collaboration and support among stakeholders, equipment management approaches, material logistics management, and poor working environments.

Waste-inducing site and human resource management approaches were the most significant cause of waste generation, indicating the need to have a strategy for facilitating an efficient human resource approach to waste management as well as a dedicated site management approach that enhances waste mitigation. This could be in the form of a site waste management plan with a detailed plan for waste minimization and consequent measures for managing waste once generated. Environmental concerns require a participatory approach in terms of collaboration and support from stakeholders, which are essential for businesses to create value, ensure deliverables to fulfill customers' needs, and improve project quality. To attain this, there is a need to increase the level of understanding of the waste problem among all project stakeholders as well as to strengthen the shared understanding of the waste problem and develop collective action. Thus, the participation of all stakeholders, through effective communication and collaboration, is essential to enhance the proper implementation of policy regulation.

In addition to the use of modern building techniques, which are considered to be effective at decreasing waste, the overall equipment management approach should be given ultimate priority to improve project performance. The choice to utilize prefabrication and modular construction could minimize waste generation and increase productivity, which ultimately helps companies reduce their carbon impact. Thus, the stakeholders involved should pay attention to optimizing machinery and its processes by choosing the appropriate equipment management approach. Consequently, it is important for Indonesian professionals to be concerned about the causes of waste generation in order to reduce its impact on the environment and achieve sustainable practices. Through adequate knowledge, training, and awareness, factors responsible for waste generation would be understood, and measures could be put in place to minimize waste and understand the actions taken for effective management of waste once generated.

This study investigated the underlying causes of waste generation, which is anticipated to fill information gaps and offer advice on how to mitigate waste generation. This study offers both practical and empirical knowledge for construction industry players in tackling construction waste generation, not only in the context of Indonesia but also in that of other developing countries with the same socio-economic problems, while providing a reference for causes of waste mitigation. Even though this study found similar results to the current conditions in many other developing countries, its findings are exclusively applicable to Indonesia. Future research could investigate its relevance to other countries.

Author Contributions: Conceptualization, H.F. and S.A.; methodology, H.F. and S.A.; validation, H.F., S.A. and S.K.; writing—original draft preparation, H.F.; writing—review and editing, S.A. and S.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data available in a publicly accessible repository.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Luangcharoenrat, C.; Intrachooto, S.; Peansupap, V.; Sutthinarakorn, W. Factors Influencing Construction Waste Generation in Building Construction: Thailand's Perspective. *Sustainability* **2019**, *11*, 3638. [CrossRef]
2. Ajayi, S.O.; Oyedele, L.O.; Bilal, M.; Akinade, O.O.; Alaka, H.A.; Owolabi, H.A.; Kadiri, K.O. Waste effectiveness of the construction industry: Understanding the impediments and requisites for improvements. *Resour. Conserv. Recycl.* **2015**, *102*, 101–112. [CrossRef]
3. Construction & Demolition Waste Statistics for Ireland. 2022. Available online: https://www.epa.ie/our-services/monitoring--assessment/waste/national-waste-statistics/construction--demolition/ (accessed on 12 November 2022).
4. U.S. EPA. Advancing Sustainable Materials Management: 2018 Fact Sheet Assessing Trends in Materials Generation and Management in the United States. 2020. Available online: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/advancing-sustainable-materials-management (accessed on 15 May 2022).
5. Bashah, K.N.A. *Sustainable Construction Waste Management: Uplifting the Malaysian Construction Industry*; CIDB: Kuala Lumpur, Malaysia, 2021.
6. Nagapan, S.; Rahman, I.A.; Azis AA, A.; Memon, A.H.; Zin, R.M. Identifying Causes of Construction Waste—Case of Central Region of Peninsula Malaysia. *Int. J. Integr. Eng. Issue Civ. Environ. Eng.* **2012**, *4*, 22–28.
7. Phillips, M. Waste Across Industries, No. 3: The True Cost of Construction Waste. 2021. Available online: https://www.linkedin.com/pulse/waste-across-industries-3-true-cost-construction-matthew-phillips/?trk=articles_directory (accessed on 15 May 2022).
8. Ajayi, S.O.; Oyedele, L.O. Waste-efficient materials procurement for construction projects: A structural equation modelling of critical success factors. *Waste Manag.* **2018**, *75*, 60–69. [CrossRef] [PubMed]
9. Khanh, H.D.; Kim, S.Y. Identifying causes for waste factors in high-rise building projects: A survey in Vietnam. *KSCE J. Civ. Eng.* **2014**, *18*, 865–874. [CrossRef]
10. Olanrewaju, S.D.; Ogunmakinde, O.E. Waste minimisation strategies at the design phase: Architects' response. *Waste Manag.* **2020**, *118*, 323–330. [CrossRef]
11. Ajayi, S.O.; Oyedele, L.O.; Bilal, M.; Akinade, O.O.; Alaka, H.A.; Owolabi, H.A. Critical management practices influencing on-site waste minimization in construction projects. *Waste Manag.* **2017**, *59*, 330–339. [CrossRef]
12. Ogunmakinde, A.E.; Sher, W.D.; Maund, K. Obstacles to Sustainable Construction in Developing Countries. In Proceedings of the Australasian Universities Building Education Association (AUBEA) Conference, Cairns, QLD, Australia, 6–8 July 2016; Volume 40, pp. 434–446.
13. Oyedele, L.O.; Ajayi, S.O.; Kadiri, K.O. Use of recycled products in UK construction industry: An empirical investigation into critical impediments and strategies for improvement. *Resour. Conserv. Recycl.* **2014**, *93*, 23–31. [CrossRef]
14. PBC Today. Which Countries Are Investing the Most in Construction? 2019. Available online: https://www.pbctoday.co.uk/news/planning-construction-news/countries-investingconstruction/54507/ (accessed on 15 July 2021).
15. Statista.com. Energy & Environment & Waste Management. Volume of Managed Waste in Indonesia 2014–2020. 2021. Available online: https://www.statista.com/statistics/1259672/indonesia-volume-of-managed-waste/ (accessed on 18 August 2022).
16. Teo, M.M.M.; Loosemore, M. A theory of waste behaviour in the construction industry. *Constr. Manag. Econ.* **2001**, *19*, 741–751. [CrossRef]
17. Ajayi, S.O.; Oyedele, L.O.; Akinade, O.O.; Bilal, M.; Owolabi, H.A.; Alaka, H.A.; Kadiri, K.O. Reducing waste to landfill: A need for cultural change in the UK construction industry. *J. Build. Eng.* **2015**, *5*, 185–193. [CrossRef]
18. Fitriani, H.; Ajayi, S. Barriers to sustainable practices in the Indonesian construction industry. *J. Environ. Plan. Manag.* **2022**, 1–23. [CrossRef]
19. Ajayi, S. Design, Procurement and Construction Strategies for Minimizing Waste in Construction Projects. Ph.D. Thesis, The University of the West of England, Bristol, UK, 2017.
20. Jain, M. Economic Aspects of Construction Waste Materials in Terms of Cost Savings—A case of Indian construction. *Int. J. Sci. Res. Publ.* **2012**, *2*, 1–7.
21. Deloittle. Construction and Demolition Waste Management in United Kingdom. 2016. Available online: http://ec.europa.eu/environment/waste/studies/deliverables/CDW_UK_Factsheet_Final.pdf (accessed on 5 June 2022).
22. Shen, L.Y.; Tam, V.W.Y.; Tam, C.M.; Drew, D. Mapping Approach for Examining Waste Management on Construction Sites. *J. Constr. Eng. Manag.* **2004**, *130*, 472–481. [CrossRef]
23. Wrap. Achieving Good Practice Waste Minimisation and Management. Practical Solutions for Sustainable Construction. 2014. Available online: https://www.yumpu.com/en/document/read/31105355/achieving-good-practice-waste-minimisation-and-management-wrap (accessed on 5 June 2022).
24. Bekr, G.A. Study of the Causes and Magnitude of Wastage of Materials on Construction Sites in Jordan. *J. Constr. Eng.* **2014**, *2014*, 283298. [CrossRef]
25. Akinade, O.O.; Oyedele, L.O.; Ajayi, S.O.; Bilal, M.; Alaka, H.A.; Owolabi, H.A.; Arawomo, O.O. Designing out construction waste using BIM technology: Stakeholders' expectations for industry deployment. *J. Clean. Prod.* **2018**, *180*, 375–385. [CrossRef]
26. Fitri, L.; Hatmoko, J.U.D.; Hermawan, F. Managing Construction Waste in Developed Countries: Lessons Learned for Indonesia. *IOP Conf. Ser. Earth Environ. Sci.* **2019**, *366*, 012016. [CrossRef]
27. Mbote, R.P.; Kimtai, A.K.; Makworo, M. An Investigation on the Influence of Factors Causing Material Waste on Construction Cost of Residential Building Frame. A Case of Northern Region of Nairobi. *Int. J. Eng. Res. Technol.* **2016**, *5*, 436–447.

28. Wang, J.; Kang, X.; Tam, V.W. An investigation of construction wastes: An empirical study in Shenzhen. *J. Eng. Des. Technol.* **2008**, *6*, 227–236. [CrossRef]
29. Jaillon, L.; Poon, C.S.; Chiang, Y.H. Quantifying the waste reduction potential of using prefabrication in building construction in Hong Kong. *Waste Manag.* **2009**, *29*, 309–320. [CrossRef]
30. Tam, V.W.; Tam, C.; Zeng, S.; Ng, W.C. Towards adoption of prefabrication in construction. *Build. Environ.* **2007**, *42*, 3642–3654. [CrossRef]
31. Ajayi, S.O.; Oyedele, L.O.; Kadiri, K.O.; Akinade, O.O.; Bilal, M.; Owolabi, H.A.; Alaka, A.H. Competency-based measures for designing out construction waste: Task and contextual attributes. *Eng. Constr. Arch. Manag.* **2016**, *23*, 464–490. [CrossRef]
32. Hasmori, M.F.; Zin, A.F.; Nagapan, S.; Deraman, R.; Abas, N.; Yunus, R.; Klufallah, M. The on-site waste minimization practices for construction waste. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *713*, 012038. [CrossRef]
33. Issa, U.H.; AlQurashi, M. A model for evaluating causes of wastes and lean implementation in construction projects. *J. Civ. Eng. Manag.* **2020**, *26*, 331–342. [CrossRef]
34. Wambeke, B.W.; Hsiang, S.M.; Liu, M. Causes of Variation in Construction Project Task Starting Times and Duration. *J. Constr. Eng. Manag.* **2011**, *137*, 663–677. [CrossRef]
35. Al-Hajj, A.; Hamani, K. Material Waste in the UAE Construction Industry: Main Causes and Minimization Practices. *Arch. Eng. Des. Manag.* **2011**, *7*, 221–235. [CrossRef]
36. Bossink, B.A.G.; Brouwers, H.J.H. Construction Waste: Quantification and Source Evaluation. *J. Constr. Eng. Manag.* **1996**, *122*, 55–60. [CrossRef]
37. Yu, A.; Wong, I.; Wu, Z.; Poon, C.-S. Strategies for Effective Waste Reduction and Management of Building Construction Projects in Highly Urbanized Cities—A Case Study of Hong Kong. *Buildings* **2021**, *11*, 214. [CrossRef]
38. Du Plessis, C. A strategic framework for sustainable construction in developing countries. *Constr. Manag. Econ.* **2007**, *25*, 67–76. [CrossRef]
39. Creswell, J.W. *Research Design: Qualitative, Quantitative and Mixed Methods Approaches*; SAGE: Thousand Oaks, CA, USA, 2014.
40. Field, A. *Discovering Statistics Using IM SPSS Statistics*; SAGE: London, UK, 2013.
41. Malhotra, N.K.; Dash, S. *Marketing Research: An Applied Orientation*; Pearson Publishing: London, UK, 2011.
42. Nunnally, J.C.; Bernstein, I.H. *Psychometric Theory*, 3rd ed.; McGraw-Hill: New York, NY, USA, 2007.
43. Fricker, R.D. Sampling Methods for Web and e-Mail Surveys. In *The SAGE Handbook of Online Research Methods*; SAGE Publications: London, UK, 2008.
44. Soemardi, B.W.; Pribadi, K.S. The Indonesian Construction Industry, 1995–2019. In *Construction Industry Advance and Change: Progress in Eight Asian Economies Since*; Anson, M., Chiang, Y.H., Lam, P., Shen, J., Eds.; Emerald Publishing Limited: Bradford, UK, 2021; pp. 63–87.
45. Yockey, R.D. *SPSS Demystified: A Step by Step Approach*; Routledge: New York, NY, USA, 2010.
46. Flannery, J.; Ajayi, S.O.; Oyegoke, A.S. Alcohol and substance misuse in the construction industry. *Int. J. Occup. Saf. Ergon.* **2021**, *27*, 472–487. [CrossRef]
47. Hair, J.F.; Black, W.C.; Babin, B.J.; Anderson, R.E. *Multivariate Data Analysis: A Global Perspective*, 7th ed.; Prentice-Hall: Upper Saddle River, NJ, USA, 2010.
48. Fitriani, H.; Ajayi, S. Investigation of requisite measures for enhancing sustainable construction practices in Indonesia. *Eng. Constr. Arch. Manag.* 2022; *ahead-of-print*. [CrossRef]
49. Ajayi, S.O.; Oyedele, L.O. Policy imperatives for diverting construction waste from landfill: Experts' recommendations for UK policy expansion. *J. Clean. Prod.* **2017**, *147*, 57–65. [CrossRef]
50. Toljaga-Nikolić, D.; Todorović, M.; Dobrota, M.; Obradović, T.; Obradović, V. Project Management and Sustainability: Playing Trick or Treat with the Planet. *Sustainability* **2020**, *12*, 8619. [CrossRef]
51. Anwar, G.; Abdullah, N.N. The impact of Human resource management practice on Organizational performance. *Int. J. Eng. Bus. Manag.* **2021**, *5*, 35–47. [CrossRef]
52. Bond-Barnard, T.J.; Fletcher, L.; Steyn, H. Linking trust and collaboration in project teams to project management success. *Int. J. Manag. Proj. Bus.* **2018**, *11*, 432–457. [CrossRef]
53. Vasconcelos, L.T.; Silva, F.Z.; Ferreira, F.G.; Martinho, G.; Pires, A.; Ferreira, J.C. Collaborative process design for waste management: Co-constructing strategies with stakeholders. *Environ. Dev. Sustain.* **2021**, *24*, 9243–9259. [CrossRef]
54. Aghania, V.; Ramzani, S.; Raju, V. The Impact of Communication through Collaboration on Building. *Int. J. Mech. Eng. Technol.* **2019**, *10*, 1773–1780.
55. Nursin, A.; Latief, Y.; Ibrahim; Hiyoshi, N.; Iriyama, Y. Critical Success Factors in Developing Collaborative Design-Build Project Team to Improve Project Performance. *MATEC Web Conf.* **2018**, *159*, 01025. [CrossRef]
56. Slehkie, C.W.S.; Dongjie, N. Assessing Stakeholder's Collaboration in the Management of Municipal Solid Waste in Monrovia, Liberia. *Int. J. Sci. Res. Publ. (IJSRP)* **2021**, *11*, 81–93. [CrossRef]
57. Kishore, M. Management of Equipment in Construction Projects. *J. Sustain. Constr. Eng. Proj. Manag.* **2020**, *3*, 1–7.
58. Phadatare, D.B.; Charhate, S.B. Impact of construction equipment's on building site productivity. *Int. J. Civ. Eng. Technol.* **2016**, *7*, 513–520.
59. Clutts, C.A. *Profitability Versus Construction Equipment Maintenance*; Construction Engineering and Management School of Civil Engineering, Purdue University: West Lafayette, Indiana, 2010; pp. 15–18.

60. Kumar, U.N. Construction Material Management on Project Sites. *Int. J. Res. Appl. Sci. Eng. Technol.* **2018**, *6*, 1371–1378. [CrossRef]
61. Said, H.; El-Rayes, K. Optimizing Material Procurement and Storage on Construction Sites. *J. Constr. Eng. Manag.* **2011**, *137*, 421–431. [CrossRef]
62. Samal, S.K. Logistics and supply chain management. *Int. J. Psychosoc. Rehabil.* **2019**, *23*, 361–366. [CrossRef]
63. Tafesse, S. Material waste minimization techniques in building construction projects. *Ethiop. J. Sci. Technol.* **2021**, *14*, 1–19. [CrossRef]
64. Eze, E.C.; Awodele, I.A.; Egwunatum, S.I. Labour–specific factors influencing the volume of construction waste generation in the construction industry. *J. Proj. Manag. Pract.* **2021**, *1*, 1–16. [CrossRef]
65. Safapour, E.; Kermanshachi, S.; Kamalirad, S. Analysis of effective project-based communication components within primary stakeholders in construction industry. *Built Environ. Proj. Asset Manag.* **2020**, *11*, 157–173. [CrossRef]
66. Chipulu, M.; Ojiako, U.; Gardiner, P.; Williams, T.; Mota, C.; Maguire, S.; Shou, Y.; Stamati, T.; Marshall, A. Exploring the impact of cultural values on project performance: The effects of cultural values, age and gender on the perceived importance of project success/failure factors. International Journal of Operations and Pro-duction Management. *Int. J. Oper. Prod. Manag.* **2014**, *34*, 364–389. [CrossRef]
67. Fitriani, H.; Ajayi, S. Preparing Indonesian civil engineering graduates for the world of work. *Ind. High. Educ.* **2021**, *36*, 471–487. [CrossRef]
68. Das, S.; Mishra, V. Achieving Project Success through Leadership Communication A Study on Construction Industry. 2020 June. Available online: http://www.teknik.uu.se/student-en/ (accessed on 6 June 2022).
69. Begum, R.A.; Siwar, C.; Pereira, J.J.; Jaafar, A.H. Attitude and behavioral factors in waste management in the construction industry of Malaysia. *Resour. Conserv. Recycl.* **2009**, *53*, 321–328. [CrossRef]
70. Al-Sari, M.I.; Al-Khatib, I.; Avraamides, M.; Fatta-Kassinos, D. A study on the attitudes and behavioural influence of construction waste management in occupied Palestinian territory. *Waste Manag. Res. J. Sustain. Circ. Econ.* **2012**, *30*, 122–136. [CrossRef]
71. Udawatta, N.; Zuo, J.; Chiveralls, K.; Zillante, G. Improving waste management in construction projects: An Australian study. *Resour. Conserv. Recycl.* **2015**, *101*, 73–83. [CrossRef]
72. Orr, K.; Gao, Y. Becoming an Architect: The Role of Work-Based Learning in Architect Training. *Vocat. Learn.* **2012**, *6*, 221–235. [CrossRef]
73. Mas, Á.; Blasco, V.; Lerma, C.; Angulo, Q. Comprehension of Architectural Construction through Multimedia Active Learning. *High. Educ. Stud.* **2013**, *3*, p1. [CrossRef]
74. Moreton, A.; Coffey, V.; Sadiqi, Z. Training for reduction of design waste. *Proc. Inst. Civ. Eng. Waste Resour. Manag.* **2016**, *169*, 123–130. [CrossRef]
75. Osmani, M.; Glass, J.; Price, A.D.F. An investigation of design waste causes in construction. *WIT Trans. Ecol. Environ.* **2008**, *109*, 491–498. [CrossRef]
76. Wang, J.; Yuan, H.; Kang, X.; Lu, W. Critical success factors for on-site sorting of construction waste: A China study. *Resour. Conserv. Recycl.* **2010**, *54*, 931–936. [CrossRef]
77. Toriola-Coker, L.O.; Alaka, H.; Bello, W.A.; Ajayi, S.; Adeniyi, A.; Olopade, S.O. Sustainability barriers in Nigeria construction practice. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Bristol, UK, 2021; Volume 1036, p. 012023.
78. Pham, H.; Kim, S.-Y.; Luu, T.-V. Managerial perceptions on barriers to sustainable construction in developing countries: Vietnam case. *Environ. Dev. Sustain.* **2019**, *22*, 2979–3003. [CrossRef]