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The Need for a Proper Waste Management Plan for the Construction Industry: A Case Study in Lebanon

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Abstract: The construction industry is known as one of the biggest generators of solid waste. Considering this, attention needs to be paid to construction and demolition (C&D) waste. Lebanon has experienced many situations that have increased the generation of C&D waste. Therefore, it is essential to manage C&D waste. This research aims to assess and analyse the importance of waste management plans and their impact on the generation of construction and demolition waste in Lebanon. For this purpose, an extensive literature review has been carried out, and a questionnaire survey consisting of five sections has been developed. Factors were ranked by using 5-point Likert scales. Additionally, four optional open-ended questions were also included in the survey for qualitative data collection. A survey questionnaire was sent to 80 Lebanese experts, and 50 questionnaires were returned. Most of the responses (i.e., consultants and academics) were from the private sector; results showed that respondents to this survey were biased for their expertise. Reliability and ranking analysis were performed on the collected data. It was found that "site management and supervision-related factors" are the main sources of C&D waste. The main barrier to implement 3R was the "lack of awareness and knowledge", and the most critical success factor was "waste management regulations". There is lack of data on construction waste in Lebanon. Therefore, there is a need to conduct research on construction waste management in Lebanon, which is the subject of the current investigation. This research is expected to generate benefits for the construction industry in Lebanon and the surrounding region.

Keywords: barriers; critical success factors; environment; reduce-reuse-recycle 3R; sustainable development

Citation: Saad, A.; Bal, M.; Khatib, J. The Need for a Proper Waste Management Plan for the Construction Industry: A Case Study in Lebanon. *Sustainability* **2022**, *14*, 12783. https://doi.org/10.3390/su141912783

Academic Editors: Paolo S. Calabrò and Daily Rodriguez Padrón

Received: 15 August 2022
Accepted: 18 September 2022
Published: 7 October 2022

1. Introduction

Population growth, combined with economic growth and associated consumption patterns, has resulted in a large increase in waste output throughout the world [1]. Since the beginning of civilisation and urbanisation, humankind has been occupied dealing with their societies' waste. The amount of waste that societies, especially industrial societies, generate, is still under exploration. Part of this waste generation, of course, is driven by the increase in the human population [2]. The amount of waste produced has soared as a result of the industrial revolution, cultural growth, and expansion of the global economy [3]. Due to climate change, global waste has become an issue of concern worldwide. The World Bank has warned that unless immediate measures are taken, environmental waste will increase to 70% above current levels by 2050. In another study, the International Financial Institution stated that within the next 30 years, global annual waste is expected to jump to 3.4 billion tons [4], and the BBC reported that "The world produces over 2 billion tons of municipal solid waste every year which is enough to fill over 800,000 Olympic sized swimming pools" [5]. This is unusual, considering that the knowledge shared today, with the development of globalisation, and new information and communication technologies, has commonly transcended traditional national boundaries [3].

The construction industry plays a crucial role in growing the world's economic productivity. The utilisation, operation, construction, and design phases of the built environment have significant economic impact, as well as overall sustainability effects. The primary driver of efficiency and development of any economy is the new and productive built environment [6]. However, the construction sector is also a large consumer of natural resources and a major generator of waste, and adherence to sustainability practices is paramount. Due to increasing complexity, inadequate communication from architecture, engineering, and construction (AEC) industry professionals and problems associated with the supply chain, the construction industry has seen its projects become increasingly difficult to manage over time [7].

During the construction, renovation, and demolition phases of a project, there is an enormous consumption of raw materials, which creates a substantial amount of waste [8,9]. The quantity of construction and demolition (C&D) waste, also known as solid waste, generated from C&D activities is increasing [10], and it is increasingly threatening to the public environment and human health globally [11]. It also generates up to one-third of the overall waste in landfills, having the construction to demolition waste ratio of 1:2 [12]. Statistics show that more than 10 billion tons of waste annually are generated from construction and demolition activities. The European Union generates more than 800 million tons, the United States generates approximately 700 million tons, and approximately 230 million tons are generated in China [13]. Moreover, due to high rates of waste generated and the negative impact of CDW on the environment, managing CDW has become a priority for sustainable development programs worldwide [14].

Waste management is defined as a process by which waste is collected, transported, and treated before any remaining residues are disposed [15]. Solid waste management can also be described as the effective handling, supervision, collection, keeping, conveying, treatment, and disposal of waste in a way that protects the public and the environment [16]. The primary purpose of managing waste is to reduce environmental pollution and to increase the efficient utilization of the land [17]. The proper organization of C&D waste management has become an essential task needed to protect the environment [8]. Construction waste management (CWM) is defined as any attempt made to eliminate, mitigate, or control the production of construction waste. CWM also includes supervision, regulation, reward-based systems, and fines [18,19]. Moreover, apart from the economic, environmental, and social benefits, saving costs and increasing profit are also important benefits of CWM [20,21]. Similarly, the minimisation of waste is designed to avoid construction waste at various stages of construction projects, in particular, during the construction and post-construction stage [22]. According to Yazdani et al., inappropriate CWM has a negative influence on the environment for using land resources as landfills [10]. Waste management plans include the concept of reduce, reuse, and recycle (3R). The primary objective of 3R is to decrease the quantity of waste generated and sending it to landfills to create a safer and healthier environment. In waste management, 3R was adopted by waste managers worldwide as the most appropriate strategy toward sustainable development [23]. We explain the three prongs—reduce, reuse, and recycle—as follows.

Reduction includes activities meant to remove or reduce the number of resources used at a construction site before they enter the stream of solid waste [24]. The quantity of waste is reduced by extending the lives of products and expanding the efficiency of resource allocation [23]. The component of reducing entails modifying designs to be modular, and allowing for the use of standard-sized resources to avoid wasting materials [24]. Memon stated that reducing the purchase of new material and consumption can achieve waste reduction [25]. In conclusion, initially careful construction planning is the key to avoiding waste.

Due to the similarity of the reduce, reuse, and recycle strategies, the main barriers to the proper implementation of waste reduction strategies occur when actors in the construction industry are vulnerable to not properly communicating and cooperating with each other and stakeholders do not have a common understanding regarding 3R CWM strategies [26].

The second prong of the 3R strategy refers to the reuse of materials in the same or similar function on the same site or on other sites, reflecting the more general reuse concept [27]. In the past, Kabirifar [28] mentioned that reuse refers to the extension of the life of a product and reusing it to include creation or modification of new uses. Reuse does not require reprocessing and thus has fewer energy requirements than recycling. In conclusion, the ultimate goal is to reuse resources without making significant changes to the design and thereby drastically reduce waste.

With regard to recycling, as Walther [29] said, recycling is the distribution and separation of waste that cannot be decreased or utilized in proper facilities but can be converted into new items. Meanwhile, Goh H.H [23] defined it as the procedure for obtaining or separating, processing, and purifying waste resources for reusing and producing a new product. Here, recycling refers to the recovery of waste materials for conversion to new uses. Recycling plays a significant role in the formation of a proactive environment and new policies; simultaneously, it creates a market that can be utilized as another item. To conclude, as recycling helps in reducing the amount of generated waste and directly helps in reducing the cost of waste disposal and preventing environmental pollution, it can be used in the building-restoration industry.

Previous studies identified the barriers of 3R practice in CWM. There are some common barriers that most of the authors agreed upon. For instance, the authors of [30] stated that most contractors concentrate only on short-term economic profits and are reluctant to expand contributions to construction waste management [31]. Time, cost, and profit are the reasons behind the lack of practices of sustainable waste management. Onsite waste segregation requires considerable resources, which raises the expense of construction projects [26].

In developing countries, the management of construction and demolition waste (CDW) is a major problem, as the waste usually ends up in uncontrolled landfills [32]. Lebanon is a country that is experiencing this problem. The Lebanese construction industry has witnessed a continuously active period since the post-war era in the early 1990s, followed by significant amounts of waste created from construction and demolition processes. The country has also suffered from a persistent solid waste management problem due to heavily populated regions, high waste generation, and poor availability of land suitable for waste disposal [33]. The annual production of Lebanese quarries is 3.0 million cubic meters, which is not enough to meet the annual demand for construction for 3.77 million people [34]. Lebanon went through a 34-day war in the summer of 2006 that contributed nearly 3 million m^3 of rubble [35]. The bulk of the resulting waste was dumped both on- and off-shore at temporary developed and reclaimed sites. Recently, on 4 August 2020, an explosion occurred at the port of Beirut, Lebanon's capital. Sadly, the resulting damage affected the area within 500 m from the explosion. This generated large amounts of C&D waste [36]. In a study by Ghanimeh et al. [37] on the construction waste generation in Lebanon, the waste consisted of 70.3% concrete, 19.9% partitioning blocks, 5.1% tiles, 3% metal, 1.1% aluminium, and a small amount, 0.6%, of wood.

Unfortunately, to date, there are no documented plans regarding processes for managing solid waste, including construction and demolition waste. In fact, the current waste management framework in Lebanon has several disadvantages: low percentage of waste recovery, high cost of collection and sweeping, and unorganised source programs [38,39].

Government organisations, project managers, waste operators, and industry associations play a major role in the factors that affect construction and demolition waste [40]. The stakeholders that are responsible for solid waste management in Lebanon are the Waste Management Board, Ministry of Environment, Minister of Interior and Municipalities, individual municipalities, the Council of Development and Reconstruction, and the private and public sectors [41]. According to Abbas et al., in Lebanon, the government is the most essential stakeholder, setting the provisions and policies of the national solid waste management framework. Next are private contractors, as well as the facility users such as, civil organizations, households, and commercial and industrial sectors. Educational and research institutions, health care centres, and farmers are the less prominent stakeholders [39].

Considering the above issue, this research mainly focuses on C&D waste in Lebanon, about which there is hardly any past literature available. The research question is to what extent can the waste management plan affect the reduction of construction and demolition waste in Lebanon. The main aim of this research is to explore the current conditions of construction and demolition waste management plans in Lebanon. To achieve this aim, it was necessary to set up the following objectives: (a) to determine sources and causes of construction and demolition waste in Lebanon, (b) to find the main barriers of 3R implementation in Lebanon, (c) to identify the success factors of the construction waste management plan in Lebanon, and (d) to determine the advantage of construction waste management in Lebanon.

2. Methodology

The main research strategy is used in this research is survey, and it is done to validate the factors extracted from the literature review. A similar research methodology had been adapted by Polat, Liu and Lu. Surveys are the most appropriate tool for collecting data in this research, as they typically increase the quality of data. When validation checks are combined with prompts, it alerts the respondents to enter implausible or incomplete responses [42]. This research is designed to collect primary data from people, organizations, or groups in a consistent way. The research methodology is shown in Figure 1.

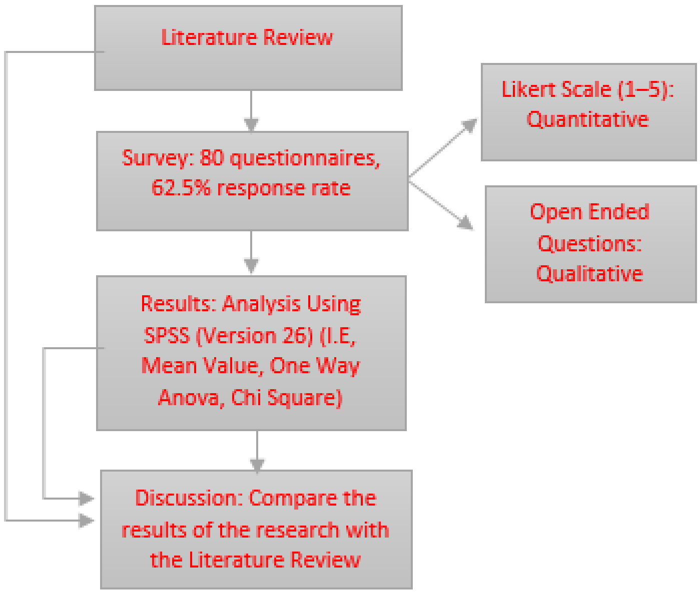

Figure 1. Schematic diagram of the methodology.

The questionnaire is designed to be web-based, and its advantage is the ability to check respondents' completion without the attendance of the researcher. First, a trial questionnaire was created and sent out to seven civil and environmental engineers who have experience in the construction field. Participants were asked to give their feedback and opinion on the quality and comprehensiveness of the questionnaire in order to verify the clarity of the vocabulary and the question-answering instructions, and the way questions are categorised. Furthermore, after implementing all modifications, 80 invitations were sent to target groups of participants (civil engineers, architects, academics, etc.) by email and social media, and 50 responses were returned. These outcome demonstrate that the response rate is 62.5%; for a postal survey, 60% must be the goal of the researcher [43].

The questionnaire was intended to gather a mix of public–private responses in order to prevent bias in the answers. In the first section, respondents were asked to give information about their background, for instance (work nature, work category, and years of experience). Similarly, in other sections respondents were asked to rank the factors with a required 5-point Likert scale (1, unlikely; 2, somewhat likely; 3, moderate; 4, likely; 5, very likely). In order to obtain genuine answers, the questionnaire was limited by allowing the participants to answer the same question in a column per section more than two times. At the end of every section, respondents were asked to add any additional data.

As shown in Figure 2, in the first section of the questionnaire, respondents were asked to fill out their information (i.e., proficiency, years of experience, private or public sector). The second section of the questionnaire was to rank the causes and sources of construction and demolition waste with seven factors. The third section is designed to rank the most significant barriers to 3R implementation, and is constituted of six factors. The fourth section was the rank of critical success factors for construction waste management with seven factors. The last section is designed to rank the advantages of construction waste management with six factors.

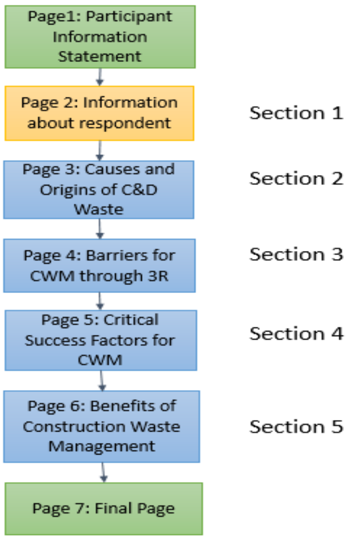

Figure 2. Structure of the survey.

Finally, the collected data was analysed by using SPSS software (version 26) by Norman H. Nie, Newyork, United States to test the reliability of the responses. In order to validate the findings, this research performed the Cronbach's alpha value. The mean value of every section's data is identified to determine the order of factors. In addition, the one-way ANOVA was performed in order to establish the significant difference between the group of respondents. A Chi-square test was also performed to determine if the difference in the work category could affect the results. Moreover, qualitative responses will elaborate upon the facts collected from the literature review by providing more justification.

Testing the reliability is important, as it confirms the consistency across the parts of a measuring instrument [44]. A Cronbach alpha coefficient is the most-used test to measure the internal consistency. Likert scales are considered the most suitable reliability test [45].

In this research study, reliability analysis was performed viaSPSS version 26. The standardized Cronbach's alpha can be calculated by using Equation (1) [46],

$$\alpha = \frac{N}{(N-1)} x \left[\frac{\sigma_x^2 - \sum_{i=1}^{N} \sigma_{yi}^2}{\sigma_x^2} \right], \tag{1}$$

where N is the number of item on the test, ${\sigma_{yi}}^2$ is the sum of all item variances, and ${\sigma_x}^2$ is the variance of the observed item scores.

Based on the results of the data collected and analysis, some recommendations were established.

3. Data Analysis

3.1. Reliability of Results

Cronbach's alpha was calculated as 0.784 by using SPSS (26) for questions related to the sources of C&D waste, barriers to implement 3R, critical success factors, and effect of waste management plan, and was considered as an acceptable internal consistency (Table 1) [46].

Table 1. Cronbach's alpha value.

Cronbach's Alpha Value	Internal Consistency
$\alpha > 0.9$	Excellent
$0.8 < \alpha < 0.9$	Good
$0.7 < \alpha < 0.8$	Acceptable
$0.6 < \alpha < 0.7$	Questionable
$0.5 < \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

3.2. Demographic Background of Respondents

Findings from the respondent's background show that 20% of the respondents were consultants, 24% were contractors, 16% were academics, 36% were engineers, and 4% were from other categories. Findings also show that 18% of the respondents had more than 20 years of experience, 18% had between 11 and 20 years, 20% had 5 to 10 years, and 44% had less than 5 years of experience. These figures demonstrate that approximately 66% of participants had more than 5 years of experience in the construction industry, which determines the possibility of reliable responses. In one of the studies, Jäckle et al. stated that experience improves the consistency and value of participants and also increases the degree of reliability [47]. Moreover, the research had five groups of specialists. In order to establish the statistically significant differences between the group of respondents as a control variable, the one-way ANOVA test was performed. The one-way ANOVA test confirms that there were statistically significant variations between groups $\rho < 0.001$ [48], and academics and consultants have more experience than other groups (Figure 3).

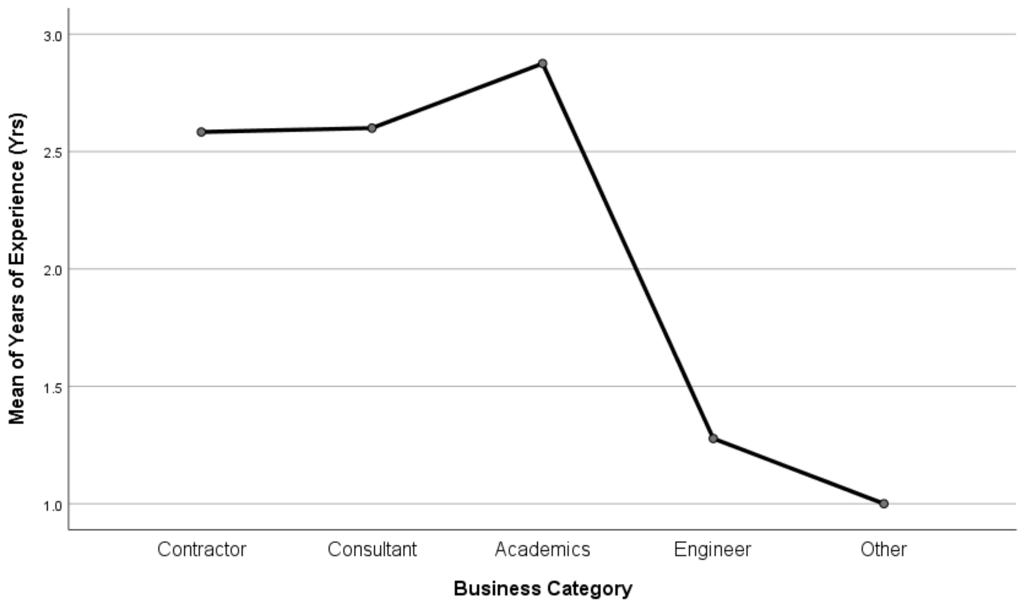

Figure 3. One-way ANOVA (categories correlated to years of experience).

The questionnaire was designed to gather mixed responses from public and private sector participants to prevent bias in the answers. The percentage of respondents belonging to the private sector (66%) is higher than the public sector percentage (34%). Therefore, the Chi-square goodness of fit test was conducted to establish whether the differences could affect the results or not. This showed a significant gap in the number of respondents from the private sector and the public sector (ρ = 0.0001 < 0.05) [49]. This gap indicates that questionnaire answers may be biased to the views of private sector workers. The high ratio of private participants is due to the fact that the survey was sent to experts who work at private companies and to professors who work at private universities in Lebanon.

The respondents' demographic allows the reader to know the work and experience of the respondents who answered the survey regarding construction and demolition waste in Lebanon. The summary of the respondents background are shown in Table 2.

Table 2. Summary of respondents' demographic background.

Items	Respondents	
	Number	%
	Business category	
Consultant	10	20
Contractor	12	24
Academics	8	16
Engineer	18	36
Other	2	4
	Years of experience	
<5 years	22	44
5–10 years	10	20
11–20 years	9	18
>20 years	9	18
	Work nature	
Public sector	17	34
Private sector	33	66

3.3. *Quantitative Data Analysis*

The second, third, fourth, and fifth sections of the survey are based on ranking the 26 factors, i.e., causes and sources of construction and demolition waste, barriers for 3R implementation, critical success factors for CWM, and advantages of CWM, respectively. SPSS (version 26) is used to analyse the mean values of the answers, following the method adopted by [50,51]. The mean value is based on Equation (2) [52],

$$MS = \frac{\sum(f \times s)}{N'} \; (1 \leq MS \leq 5)\,, \tag{2}$$

where S is the given score to each factor by participants from (1 to 5), 1 is "unlikely" and 5 is "very likely", f is the frequency of participants to the ratings (1 to 5) to every factor, and N' is the total number of participants concerning that factor.

The results of the mean value of every section are shown in the following.

3.3.1. Sources and Causes of C&D Waste

The results shown in Figure 4 suggest that the main cause and source of C&D waste in Lebanon is the site management and supervision with a mean of 4.24, which is likely due to the lack of waste management plans, lack of supervision, and damage caused by subsequent trades, etc. Similarly, the worker-related factors have a 3.28 mean value, which may be caused by the damages due to the lack of experience of workers and poor workmanship [46]. This supports the statement from the open-ended questions with "Lack of experience and miss calculations about project need and content". Another previous study [53] identified that management-related factors and worker-related factors are the main contributor to construction and demolition waste in Jordan. Moreover, external factors, such as weather conditions, theft or vandalism, and wars had a mean value of 3.26. This was also supported by the participants during the interview. This factor is also directly connected to the fact that wars in Lebanon played a key role in generating construction and demolition waste. Participants were motivated by the explosion in Beirut on 4 August 2020 and considered it as one of the main contributors.

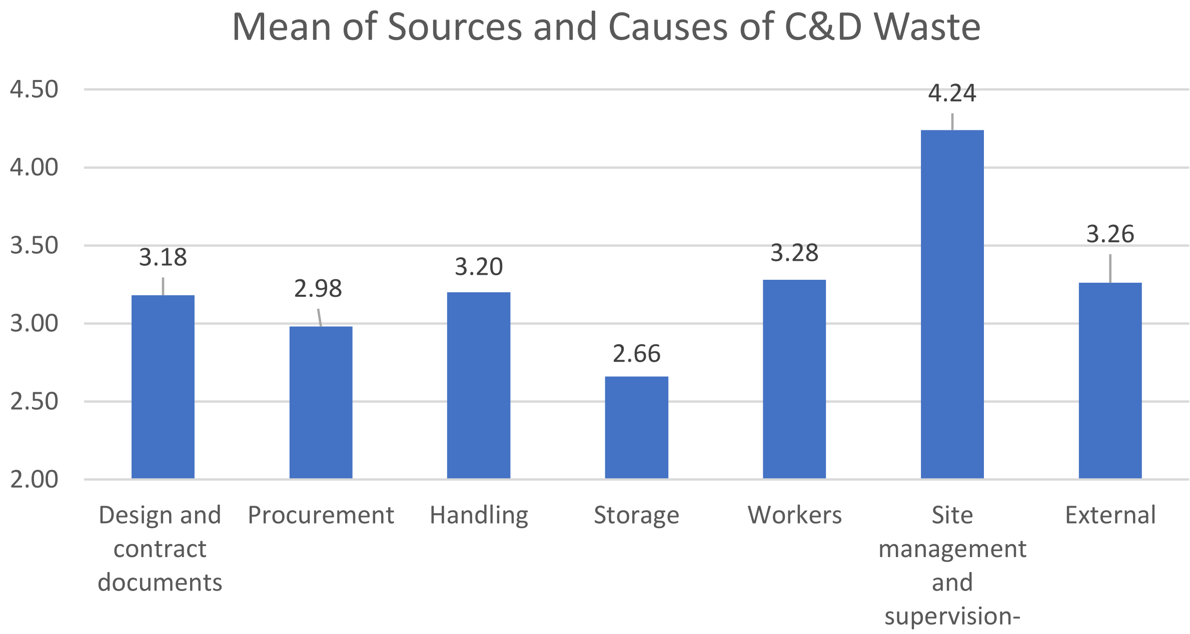

Figure 4. Mean value of sources and causes of C&D waste.

On the other hand, factors having a lower mean value also have equal importance. Handling-related factors was the fourth factor with a mean of 3.2. It is a source of C&D waste caused by the damage during transportation onsite or to the site, materials supplied in loose form and unnecessary onsite material handling. Furthermore, as design and contract document-related factors came in the fifth order with a mean of 3.18, that does not mean that it is not one of the highest factors. In one earlier study, Ghafourian [54] showed that the highest sources of construction and demolition waste are the design and contract documents, and procurement-related factors with a mean value of 2.98. These are caused by errors in contract documents, frequent design changes and changing orders, construction and detail errors, purchasing materials not complying with specifications, supplier's errors, and mistakes in quantity take-offs. Finally, the storage-related factor is the lowest important factor with a mean of 2.66, which was mentioned by the interview respondents. Earlier research studies did not consider storage as an important factor; however, people were cautious on improper storage methods and inappropriate site storage areas leading to deterioration. Site management and supervision, and worker-related factors are the main sources of construction and demolition waste in Lebanon. Construction professionals through the Institution of Engineers & Architects in Lebanon can play an important role in setting up of guidelines for reducing and managing non-emergent construction waste.

Additionally, the origins and causes of C&D waste is comprised of 34 factors that are categorized into seven main groups [46]. This is illustrated in Figure 5.

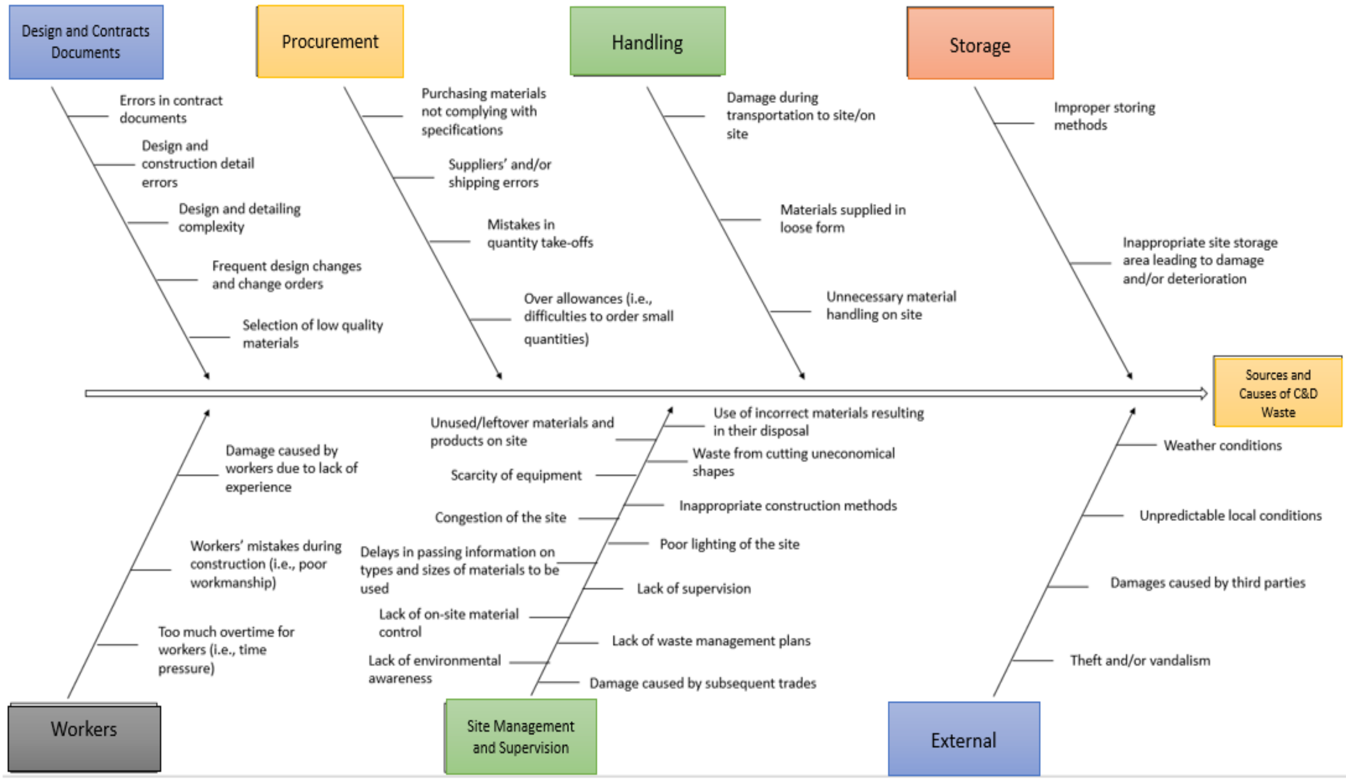

Figure 5. Ishikawa diagram for sources and causes of C&D waste.

3.3.2. Barriers for Implementing 3R

Figure 6 shows that lack of awareness and knowledge are the main barriers for implementing 3R in Lebanon with a mean value of 4.08. This agrees with the study done by [55], in which awareness and knowledge are found to be the highest barriers in implementing 3R. The awareness and knowledge of implementing 3R in CWM is still limited among the contractors. Regarding the awareness and knowledge of reducing waste generation through 3R, there is a lack of connection among contractors and governing bodies. Environmental education on construction sites and in construction training courses should be provided prior to the beginning of work. Then, 3R will be followed by contractors if they understand the meaning of 3R and the benefits of environmental protection. However, some contractors are more concerned about economic factors and profit. Therefore, incentives should be provided when law and regulations are enforced, which is the second main barrier for implementing 3R in Lebanon with a mean value of 4.00. There are regulations enforced with regard to construction waste reduction through 3R in Lebanon. Lack of law enforcement and precise regulations is a significant barrier which influences other factors, and this is considered as a political factor [56]. In tackling and assessing the involvement of policy execution, lack of enforcement leads to the ambiguity of limits and responsibilities of contractors and governing bodies. This barrier leads to unclear limitations and responsibilities of governing bodies and contractors in determining and tackling policy implementation participation. Law enforcement would be the best way to strengthen the mindset and attitude of contractors and simultaneously improve contractor involvement in waste reduction by adapting 3R. The enforcement must be carried out in several stages and different engagements.

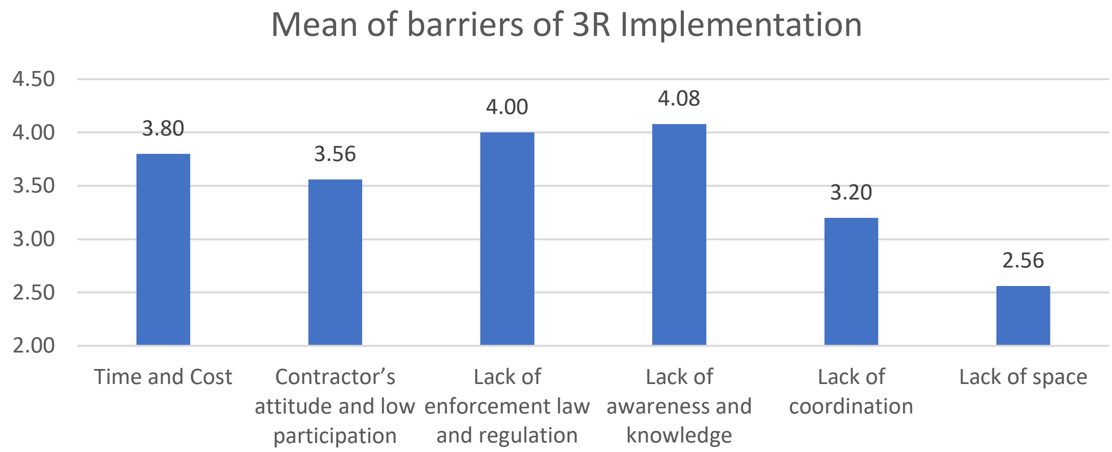

Figure 6. Mean of barriers of 3R implementation.

Moreover, time and cost are the third barrier to implement 3R with a mean value of 3.8; these are financial factors [56]. Due to the fact that handling recycled waste has a higher cost than disposal, most contractors prefer to follow a simplified approach, except with regard to recycling. While calculating the budget of any construction project, CWM cost must be included. Good incentives should be included to encourage the contractor to practice 3R in waste management as the expenses of recycling waste are beared solely by contractors. Furthermore, the contractor's attitude and low participation is the fourth barrier with a mean value of 3.56. Contractors' low participation and attitude are affected by the lack of law enforcement, poor knowledge, lack of self-awareness, and very little financial support. Therefore, contractors should be committed to eliminate the construction waste by effectively implementing 3R activities that would reduce and reuse the construction waste as much as possible at the construction site. Consequently, the fifth factor is the lack of coordination with a mean value of 3.2, which is also dependent on the collaboration between contractors and government. In one study, Ng et al. highlighted the lack of awareness of 3R CWM, as proposed by coordinating bodies of government [57]. Consequently, Lebanese experts answering the questionnaire did not emphasize this barrier as they do not consider that 3R has been proposed by the government. Another barrier is the lack of space with a mean value of 2.56, as this depends on the size of the project, location, and type. Regardless of this factor's ranking, the size of space for recycling must always be determined ahead of project commencement because it affects the construction site layouts [57].

All constraints are directly related to the first two constraints, which are lack of awareness and knowledge and lack of law enforcement. To develop the process of 3R implementation in Lebanon, there must be an implication of waste management regulation, which is discussed in the next section as it is considered to be the highest critical success factor for CWM.

3.3.3. Critical Success Factors for (CWM) Construction Waste Management

The results shown in Figure 7 depict waste management regulations as the highest critical success factor for CWM with a mean value of 4.16. This result agrees with the studies done by [51,58]. Comparing the results, as waste management regulation is the highest critical success factor, it is related to the results of the highest barriers for 3R implementation which is "lack of enforcement law and regulation" in Figure 6. This shows that experts in Lebanon are focusing on the law enforcement, especially for those who work in the private sector. Therefore, due to the absence of well-defined legislation and more stringent controls, the composition of Lebanon's construction and demolition waste is poorly documented, and no plans are available for construction treatment. Additionally, one of the respondents mentioned that "taking waste management into consideration in bidding and tendering" (Table 3) is related to the laws that must be enforced in the construction sector by the government and the Institution of Engineers and Architects in Lebanon.

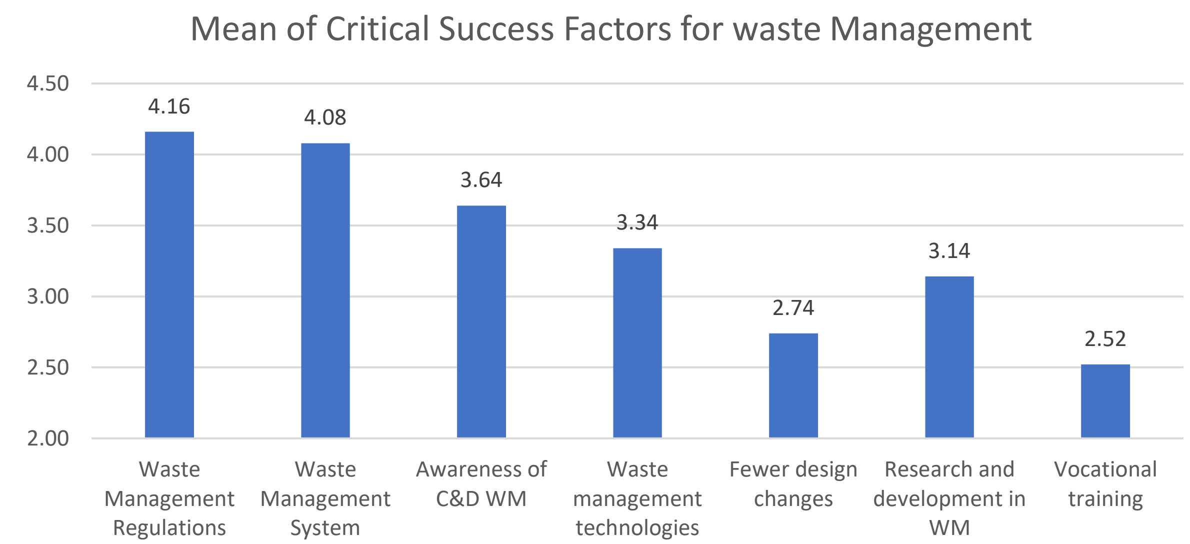

Figure 7. Mean of critical success factors for waste management.

Table 3. Suggestions by the respondents.

Survey Sections	Suggestions	Categories
Construction and demolition waste	1. Manufacturing defects 2. Lack of work experience and mis-calculations about the project need & content 3. People education and awareness	Worker-related Factors
	4. Oversized of building elements during execution due to non-straightness of construction works 5. Lack of work experience and mis-calculations about the project need & content 6. lack of waste management plan 7. Equipment on the site or bad management of the site 8. Equipment on the site or bad management of the site 9. Lack of supervision and lack of waste management plan 10. Lack of onsite material control	Site management and supervision
	11. War and carelessness Natural factor 12. Effect of weather 13. Theft and vandalism is one of the mosts important factor 14. Theft, vandalism and wars	External factors
	15. Unnecessary material handling on site	Handling factor
Suggested barriers for implementing 3R	1. No use of: Waste collection and sorting infrastructure and producing waste management equipment	Time and cost
	2. Require additional resources	Contractor's attitude
Suggested critical success Factors for construction waste management	1. Environmental knowledge for all workers and engineers who work that works in the construction field	Awareness of C&D waste management
	2. Implement project management methodology for construction waste management	Waste management system
	3. Take waste management into consideration in bidding and tendering	Waste management regulations
Suggested advantage of construction waste management	1. Decrease of waste going to landfills	Waste disposal saving
	2. Sustainability 3. Less use of natural resources	Reduction in negative environmental impact due to waste

Furthermore, the waste management system is the second-highest success factor for CWM with a mean value of 4.08. The waste management system is best defined as 3R. Waste management hierarchy method is believed to be a better method according to the study and data presented by [55]. The 3R was adopted by waste managers worldwide, as it is considered as the most appropriate strategy toward sustainable development [23,59]. This is directly related to awareness and knowledge of C&D waste, which is the third-highest factor with a mean value of 3.64 amongst the seven factors. This resonates with studies that demonstrate that the knowledge of resource-saving and environmental protection by practitioners is a key driver for reducing C&D waste [60]. In Lebanon, C&D waste management awareness development is a lengthy process which includes practitioners' vocational training and education, and the knowledge of site waste management (SWM) is still new to old contractors.

3.3.4. Advantages of Construction Waste Management

The main advantage of construction waste management in Lebanon is the reduction of negative environmental impacts due to waste with a mean value of 4.34, as shown in Figure 8. This agrees with the study done by Nigel et al., which shows that specialists from Lebanon and outside Lebanon are still focusing on the reduction of negative environmental effects due to construction waste and other waste [20]. On the contrary, in 2020 Mawed argued that construction industry professions in the UAE pay less attention to the environmental issues, and all their efforts and focuses are on early completion of work [61]. Therefore, these results in Lebanon demand the emergency need for a waste management plan to decrease the amount of waste going in to the landfills, especially after the waste crisis that occurred after closing Naameh Landfill because it reached capacity [62]. Moreover, one of the respondents addressed acheiving the sustainability target as an advantage for construction waste management. Considering the situation in Lebanon, implementation of sustainable construction principles is an effective way to control the construction waste, as sustainable construction focuses not only the environmental issues but also on the social and economic aspects. The advantage of sustainability in CWM can be achieved through the waste management hierarchy (3R) as mentioned elsewhere [63]. The authors of [63] mentioned that to acheive the overall sustainability standards rather than cost alone it is necessary to implement sustainable waste management. Furthermore, purchase cost savings due to the reduced wastage of materials is the second key advantage of CWM with a mean of 3.84. Implementing 3R, especially reusing and recycling waste management, will save costs. Unnecessary purchasing of new construction materials leads to additional costs [64]. This is also agreed upon by the study conducted in the UAE, which identified that time and cost are still one of the most important benefits in implementing CDW management [61]. In addition, due to the excessive generation of construction and demolition waste caused by the explosion, some organisations are working to reuse and recycle the demolition waste to rebuild the country following the construction engineering specifications. In addition, waste management can reduce the expenses of the transportation of waste going from sites to landfills.

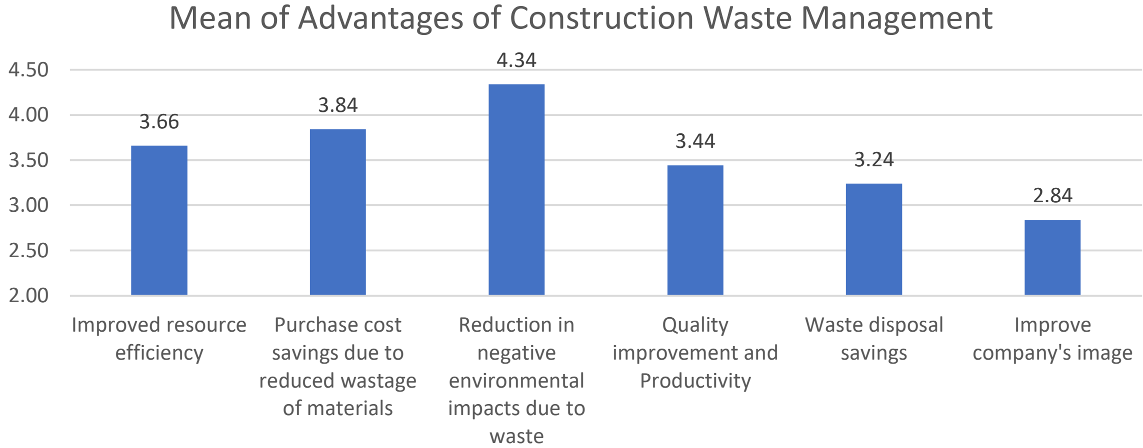

Figure 8. Mean of advantages of construction waste management.

Nevertheless, improving the management of resources is the third factor to acheive construction waste management effectively. Waste management requires planning and monitoring to track the amount of waste produced. This advantage may not be achieved until previous causes, such as site supervision and workers (Figure 4), are resolved and the causes of construction and demolition waste in Lebanon are identified. This is considered as a lack of a site waste management plan and supervision and a lack of awareness among the workers (Figure 4), because if there is a lack of knowledge of site management, it will be difficult to track the amount of waste produced. An efficient resource control system can also be achieved by reducing waste and improving the efficiency of resource management [20]. Moreover, improving quality and productivity is the fourth factor with a mean value of 3.44, and its benefit is less significant than others in Lebanon. Contractors in Lebanon can avoid the production of large amounts of waste by substituting the low-quality material over the life cycle of the facility by choosing high-quality material.

Furthermore, waste disposal savings constitutes the fifth advantage of construction waste management with a mean value of 3.24; it can be directly related to the economic and environmental aspects, as mentioned above as an effect of reducing waste going to landfills and transportation costs, etc. Finally, improving the company's image is the last factor with a mean value of 2.84, from which we can see that experts considered this factor to be less important than others. However, this does not mean that companies or contractors in developed countries do not take this advantage into consideration. They consider that it can be equally beneficial to have a simple dedication to eco-principles and sustainability, effectively aligning the organisation with a more ethical practice and giving the customer base greater accountability [65].

3.4. Qualitative Data Analysis

Though some of the categories obtained minimum comments, considering their relevance, these are still important, and those categories express the respondents' opinions. These are also supported by statements made in the open-ended question. It is equally worthwhile that these results have improved the outcome of the findings from the survey. The listed suggested factors mentioned by respondents are stated in the Table 3.

Additionally, Table 3 represents the participants' views (Suggestions) considering the pre-determined factors (Categories). Respondents answered the open-ended questions highlighting the factors mentioned in the survey, for example, stating that war, carelessness, and natural factors are the sources of construction waste, which is entirely connected to the external factor. Another respondent mentioned that poor control of the onsite material is also a source for C&D waste which is related to site management and supervision. Furthermore, in terms of barriers of implementing 3R, one of the respondents mentioned the requirement of additional resources, and this is related to the attitude of the contractor. Likewise, in the success factors, another participant stated that waste management must be taken into consideration during the bidding and tendering process, which is directly related to the waste management regulations.

4. Conclusions

To conclude, waste management is one of the biggest challenges the world is facing today on a global scale. It can make a significant contribution to a more sustainable future by reducing the destruction of nature and human health. The aim of this research is to explore the current conditions of a construction and demolition waste management plan in Lebanon. From the above discussion, the following conclusions are drawn.

- The main source and cause of construction and demolition waste in Lebanon is site management and supervision and the worker-related factors with the mean value of 4.24.
- The main barrier for implementing 3R is lack of awareness and knowledge and lack of law enforcementand regulation with a 4.08 mean value.

- The results revealed that the main critical success factor for construction waste management is waste management regulations and the waste management system with 4.16 and 4.08 values, respectively.
- The main advantage of the construction waste management is the factor denoted as "Reduction in negative environmental impact due to waste" with a mean value of 4.34.

From the above findings, the researchers can also conclude that Lebanon needs urgent and accurate construction and demolition waste legislation that can be applied by all construction companies by training and educating their employees on managing construction waste. This action will automatically lead to the reduction of the negative environmental effect created by uncontrolled waste.

To summarise the above findings, we can make the following recommendations.

1. We should implement construction waste-sorting procedures onsite and manage the amount of waste and compare it with the ex-determined targets to identify and handle potential sources of waste.
2. We should enhance the skills of construction site workers and manage the team by providing them with necessary training courses.
3. We should note that external factors and their natual effects are beyond human control, but waste caused by external factors can be mitigated by including this cause in the project risk assessment process and implementing a mitigation strategy.
4. We should provide training and educational programs on environmental management to raise awareness and knowledge on the implementation of 3R and conduct awareness campaigns to encourage and motivate contractors to practice 3R in the construction industry.
5. We should provide subsidies to contractors in order to reduce the CW by implementing the 3R strategy to improve the CWM plan. This also implies that the application of additional charges as penalties for sending construction waste to a landfill instead of recycling and reusing this waste would be effective.

Limitations and Future Improvement

This study also has some limitations. A focus group discussion with some construction professionals would allow a more reliable outcome through the validation of data. The low number of prior research articles related to C&D waste management in Lebanon has created constraints for the researchers with regard to data collection and the existence of accurate, trusted information on which to base the research presented in this article.

Future research can be extended by conducting questionnaires that involve larger number of respondents, and the study should be done on experts that work mainly in public sectors so that comparative analysis between results of public and private sectors in Lebanon can be conducted. Furthermore, future research should involve other stakeholders, for example clients, laborers, environmentalists, and decision makers (government professionals, civil servants). This could be extended by making a comparative analysis of barriers to implement 3R between Lebanon and another developed country. The research can be extended by collecting data on the quantities and characteristics of the different types of waste produced in the construction site and the type of materials that need to be recovered.

Author Contributions: Conceptualization, A.S. and M.B.; methodology, A.S. and M.B.; software, A.S.; validation, A.S., M.B. and J.K.; formal analysis, A.S., investigation and data curation, A.S.; writing—original draft preparation, A.S. and J.K.; writing—review and editing, A.S., J.K. and M.B.; supervision, M.B. 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: Not applicable.

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

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