Environment and Ecology Research 11(2): 249-273, 2023 http://www.hrpub.org
DOI: 10.13189/eer.2023.110203

The Implications of Construction and Demolition Waste Management in Jordan

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Received November 28, 2022; Revised February 15, 2023; Accepted March 12, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Abdallah Hussein Al-Khraisha , "The Implications of Construction and Demolition Waste Management in Jordan," Environment and Ecology Research, Vol. 11, No. 2, pp. 249 - 273, 2023. DOI: 10.13189/eer.2023.110203.*

(b): *Abdallah Hussein Al-Khraisha (2023). The Implications of Construction and Demolition Waste Management in Jordan. Environment and Ecology Research, 11(2), 249 - 273. DOI: 10.13189/eer.2023.110203.*

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Abstract Jordan's economy is one of the most robust and rapidly expanding in the Middle East. Construction and demolition (C&D) waste generation in the nation has dramatically increased due to the country's fast industrialization. Therefore, there is a raging concern over waste management infrastructure, particularly when most C&D waste in Jordan is disposed of informally. Hence, the research has reviewed previous literatures to identify the gaps in the body of knowledge about C&D waste management which helped in determining the method of quantitative questionnaires with practitioners and governmental bodies involved in C&D waste management in Jordan to be used. The literature analysis showed the construction sector and its components, legal frameworks, environmental, social, and economic ramifications, as well as the primary C&D waste management strategies and reveals that current strategies for managing C&D waste in Jordan are insufficiently developed. Thus, the purpose of the research in response to the findings of the literature was to ascertain what is lacking in the Jordanian context in terms of C&D waste management including informal dumping, aspects within Jordanian construction industry contracts, missing C&D waste management activities, encouragements to improve C&D waste management strategy, and the industry actors' perspectives.

The main findings demonstrate that the construction sector has a significant impact on Jordan's environment by nearly informally dumping 50% of the total volume of C&D waste generated. The findings have identified that most problems relating to C&D waste are associated with governmental controls and industry actors (construction and demolition contractors). Including a general lack of legislative control and its enforcement accompanied with poor oversight and contractors' perspective and willingness. In addition, appropriate procurement methods are not adopted, particularly for demolition projects. Results have shown that the absence of design codes of practice for recycled waste materials and poor waste disposal systems are strongly influential factors too.

The findings identify the measures necessary to push the Jordanian construction industry toward improved C&D waste management by developing a set of encouragements. The key aspects of these encouragements include modifying the current regulations, the imposition of penalties or fines on polluters, enriching the local market with recycled waste material market, increasing the fees of disposal, and providing tax exemptions. The research not only develops enhancements to Jordan's C&D waste management strategy, but also provides a future benchmark for a successful national C&D waste management plan.

Keywords Waste Management, Informal Dumping, Industry Actors, Construction and Demolition, Legal Framework, Deign Out Waste, Government Controls

1. Introduction

Most C&D waste in Jordan is disposed of without environmental protection measures in roadside ditches and residential areas [1]. An analysis of a desk assessment revealed that the problem is intimately related to inadequate waste management, which remains the most intriguing modern challenge facing the country. In order to

optimize C&D waste management by addressing its concerns, this prompted the investigation of the nation's C&D waste management. Following the above discussion, consensus was reached on the study's principal title, purpose and objectives, as well as its uniqueness. Based on the preliminary research, the key question, purpose and objectives of the study are as follows:

Research Question:

"How can Jordan successfully improve the present C&D waste management situation?" By providing a set of encouragements aimed at improving Jordan's national policy for controlling C&D waste.

During the research process, the study presents the two primary objectives that have been developed to accomplish the overall aim of the research and provide its output and results as follows:

(i). Review of solid waste management in Jordan to identify local context current practices by:
   1. Investigating the types and quantities of solid waste generated in Jordan.
   2. Identifying and assessing the solid waste management approaches currently used.

(ii). Review and investigate C&D waste management in Jordan through:
   1. Identifying the construction and demolition methods currently employed in Jordan.
   2. Studying the types and volumes of construction materials used, quantifying the volumes of raw materials consumed and C&D waste generated.
   3. Recognizing the environmental, social, and economic impacts that changes in the construction sector have brought about.
   4. Investigating concerns related to C&D waste, including informal disposal and its causes.
   5. Critically assessing the current C&D waste management strategy, with an emphasis on how it permits and encourages informal dumping
   6. Identifying the obstacles to recycling and reusing C&D waste and the necessary adjustments to encourage the construction industry to recycle C&D waste.

The scope of the literature review includes a comprehensive assessment of secondary data on the Jordanian construction sector, with a focus on the fact that relatively little waste is being recycled at present. However, previous studies on the management of C&D waste in Jordan required more trustworthy data. The purpose of the research is to get a better understanding of the local waste management situation by focusing on solid waste management. In the meanwhile, the primary study was planned to address the literature gaps revealed by the research objectives and to produce the research output using closed- and open-ended questionnaires. The goal of these surveys was to enhance the information indicated in the stated objectives and to provide a holistic perspective and comprehensive insight to determine the Jordanian restrictions that limit the effectiveness of the present C&D waste management strategy. The outcomes of surveys conducted with government officials, contractors, designers, and suppliers, among other construction industry participants, are presented in the results section. It comprises participant responses and analyses regarding informal C&D waste dumping, its causes, accountable parties, and effective reduction strategies, as well as assessing the contractual arrangements for construction and demolition activities, existing activities of C&D waste management, waste reduction in projects, encouragements, perspectives of local actors, and their compliance with legislations.

2. Literature Review

As a consequence of urbanization, the global construction industry annually consumes over half of the world's natural resources, resulting in the depletion of natural resources. In addition, the construction industry is directly and indirectly responsible for huge worldwide waste flow streams [2]. Several previous studies [3, 4, 5, 6] determined that C&D waste accounted for about 45% of all solid waste. Moreover, according to Eurostat statistics from 2016, C&D waste comprised 36% of all solid waste in the EU [7]. According to another data conducted by Eurostat in 2018, in France, the United Kingdom, and the Netherlands, C&D waste accounted for over 75% of solid waste [7].

Due to the paucity of reliable data on C&D waste in Jordan, the literature research concentrated on solid waste management to better comprehend local attitudes toward waste management. In their analysis of solid waste management in Jordan, Amine et al. [8] note that the MENA region generated around 63 million tons of solid waste in 2017, which is currently expected to be even doubled. Alshoubaki and Harris [9] indicate in their study that the recent regional conflict has resulted in a massive influx of refugees into Jordan, which has accelerated the country's urbanization and industrialization to keep up with the global trend of urbanization and industrialization and meet the enormous demand. In addition, even while it has increased demand for commodities, food, energy, housing, and infrastructure, waste generation has increased dramatically. This data should aid in forecasting the impact of the construction industry on the nation's natural resources. DOS [10] reports that the construction industry employs multiple industrial sectors in varying proportions, including mining (9.31%), as 58% of the mining sector's output is directly used as aggregates, plastics (36.09%), wood (76.4%), cement (83.75%), steel (85.42%), and other construction materials including concrete (91.52%).

Due to their limited generalizability, the most major criticism of all studies is that they should have addressed the production rates of materials, particularly construction materials. Additionally, the majority of research on the

construction industry has concentrated on a restricted number of topics, omitting one of the sector's most critical problems, C&D waste. Because there are currently no reliable and accurate data on C&D waste in Jordan, their questions would have been more beneficial if they had focused on this problem. Therefore, a review of Jordan's industrial sector might be a viable technique for tackling this issue including solid waste generation comprising its types, quantities, and management.

Despite the fact that sorting is a necessity for implementing solid waste management, Jordan's solid waste management system seems to be based only on collection and disposal of waste in designated landfill sites with no sorting in place [14]. In their research, Amine et al. [8] examine the issue of waste recycling in Jordan. According to the authors, Jordan's recycling rates remain below 7%, and the low recycling rates are mostly attributable to the government's lack of involvement in recycling management initiatives. Amine et al. [8] emphasize that Jordan continues to struggle with method integration, necessitating a reevaluation of recent legislative and legal improvements in solid waste management. In addition, Amine et al. [8] emphasize that the failures were also the result of the national government enacting updated regulations controlling solid waste management without involving the private sector and instead delegating the collection and lawful disposal of solid waste to the municipalities. On the other hand, the UNDP [15] indicates that there must be a consensus on the participation of the private sector, despite the fact that this information must be more reliable. Since GAM suggests engaging the private sector in solid waste management to achieve its objectives [15], it also contradicts multiple Amine et al. [8] findings suggesting that scavengers are responsible for the bulk of recycling.

In developing nations, the construction sector is characterized by a lack of expertise and a predisposition for change [16]. Despite this, Ali & Al Nsairat's [16] study contributes to our understanding that Jordan's construction industry is more structured, organized, and adequate than those of other developing countries. Due to its affiliation with several government organizations, including the Ministry of Public Works and Housing (MPWH), the Jordanian Construction Contractors Association (JCCA), and the Jordanian Engineers Association (JEA) [16].

According to this study, Jordan's construction industry is a substantial and rapidly expanding sector. It was anticipated that Jordan will issue around 11.8 million square meters of construction licenses in 2014 [11]. The anticipated cost of residential building is $954.8 million [17]. According to Fanack's [17] estimation, the construction industry is one of the greatest contributors to the Jordanian economy. It comprises between 5 and 10% of Jordan's Gross Domestic Product (GDP) and expands at a compound annual growth rate (CAGR) of 20.5% in 2008, 24.4% in 2009, and 34.3% in 2010 [14]. In addition, Sweis et al. [18], [19], and the Department of Jordanian Statistics [20] discovered that the industry was on track to contribute 4.6% of the country's gross domestic product between 2002 and 2011. According to the Jordanian Department of Statistics [21], its contribution to the nation's gross domestic product has increased to 5% and is expected to reach 8.3% over the next five years.

The grades of contractors in Jordan are classified by their financial condition, administrative and technical staff, equipment, and expertise [22, 20, 23, 24]. Therefore, Grade 1 contractors are the most competent and experienced for large-scale projects, whereas Grade 6 contractors are the opposite [23, 24]. Alkilani et al. [24] state that a committee may assess contractor proposals for projects published in official publications or on the website of the Jordanian Government Tendering Department. In contrast to other developed nations, such as the United Kingdom, these contractors are selected by the lowest price tender mechanism, as is typical in other developing nations [25, 24]. Therefore, this bid assessment verifies that the price matches the contractors' selection criteria [24]. According to Sweis et al. [26], "a big number of the Jordanian construction contractors are independent, small in size and often resort to under-bidding rivals to win contracts". This negatively impacts the attitudes of contractors and reduces the price to win on biddings. In AlZohbi's [27] research, a planner said: "Reducing the tender's cost can lead a contractor to look for material that meets the minimum specifications and limit some unnecessary producers or activities within the project". According to Sweis et al. [19], "The value of the contract is one of the factors that can affect the production-quality of the projects in Jordan". As noted by JGBC [12] and GIZ [11], this may lead contractors to disregard excessive activities such as C&D waste management or the legal disposal of C&D waste in designated landfill sites, resulting in informal dumping, which improves the accuracy of projections about the many reasons against the legal disposal of C&D waste.

Jordan's urbanization has been aided by the construction industry; yet, due to its operations and activities, Jordan's construction sector uses a significant quantity of raw materials resulting in deplete of natural resources, consume energy, and generate greenhouse gases [13]. In addition to the informal disposal of C&D waste, the generation of C&D waste and its repercussions are a significant problem for the Jordanian construction industry [14]. According to JGBC [12] and GIZ [11], the majority of excavation material, debris, and C&D waste is disposed of informally without a license or authorization to accept such an action in roadside ditches or open spaces near residential areas. It includes, but is not limited to, timber, steel, and other removable or disassembled components such as door and window frames, as specified in other sections [11, 12, 14].

According to a study conducted by GIZ [11], Municipal waste is classified into six types, one of which is other types of waste including C&D waste accounting for around 15.5% of the total composition of C&D waste. This percentage of C&D waste must be considered with extreme

caution. As according to a study conducted by JGBC [12], C&D waste accounts for approximately 43% of total solid waste composition. This apparent contradiction may be the consequence of the complexity involved in estimating C&D waste as a result of the variety of disposal approaches adopted. This is supported by the findings of international research, which indicate that C&D waste accounts between 30% to 40% of total solid waste composition and that clearly comes in line with JGBC [12] study. As a result, this waste pollutes the environment and has a severe influence on people's health and well-being, as well as the economy via disposal fees and transportation expenses [13].

According to a research by Bekr G.A. [28], between 2010 and 2012, C&D waste increased from 11.5% to 15.2%. The author highlighted that Jordanian construction projects generate only 15% to 21% of C&D waste. A more informative analysis would have included demolished structures. Nonetheless, several studies indicate that rehabilitation and demolition debris account for the majority of C&D waste. Consequently, the majority of Jordan's C&D waste should have resulted from rehabilitation and demolition projects [29, 30, 1].

If improper solid waste management in Jordanian municipalities is not successfully addressed [14], future repercussions will intensify and it may continue to contribute to the generation of more waste. In order to avoid future repercussions, Jordan, like other developed countries, should pay early emphasis to the management of C&D waste in the construction industry [31].

3. Methodology

The methodology portion of the study explains the methodologies, techniques, and procedures utilized to illustrate, select, and analyze the material about the impact of C&D waste management in Jordan [32]. Holden & Lynch [33] examine the link between the significance of research philosophy and its roles in providing the researcher with a variety of alternatives, as it fosters confidence in the implementation of appropriate methods while enhancing the study's credibility. Several stages of decision-making are connected with research methodology [34, 35, 36]. Quantitative, qualitative, and triangulation research approaches are the most successful [35, 38, 36, 39, 33].

Study Strategy Decision and Selection Methods

Research Philosophy and Methodology Selection – Research Strategy Decision and Selection Methods

The fundamental philosophy of the study is epistemological philosophy; it was supplemented by a variety of methodologies designed to address the research problem and questions. To diversify the approach to the problem statement and questions, a pragmatic technique associated with the use of surveys using both subjective and objective quantitative methodologies is performed.

Selection of Data Collection Techniques

According to Fellows and Liu [35], the reliance on data is increased when a variety of sources are employed to examine the same phenomenon; for example, reviewing of previous literatures and conducting open-ended questionnaire surveys.

Reviewing of Secondary Data

Analysis of peer-reviewed articles, Ebooks, textbooks, books, and journals from online and offline sources such as University Libraries, Science Directories, Elsevier, Google Scholar, and Conference Proceedings made the literature feasible.

Questionnaires Surveys

The most efficient way to obtain data from the larger community and construction management is via surveys [40]. The survey allowed for the effective and fast collecting of trustworthy firsthand information from respondents of various backgrounds in the Jordanian construction industry.

Sampling Methods

Single-stage and multistage sampling methods are provided as the two main options for this study. Multistage sampling method is particularly suitable for the Jordanian construction industry, where twenty-person groups of personnel were clustered [41]. As it permits the surmounting of obstacles posed by the random selection of large populations. The survey questions were used to fill in the gaps in the literature review, such as assessing the rate of informal dumping, identifying the root causes of informal dumping, and determining the approach for preventing informal dumping in Jordan [42]. Table 1 below represents the questionnaires' sampling selection method and the number of participants.

Data Analysis

Analysis of quantitative data permitted the interpretation of the questionnaire results. The initial phase of the analysis investigated, sorted, and grouped the data for legitimacy and dependability. Data screening, descriptive analysis to simplify and summarize the large quantity of data, and the use of percentages, averages, and the Likert scale to quantify the data and rank variables based on their values were relevant data analysis approaches.

Table 1. Questionnaires' Sampling Selection Criterion (own creation)

No. of participants	Sampling Selection	Target Professional Positions
> 300	Actors randomly sampled from industry associations such as: Greater Amman Municipality (GAM). Ministry of Local Administration (MLA). Ministry of Public Works & Housing (MPWH). Ministry of Environment (MoE). Academics. Contractors. Concrete Suppliers	Construction engineers Environmental engineers Supervision specialists Contractors Structural engineers Consultants Architects Academics Quality assurance specialists Clients

Study Validity and Reliability

The validity and dependability of the study's data were measured based on prior research. The literature permits the formulation of questionnaires, the collection of data, and exploring the diversity of the research topic. Validity and dependability of the study were ensured by the use of computer equipment and software for transcribing and assessments, along with using experienced and informed participants.

Bias

Specific question content, questionnaire length, and question clarity were considered to avoid possible biases.

Ethical Consideration

The study obtained the required authorization to carry out the project. Before involving the participants in the research, a Participant Information Sheet (PIS) and a Participant Consent Form (PCF) were employed. The PCF recorded participants' details and consent.

4. Results and Discussion

This section uses questionnaire surveys to determine what is lacking in Jordan's C&D waste management by analyzing, synthesizing, and assessing survey results. The purpose of these surveys was to elicit a broader response from qualified Jordanian construction specialists. It incorporates additional information on the number of replies and detailed descriptions of typical and unusual questions, respectively, in order to construct a comprehensive and systematic study. The data analysis is summarized in tables and graphs that show similarities and differences in participant percentages, the connection between respondents, and provide enough context and clarity for participant replies.

The surveys were divided into five categories that would influence the process of data analysis.

(i) Informal Dumping.
(ii) Aspects of Jordanian Construction Industry Contracts.
(iii) Encouragements to Improve C&D waste management Strategies.
(iv) Industry Actors' Perspectives.

Questionnaire Analysis

Informal Dumping

This section analyzes and depicts the realities of informal dumping, its percentage, the causes of informal dumping, approaches for mitigating it, and the parties involved on informal dumping.

(i) Percentage of Informal Dumping

This section depicts actors' predictions regarding the proportion of C&D waste disposed of informally in Jordan as a proportion of total C&D waste produced, which are presented in figure 1 below.

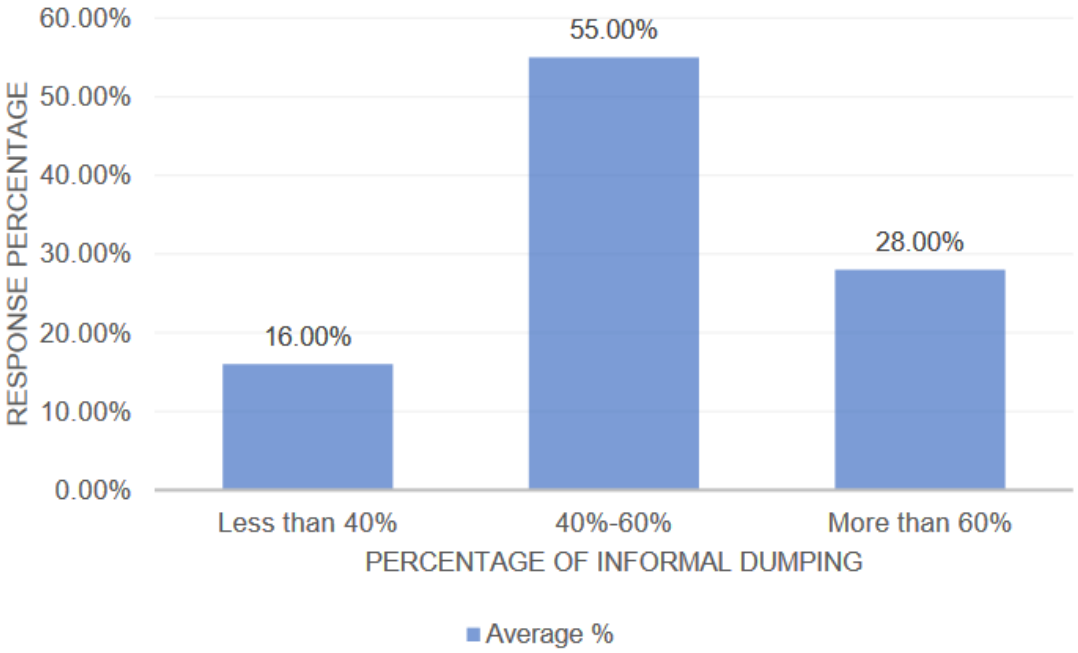

Figure 1. Percentage of Informal Dumping (own creation)

According to the aforementioned statistics in figure 1, responses on the percentage of informal dumping vary from less than 40% to more than 60%. The majority of responders agreed on a range of 40% to 60%, while only around 55% of all actors agree with this range. The empirical finding of figure 1 reveals that informal dumping happens regularly and at a high frequency, which critiques the government's ability to regulate appropriate landfilling. Particularly when present regulations require C&D waste to be disposed of in designated landfill sites.

(ii) Reasons for the Informal Dumping

This section covers in figure 2 the potential causes of C&D waste informal dumping in Jordan's construction sector.

As seen in figure 2, the primary causes of informal dumping are distributed across Governmental controls; which facilitated informal dumping with an average of roughly 45% of all participants. These inadequate restrictions include the absence of legal frameworks and regulations, oversight, supervision and strictness, management and waste disposal systems. Simultaneously, as seen in the same figure, the involvement of local actors shows a 30% participation rate, while the cost and expenditure rate is 6%.

(iii) Approaches for Mitigating the Informal Dumping

This section analyzes various approaches for reducing the percentage of C&D waste informal dumping. Figure 3 outlines the responses of participants on these approaches as seen below.

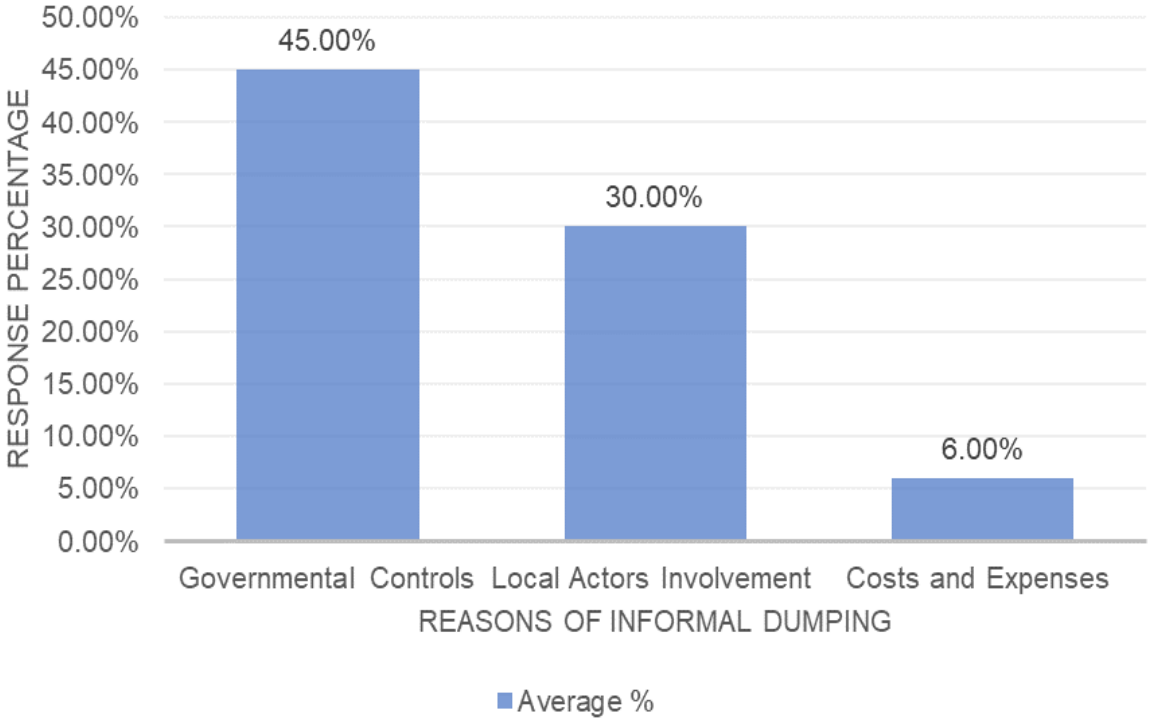

Figure 2. Reasons of Informal Dumping (own creation)

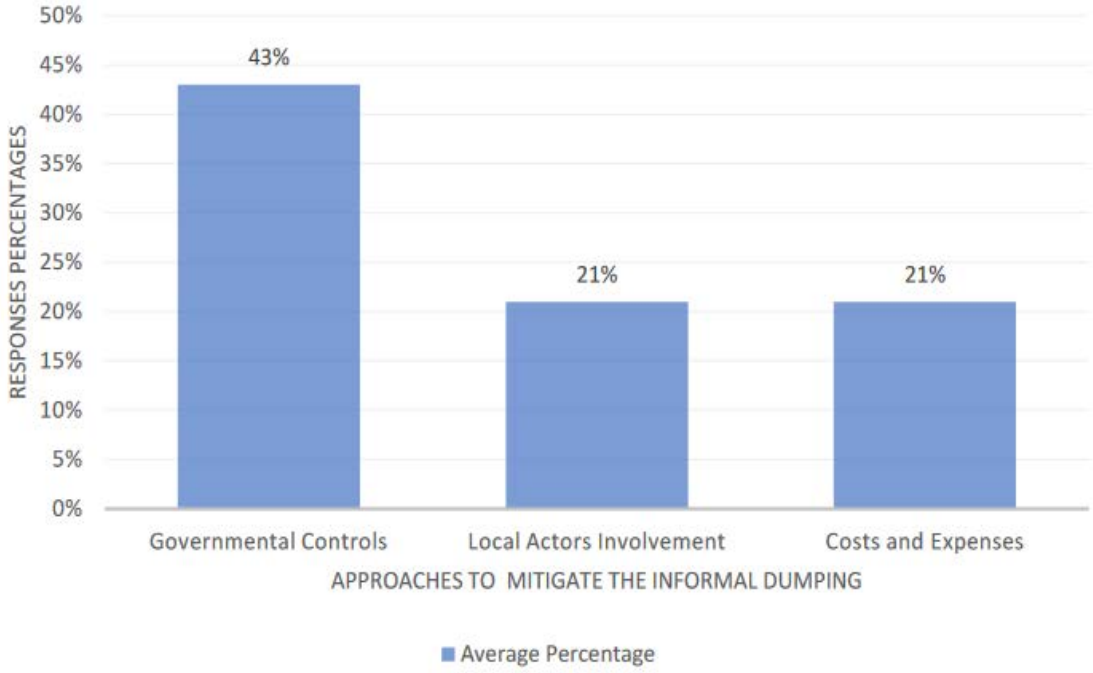

Figure 3. Approaches for Mitigating the Informal Dumping (own creation)

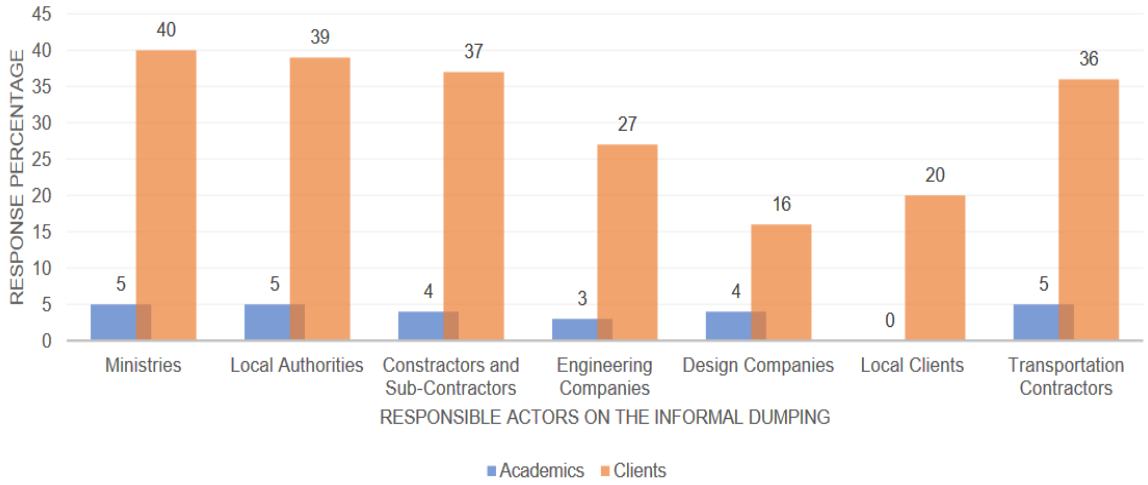

Figure 4. Responsible Side of the Informal Dumping (own creation)

The survey questions for this study are intended to elucidate implementable approaches for illegal dumping. As outlined in figure 3, almost 43% of responders firmly believe that government controls, restrictions, and regulations are the answer. This involves enhancing and modifying legal frameworks and regulations, increasing government monitoring and rigor, and providing tax exemptions.

(iv) Responsible Side of the Informal Dumping

This section outlines through figure 4 the parties accountable for C&D waste informal dumping in the Jordanian construction industry.

According to figure 4, an average of 28% of participants suggest conclusively that public institutions, including ministries and local authorities, are to blame and liable for informal waste disposal. Surprisingly, the results show that the government is not the only actor responsible on such an informal practice. Since, construction and transportation contractors should comply with the current regulations (proper landfilling), although, they are currently inappropriately dumping C&D waste.

Aspects of Jordanian Construction Industry Contracts

This section discusses public and private construction, demolition, and design contractual arrangements. By assessing the exclusion of C&D waste from current regulations, contract types, and procurement for construction and demolition projects. These tables and graphs summarize survey findings.

(i) C&D Waste Exclusion

Participants were asked to rate on a scale from 1 to 5 the potential reasons for the exclusion of C&D waste from present legislation (1 for strongly disagree and 5 for strongly agree). Results are obtained from figure 5 as seen below.

As demonstrated in figure 5, all participants acknowledged that there is a weak correlation between the absence of design codes of practice in the country that are intended to govern the design of a new development throughout the design and planning process and the exclusion of C&D waste from current solid waste regulation systems. This consistency is an excellent indicator of how aware people are on C&D waste issues in Jordan. Although, figure 5 validates that over 90% of respondents from both departments of GAM and MoE agreed that lack of awareness contributed to exclusion and considering C&D waste as a unique type of waste that requires specific legislation and treatment. In addition to other causes that do not preclude their influences.

(ii) Types of Contracts Used

This section distinguishes between the many types of contracts used in the Jordanian construction sector for construction and demolition projects. This distinction could be seen in figure 6 below.

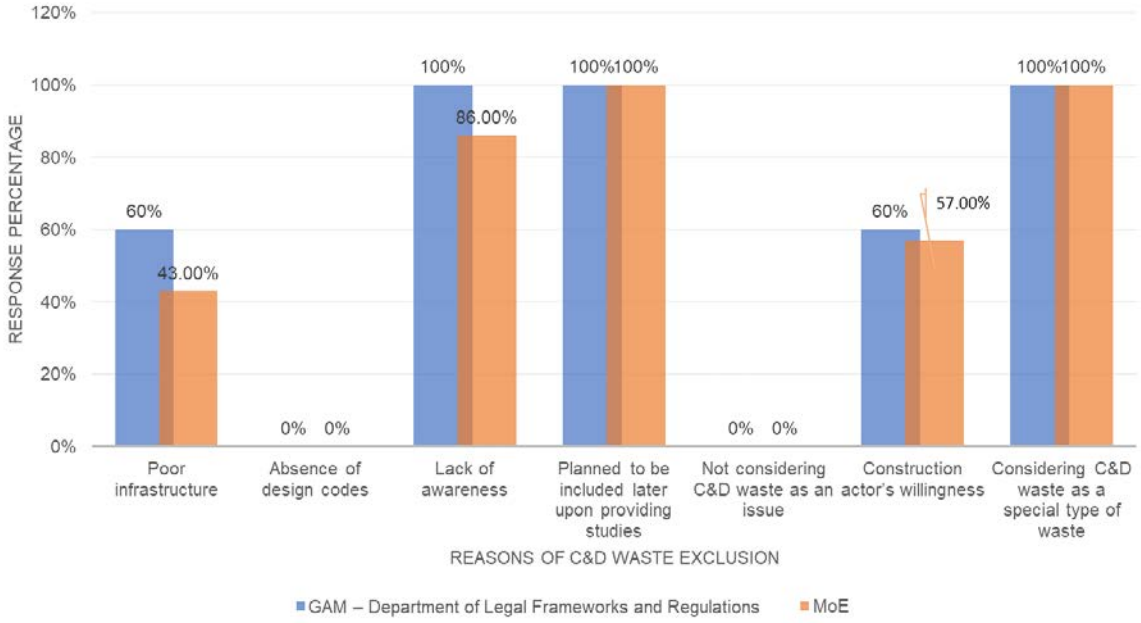

Figure 5. Reasons of C&D Waste Exclusion (own creation)

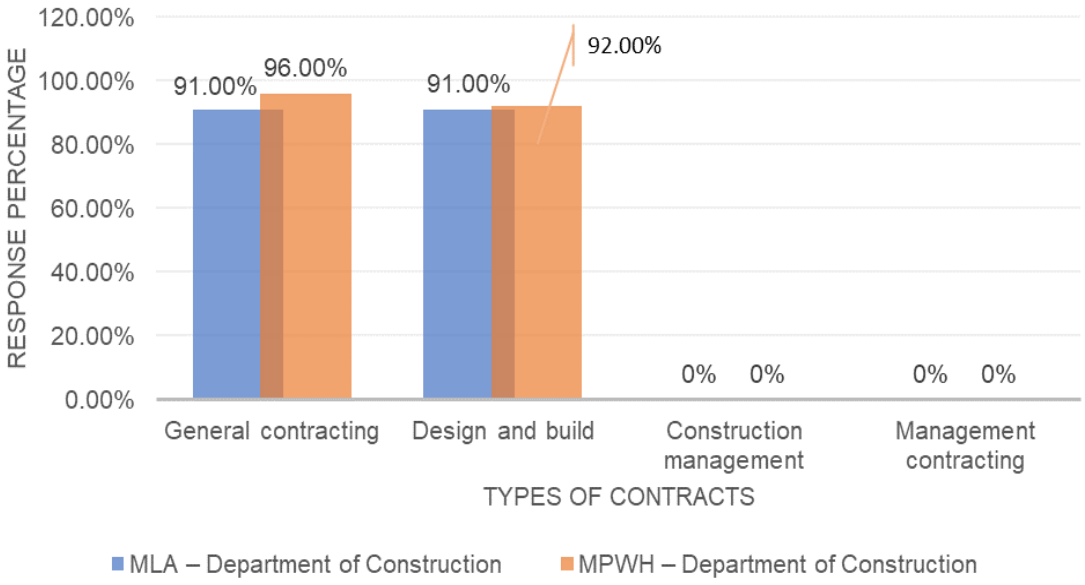

Figure 6. Types of Contracts Used (own creation)

The findings of this survey as shown in figure 6 add to the current knowledge that general contracting and design-build contracts are the only forms of contracts utilized in government projects as reported by more than 90% of participants.

(iii) Procurement Methods for Bidding

This section distinguishes between methods of procurement for construction and demolition projects through table 2.

As shown in table 2, over 90% of respondents indicated that the only way to get construction contracts is via low bidding. This study aimed to differentiate between construction and demolition procurement processes. As an average of 38% of respondents reported that demolition projects are purchased via low bidding. While as presented in table 2, almost twice as many respondents claimed that no selection method is utilized and employs no pre-existing selection criteria, which demonstrates a strong correlation between the procurement of demolition projects and the obstruction of C&D waste management. Indeed, only two aspects are addressed during demolition: safety precautions and legal disposal of C&D waste.

Missing Construction and Demolition Waste Management Activities

This section investigates the present C&D waste management activities in Jordan and discusses the

underlying reasons for their lack of acceptance or non-adoption including:

(i) Waste collection.
(ii) Sorting.
(iii) Recycling
(iv) Legal disposal.
(v) Design waste-out on projects.

Table 2. Procurement Methods for Bidding (own creation)

Actors	No. of Participants	Procurement Methods						
		Type of Project	Best Value	Low Bidding	Negotiated	Qualification Based	Direct selection	No Methods for Selection
MLA – Department of Construction	11	Construction Projects	0%	100%	0%	0%	0%	0%
		Demolition Projects	0%	55%	0%	0%	0%	45%
MPWH – Department of Construction	24	Construction Projects	0%	92%	0%	4%	4%	0%
		Demolition Projects	0%	21%	0%	0%	4%	75%

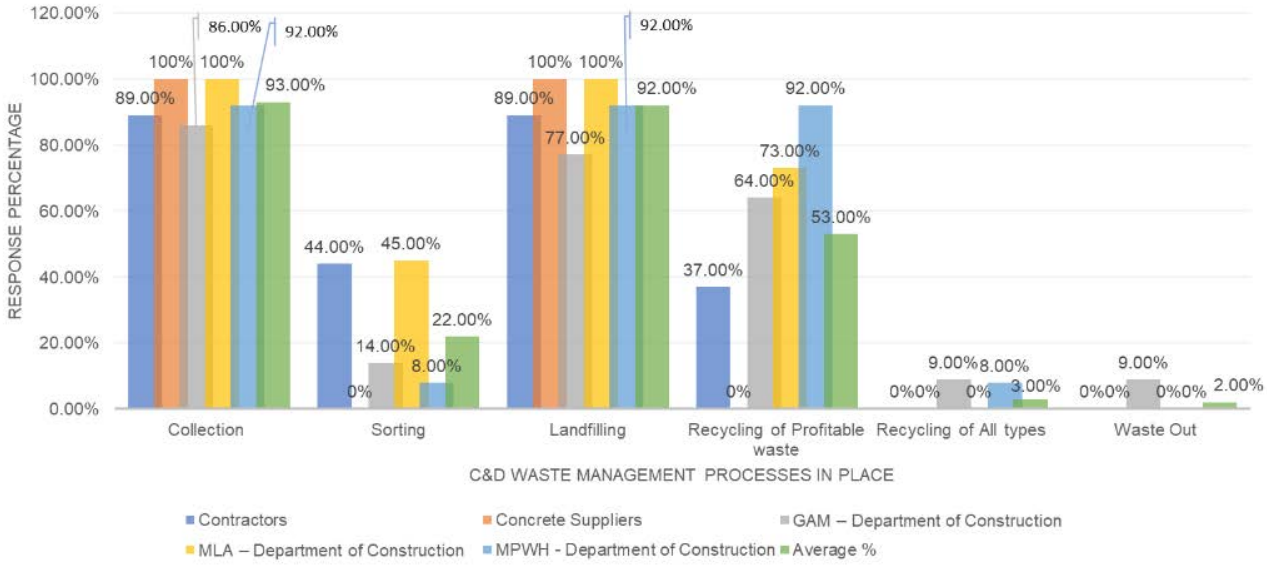

Figure 7. Current Applied C&D Waste Management Activities (own creation)

(i). Construction and Demolition Projects

This section recognizes the industry's current C&D waste management practices in construction and demolition projects by presenting participants' responses in figure 7.

As revealed in figure 7, the average proportion of replies for collection was around 93% and for landfilling, it was almost 92%, with a range of 75% to 100% for both activities. Over 75% of respondents indicated that sorting and recycling of all waste categories, as well as the designing out waste, do not exist. However, it could be seen from figure 7 that 53% of participants believe that recycling only happens on a small number of C&D waste materials that seem to generate direct money or profit. As industrial actors in Jordan recycle valuable waste materials such as steel and timber for profit without the presence of regulations.

Construction and Demolition Waste Management

In this section, respondents are asked to select three of the most probable factors prohibiting each C&D waste management activity, including collecting, sorting, transporting waste to designated landfill sites, recycling, and reusing, from occurring on-site.

(ii). Reasons Preventing Collection of Construction and Demolition Waste

This section seeks to identify the interconnected issues that impede on-site C&D waste collection by presenting them in figure 8.

Figure 8 exposed that the involvement of informal workers and the lack of skills and knowledge among local actors have a significant impact on the collection of C&D waste, with response rates of around 50 and 45%, respectively. These consequences do not exclude the impact of additional obstacles. Such are the lack of management system, as indicated in figure 8 by an average of 43% of participants, the time restrictions, as indicated by an average of 63% of MLA participants, and the seeming lack of awareness, as indicated by an average of 40% of participants.

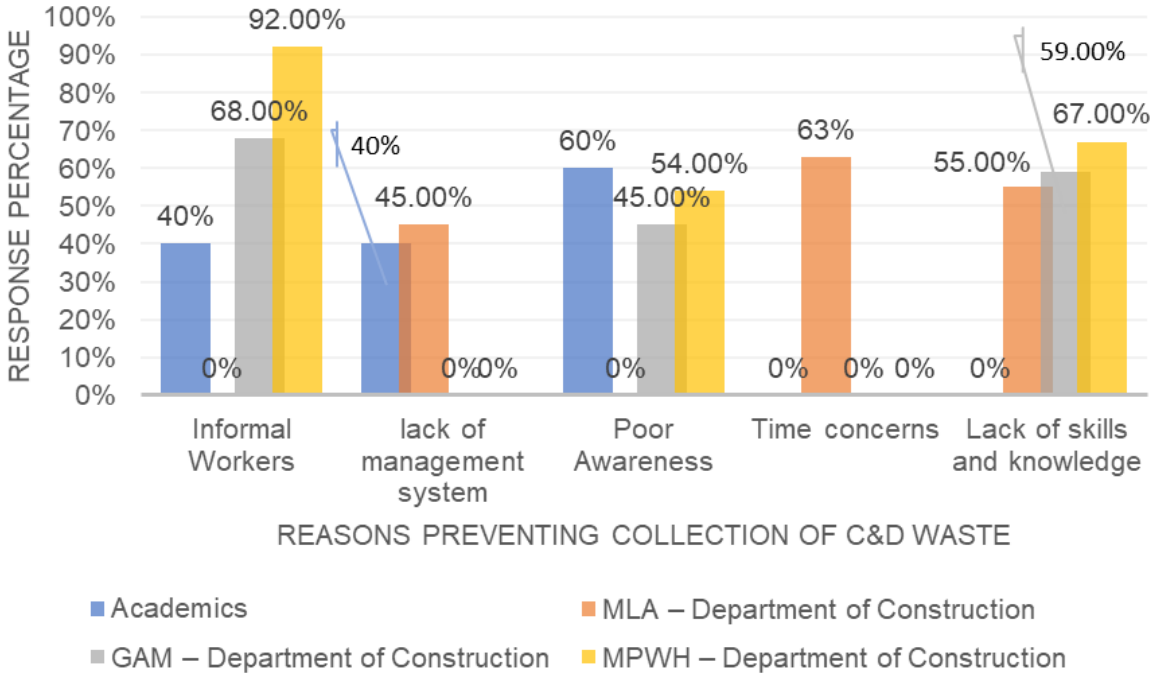

Figure 8. Reasons Preventing the Collection of C&D Waste On-Site (own creation)

(iii). Reasons Preventing Sorting of Construction and Demolition Waste Management

This section was developed to identify several factors that lead to the difficulty to sort out C&D waste. Figure 9 signifies the reasons preventing the sorting of C&D waste based on participants' involvement.

According to the findings of this survey presented in figure 9, the most major barrier to sorting is the lack of equipment, including crushers, shredders, and screening equipment, as reported by roughly 55% of respondents on average. The results of figure 9 also reveal that the lack of regulations may have a substantial effect on the implementation of sorting. As roughly 30% of the same participants concur. With an average of almost 24%, informal workers are a key element in hampering sorting, according to the data shown here.

(iv). Reasons Preventing Recycling of Construction and Demolition Waste

This section highlights in table 3 the significant obstacles identified as hindering the implementation of C&D waste recycling.

The absence of design codes of practice seems to be the most significant barrier to C&D waste recycling as reported in table 3 by an average 52% of participants. A little less than 24% of MLA and GAM participants agreed that a lack of demand for recycled waste material may limit C&D waste recycling. On average, around 21% of academics and MLA participants and 20% of GAM and MPWH participants agreed with the statement that there is inadequate infrastructure and a lack of recycling equipment respectively. As outlined in the same table, the lack of financial incentives hinders C&D waste recycling with an average response rate of around 34%.

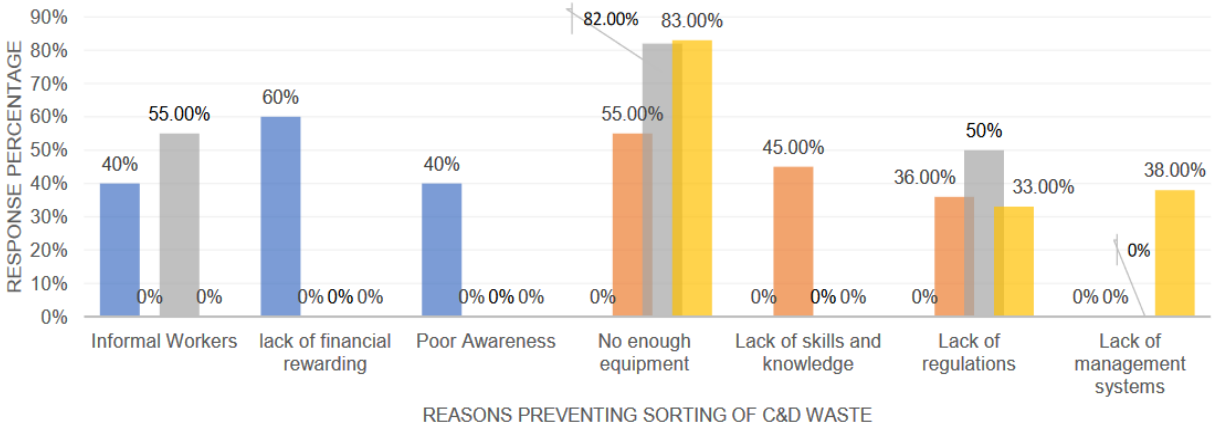

Figure 9. Reasons Preventing Sorting of Construction and Demolition Waste (own creation)

Table 3. Reasons Preventing Recycling and Reusing of Construction and Demolition Waste (own creation)

Actors	No. of Participants	Reasons		Respondents % (Confirmed)
Academics	5	lack of financial rewarding	3	60%
		Limited availability of infrastructure facilities	2	40%
		Absence of recycled waste material design codes of practice	2	40%
MLA – Department of Construction	11	Absence of recycled waste material design codes of practice	7	64%
		Limited availability of infrastructure facilities	5	45%
		Lack of demand on recycled waste material	5	45%
GAM – Department of Construction	22	Absence of recycled waste material design codes of practice	12	55%
		Lack of demand on for recycled waste material	11	50%
		Absence of equipment	8	36%
MPWH – Department of Construction	24	lack of financial rewarding	18	75%
		Absence of recycled waste material design codes of practice	12	50%
		Absence of equipment	10	42%

(v). Reasons Preventing Transportation of Construction and Demolition Waste to Landfill

This section illustrates the assessment of the potential reasons for preventing transporting C&D waste to permitted landfill sites in figure 10 below.

Long transportation distances to landfill sites are a key barrier impeding the transportation of C&D waste to designated landfill sites, according to figure 10 by an average of 84% of participants. This approach was effective in broadening our awareness that approved landfill sites are situated distant from construction locations. Thus, they may result in an increase in transportation expenditures, as about 26% of GAM and MLA participants indicated on average. In this study figure, an average of 45% of academics, MLA, and MPWH participants agreed that insufficient oversight on waste disposal activities was a major problem.

(vi). Design out Waste

This part investigated existing C&D waste management design methods, including impediments to application of design waste out approaches, such as reduction, prevention, and deconstruction. In addition to defining the essential driving encouragements to eliminate waste in project design. Besides, it provides a comprehensive explanation of the absence of recycled waste material design codes of practice by identifying the most probable reasons.

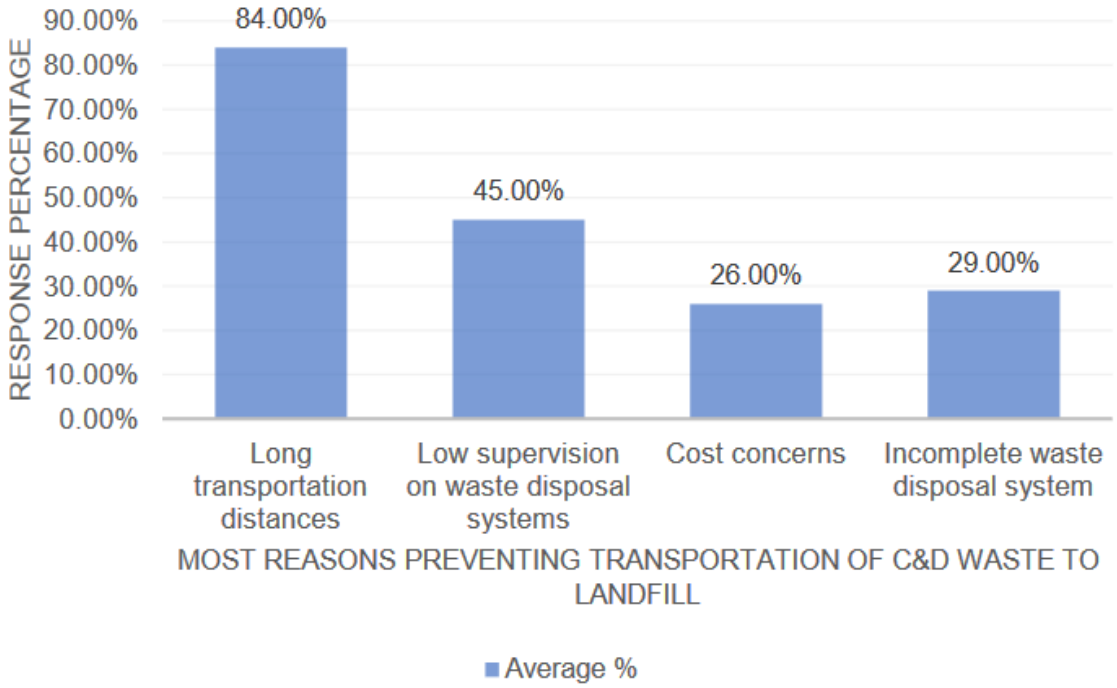

Figure 10. Reasons Preventing Transportation of Construction and Demolition Waste to Landfill Sites (own creation)

(i). Adoption of Design out Waste Approach

The sub-section examined the frequency or possibility of the construction sector implementing any of the design-out waste methods in projects. This observation is outlined in figure 11 below.

The results of this study as presented in figure 11 support the premise that C&D waste is disregarded throughout the design phase of projects. According to the investigation, Jordanian design companies do not use any design out waste approaches as indicated in the same figure by over 95% of academics, MLA, and MPWH respondents. As it seems to confirm the assumption that this phase focuses mostly on generic design elements.

(ii). Reasons behind Not Designing out Waste

This sub-section describes through figure 12 the essential factors that contributed to the governmental departments' and design firms' prior adoption to design out waste on projects.

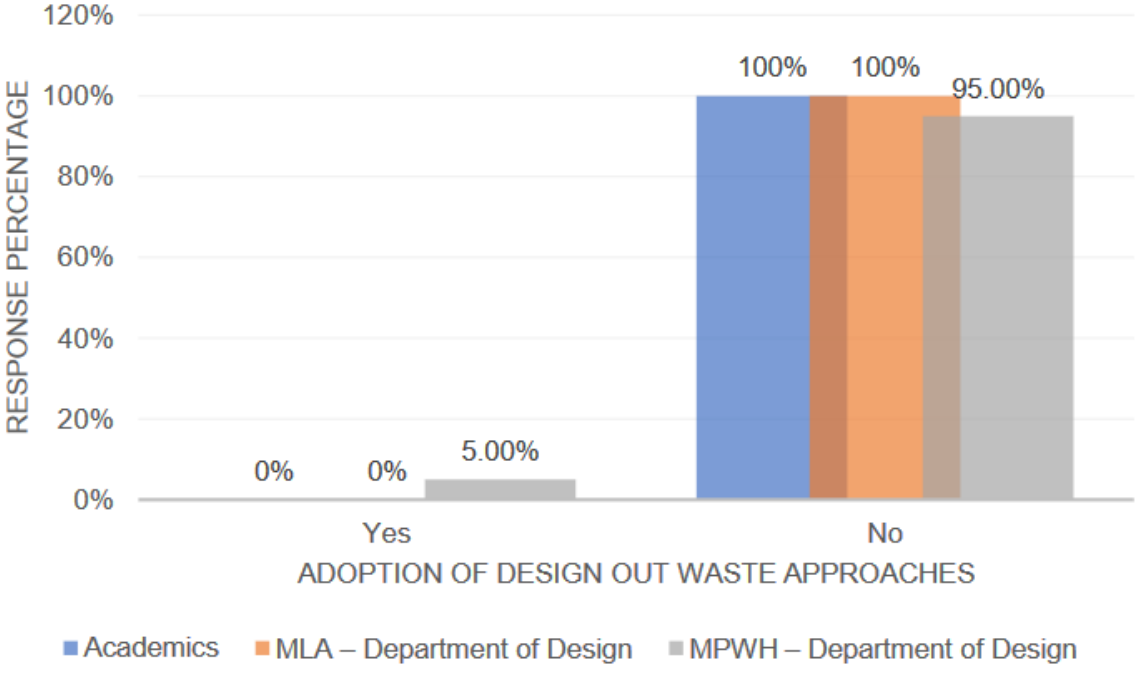

Figure 11. Adoption of Design out Waste Approach (own creation)

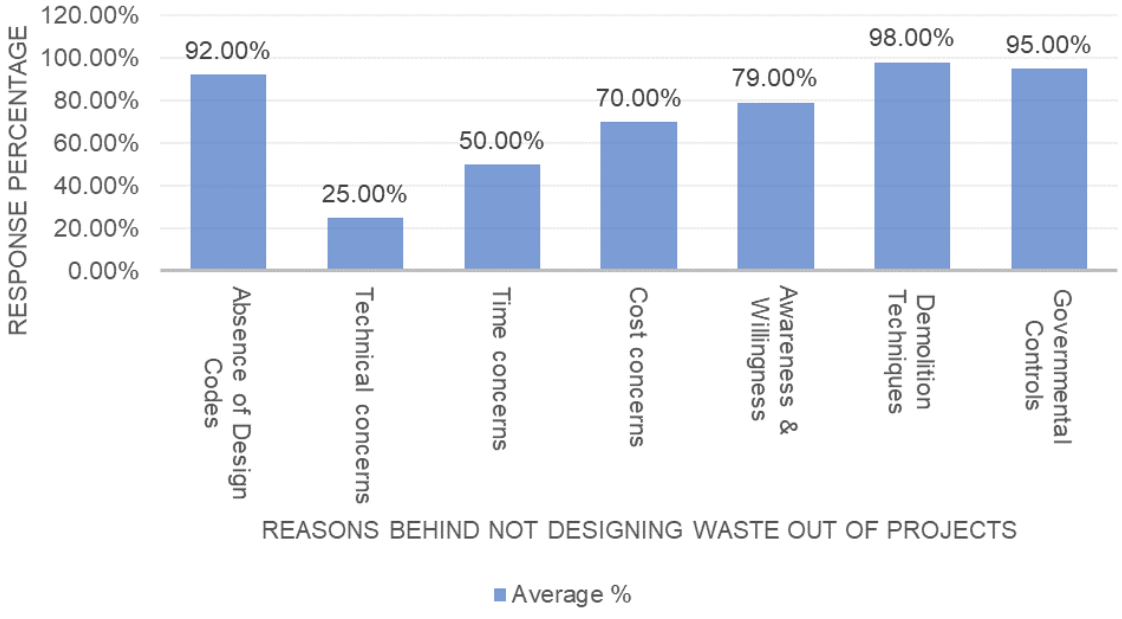

Figure 12. Reasons behind Not Designing out Waste (own creation)

According to the results observed in figure 12, an average of 98% and 95% of academics, MLA, and MPWH participants believed that inefficient demolition techniques and inadequate government controls inhibit design out waste alternatives. The lack of design codes of practice was cited by figure 12 with an average of almost 92% of respondents as one of the primary reasons design firms and departments do not design out project waste. In addition to the cost, time and technical concerns, and the awareness and compliance of local actors.

(iii). Approaches to Adopt Design out Waste

This sub-section assesses the effectiveness of many design-out waste strategies. It requests that respondents scale the following approaches that might aid in the implementation of design of C&D waste out on projects. Respondents' assessment is presented in figure 13 below.

The current results highlight the importance of encouraging the implementation of design out waste programs. By creating design codes of practice, regulating design out waste on projects, and establishing recycling facilities, as 98.24% of participants agreed on average as seen in figure 13. Participants exhibited a remarkable degree of consensus for these three encouragements. Therefore, they should be initiated simultaneously to be effective.

(iv). Hindrance to Design Codes of Practice Existence

This last sub-section covers through figure 14 the issues that contribute to the lack of a design codes of practice for recycled C&D waste materials. Respondents are asked to rate from 1 to 5 the obstacles to the establishment of such codes of practice.

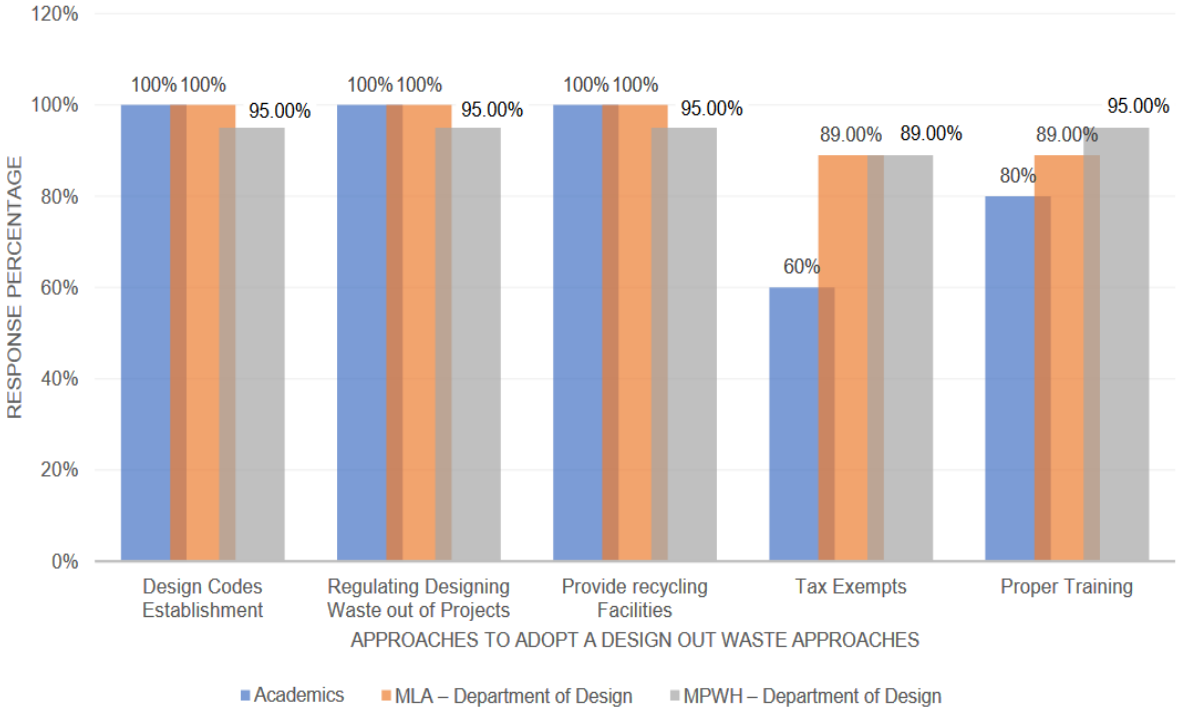

Figure 13. Approaches to Adopt Design out Waste (own creation)

Figure 14 has shown that almost 95% of participants on average, indicated that time restrictions is a contributing reason to the absence of design codes of practice due to experimental testing. Moreover, an average of around 84% of all participants attributed the absence to financial concerns. These do not rule out the effect of other factors, as shown in figure 14 by the fact that 78% of participants regard C&D waste recycling to be a relatively recent technology on average.

Encouragements to Improve C&D Waste Management Strategy

This section attempts to persuade industry actors to engage in C&D waste management in Jordan, specifically C&D waste recycling. Participants are asked to rank on a scale from 1 to 5 the following encouragements that may shift the construction sector into adopting a C&D waste management strategy. Results of such are presented in table 4 below.

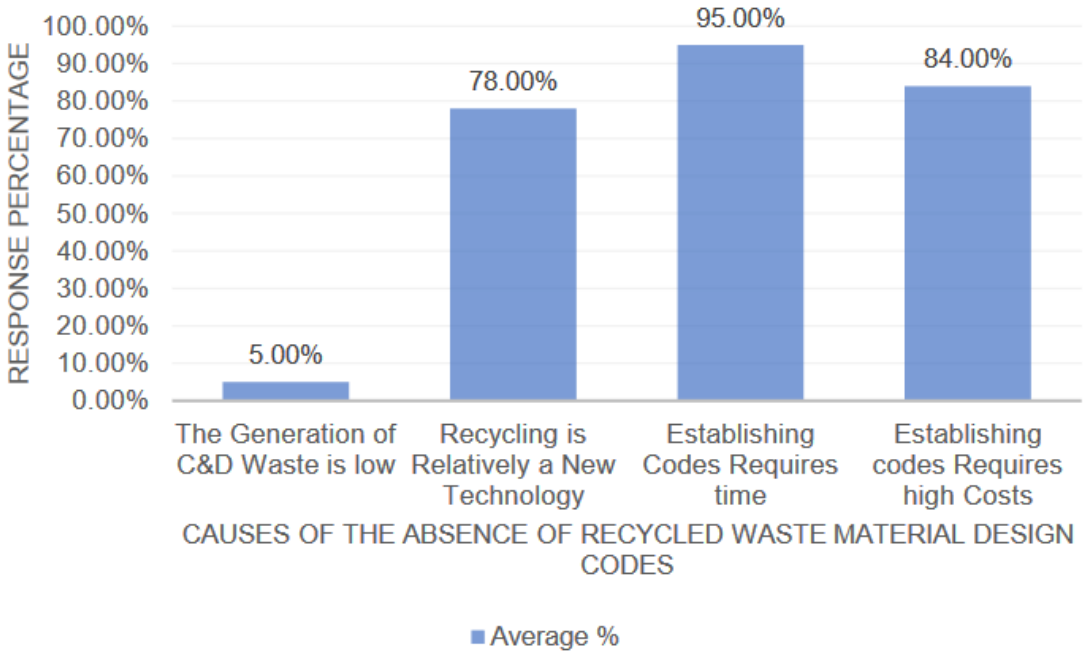

Figure 14. Hindrance to Design Codes of Practice Existence (own creation)

Table 4. Encouragements to Improve C&D Waste Management Strategy (own creation)

Actors	No. of Participants	Respondents % on Encouragements				
		Modifying the regulations and legal frameworks	Enriching the local market with recycled waste material market	Tax exempts	Increase the disposal fees	Apply Fines or penalties for Polluters
GAM – Department of Construction	22	100%	100%	73%	36%	100%
GAM – Department of Legal Frameworks and Regulations	5	100%	100%	100%	60%	100%
MoE	7	100%	100%	100%	29%	100%
MLA - Department of Construction	11	100%	82%	82%	27%	91%
MLA - Department of Design	18	100%	100%	100%	33%	94%
MPWH - Department of Construction	24	96%	92%	92%	33%	100%
MPWH - Department of Design	19	100%	100%	100%	5%	100%
Average %	--	**99%**	**96%**	**92%**	**32%**	**98%**

According to the data presented in table 4, more than 95% of respondents indicated that the primary encouragement for promoting C&D waste management includes modifying existing regulations, imposing fines or penalties on violators or polluters, and enriching the local market with recycling marketplaces. In addition to the aforementioned encouragements, an average of 92% of respondents and more than 70% of each actor agreed that tax incentives may affect the result. Along with boosting disposal fees as shown in the same table by an average of 32% of participants, the nation might encourage C&D waste management.

Because of their distinct roles in Jordan, the participants' responses, particularly those of GAM, MLA, and MPWH, varied. Since GAM is responsible for providing public services to citizens in the capital in various fields such as licensing, engineering and other services. Meanwhile, MLA functions the preparation of general policies of the local administration and developing the necessary plans and programs for its implementation. In addition to coordinating councils and municipalities excluding GAM to achieve comprehensive local development and guide their needs and budgets efficiently within their priorities. Nonetheless, MPWH is responsible for connecting cities, population centers, and neighboring nations with a network of high-quality roads, preserving their sustainability, increasing road traffic safety, and expanding the construction industry by implementing best practices and cutting-edge technologies that keep up with global developments.

Industry Actors Perspective

This section explored environmental, social, and economic factors from the perspective of the construction industry actors, as well as their readiness to promote C&D waste management. The tables and figures below provide a summary of the principal results of these surveys, as reported by respondents.

(i). Possible Concerns

This sub-section emphasizes the government's interests by exhaustively analyzing their environmental, social, and economic considerations. Participants are thus asked to indicate on a scale from 1 to 5 the potential considerations taken by their authority, which has been represented in figure 15 below.

According to the findings of this survey presented in figure 15, the economic concerns seem to be the top preoccupation of the Jordanian construction industry actors. This was stated by an average of more than 90% of individuals. The results of the survey reveal that environmental and social considerations are less significant than economic ones, as evidenced in figure 15 by an average percentage range of 60% to 70% and 50% to 95% of all participants, respectively.

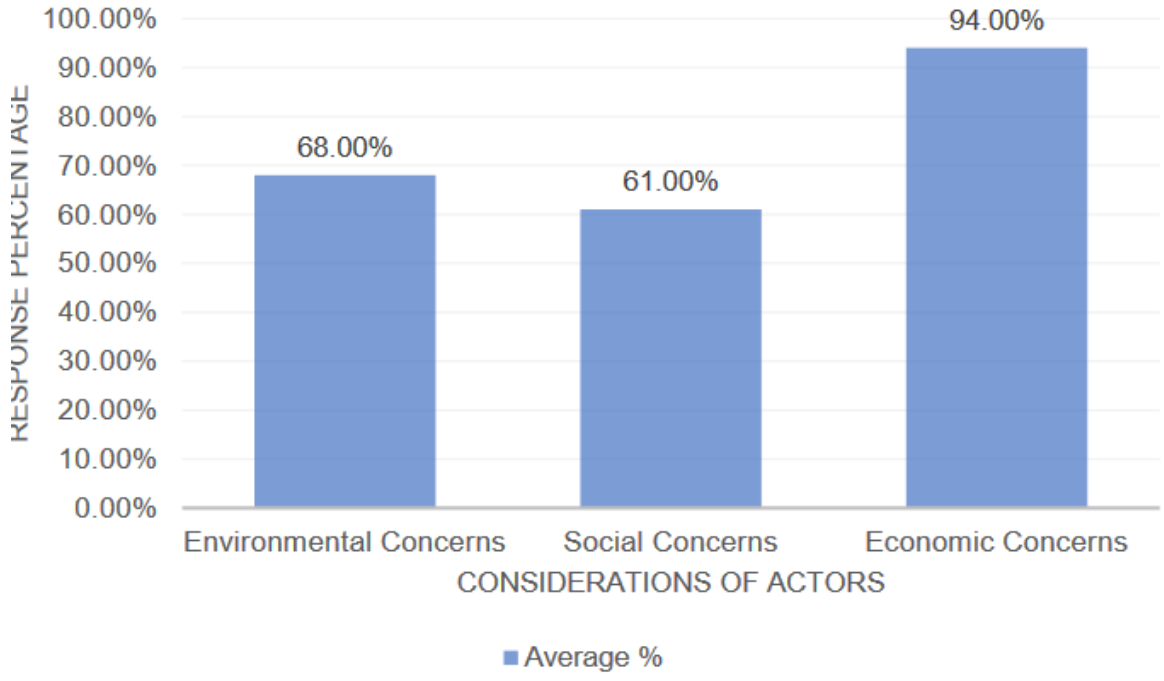

Figure 15. Possible Concerns (own creation)

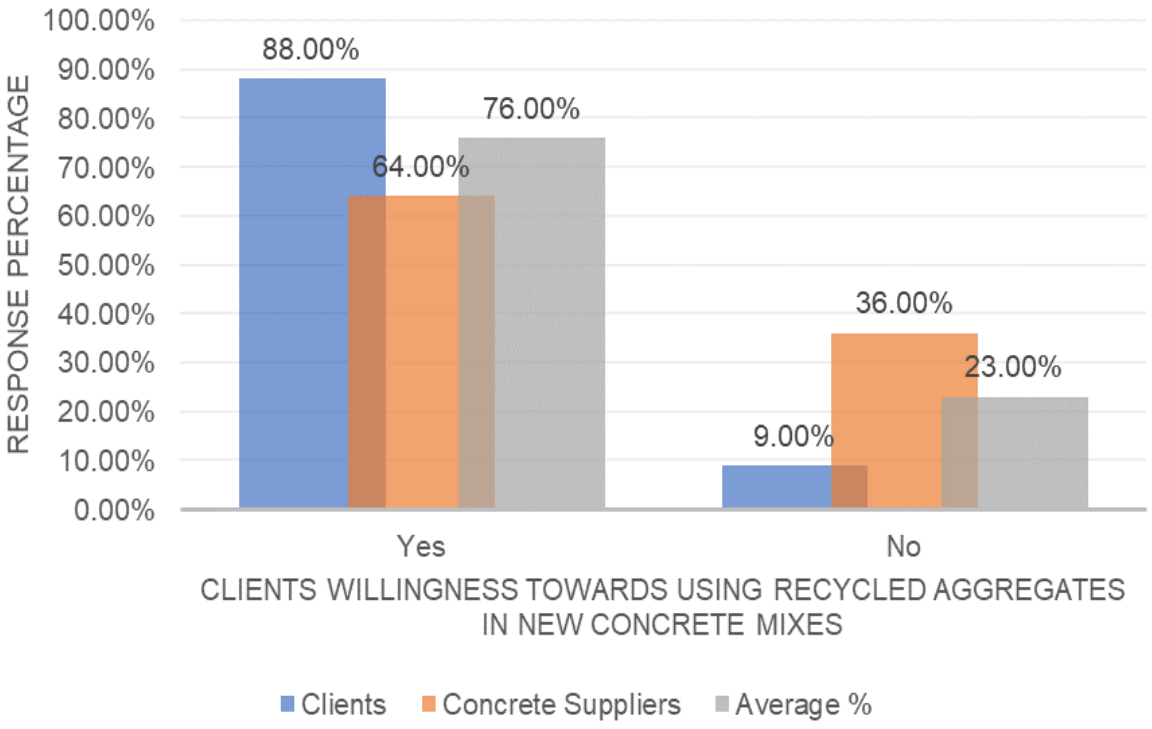

Figure 16. Clients' Willingness towards using Recycled Crushed Concrete Aggregate (own creation)

(ii). Willingness towards Using Recycled Crushed Concrete Aggregate

This sub-section evaluates the industry's willingness to use recycled aggregates into new concrete mixes. The tables and figures below provide a summary of the principal results of these surveys, as reported by respondents.

(i). Clients' and Concrete Suppliers' willingness towards using Recycled Crushed Concrete Aggregate

This section examines the willingness of clients and concrete suppliers to use crushed concrete aggregates in concrete mixes as seen in figure 16. By posing how clients consider utilizing recycled aggregates in new concrete mixes for new projects under design codes of practice and specifications. Besides concrete suppliers by posing how aware about construction actors willingness to use recycled aggregates in new concrete mixes.

According to figure 16 data, around 89% of clients and 64% of concrete suppliers report that clients are willing to use recycled aggregates in new concrete mixes. Although, the presence of design codes of practice for recycled waste material is inexorably related to the clients' willingness to authorize.

(ii). Contractors Willingness

This sub-section describes the contractor's readiness to use recycled aggregates into new concrete mixes. Participants are asked whether they would consider the use of recycled material if they were designed under design codes of practice as demonstrated in figure 17 and table 5.

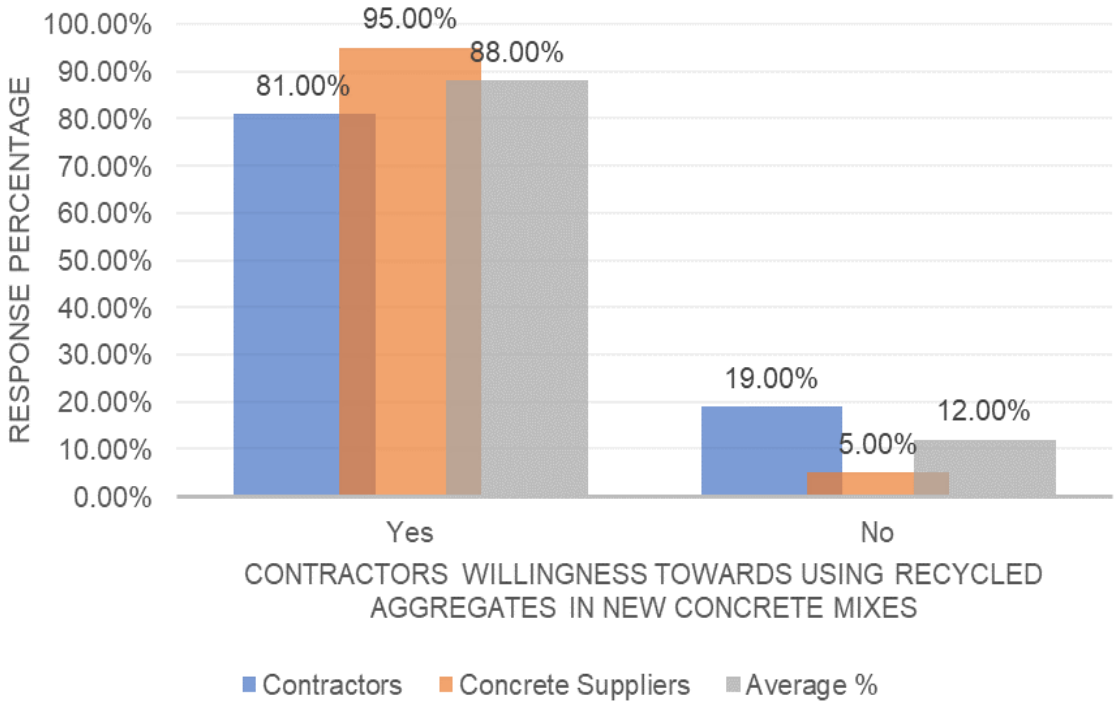

Figure 17. Contractors' willingness towards using Recycled Crushed Concrete Aggregate (own creation)

Table 5. Willingness towards Using Recycled Crushed Concrete Aggregate (own creation)

Actors	No. of Participants	Respondents %	
		Yes	No
Contractors	27	81%	19%
Concrete Suppliers	22	95%	5%
Average %	--	**88%**	**12%**

According to figure 17 and table 5 above, only 19% of contractors are opposed to utilizing recycled aggregates in new concrete mixes. The reported facts are rather uncontroversial, and around 5% of concrete providers concur.

(iii). Government willingness towards using Recycled Crushed Concrete Aggregate

This subsection evaluates as revealed in table 6 the readiness of government actors to employ recycled aggregates in new concrete mixes. Participants in the government are asked whether the governmental departments would consider utilizing recycled aggregates in new concrete mixes for new construction projects if designed by design codes of practice and specifications.

It has been seen from table 6 that over 90% of government responders claimed that governmental departments would be willing to utilize recycled aggregates in new concrete mixes only when specifically authorized by design codes of practice and specifications. Other participants, with an optimal proportion of around 10% of all participants and an average of 5%, prefer not to use recycled aggregates in new concrete mixes.

Table 6. Governmental Departments Willingness towards Using recycled aggregates in new concrete mixes (own creation)

Actors	No. of Participants	Respondents %	
		Yes	No
GAM – Department of Construction	22	95%	5%
MLA - Department of Construction	11	91%	9%
MLA - Department of Design	18	100%	0%
MPWH - Department of Construction	24	96%	4%
MPWH - Department of Design	19	95%	5%
Average %	--	**95%**	**5%**

(iv). Government Willingness for designing Waste out

This sub-section highlights the willingness of governmental design departments to design out waste on projects as seen in figure 18. The respondents are asked whether the governmental authorities consider designing governmental projects with recycled aggregates in new concrete mixes.

Current accounts in figure 18 support the findings presented before, as according to the study, the governmental design departments of both ministries would be willing design governmental projects with recycled aggregates in new concrete mixes with an average of 100%

of participants.

(v). Evaluation

This section assesses the current regulations controlling C&D waste collection, sorting, disposal, and recycling. Also reviewed is the contractor's compliance with current regulations and government monitoring and inspection. Participants are asked to rate the efficacy of C&D waste regulations in terms of collection, sorting, disposal, and recycling as shown in figure 19 below.

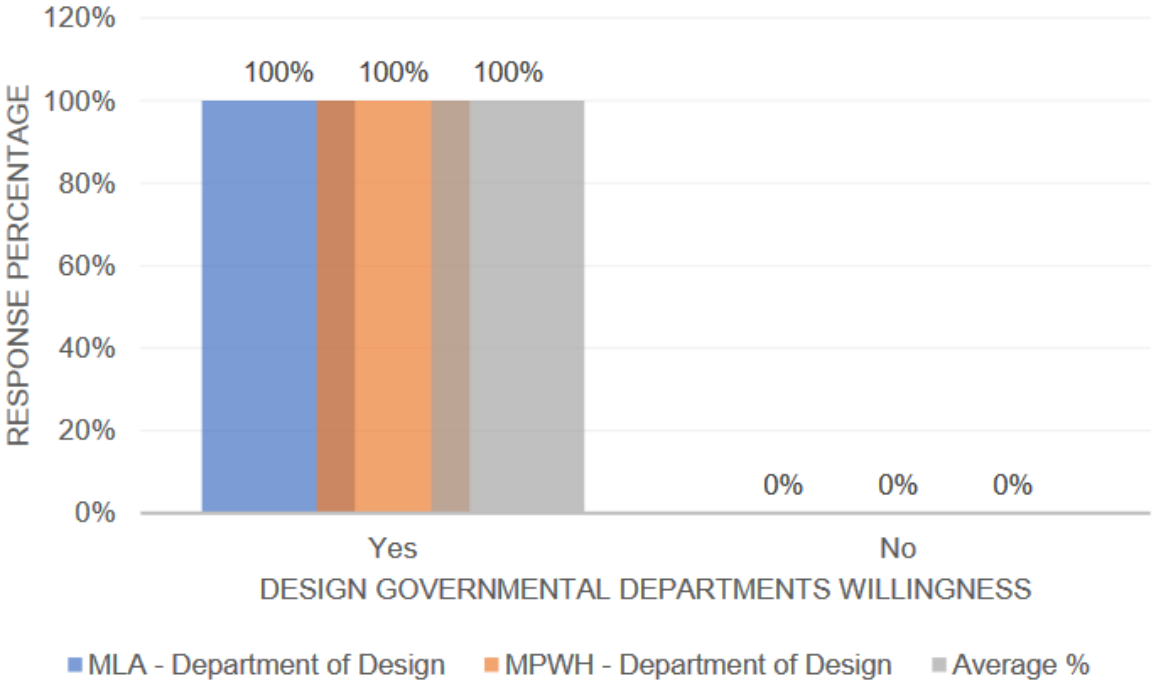

Figure 18. Government Willingness for designing out Waste (own creation)

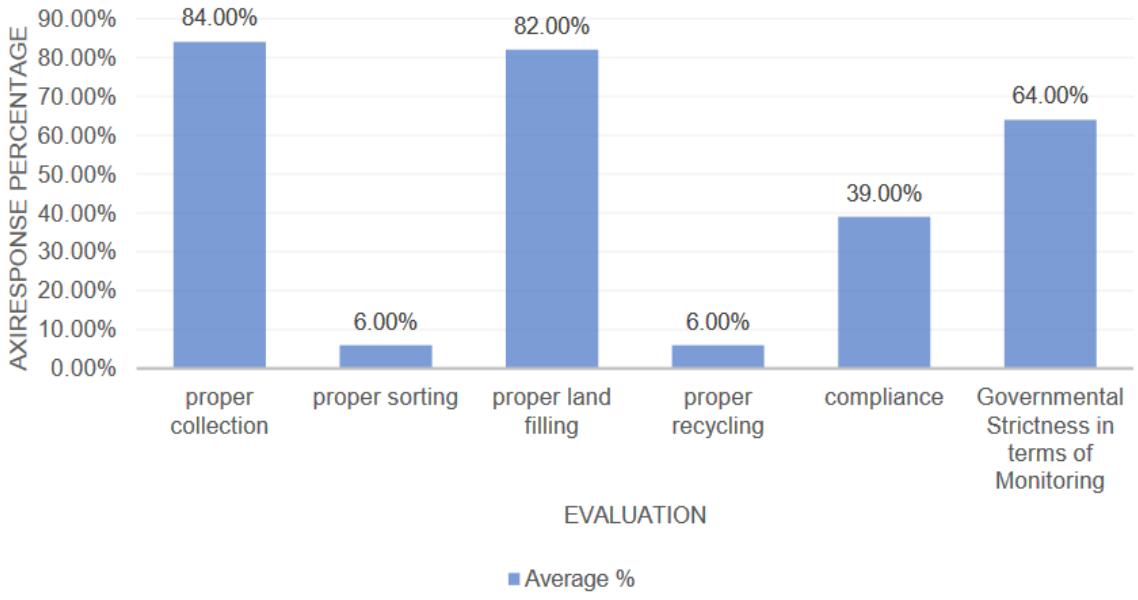

Figure 19. Evaluation (own creation)

The results of this survey show that present legislations adequately regulate C&D waste collection and disposal. Approximately as presented in figure 19, 80% to 85% of the participants were in agreement with this statement. It is essential to consider the possibility of bias in these replies; as informal dumping would be infrequent if landfilling restrictions were adequate. Notably when participants estimated previously that informal dumping accounts for 40% to 60% of all C&D waste generated. In addition, this figure revealed that sorting and recycling regulations are inadequate, as reported by an average of 7% and 6% of respondents. The current results tend to confirm earlier studies revealing the lack of sorting and recycling regulations in the legislative framework.

This survey's findings help evaluate contractors' compliance with current C&D waste regulations. This study reveals by figure 19 that, on average, around 39% of contractors comply with C&D waste regulations. This does not exclude government responses from being biased, since they may be hesitant to acknowledge their inadequate monitoring and place responsibility on contractors for their misconduct. Despite the fact that around 64% of respondents claimed that the government is strict in its surveillance of such informal practices, the government does not seem to be doing so.

5. Conclusions

This section provides an overview of the study objectives encountered in the preceding sections in order to attain the aim specified in the introduction section. The study's purpose, aims, and question have been addressed and answered via the use of a mixed, eclectic approach that used the two techniques which are literature review and questionnaires.

The literature review section provides the results about the gaps and dated nature of the current literature on the Jordanian construction industry. In reality, there is a paucity of comprehensive literature about the Jordanian construction industry. Included are current methods for construction and demolition (contractual arrangements) and waste management. Through an assessment of the material extraction and regulatory and legal frameworks, the research provided a better understanding of C&D waste management techniques, encompassing the essential activities of design, construction, and demolition. Unfortunately, the existing research on the topic is descriptive and restricted in scope. The Jordanian construction industry has also received less attention and no research has sought to measure the consequences of the sector. This involves analyzing the use of construction materials and the generation of C&D waste. The necessity to assess the ramifications of C&D waste management in Jordan prompted the investigation. Particularly when most C&D waste in Jordan is dumped informally on the sides of highways and in open areas. Significant literature research has been conducted to achieve the study's objectives by including Jordan's distinctive construction industry characteristics.

As mentioned in the methodology, the literature gaps have identified a number of questions requiring more investigation. Utilizing research to fill in knowledge gaps and undertaking a thorough analysis of the topic, as indicated in the section on surveys to identify the actions necessary to drive the construction industry toward adopting a C&D waste management strategy and addressing the issues related to C&D waste. Questionnaire surveys were one of the methods used to analyze data on C&D waste management and formal landfilling impediments. By discovering the underlying reasons that may be considered substantially related to its present failure throughout the design, construction, and demolition processes. The data were statistically analyzed using percentages or actual numbers. To depict the respondent's distribution across all investigational factors. In addition, a considerable quantity of raw data was summarized and categorized using the frequency distribution (category frequency). To ascertain the number of persons or instances that belong to each category.

To have a deeper understanding of the effects of C&D waste management. This study investigated the limitations of successful C&D waste management and formal landfilling approaches and implementation. To summarize the findings of the investigation, the following categories were developed:

1. Identifying the obstacles impeding the efficiency of C&D waste management.
2. Identifying approaches that might mitigate the effects of inefficient C&D waste management.
3. Assessing the perspectives of the construction sector, including its willingness and practicability.
4. Analyzing the most probable reasons of illegal dumping.
5. Evaluating the causes that might contribute to a decrease in informal dumping.

In conclusion, the gaps presented a number of issues that need more investigation. Therefore, the study attempts to take a more holistic approach to bridging knowledge gaps and investigates the topic in depth. To address the problem of construction and demolition (C&D) waste in Jordan and to identify the required sector-wide solutions. By formulating a set of encouragements aimed at enhancing the current national strategy for managing C&D waste in Jordan as outlined in table 4. Furthermore, the purpose of these encouragements, which are based on the findings of surveys, is to provide a uniform standard benchmark for a successful national C&D waste management plan.

The encouragements to improve the current C&D waste management strategy in Jordan are as follows:

1. Modifying the current regulations.
2. The imposition of penalties or fines on polluters.

3. Enriching the local market with recycled waste material market.
4. Increasing the fees of disposal.
5. Providing Tax exemptions.

The study has also demonstrated several approaches have been implemented in several nations around the globe to compare the conducted research with other works published on the same topic from other regions and demonstrate their successful application. For instance, Dubai municipality implements green construction rules by issuing building permits for projects within its authority [43]. All new buildings, except those in the central business district, must divert at least 50% by volume or weight of C &/or D waste from landfill sites via reuse and recycling activities [43,44] by achieving:

(i). Diverting concrete waste to a construction waste treatment facility.
(ii). Redirecting excavated soil, land-clearing waste, and hazardous waste to Dubai Municipality Department-designated locations.
(iii). Additional recyclable materials, including timber, plastic, and metals, may be used on-site.

Prior to collection, Dubai's green building regulations demand that construction debris be sorted and stored on-site [44]. Minimum requirements for segregation include properly labeled storage for inert aggregates, metals, timber, dry recyclables, and hazardous materials [44]. Another approach implemented by Dubai municipality is regulating at least 5% of the total volume of materials used in the construction of all new projects must consist of recycled materials [44].

In Abu Dhabi, a second certification system, the Pearl Rating System for Estidama, was developed. Under this approach, it is required that at least 30% of C&D waste be recycled. This approach provides the following chances for gaining credit for retaining a piece of the building's structural structure:

(i) 1 point of credit for reusing 25% of the building's structural system by surface area.
(ii) Two credit points for reusing fifty% of the material. In the area of material reuse.

The Moroccan government is concentrating on implementing a program that would incentivize developers to construct affordable housing units [45]. By providing a variety of tax and non-tax incentives to participating enterprises, membership may be increased [45]. In return for the Ministry of Finance paying the developer's 20% sales tax upon completion of the units, this initiative intends to give tax-free flats to recipients [45]. In addition, these developers get other incentives, such as tax exemptions, land registration fees, and ownership transfer fees, in order to make affordable housing available to the targeted populations of the Kingdom of Morocco [45].

The aggregate levy in the United Kingdom, which is currently set at £2.00 per ton, is imposed on companies that extract natural resources [46]. The key benefits of pricing natural resources are encouraging aggregate recycling and the replacement of waste and byproducts from other activities for natural resources. As a consequence, depletion of raw materials is prevented, waste generation is decreased, and other pollutant emissions during extraction are reduced. This, according to Silva R.V. et al. [46], will encourage more efficient use of natural aggregates and force consumers to seek for more sustainable alternatives, such as processed waste material. The significantly increased landfill tax rates in a number of nations are an effective strategy to promote the construction and demolition industries [46]. To reduce waste production and recover/recycle materials from C&D waste [46]. Increasing yearly, the UK landfill tax is now £2.65 per ton of material with a loss on ignition (LOI) of less than 10%, compared to £84.4 at the regular rate [47].

Numerous countries, such as Japan, South Korea, and the United Kingdom, impose diverse penalties for informal dumping [48]. According to Liu Yi. et al. [49], a 1% increase in informal dumping sanctions leads to a 22% reduction in unlawful dumping. As waste treatment facilities and penalties have grown in Japan, informal dumping has decreased [50].

Monitoring coverage influences the ease of informal dumping, according to Du L. et al. [51]. This is consistent with Choe C. and Fraser I.'s [52] contention that the theoretically optimum answer is to undertake explicit monitoring of informal waste disposal. The assistance and laws provided by the Chinese government in the form of "mandatory requirements or financial incentives, guidelines, and effort in monitoring the industrial behavior of recycling and reusing C&D waste" have been identified as the most important factor in promoting C&D waste management in China, particularly in its early stages [53].

Prior to commencing construction/demolition operations, the contracting business must create a strategy for C&D management in accordance with Article 11 of the Bulgarian Waste Management Act [54]. In addition, this act mandates that the contracting entity commissioning construction and works and the contracting entity commissioning the removal of construction works develop a plan for C&D waste management consistent with the scope and content of the ordinance on C&D waste management and the use of recycled construction material [54].

In the Netherlands, the government outlawed the disposal of mixed C&D waste in landfill sites, requiring the construction of new facilities for sorting C&D waste, which comprises timber, metals, plastics, and inert waste [55].

The significance of the work stems from its contribution to bridging the gaps in previous literatures. On the basis of an in-depth study and critical evaluation of earlier studies, particularly those on Jordan, one may comprehend the relevance of this research and its indispensable contribution to knowledge and society. By identifying the

implications of C&D waste management in Jordan particularly when observations indicated that most C&D waste in the nation is disposed of without environmental protection beside roads or in open spaces. To improve Jordan's approach to handling C&D waste in the construction sector in an acceptable manner.

Based on a comprehensive review of main research streams and scientometrics and in light of the observed research gaps and the investigation's restricted scope. The study was unable to analyze all aspects of the Jordanian construction sector, including C&D waste. Therefore, several suggestions for further research on C&D waste management in Jordan were made by this study and must be broadened by others. Before addressing these patterns, it is necessary to recall that this is the first complete study to date documenting the delayed implementation of construction and demolition waste management in Jordan. Therefore, in order to create systematized control measures, it is suggested that future studies should focus on the following topics:

1. Current research in Jordan must differentiate between C&D waste management and its advantages. Consequently, further research should be conducted to develop, simulate, and assess the feasibility of implementing C&D waste management in Jordan.
2. Existing research on the environmental, social, and economic implications of the construction sector has been descriptive in nature and based on data spanning over 10 years.
3. Jordan requires a greater source categorization and estimations of C&D waste volumes. In addition to the problems caused by this type of waste that is often disregarded, which have grown more apparent in recent years. Particularly when C&D waste has a reasonably high economic value.
4. These researches need to have sought to quantify the correlation between demolition and waste generation. As a small number of them were solely concerned with construction-related waste.
5. Current research has not yet considered the dynamic nature of C&D waste disposal in Jordan, regardless of whether the material was dumped formally or informally.
6. All studies have ignored the establishment of a national C&D waste management strategy, as well as its hindrances and implementation approaches.

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