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Construction and Demolition Waste Management in Kabul, Afghanistan

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Abstract

Construction and demolition (C&D) waste constitutes a significant global waste stream with substantial environmental, social, and economic implications. In Kabul, rapid urbanization and redevelopment have increased C&D waste generation, yet information on its management is limited. This study examines the sources, management challenges, stakeholder roles, and policy frameworks associated with C&D waste in Kabul, addressing a gap in the literature that has largely overlooked this specific waste stream. Employing a mixed-methods approach, the research utilizes a structured questionnaire with 100 participants, semi-structured interviews, and direct observations. Quantitative data were analysed using descriptive statistics, while the qualitative data were analysed through thematic analysis. The primary causes of construction waste include inadequate planning, excessive material procurement, and frequent design modifications. Significant challenges identified are weak regulatory enforcement, insufficient recycling infrastructure, and low public awareness. The study recommends strategic interventions, including stricter regulations, improved recycling systems, and enhanced stakeholder collaboration. By referencing global best practices, it outlines a roadmap to align Kabul's C&D waste management with international sustainability standards. While this study addresses policy and management frameworks, religious matters are handled separately and fall outside its scope.

Keywords: Construction and demolition waste, Waste management, Policy framework, Barriers, Sustainability

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Introduction

Construction and Demolition (C&D) waste is generated by construction, renovation, and demolition activities. It includes inert materials, such as concrete, bricks, and glass, as well as wood, metals, and potentially hazardous materials, including paints, solvents, and asbestos (Torgal & Jalali, 2011). C&D waste is one of the fastest-growing waste streams worldwide, accounting for more than a third of all waste in the European Union (Hakalehto and Jäaskelaelinen, 2017). In most areas, it covers up to 50% of landfill contributions (Joseph et al., 2023).

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C&D waste is a lifecycle process because it encompasses extraction of materials, construction, use, demolition, and disposal. Massive quantities of raw materials are produced during construction, and multiple waste streams are generated during demolition; some components cannot be recycled, and others are hazardous waste (Dijoo & Khurshid, 2022). The figure shows that construction and demolition waste is generated throughout a building's life cycle, with significant impacts during the end-of-life stage. Effective waste management, including reduction, reuse, recycling, and proper disposal, is essential to minimize environmental impacts and improve sustainability in construction practices.

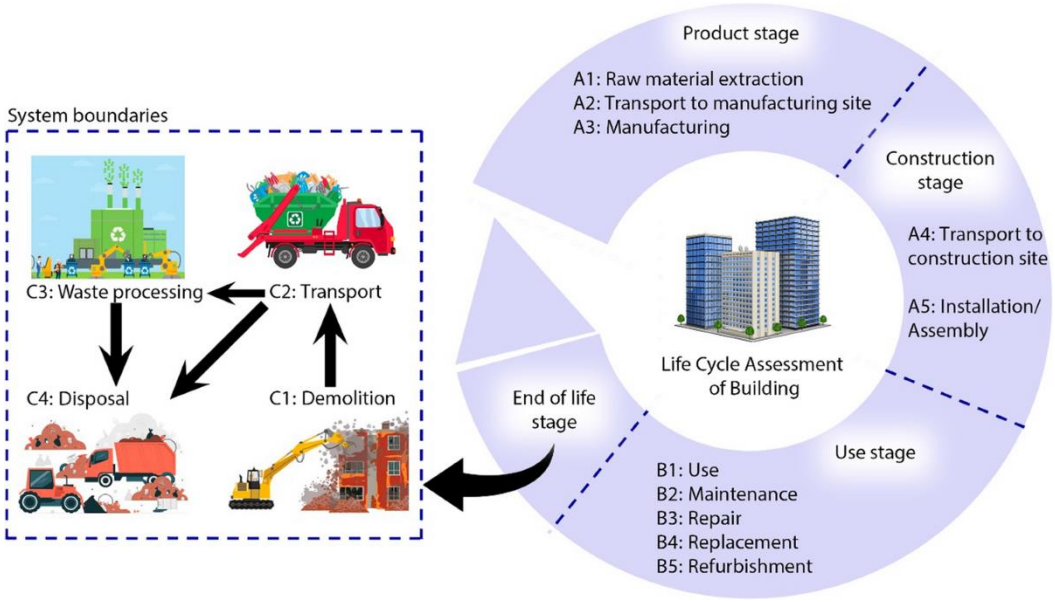

Figure 1. *Life Cycle Assessment of Construction and Demolition Waste (Zakerhosseini et al., 2024)*

Figure 1 presents a Life Cycle Assessment (LCA) of C&D waste, with emphasis on the environmental impact of each phase (Zakerhosseini et al., 2024). These materials must be managed to reduce their negative environmental and human health impacts and to prevent resource loss (Gomes da Silva & Gouveia, 2019).

The global generation of construction and demolition (C&D) waste is on the rise. C&D waste accounts for approximately 30-40% of total solid waste (Jain et al., 2021). In 2020, worldwide solid waste production reached 2.24 billion tonnes, with at least 30% attributed to construction and demolition activities (World Bank, 2022; Soto-Paz et al., 2023). Projections indicate that by 2025, annual solid waste generation could reach 2.2 billion tonnes, underscoring the urgent need for improved waste management strategies. In high-income countries, construction and demolition (C&D) waste can account for up to 50% of landfill content (Jebaranjitham et al., 2022). The substantial volume of C&D waste reflects the extensive material consumption in the construction sector, emphasizing the importance of adopting circular economy principles (Bonifazi et al., 2025). Figure 2 presents the main categories of C&D waste generated from building activities. It identifies key material types that commonly contribute to waste streams. This classification helps in understanding waste composition and supports effective planning for sustainable waste management strategies.

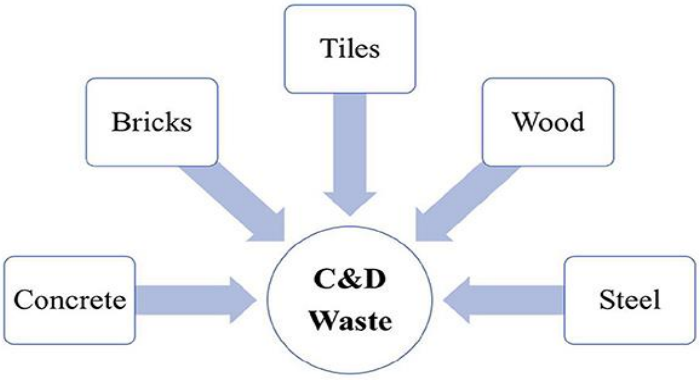

Figure 2. *C&D Wastes Major Components (Mazhar et al., 2023)*

Figure 2 shows the various categories of building and demolition (C&D) waste products. The text "C&D Waste" is placed in the middle, and five arrows point towards it. These arrows indicate the major elements of C&D waste: Concrete, Bricks, Wood, Steel, and Tiles. The materials are marked in a different box, and they state the particular types of waste produced during the construction or demolition sites. This visualization highlights the diversity of the materials that give rise to C&D waste, which may have serious environmental and management issues when not managed well.

Construction and Demolition (C&D) waste management in Kabul is also a priority issue due to the high rate of urbanization and historical obstacles (Safi et al., 2025). The population of Kabul has grown rapidly over the past decade, increasing pressure on infrastructure, housing, and waste management systems. The population rose from 4.372 million in 2015 to about 6.17 million in 2025, an increase of approximately 41.1% (National Statistics and Information Authority. (n.d.). This rapid growth has accelerated construction activities and contributed to increased construction and demolition waste generation in the city.

The city's large-scale construction and renovation have made inadequate waste management infrastructure a major impediment (Wang et al., 2010). The majority of waste is disposed of informally, mostly dumped in open areas or combined with domestic waste, whereas only 25% is collected in an organized way (Mihai & Grozavu, 2019). This has led to unofficial recycling methods, mostly of metals and timber, due to the lack of recycling facilities in the country (Kumar et al., 2009).

C&D waste management follows a hierarchy that prioritizes reduction, reuse, and recycling over disposal. Recycling and reuse reduce environmental impacts by conserving raw materials and reducing greenhouse gas emissions (Gomes da Silva & Gouveia, 2019). The EU Waste Framework Directive is a set of regulations that require the recycling or reutilization of at least 70% of non-hazardous C&D waste (Borghi et al., 2018). The Netherlands and Ireland have recorded recovery rates of more than 70%, and Japan has recycled over 95% of the materials (Shah et al., 2023). The most important of them are on-site sorting of materials, modern recycling technology, and Building Information Modelling (Iyiola et al., 2024). Additionally, economic incentives, such as landfill taxes and recycling subsidies, help develop a more sustainable waste management system (Kühlen et al., 2016).

Underdeveloped countries encounter distinct obstacles in managing C&D waste. Weak regulatory enforcement often results in non-compliance among contractors (Yuan, 2017). Inadequate infrastructure, including limited sorting and recycling facilities and a lack of dedicated landfills, hinders responsible waste disposal (Al-Otaibi et al., 2022). Ghisetti et al. (2017) examined how financial barriers affect environmental innovation adoption among manufacturing small and medium-sized enterprises (SMEs) in Europe. Insufficient technical expertise and limited awareness among contractors and residents hinder the effective sorting and recycling of waste (Wang et al., 2010; Lu & Yuan, 2010). Prevailing cultural norms may favour disposal over reuse, while restrictive market standards limit the adoption of recycled materials. Overcoming these governance, infrastructure, economic, and cultural barriers requires a comprehensive and coordinated approach (Ranta et al., 2018). Although waste management has improved, developing countries face significant challenges, including ineffective regulations, infrastructure gaps, and financial constraints (Yuan, 2017).

These challenges are particularly pronounced in Kabul, where decades of conflict and reconstruction have driven rapid urban expansion (Ahmadi et al., 2024). The absence of national recycling facilities means that only informal reclaiming of metals and timber occurs (Kumar et al., 2009). Building permits do not mandate waste management plans, and poor inter-agency coordination with unclear responsibilities exacerbates the issue. These conditions underscore the urgent need for targeted research and policy interventions.

Figure 3 gives a global overview of the magnitude and intensity of C&D waste issues; these dynamics are particularly acute in urbanizing metropolises with a conflict history, like Kabul. The years of war and rebuilding after the war have led to a high rate of urban growth, and the population in Kabul has skyrocketed. It is reflective of the trends in the world and an increase in construction activity that results in an increase in waste production, but in a setting where the institutional capacity is much weaker (Soto-Paz et al., 2023; Jebaranjitham et al., 2022; Jain et al., 2021). In contrast to the high-income states, the city of Kabul does not have formal recycling facilities or informal material recovery, and it does not require waste management plans in building permits. (Safi et al,2025). Figure 3 shows that C&D waste is rapidly increasing worldwide, contributing significantly to total solid waste. With rising future projections and major impacts in high-income countries, effective waste management strategies are essential to reduce environmental pressures and improve sustainability globally.

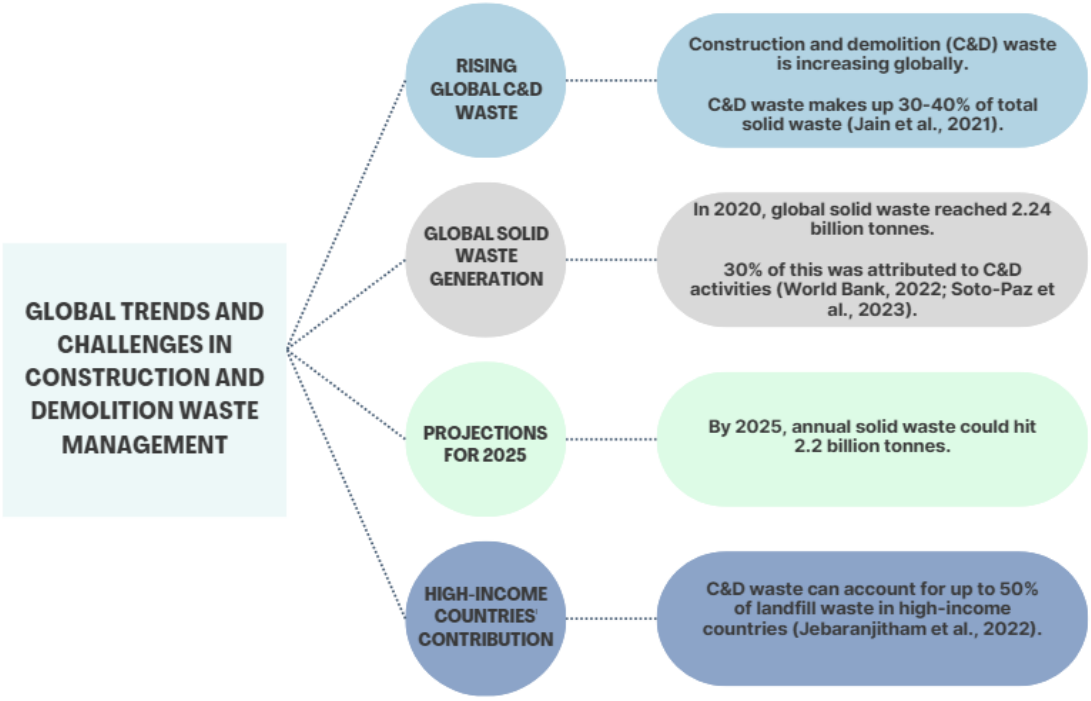

Figure 3: *Global Trends and Challenges in Construction and Demolition Waste Management (Soto-Paz et al., 2023; Jebaranjitham et al., 2022; Jain et al., 2021)*

Figure 3 demonstrates the tendencies and issues of construction and demolition (C&D) waste management globally. It emphasizes the increasing world C&D waste, which is 30-40% of the total solid waste. By 2020, the world generated 2.24 billion tonnes of solid waste, and 30% of it belonged to C&D operations. It is estimated that solid waste might reach 2.2 billion tonnes/year by 2025. In high-income nations, C&D waste contributes to 50% of waste in landfills.

Metals, aggregates, and timber present in C&D waste are valuable resources that can be reused or recycled for various purposes (Behera et al., 2014). The reuse of these materials conserves virgin resources and reduces greenhouse gas emissions. Despite this potential, significant quantities remain unrecovered (Reis et al., 2021). For example, in 2018, the United States generated 600 million tonnes of construction and demolition (C&D) waste, of which 76% was recovered, while 143 million tonnes were landfilled. Recycling rates across the European Union vary considerably, with some countries recovering less than 10% (US Environmental Protection Agency, 2025). Failure to recycle leads to resource depletion, increased energy consumption, and higher carbon emissions (Ma et al., 2019). In resource-constrained countries like Afghanistan, material recovery can lower construction costs, generate employment opportunities, and conserve natural resources—investment in recycling infrastructure yields both economic and environmental benefits (ESCAP, 2012).

Inadequate management of construction and demolition (C&D) waste has significant environmental and public health consequences (Cook et al., 2022). Excessive waste accumulation in landfills degrades land quality and contributes to urban destruction (Vaverkováet al., 2019). Materials such as concrete and soil can obstruct drainage systems,

increasing the risk of flooding (Siddiqua et al., 2022). Construction dust exacerbates air pollution and may contain hazardous substances, including asbestos. When C&D waste is mixed with municipal solid waste, contaminants can leach into soil and water sources (Sandil & Kumar, 2022). Landfilling recyclable materials necessitates the production of new materials, resulting in additional greenhouse gas emissions. Improperly managed dumpsites also pose safety hazards and can attract disease vectors (Lou & Nair, 2009). Effective waste management, regulatory enforcement, and public education are crucial in mitigating these impacts (Patil et al., 2024).

The waste management hierarchy is one of the most popular models according to which the priority in the management of waste is given to the following strategies: waste reduction, waste reuse, waste recycling, and waste disposal, where the last is the least preferable variant (Al-Otaibi et al., 2022; Awino and Apitz, 2024). Several researchers have created a hierarchy of waste management techniques, and the hierarchical model includes four to seven strategies. Yuan and Shen. (2011) noted, for example, that there are four strategies in the waste management method hierarchy. These strategies include reduction, reuse, recycling, and disposal, and they are ranked from least to most environmentally beneficial.

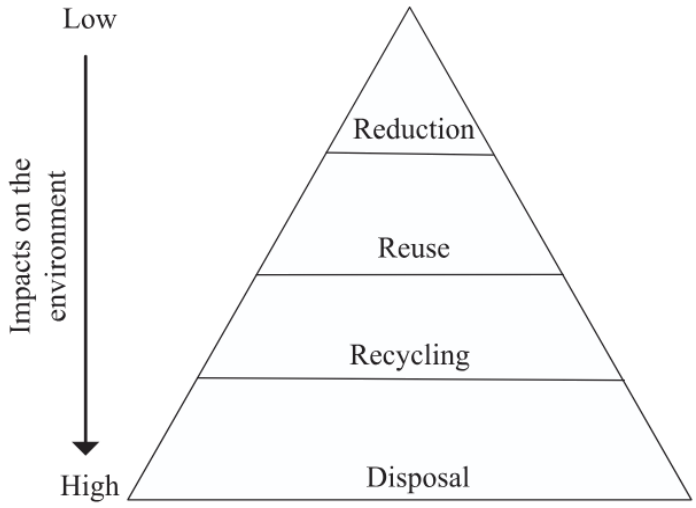

Figure 4: *The C&D waste management method hierarchy (Yuan and Shen, 2011)*

The given hierarchy supports waste management policies in most developed and developing nations and is intrinsically intertwined with the principles of the circular economy. Reduction aims to reduce waste creation at its source by designing effectively, estimating materials correctly, prefabricating, and minimizing on-site construction (Gálvez-Martos et al., 2018; Iyiola et al., 2024). Germany, the Netherlands, and the United Kingdom tend to focus on waste prevention through building-to-deconstruct designs and site waste management plans, which reduce material waste throughout the construction process (Lawson et al., 2001; Kühlen et al., 2016).

Reuse includes recycling of construction materials, including bricks, timber, steel structures, and fixtures, directly to reuse on-site or in the secondary markets. In Japan and Ireland, where

selective demolition and material certification systems are obligatory by law, high reuse rates were reported (Sumikura and Katsumi, 2022; Shah et al., 2023). By comparison, in numerous developing nations, the process of reuse is mostly unstructured and based on market value, with the most popular materials reused being metals and timber (Yuan, 2017; Kumar et al., 2009).

The third tier of the hierarchy is recycling, which involves using materials such as concrete, bricks, asphalt, and metals to produce aggregates and scrap for the second process. Under the European Union Waste Framework Directive, a 70% recovery rate is required of non-hazardous construction and demolition waste, so in some countries (Germany, Belgium, and the Netherlands) the recycling rates are higher than that (Borghi et al., 2018; European Demolition Association, 2025). In the same way, the Construction Material Recycling Law has led to more than 95% recycling in Japan, which is promoted by mandatory on-site sorting and well-developed recycling facilities (Sumikura & Katsumi, 2022). In comparison, recycling in developing nations is not even prevalent due to a lack of infrastructure, weak enforcement, and financial constraints, although it has significant potential to impact the environment and the economy (Ma et al., 2020; Soto-Paz et al., 2023).

Location-based sorting is an essential enabler of reuse and recycling. Investigations conducted in China, Europe, and the US demonstrate that the use of compulsory on-site sorting, backed with inspection and punishment, leads to significant improvements in the working performance of recycling (Wang et al., 2010; Gálvez-Martos et al., 2018). In most low-income and post-conflict settings, sorting is not compulsory and is instead informal, leading to mixed waste streams and more frequent use of disposal (Yuan, 2017; Al-Otaibi et al., 2022).

In most developing countries, the most common method is disposal in landfills or open dumping, which is associated with significant environmental and health hazards (Reis et al., 2021; Siddiqua et al., 2022). In developed nations, the practice of disposal is becoming less popular due to landfill taxes, bans on recyclable waste, and producer responsibility schemes (Kühlen et al., 2016; Ranta et al., 2018). In general, the practice on the international level has shown that sustainable application of the waste management hierarchy requires powerful regulatory frameworks, economic stimuli, technological favor, and institutional alignment - aspects, which are usually absent in the post-conflict urban setting and in developing economies.

The Waste Framework Directive sets a 70% recycling target for construction and demolition (C&D) waste in the European Union (European Demolition Association, 2025). This speeds up the development of separation systems and recycling plants.

Strict regulations and investments have helped Ireland, the Netherlands, and Belgium to exceed the 70% recycling goal. Germany requires the generators of waste to sort and recycle as much C&D waste as possible and provides quality standards on the recycled aggregates (Gálvez-Martos et al., 2018). The UK has reused more than 90% of materials, and California has a 65% requirement for federal project diversion rates (Lawson et al., 2001). The Construction Material

Recycling Law of Japan has a 95% recycling rate (Sumikura and Katsumi, 2022), and China has a mandatory recycling center in large cities (Ma et al., 2020).

Nevertheless, issues such as a poor enforcement system, inadequate infrastructure, financial limitations, and the lack of awareness among people are a threat to successful C&D waste management in developing countries (Sandil and Kumar, 2022; Borghi et al., 2018). It is essential to overcome such obstacles in order to succeed (Al-Otaibi et al., 2022). C&D waste in Afghanistan remains in the early stages of development, and there are considerable gaps in waste management structures and regulations. Azimi (2021) reports that there is no formal waste-separation and recycling system in the city, and all waste is dumped in open areas and riverbeds. The lack of mandatory waste management plans on construction projects is also a contributing factor, as contractors often give little consideration to waste reduction measures. Moreover, the low awareness of the population and cultural values that prioritize disposal over recycling prevent changes in waste management practices (Ranta et al., 2018). To enhance C&D waste management in Afghanistan, it is essential to strengthen regulatory frameworks, raise awareness, and invest in recycling facilities (Safi et al., 2025).

There is a limited body of research on C&D waste management in Kabul, and reliable data on waste volumes are scarce. Few studies have investigated solid waste and the coordination among municipal authorities, contractors, and informal recyclers. The effectiveness of national policies introduced in 2010 has not been thoroughly evaluated. Furthermore, international best practices have seldom been adapted to the context of Kabul. This study aims to address these gaps by collecting empirical evidence, analysing stakeholder interactions, assessing the effectiveness of policies, and exploring the applicability of international best practices. This study will evaluate barriers and opportunities for sustainable management of C&D waste in Kabul concerning its generation, management, recovery, and offering policy and appropriate technical recommendations.

Methods and Materials

The study adopts a mixed-methods approach, incorporating questionnaires, interviews, and project field observations to ensure comprehensive data collection. Questionnaires are structured tools that produce numeric records for statistical analysis. The research used purposive sampling to select respondents with direct experience in the management of C&D waste. The sample consists of 100 valid respondents of targeted participants, including engineers, contractors, project managers, municipal officers, and waste management staff, ensuring that responses are grounded in professional practice.

The questionnaire was developed through a literature review and consultation. It covers demographic data, characteristics of C&D waste, waste management practices, challenges, barriers, and institutional frameworks. The sections address the following dimensions: respondent roles, materials produced and periods of maximum waste, sorting and storage, recycling and disposal, barriers such as permit issues, perceptions of costs and knowledge gaps, and judgments of legislation, agencies, and coordination. The survey employs closed-ended questions in multiple-choice and Likert scale formats to collect quantifiable data. The

instrument was pre-tested among professionals for relevance and clarity, then amended for improvement. This testing increases reliability and validity.

Data collection comprised face-to-face interviews, remote sessions, and site visits. The study's objectives and assurances of participant confidentiality were communicated via email, and informed consent was obtained. Semi-structured interviews focused on waste management practices and barriers, while also permitting discussion of additional relevant topics. Each interview lasted approximately 30 minutes.

For the demolition context, three ongoing projects (1- Construction of the Connecting Road from Kulula Pushta to Dahane Bagh, 2- Expansion of the Connection Road from Joye Sheer to Dehmazang Square, 3- Demolition of a Three-Story Residential Building) were selected; the first two of them were being implemented by the Kabul Municipality as part of the city's road expansion program. These projects involved the demolition of approximately 66 and 200 existing structures/houses to widen transportation corridors (Kabul Municipality, 2025).

In addition, five ongoing construction projects were visited, representing both residential and commercial buildings. These projects were strategically selected from different parts of Kabul city, specifically PD1, PD4, PD7, and PD10, to capture variations in urban development patterns. Each project was at a different stage of progress, which enabled the study to document how construction waste is generated and managed throughout various phases of the building process. The combination of demolition and construction site observations provided a holistic perspective on the current practices, challenges, and gaps in C&D management across Kabul city.

The projects involved demolishing roadside buildings, boundary walls, and informal structures, producing large amounts of concrete, masonry, asphalt, timber, and mixed debris. The sampled locations were representative of common municipal infrastructure developments in Kabul, where demolition work is carried out under time constraints and with inadequate formal waste management planning — observations documented waste generation, categorization, storage, recycling, and disposal processes—on-site interviews with workers and contractors supplemented survey data. Integrating survey responses with field observations enabled a comprehensive understanding of current practices and challenges.

Quantitative data were analysed using SPSS and Excel. Descriptive statistics (frequencies, percentages, mean scores, and standard deviations) described the responses. Cross-tabulation explored connections among variables such as profession and perceptions of obstacles. Graphical outputs, including bar and pie charts, illustrated practices, material types, and disposal methods. Cronbach's alpha measured internal consistency, with values above 0.70 indicating high reliability. Content and construct validity were ensured through literature reviews and expert consultations, as well as the development of items designed to capture specific attitudes and behaviours. Interpretations and observations were transcribed and coded thematically. Multiple coders and member checking improved thematic reliability. Ethical considerations included voluntary participation, encryption of data, and secure storage.

Findings

The results of this study show that the construction industry in Kabul produces large quantities of C&D waste, most of which results from rapid urbanization and infrastructure development. The waste products produced are mainly concrete, Brick, wood, metals, glass, and plastics. The research points out that waste sorting is not systematic but remains unequal and unorganized, even though the practice continues. The survey indicated that 77% of participants sort metal, and 64% sort wood, which is the most commonly separated material on construction sites. However, concrete, excavated soil, and plastic are separated into these categories far less often, with only 39% and 21% of respondents sorting these waste materials, respectively (Figure 4). This implies that although there is some awareness of sorting waste, sorting does not occur systematically and is mainly influenced by the marketability of materials such as metals and timber.

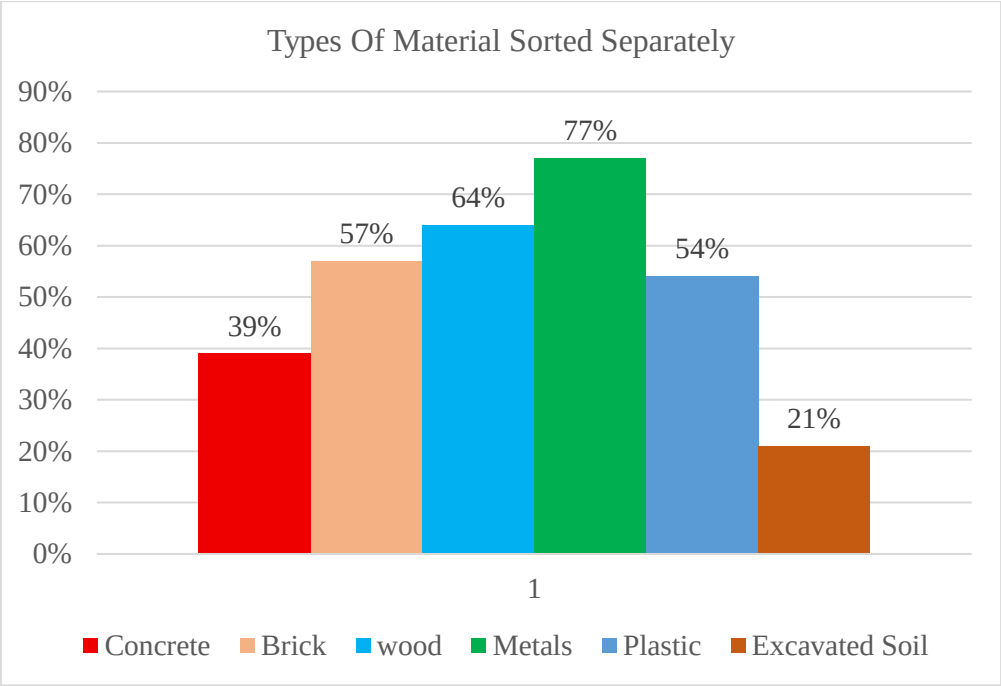

Figure 5: *Waste Sorting*

The research also found that 85% of the interviewees reported engaging in on-site waste sorting, although this is not regular. Metals and wood are given priority due to their resale value, whereas other materials, such as plastics and soil, are not. In addition, waste sorting is mostly conducted at the individual level, with no guidelines or inspections, resulting in unorganized activities in the construction sector in Kabul (Figure 5).

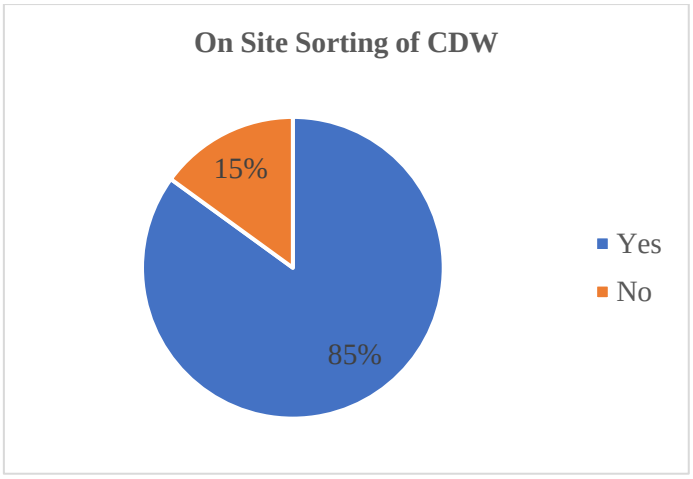

Figure 6: *Sort Construction and Demolition Waste on Site*

Regarding disposal practices, the study found that 59% of the respondents said that construction waste is disposed of by informal dumping areas, which poses a major threat to the environment. While nearly 6% of the respondents said waste is brought to recycling or crushing facilities, this is the adoption of very few sustainable waste management practices (Figure 6).

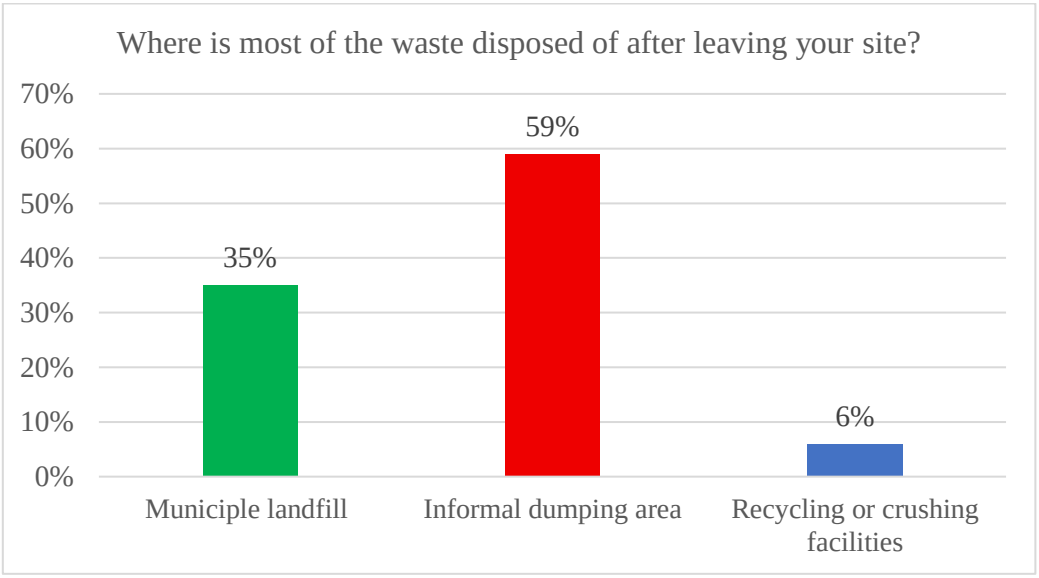

Figure 7: *Disposal Destinations*

Other challenges to effective waste management in Kabul's C&D sector included poor enforcement, limited recycling facilities, no formal waste collection or disposal system, inadequate technical skills, lack of fundamental data on C&D waste, and limited stakeholder awareness. According to the respondents, the issue of illegal dumping due to poor monitoring and a lack of corrective actions was a major concern (Mean = 2.98). The other barriers, which were noted to be prominent, were a lack of trained personnel (Mean = 3.80), the absence of waste sorting (Mean = 3.72), and the cost of properly managing waste (Mean = 3.77). These impediments can explain the poor management of C&D waste and the urgent need for institutional reform and improved governance (Figure 8). Another finding of the survey indicated that most construction sites lack the infrastructure to manage waste properly and

instead rely on informal methods, such as open-site dumping, which further contributes to environmental pollution and health hazards.

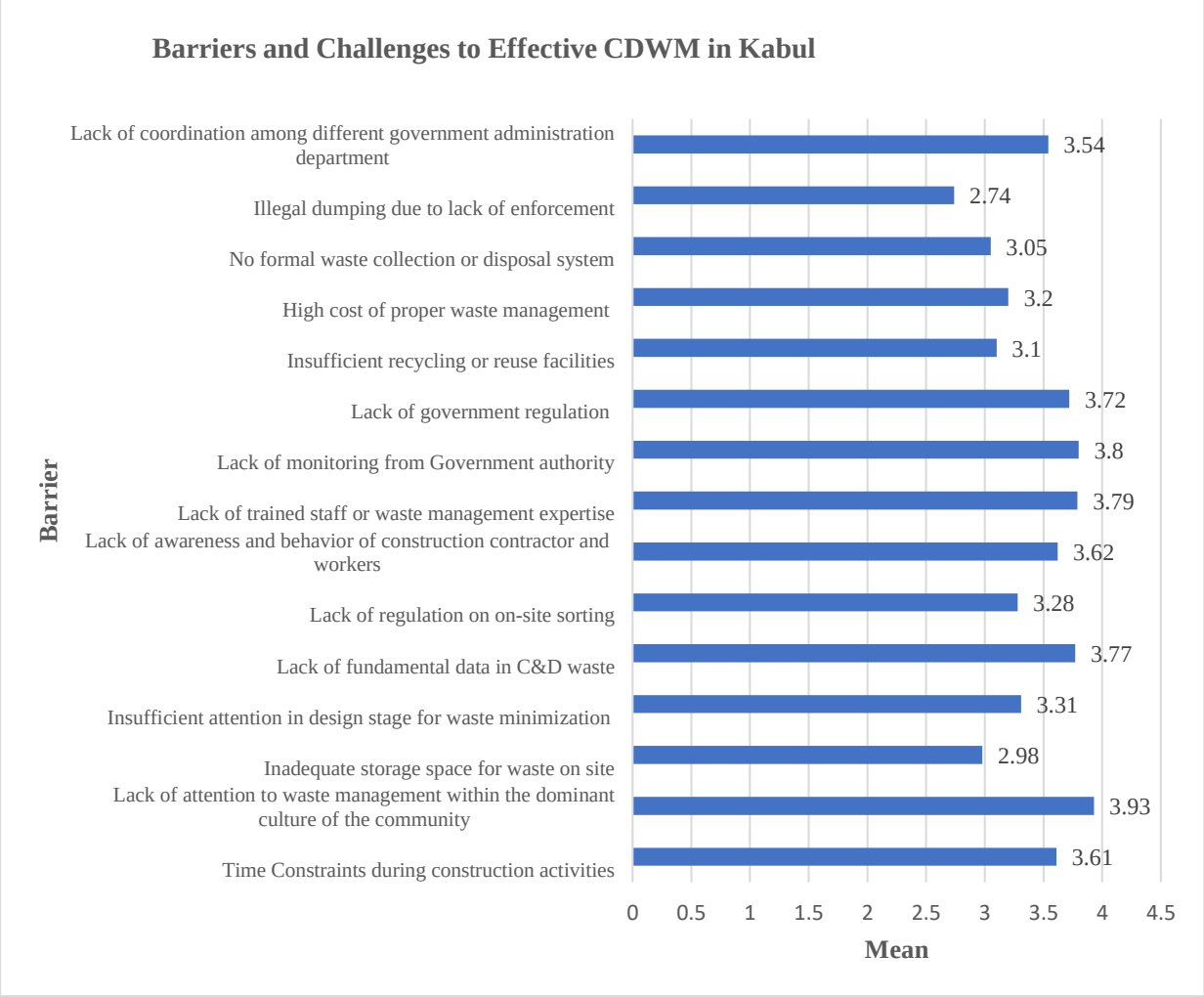

Figure 8: *Descriptive Statistics for Barriers and Challenges to Effective CDWM in Kabul*

The study revealed major gaps in stakeholder roles, policy structures, and guidelines governing C&D waste management in Kabul. The respondents reported a lack of understanding of which institutions are responsible for preparing and enforcing C&D waste regulations, with an average rating of 2.20 for the existence of the regulations. This institutional ambiguity is further exacerbated by poor enforcement and stakeholder involvement. According to the respondents, there is poor support of waste management by Kabul Municipality and government structures and limited interagency coordination (Mean = 2.94). In addition, not all contractors are legally required to develop waste management plans before commencing construction or demolition, and there is no official notification system prior to demolition (Mean = 1.65). These results indicate that the C&D waste management system at Kabul is decentralized, poorly coordinated, and technically organized (Figure 9).

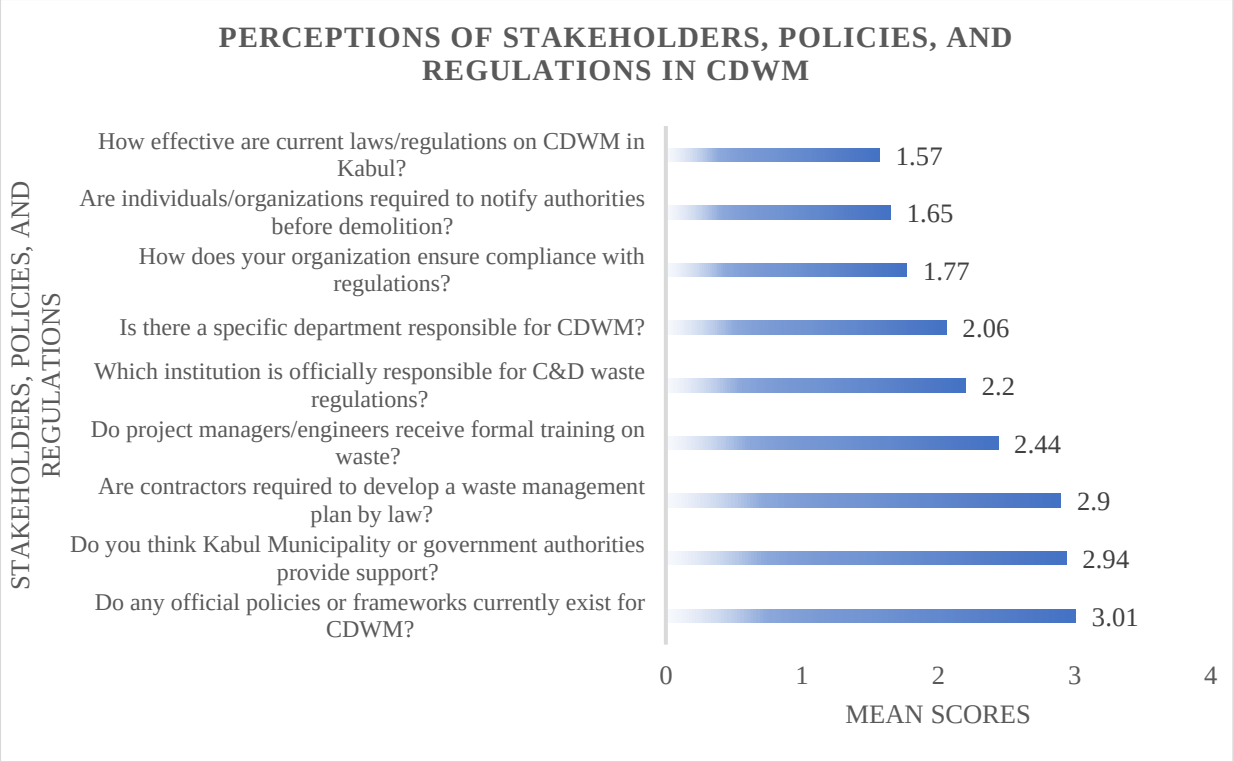

Figure 9: *Perceptions of Stakeholders, Policies, and Regulations in CDWM*

One of the most important approaches to address the Construction and Demolition (C&D) waste in Kabul is the concept of 3R: Reduce, Reuse, Recycle, but its practical implementation is still at an early stage. Waste reduction, such as proper material planning and selective demolition, can go a long way toward reducing waste. However, in Kabul, 40% of respondents cited poor planning, and 30% cited over-ordering materials as a source of construction waste. Selective demolition techniques are employed, but they are not consistently implemented due to the absence of a properly designed waste management system, training, and financial limitations.

There is potential to reuse materials such as metals and timber in Kabul, with 55% of respondents reporting metal reuse. Nevertheless, reuse efforts are curtailed by improper sorting and storage, as well as fragmented practices in the construction industry. Besides, recycling is still in its infancy, with respondents reporting that only 6% of C&D waste is recycled, primarily metals. Lack of recycling infrastructure, sorting practices, and government support are among the factors that discourage the growth of recycling activities in Kabul. They should create dedicated recycling centers and educate people about the importance of recycling to increase recycling rates and ensure effective waste management.

Figure 8 shows the most recent data available regarding the generation and management of Construction and Demolition (C&D) waste. It shows that C&D waste comes from either construction and/or demolition activities. In construction and demolition activities, two types of materials are generated and can be classified as either economically valuable or not. Typically, in the construction and demolition activities, the materials that have no direct economic value include concrete, mortar, bricks, soil, and other mixed materials. These types of materials are often illegally disposed of. On the other hand, construction and demolition

activities also include economically valuable materials, such as bricks, soil, metals, and timber. These types of materials are either sold for reuse or sent for recycling. This case illustrates the informal and fragmented systems in the management of C&D waste, characterized by inadequate systems for the sorting and recycling of waste.

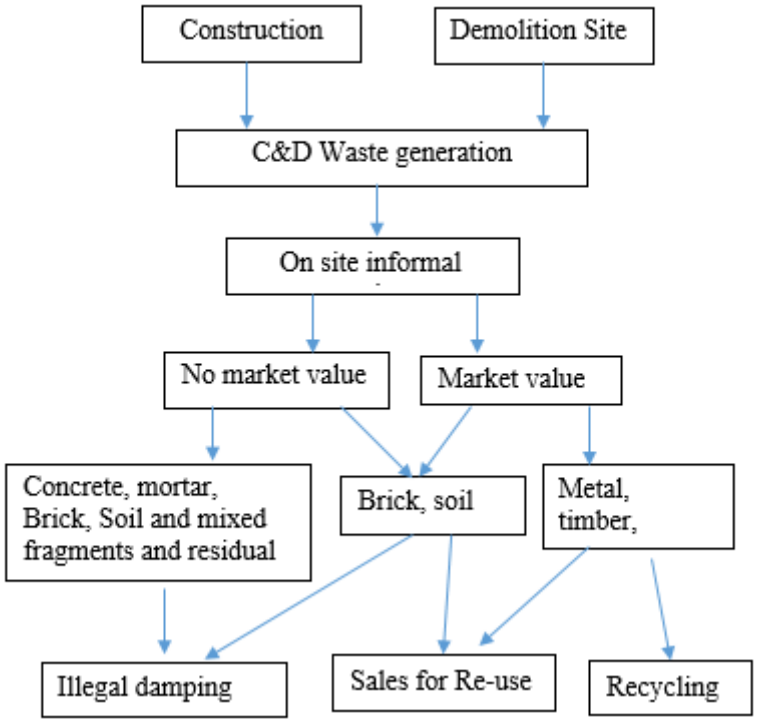

Figure 10: *Current State of Construction and Demolition Waste Disposal and Management*

The review of current policies and the regulatory framework has shown that the Construction and Demolition (C&D) waste management in Kabul lacks a committed, enforceable legal framework. According to the survey findings, the majority of participants did not know of any specific national or local policies that regulate C&D waste, suggesting a lack of policy awareness and ineffective institutional communication. A negligible percentage of respondents acknowledged environmental regulations related to waste management, and these were, in most cases, seen as general environmental rules rather than C&D-specific ones.

The results also indicate that there are no mandatory requirements for contractors to prepare Site Waste Management Plans (SWMPs) before construction or demolition work takes place. This has left waste handling to individual contractors, resulting in inconsistent practices across projects. The field analysis found that demolition and construction processes are conducted without formal waste segmentation, monitoring systems, or an obligation to report, even in municipal projects funded by the state.

The weakest area was always regulatory enforcement, as illegal dumping of C&D waste was rarely punished. Although the environmental laws of Afghanistan assign responsibility for environmental protection, such as waste control, implementation is poor due to a lack of staffing, technical knowledge, and coordination among agencies. The current policies are therefore operating at a theoretical level, and there is little practical efficiency in on-site waste

management behaviour. On the whole, the results show that the lack of C&D-specific policies, along with the ineffective implementation of current environmental policies, is a key institutional obstacle to sustainable construction waste management in Kabul.

The study also evaluated the roles and duties of key stakeholders in C&D waste management, which are the National Environmental Protection Agency (NEPA), Kabul Municipality, and the Ministry of Urban Development and Housing (MoUDH). The results show that these institutions are technically engaged in waste governance, but their functions are poorly defined, and their coordination is ineffective.

NEPA is mandated to provide environmental protection and regulatory controls, but respondents reported that NEPA's involvement in C&D waste management is quite indirect, limited to broad environmental observation. The agency does not regularly inspect construction or demolition sites and does not provide technical advice on C&D waste segregation, recycling, or disposal. Consequently, NEPA regulatory functions are primarily advisory rather than operational.

The Kabul Municipal Authority was identified as the main institution responsible for waste collection and city hygiene. Nevertheless, it has been found to do little more than handle municipal solid waste, with C&D waste treated as a secondary or informal concern. City collection services generally do not focus on construction debris, and no specific facilities or special routes exist for disposing of C&D waste. Another observation made by the respondents was that the municipality lacks adequate equipment, budget, and trained personnel to handle the increasing volume of construction waste.

MoUDH has been at the center of urban planning, construction permits, and infrastructure development, but research indicates that waste management requirements are not factored into the building permit process. Approval of waste management is not a compulsory requirement in construction approval, nor are post-demolition inspections on debris management. This lack of connection limits MoUDH's role in preventing and minimizing waste during design and planning.

It was found that coordination among these institutions was weak to very weak. It lacks a centralized structure or a collaborative task system to coordinate planning, regulation, enforcement, and waste management. Interviews also showed that there is ambiguity about who is in charge of C&D waste management, creating institutional loopholes; as a result, the waste becomes unmanaged. There is little data sharing, joint inspections, or policy congruence between agencies, as they operate within their mandates.

These findings show that disjointed governance and institutional coordination are major factors contributing to insufficient C&D waste management in Kabul. Sustainable waste management goals could not be met without a clear assignment of the roles and coordinated work of NEPA, Kabul Municipality, and MoUDH. Therefore, this research suggests that the following strategic measures can help to increase the C&D waste management in Kabul. The regulatory framework and enforcement mechanisms have to be strengthened. The laws and regulations should be defined, and penalties for non-compliance should be enforced. Moreover, infrastructure for recycling needs to be invested in, including specialized sorting facilities,

concrete crushing plants, and certified dumping sites. Third, it should focus on capacity-building measures to enhance technical knowledge and raise awareness among contractors, engineers, and municipal personnel. Professional development should include training on reducing waste and recycling. Lastly, cultural perceptions of the use of more sustainable waste management methods should also be changed through public awareness campaigns. Better coordination among stakeholders, especially the Kabul Municipality, the national environmental protection agency (NEPA), and the Ministry of Urban Development and Housing (MoUDH), will also be instrumental in achieving sustainable waste management solutions.

Discussion

This paper provides a global perspective on the current state of construction and demolition (C&D) waste management in Kabul, combining evidence from questionnaires, interviews, and field observations. The results reveal that C&D waste management in Kabul is characterized by high levels of waste, an informal approach, weak institutional regulation, and limited application of sustainable waste management principles. Motivated not solely by a lack of awareness, the findings also point to the issue's inherent structural and governance-related nature, as well as the influence of economic and institutional factors on waste-handling behaviour in the construction sector.

The large amounts of C & D waste generated in Kabul are closely linked to high rates of urbanization, infrastructure development, and ongoing reconstruction. The preponderance of the materials, concrete, Brick, wood, metals, glass, and plastics, demonstrates how the construction practices in the city are. Nonetheless, the analysis shows that material recovery is highly selective, favouring only materials with short-term economic significance. The sorting rates for metal and wood are quite high, indicating that market motives are the main drivers of waste management decisions rather than environmental factors. That is why non-biodegradable materials like concrete, soil, plastics, and other materials that make up a significant percentage of C&D waste are not often recycled.

Although a large percentage of respondents reported performing on-site sorting, the analysis of the results reveals that this sorting is irregular, informal, and unstandardized. This leads to the fact that there are no guidelines, inspections, or formal requirements, so that the sorting practices differ widely between sites and are mostly based on personal initiative. Such a piecemeal strategy compromises the effectiveness of sorting as a basis for recycling and reuse, and it can help explain why general recycling levels are incredibly low despite a half-hearted awakening to waste segregation.

It is also evident in disposal practices, which indicate weak governance. The informal dumping is extensive due to the absence of proper disposal pathways, recycling centers, and enforcement. Informal dumping is the option of choice when disposal options are limited, and penalties are not frequently enforced, allowing contractors to do their work in the most cost-effective and time-saving way. This observation demonstrates a direct relationship between institutional failure and environmental degradation: uncontrolled disposal leads to pollution, blocked drainage systems, and increased health risks for people.

This interpretation is supported by the barrier analysis. The mean scores for the lack of trained personnel, the high cost of proper waste management, the lack of sorting regulations, and insufficient recycling infrastructure are high, indicating that these issues are interrelated. All these barriers make it hard to implement sustainable waste management practices, even when contractors understand how important they are. The results indicate that gains in individual behaviour will be limited unless these systemic constraints are addressed.

The strength of this study is that it assesses the stakeholder positions and institutional command. This is demonstrated by the findings that the National Environmental Protection Agency (NEPA), Kabul Municipality, and the Ministry of Urban Development and Housing (MoUDH) have not only been involved in waste governance, but also have poorly defined roles and weak coordination. This splitting up of institutions creates gaps in which C&D waste is virtually uncontrolled. The role of NEPA is rather advisory; the municipality's role is mostly household waste, and MoUDH is not involved in planning and permitting processes with reference to waste management requirements. These bodies are not coordinated, which prevents the formation of a consistent C&D waste management system and undermines enforcement capabilities.

These institutional shortcomings are also evident in the limited implementation of the 3R (Reduce, Reuse, Recycle) principle. Although there is an undoubted opportunity to reduce waste through better planning and selective demolition, the research results demonstrate that improper planning and excessive ordering are among the leading causes of waste. Reuse activities are limited to metals and timber, and, once more, they are motivated by resale value rather than by well-organized recovery systems. Recycling is at an infantile stage; it is constrained by a lack of facilities, poor sorting, and insufficient government patronage. Such a scenario shows the discrepancy between the theoretical acceptance of the waste hierarchy and its implementation in Kabul.

In general, the analysis of findings shows that C&D waste management in Kabul is informal, reactive, and disposal-based, rather than preventive or recovery-based. The results provide evidence of the necessity of institutional change, including the creation of C&D-specific regulations, obligatory planning for waste management, financial investment in recycling infrastructure, and the distribution of responsibilities among stakeholders. Without these systemic changes, Kabul is bound to remain in a state of unregulated waste production, environmental degradation, and lost economic opportunities from material recovery.

The study's implications for urban sustainability in Kabul are far-reaching. Proper C&D waste management can minimize environmental pollution, enhance people's health, reduce construction costs through material recycling, and generate employment. Nevertheless, to realize these benefits, it is necessary to go beyond individual technical solutions to a coordinated, policy-based, and institutionally reinforced framework to coordinate planning, regulation, enforcement, and practice.

Conclusion

This research discussed Construction and Demolition (C&D) waste management in Kabul, Afghanistan, to address major problems in waste generation, treatment, and disposal. The

results confirm the urgent need to adopt an integrated, sustainable solution to C&D waste management in Kabul. It also underscores the importance of regulations, infrastructure, and stakeholders in shaping the current waste management situation.

The analysis shows that C&D waste in Kabul is generated mainly by the current rapid construction and urbanization. However, the modern way of waste management is poor. Most C&D waste is disposed of improperly. There are limited recycling and reuse, with informal salvaging of metals and wood being the most practiced ones. The lack of dedicated recycling centers and a well-organized waste-disposal system contributes significantly to this inefficiency.

Several challenges hinder effective waste management, including poor enforcement of regulations, insufficient infrastructure, and limited public awareness. Existing environmental and waste management laws are often poorly implemented, leading to insufficient waste separation and widespread illegal dumping. In addition, Kabul lacks specialized facilities for sorting and recycling C&D waste, while financial constraints and limited technical capacity further worsen the situation.

The study also reveals that current policies and regulatory frameworks are general and lack specific provisions for C&D waste management. There are no clear requirements for C&D waste sorting, disposal, recycling, or site waste management planning. Although institutions such as NEPA, Kabul Municipality, and MoUDH play roles in waste management, coordination among stakeholders remains weak, and incentives for sustainable practices are limited.

Overall, C&D waste management in Kabul should be viewed as an integrated strategy that incorporates improved governance, enhanced infrastructure, and stakeholder cooperation. The study's results provide crucial insights and recommendations that policymakers, construction workers, and waste management authorities in Kabul can implement to address the city's waste problems. In the future, when these recommendations are implemented, the urban sustainability and the environmental health of Kabul may significantly improve.

Recommendations

1. Afghanistan ought to expand on the available policies on environmental and local administration by NEPA, Kabul Municipality, and MoUDH to formulate articulate, enforceable policies for Construction and Demolition (C&D) waste management. This involves incorporating building permits, mandatory site waste management plans, allocating duties for waste separation and disposal, and enhancing monitoring and enforcement of illegal dumping.
2. In a sustainable C&D waste management system, there should be dedicated infrastructure, including sorting facilities, a concrete crushing facility, and disposal areas for construction debris. Concurrently, capacity-building programs should be implemented to enhance the technical capabilities of municipal staff, engineers, and contractors, enabling effective waste reduction, reuse, and recycling.

3. To have an integrated waste management system, there is a need to improve coordination between NEPA, Kabul Municipality, MoUDH, and the private sector. The shift from current practices to a more sustainable, circular approach to C&D waste management in Kabul and across Afghanistan can be achieved through public awareness campaigns, stakeholder involvement, and recycling and reuse incentives.

Authors Contributions

- Imran Safi was responsible for the conceptualization, design, and writing of this article, including data collection, literature review, analysis, and preparation of the initial manuscript draft.
- Abdulhai Kaiwaan critically reviewed the manuscript and provided substantial feedback that improved the quality and clarity of the final paper.
- All authors reviewed and approved the final version.

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