# Mapping the Policy-Economic-Technological Barriers in Construction & Demolition Waste: Cause–Effect Insights from a DEMATEL Analysis

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**Abstract.** The construction activities are done to improve the construction infrastructure, which impacts the social, economic, and environmental sustainability factors. The construction and demolition (C&D) waste management is a big issue that impacts the global economies due to rapid population growth, leading to construction waste generation, thereby affecting sustainable development goal achievement. The construction and demolition waste management have shown barriers to construction management, but very few researchers have explored the intersection through regulatory, financial, and infrastructural challenges, thereby constraining construction waste management initiatives. The research aims to bridge the knowledge gap on construction wastes, including the construction activities that need to be done to improve construction infrastructure, thereby impacting social, economic, and environmental sustainable developments. Adequate knowledge on construction wastes, construction activities to improve construction infrastructure, challenges, barriers to construction wastes, construction wastes, cause-effect diagram, decision-making trial evaluation laboratory, is also explored to obtain the construction wastes management barrier values to understand the results, thereby improving construction wastes management challenges.

## 1 Introduction

The construction sector uses natural resources extensively while producing substantial waste that consists of unused materials which builders create during their construction work and building upgrades and building demolitions [1]. In addition to that, natural disasters also generate a large amount of demolition waste. C&D waste is composed of a variety of materials, such as plasterboard, rocks, sand, asphalt, metals, masonry, and so on [2]. On a global level, C&D waste accounts for almost 40% of total solid waste generated [3].

The problem is even more serious in developing nations, where the growth of population followed by a process of rapid urbanization has led to unprecedented levels of infrastructure development, which in turn has resulted in unsustainable C&D waste. The issue of managing demolition waste is one of the most serious challenges to sustainable development in both developed and developing nations because of the lack of space in landfills, gas emissions and water pollution [4]. The problem is even more serious in developing nations due to a number of challenges.

The idea of circular economy which is based on the 3R principles (Reclycle, Reduce, & Reuse) of C&D waste management is gaining momentum among the researchers of construction waste management. But the circular economy idea in C&D waste management is a complex phenomenon that requires an holistic approach to the policy–finance–infrastructure nexus. Few studies have looked at how these obstacles interact with one another, despite the fact that earlier research has documented the difficulties in managing construction and demolition waste. To create successful policy interventions, it is essential to comprehend how these barriers interact. If these systemic interdependencies are not addressed, these interventions may be undermined and inefficiencies may continue. In order to achieve sustainability by lowering environmental impacts and promoting circular economy practices, it is essential to highlight the intricate relationships among these obstacles. The current study seeks to close this research gap by identifying the obstacles from the literature and further analyzing the intricate cause-and-effect relationships using the Decision Making Trial & Evaluation Laboratory (DEMATEL) approach. The study provides insights into coordinated policy by mapping these connections. It also promotes the construction industry's contribution to the UN SDGs by giving perspectives into the impact of coordinated policy, investment, and infrastructure strategies on accelerating the adoption of sustainable waste practices.

The remaining paper is as follows: The literature background and the obstacles to C&D waste management are reported in Section 2. The methodology used is explained in Section 3, and the analysis in Section 4 follows. The study is concluded and future research directions are listed in the final section.

## 2 Literature Background

The implications of C&D waste management for social, economic, and environmental sustainability have attracted a lot of research interest. In quickly urbanizing economies, resource scarcity, inadequate institutional capacity, and disjointed governance structures make C&D waste management problems worse. Research to date has concentrated on investigating sustainable methods for handling construction and demolition waste and lessening its negative effects on the environment and society. An overview of important research in the field is given in this section, with a particular emphasis on obstacles to C&D waste management.

Some research studies have examined the issues associated with the efficient management of C&D waste. Bufoni et al. [5] and Menegaki and Damigos [6] reported several socio-political, and human resource issues. Udawatta et al. [7] found that inflexible construction methods, lack of knowledge, lack of experience, and inefficient waste management systems are some additional issues. Moreover, Aghimien et al. [8] identified the lack of green certification, lack of government support, and fear of cost increases as important barriers.

As stated by Karji et al. [9], the major limitations in managing C&D waste can be categorized into pre-construction, management, legislative, financial, and planning difficulties. In another study, the inefficiencies of management systems, the lack of maturity in recycling technologies, and the underdeveloped market for recycled materials were identified as major limitations by Huang et al. [10]. Moreover, these limitations may differ from one geographioes to another due to variations in socio-economic and cultural settings.

Economic barriers, especially the consideration of financial returns by contractors, have also been identified in many studies. Lockrey et al. [11] identified that economic viability is a major factor that affects the contractor's actions, and Negash et al. [12] emphasized that it is important to understand the economic challenges faced by contractors to improve C&DWM practices. Similarly, studies also reported social barriers, including low contractor awareness and insufficient community involvement, as further hindrances to sustainability efforts [13]. Lastly, weak policies and inadequate supervision, are frequently cited as regulatory barriers to achieving sustainability in C&D waste management [14], [15].

Some recent studies have attempted to establish the relationships among the barriers to C&D waste management. However, they focus broadly on ranking and linking barriers without explicitly framing them around the interconnections between policy design, financial mechanisms, and infrastructure readiness. The present study addresses this gap by reframing the problem through the lens of systemic interdependence of barriers within the policy–finance–infrastructure framework.

## 2.1 Identified barriers

Initially, fourteen factors were explored from the research works. These barriers were shown to a panel of five experts from academia to obtain feedback. The panel suggested to remove some of the overlapping barriers. After receiving the inputs from the panel, a final set of eight barriers were identified for further analysis. The barriers are given below:

### *2.1.1 Unclear Institutional Responsibilites (UIR)*

Since numerous institutions and stakeholders are involved in the management of construction and demolition waste, there is a state of confusion regarding responsibilities and ownership, leading to inefficient management. Further, the collaboration between the parties is often weak, which further results in uncoordinated efforts.

### *2.1.2 Limited Data Availability (DA)*

Effective management of C&D waste needs accurate and up-to-date information regarding the rate of generation and composition of waste. However, there is a lack of information or data regarding C&D waste, which is essential for proper planning. Notwithstanding this, C&D waste is the largest waste stream in most developed countries and is growing at a fast pace in developing countries due to rapid urbanization.

### *2.1.3 Lack of Regulations (REG)*

The fact that there are regulations that control C&D waste management in the environment ensures that it is managed effectively. The challenge, however, is that the regulations are not enforced effectively, and this makes construction companies disregard them. It becomes difficult to ensure that C&D waste is recycled and disposed of properly.

### *2.1.4 Lack of Infrastructure (INF)*

There is a lack of appropriate infrastructure to facilitate sustainable waste management practices. In fact, many developing nations lack the appropriate infrastructure to manage C&D waste. In addition, land constraints in urban areas make it difficult to establish the necessary infrastructure to dispose of or recycle C&D waste. Moreover, the informal sector is often responsible for managing C&D waste, and it lacks the capacity to manage C&D waste on a large scale.

#### *2.1.5 Limited Economic Incentives (ECI)*

Lack of proper economic policies, tax breaks, incentives, or subsidies provides very little incentive to develop proper C&D waste management infrastructure in most developing countries.

#### *2.1.6 Lack of Technology (TCH)*

There is a lack of availability of technical information, advanced technologies and methodologies for sustainable construction. Even in areas where they are available, their accessibility is limited due to high costs and lack of expertise. The use of traditional construction methods, which produce more waste, is still prevalent in many developing countries.

#### *2.1.7 Limited Financing (FIN)*

Financial resources are necessary for proper waste management, but in many countries, they are limited. Developing countries are faced with minimal investment in C&D waste sorting, recycling, and disposal.

#### *2.1.8 Lack of Management Support (LMS)*

There are a number of management challenges that influence the management of C&D waste. These challenges include poor definition of project parameters, resource allocation, lack of commitment from management, transparency, and so on. These challenges are linked to the top management, which is commonly associated with the management of construction projects.

## 3 Methodology

The current study uses a multi-criteria decision-making (MCDM) approach to analyze associations between the barriers of C&D waste management. This method is most suitable because of its capacity to deal with the interdependencies even with small sample size. It is a powerful tool to assess a hierarchical model that represents the interdependencies among the barriers. In addition, DEMATEL can assist decision-makers in finding the most important driving factors by investigating the interdependencies and effects of interaction among variables. The ability to investigate interdependencies makes DEMATEL the most suitable technique to investigate the barriers to C&D waste management.

Following are the DEMATEL steps:
Step 1: The data collection process was done by evaluating the impact of each element i on every other element j, indicated by $b_{ij}$ on a scale from 0 (No influence) to 4 (very high influence) for which experts were invited. These scores help in constructing a direct relations matrix $A$. Matrix $A$ shows a pair-wise comparison of interactions among the elements and is given in Eq. (1).

$$A = \begin{bmatrix} 0 & a_{12} & \cdots & a_{1n} \\ a_{21} & 0 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 0 \end{bmatrix} \quad (1)$$

Step 2: Equations (2) & (3) are used for normalization of A.

$$\boldsymbol{M} = \boldsymbol{A}/q \quad (2)$$

$$q = max_{1 \le i \le n}\{\textstyle\sum_{j=1}^{n} a_{ij}\} \quad (3)$$

Step 3: $\boldsymbol{TRM}$ (Total relation matrix) is developed from $\boldsymbol{M}$, using eq. (4) and identity matrix $\boldsymbol{I}$.

$$\boldsymbol{TRM} = \boldsymbol{F}(\boldsymbol{I} - \boldsymbol{M})^{-1} \quad (4)$$

Step 4: $R$ and $S$ are developed from the aggregated rows and columns.

$$\boldsymbol{R} = \left[\textstyle\sum_{j=1}^{n} m_{ij}\right]_{n\times 1}, = (r_1, r_2, \dots, r_i, \dots, r_n) \quad (5)$$

$$\boldsymbol{S} = \left[\textstyle\sum_{i=1}^{n} m_{ij}\right]_{1\times n}' = (s_1, s_2, \dots, s_i, \dots, s_n) \quad (6)$$

$$\boldsymbol{TRM} = m_{ij} \quad i, j = 1,2,3,..n$$

Step 5: The values $\{r_i + s_i, r_i - s_i\}$ are pictorially represented on a 2-dimensional plane using $(r_i + s_i)$ and $(r_i - s_i)$ as the two axes.

## 4 Analysis

A total of ten experts, with an experience tenure of twelve years, were employed for determining opinions about the causal relationships between these eight variables. The experts shared their responses using the scale of Step 1. Table 1 below shows the direct relation matrix, derived from consolidated results of all experts.

**Table 1.** Direct Relations Matrix

| | UIR | DA | REG | INF | ECI | TCH | FIN | LMS |
|---|---|---|---|---|---|---|---|---|
| **UIR** | 0.125 | 2.250 | 1.750 | 1.625 | 2.125 | 0.125 | 0.000 | 3.000 |
| **DA** | 0.250 | 0.000 | 0.250 | 2.125 | 0.125 | 2.125 | 0.125 | 1.125 |
| **REG** | 2.000 | 3.250 | 0.000 | 3.250 | 3.000 | 2.750 | 2.625 | 2.750 |
| **INF** | 0.000 | 1.000 | 0.000 | 0.000 | 0.000 | 2.000 | 0.000 | 1.500 |
| **ECI** | 1.750 | 2.875 | 0.000 | 3.000 | 0.000 | 1.000 | 0.000 | 2.125 |
| **TCH** | 0.125 | 2.875 | 0.000 | 3.375 | 1.000 | 0.000 | 0.000 | 0.000 |
| **FIN** | 2.375 | 2.375 | 0.000 | 3.500 | 3.000 | 3.500 | 0.000 | 2.375 |
| **LMS** | 3.125 | 2.125 | 1.625 | 2.250 | 2.750 | 0.000 | 1.875 | 0.000 |

The normalized matrix is shown in Table 2.

**Table 2.** Normalized Matrix

| | UIR | DA | REG | INF | ECI | TCH | FIN | LMS |
|---|---|---|---|---|---|---|---|---|
| **UIR** | 0.006 | 0.115 | 0.089 | 0.083 | 0.108 | 0.006 | 0.000 | 0.153 |
| **DA** | 0.013 | 0.000 | 0.013 | 0.108 | 0.006 | 0.108 | 0.006 | 0.057 |
| **REG** | 0.102 | 0.166 | 0.000 | 0.166 | 0.153 | 0.140 | 0.134 | 0.140 |
| **INF** | 0.000 | 0.051 | 0.000 | 0.000 | 0.000 | 0.102 | 0.000 | 0.076 |
| **ECI** | 0.089 | 0.146 | 0.000 | 0.153 | 0.000 | 0.051 | 0.000 | 0.108 |
| **TCH** | 0.006 | 0.146 | 0.000 | 0.172 | 0.051 | 0.000 | 0.000 | 0.000 |
| **FIN** | 0.121 | 0.121 | 0.000 | 0.178 | 0.153 | 0.178 | 0.000 | 0.121 |
| **LMS** | 0.159 | 0.108 | 0.083 | 0.115 | 0.140 | 0.000 | 0.096 | 0.000 |

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Table 3 below shows the Total relation matrix.

**Table 3.** Total Relations Matrix

| | UIR | DA | REG | INF | ECI | TCH | FIN | LMS |
|---|---|---|---|---|---|---|---|---|
| **UIR** | 0.0806 | 0.2233 | 0.1187 | 0.2095 | 0.1799 | 0.0853 | 0.0397 | 0.2349 |
| **DA** | 0.0365 | 0.0541 | 0.0240 | 0.1641 | 0.0366 | 0.1396 | 0.0183 | 0.0881 |
| **REG** | 0.2011 | 0.3425 | 0.0450 | 0.3739 | 0.2614 | 0.2662 | 0.1681 | 0.2740 |
| **INF** | 0.0219 | 0.0911 | 0.0109 | 0.0512 | 0.0258 | 0.1220 | 0.0111 | 0.0946 |
| **ECI** | 0.1313 | 0.2242 | 0.0288 | 0.2437 | 0.0532 | 0.1115 | 0.0217 | 0.1723 |
| **TCH** | 0.0227 | 0.1829 | 0.0076 | 0.2186 | 0.0646 | 0.0476 | 0.0060 | 0.0394 |
| **FIN** | 0.1913 | 0.2674 | 0.0391 | 0.3415 | 0.2308 | 0.2657 | 0.0285 | 0.2256 |
| **LMS** | 0.2319 | 0.2455 | 0.1171 | 0.2694 | 0.2268 | 0.1057 | 0.1248 | 0.1262 |

The effects given and received by each variable were determined and are described below in Table 4.

**Table 4.** Cause-Effect Strengths

| | d | r | d+r | d-r |
|---|---|---|---|---|
| **UIR** | 1.17197 | 0.917298 | 2.0893 | 0.2547 |
| **DA** | 0.56126 | 1.630995 | 2.1923 | -1.0697 |
| **REG** | 1.93229 | 0.391216 | 2.3235 | 1.5411 |
| **INF** | 0.42860 | 1.872 | 2.3006 | -1.4434 |
| **ECI** | 0.98678 | 1.07908 | 2.0659 | -0.0923 |
| **TCH** | 0.58947 | 1.143619 | 1.7331 | -0.5541 |
| **FIN** | 1.58993 | 0.418303 | 2.0082 | 1.1716 |
| **LMS** | 1.44735 | 1.25514 | 2.7025 | 0.1922 |

An influence map is developed to explain the relationship between various dimensions. The map shows the influence of various dimensions to others. This diagram is shown below in Figure 1.

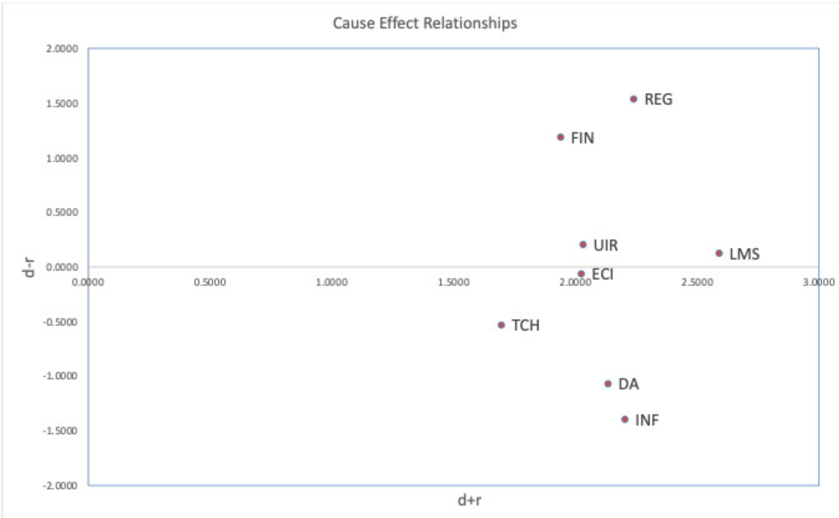


Fig.1. Causal positions of Factors

The above figure indicates that the lack of regulations and limited funds are revealed as the most influential barriers, having a significant impact on other barriers. Further, the lack of Infrastructure, limited data availability, and limited technology are identified as the impact barriers. Based on the information shared by the experts, the lack of economic incentives has been considered as the weaker factor in the current scenario.

## 5 Discussion & Conclusion

The results report that lack of regulation has emerged to be the most critical barrier that affects the C&D waste management. It leads to poor clarity of roles and limited management commitment to an efficient management of waste generated from the construction sites. It is followed by limited financing available to the C&D waste management. This leads to lesser economic incentives, that inhibits the motivation to reduce and recycle waste. The barrriers' cause-effect relationships are shown in Figure 1. The higher level barriers are causal barriers adn the lower level factors are effect barriers, as they are affecxted by the causal barriers.

This study employed DEMATEL approach to explore the key factors that prevent an effective C&D waste management. The results reveal that the most critical barriers are lack of regulation (REG), inadequate financial support (FIN), and unclear institutional responsibilities (UIR). They pose significant challenges by limiting investment in sustainable management practices. Lack of regulations and policies lead to weak implementation of waste management procedures, while financial constraints also slow down the development of infrastructure. Further, limited economic motivations to stakeholders further disturbs the issue.

It is therefore important to meet these challenges through collective actions of all stakeholders. A substantial progress in the C&D waste management practices can be achieved by appropriate frameworks for policy and finance. Future studies can use statistical analysis to confirm the relationships between the barriers identified above and pilot studies to gain deeper insights into the relationships identified in this paper..

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