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Research paper

A Sustainable Business Model for Converting Construction and Demolition Waste to Wealth

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Abstract

India's rapid urbanisation necessitates a planning approach that ensures the sustainability of its cities through efficient waste management. This swift urban growth has significantly accelerated modern construction and demolition of older infrastructure or structures within Indian cities. C&D (Construction and Demolition) waste is accountable for approximately 30 percent of urban municipal waste within metropolitan areas. Managing C&D waste and transforming it into valuable resources presents considerable challenges for all urban local bodies (ULBs). Recycling C&D waste offers dual benefits: it reduces pressure on the extraction of virgin construction materials and helps mitigate environmental pollution. Recycled C&D waste can produce various valuable products, including aggregates of different sizes, manufactured sand, paver blocks, concrete bricks, double-tee precast panels for boundary walls, manhole covers, water tanks, and more. These products are durable and eco-friendly building materials that contribute to the conservation of natural resources. However, a sustainable business model is essential for understanding the volume of C&D waste produced and for addressing current challenges and opportunities at the city, regional, and state levels. The current research aims to gather information about the overall scenario of C&D waste management procedures in India, relying on secondary resources. It proposes a sustainable business model for C&D waste handling that transforms this specific waste into a valuable resource, identifying possible advantages and the resource efficiency of recycled items.

Keywords: *Processing Plant; Construction and Demolition Waste; Resource Efficiency; Recycled Products; Sustainable Business Model.*

1. Introduction

Rapid urbanization in India continues to increase the burden on 'virgin' construction materials and escalate the volume of C&D waste significantly. Resource consumption and waste generation have been positively correlated; higher consumption leads to increased waste output. India ranks as the third-largest producer of carbon dioxide (CO_2) globally, following China and the United States. Its greenhouse gas (GHG) footprint grows alongside population increases. The top 25 Indian cities emit over 15% of the country's greenhouse gases.[1] United Nations' Sustainable Development Goal 11 calls for minimizing the environmental impact of cities by 2030, with an emphasis on urban waste management and air quality. The construction sector is responsible for a huge volume of material extraction, environmental pollution, and at the same time generates a significant amount of waste in the country. Therefore, C&D waste management was regarded as a significant issue in Indian cities in contrast to alternative waste management methods.

C&D waste includes materials and debris from building, remodelling, demolition, and repair operations. This type of waste encompasses metals, fixtures, wires, fittings, and wood, which can be recycled in the secondary market. Such materials are typically sorted and collected on-site. However, concrete and brick debris need to be either disposed of or recycled properly.

Designing sustainable cities that achieve zero waste presents significant challenges. C&D waste's makeup varies by region, making it region-specific. A substantial portion of this waste is collected on-site by the unorganized sector for recycling and reuse. The remainder is classified as debris, which complicates transportation, disposal, and recycling efforts.

C&D waste is often mixed with municipal solid waste due to inadequate legislation and limited recycling facilities for municipal waste. Additionally, some of it is illegally disposed of along roadsides, in low-lying areas, and in riverbeds within urban environments.

Sustainable C&D waste management on a global basis has emerged as an increasing concern because of the significant amount of waste produced and its detrimental effects on society, the environment, alongside the economy (Pickin et al. 2022). Both hazardous and non-hazardous materials produced by new buildings, remodelling, and demolition make up C&D waste. (Menegaki, M. & Damigos, 2018). Approximately 90 to 95 percent of total C&D waste can be recycled (Miranda et al.,2017); however, currently, barely 5 percent of this waste gets recycled in India (MoUD, 2000).

According to a study by IIT Kanpur (2017), the main cause of urban pollution is road dust from C&D operations. This dust accounts for 56 percent of coarse PM_{10} pollutants as well as 38 percent of harmful, respirable $PM_{2.5}$ particles. The construction industry also uses various

pollutant fluids, such as paints, oils, solvents, and washing water, which can adversely affect the land. To minimize on-ground pollution risks, these contaminant fluids should be handled with care. Workforces should reduce the use of non-essential shuttering oil by making better use of available materials. Although alternative, environmentally friendly oils, derived from vegetable and synthetic sources, are typically more expensive, they are recommended because they pose less risk to the workforce.

Housing, building, and infrastructure development account for 40–50% of global resource extraction, highlighting the construction industry's reliance on virgin materials. Sand and gravel are the most frequently extracted minerals, representing 69 to 85 percent of annual mining activities (B Catriona et al. 2021).

Resource depletion is exacerbated by substantial demand for housing, infrastructure, and other products and services brought on by economic expansion and fast metropolitan city growth. The Pradhan Mantri Awas Yojana (Housing for All by 2022) initiative of the Indian government calls for the construction of two crore dwelling units, which will increase the demand for building materials. The strain on coarse and fine aggregates will significantly increase because residential buildings make up approximately 67 percent of the total weight of coarse and fine aggregates (Devi & Palaniappan, 2014). Due to a lack of raw resources, fine aggregates are carried 70–100km in cities like Bangalore (Venkatarama Reddy & Jagadish 2003).

C&D Waste Recycling Company, which emerged before 2000, initially used on-site sorting and picking methods before progressing to the implementation of a sorting line. In late 2007, as transportation fuel prices increased, businesses began to place greater emphasis on waste management. As a result, issues like climate change, plastic pollution, and resource efficiency highlight the importance of recycling (Redling, A. 2019).

To support economic growth, social justice, and environmental sustainability for present and future generations, CDW (construction and demolition waste) management must be done effectively (Gherman et al., 2023).

A study on sustainable C&D waste management (Ma et al., 2023) emphasized the importance of reuse, waste reduction, as well as recycling by putting in place laws that are focused on resource circularity, reduction, alongside recycling. The primary purpose will be to create a more sustainable construction industry by avoiding environmental deterioration as well as decreasing dependency on non-renewable resources.

Developing a systematic and sustainable model for managing C&D waste has been essential for urban areas within India. Converting waste into wealth has significant potential to address environmental challenges while creating economic opportunities and improving resource efficiency. By utilizing innovative recycling technologies, waste can be transformed into valuable resources, thereby reducing landfill usage and lessening natural resource depletion. However, achieving these changes requires collaboration among central, state, and local governments.

The present study evaluates the current challenges faced by India's C&D waste management practices, utilizing secondary data as the only source. The objective is to gain a comprehensive understanding of how India handles the waste generated from C&D. Moreover, it seeks to propose a sustainable business model for managing C&D waste, which will transform waste into profit while emphasizing the benefits and resource efficiency of recycled materials.

1.1. Objectives of the study

1) To understand the current state of C&D waste management practices in Indian cities.
2) To propose a sustainable business model for converting waste into wealth.
3) To conduct a SWOT analysis of C&D waste management and identify the resource efficiency of recycled materials.

1.2. Overall scenario of construction and demolition (C&D) waste management in India

Many cities in India are inadequately prepared to control C&D waste systematically. Implementation of the C&D Waste Management Rules, 2016, has progressed slowly in urban areas. The difficulties in handling C&D waste differ significantly from one city to another, prompting each city to create its own management system. In 2009, the first facility for treating C&D waste was constructed in Delhi, with a 500-TPD (ton-per-day) recycling capability, followed by a second plant in Ahmedabad in June 2014.

C&D Waste Management Rules, 2016, outline timelines for urban areas for establishing and operating their recycling facilities. 53 of 131 NACs (Non-Attainment Cities) provided information on the condition of their plants. Currently, there are over 34 C&D waste recycling plants of various sizes located in 28 cities across the country. According to data collected from multiple sources, more than 36 additional C&D recycling plants are expected to be established in the coming years, including in cities such as Delhi, Gurugram, Ghaziabad, Noida, Agra, Pune, Varanasi, Ahmedabad, Indore, Pimpri-Chinchwad, Chandigarh, Thane, Rae Bareli, Bhopal, Surat, along with Hyderabad. As per the PRANA website, only 35 cities (26 percent) out of 131 NACs have data on the volume of C&D waste production. These cities produce a total of 6,563.48 TPD C&D waste, with Delhi producing the most at 3,448 TPD nationwide, followed by Ahmedabad (1,000 TPD), Noida, Faridabad, and Ghaziabad. (Roychowdhury et al. 2023).

(MoEFCC, 2025), The Environment (Construction and Demolition) Waste Management Rules, 2025, introduced by the Indian government, represent a significant step towards sustainable waste management in the construction sector. These regulations are issued on April 4, 2025, and will be effective from April 1, 2026. These rules shall supersede Construction and Demolition Waste Management Rules, 2016. New rules take aim at construction and demolition (C&D) debris to enhance its recycling. These new rules intend to make regulations stronger and steer practices toward being more sustainable for C&D waste management. The Rules provide a legal structure for the management of C&D waste uniformly throughout India. They require stakeholders, including government agencies, contractors, and waste processors, to adhere to new standards and procedures. They foster a move towards a circular economy by emphasizing recycling and resource recovery. The main objective of this rule is to regulate and oversee the handling, transportation, processing, and disposal of C&D waste. To promote environmentally sustainable practices in construction and demolition activities. To minimise the unauthorised disposal of C&D waste and the resulting environmental degradation, and to promote resource recycling and reuse of C&D waste. There are exclusions from these rules for various waste as Waste covered by the Atomic Energy Act, Waste of Defence, Waste due to natural disaster or by acts of war, Waste as covered under other sectoral specific rules.

1.3. Major environmental impacts of C&D waste

Main factors contributing to environmental pollution from C&D waste are dust & noise. C&D waste is a significant source of fugitive dust pollution. When this waste is improperly disposed of, it leads to air along water pollution. Degradation of the natural world occurs when a

significant portion of C&D waste is dumped in landfills. This practice not only contributes to air pollution but also contaminates groundwater, posing serious risks to ecosystems and public health.

1.4. Quantification of C&D waste

Due to ambiguities in calculating volume produced, there is a dearth of trustworthy information on C&D waste creation in India. This uncertainty arises from different estimation methods, varying rates of development and redevelopment, and an increase in the demolition of old structures. Various agencies, including SBM 2.0 and TIFAC, have proposed different estimation procedures, but significant inconsistencies exist among these estimates. C&D waste data is often underreported regionally, with many cities failing to assess this accurately. Most cities lack designated collection points, adequate transportation systems, and recycling plant facilities.

1.5. Different types of recycling plants for C&D waste

C&D waste processing plants are classified as mobile, semi-mobile, or stationary. Additionally, C&D waste collection alongside transport to recycling facilities incurs costs, contributes to pollution, and causes traffic congestion (Constro Facilitator, 2023; Ulubeyli et al., 2017). Consequently, the choice of recycling plants depends significantly on the plant's capacity, the volume of waste, the location, and the specific requirements of a construction project (Joshi et al. 2024).

1.5.1. Stationary recycling plants

Stationary recycling is recycling facilities that are stationary and process a significant volume of waste over time at a specific location. They are packed with technology and require a larger initial investment to get set up. Such plants are ideal for high-density regions and are the most cutting-edge type of recycling plants, with the provision of both dry and wet processing systems. They are designed to handle huge capacities of C&D waste and to sort out unwanted materials.

1.5.2. Mobile recycling plants

Mobile recycling plants with a capacity of up to 100 tonnes per hour are available and can be transported by truck to different project sites if necessary. These units can handle small - medium quantities of C&D waste and can be used at various C&D sites.

15.3. Semi-mobile recycling plants

Semi-mobile recycling plants are generally larger and can handle greater C&D waste volumes compared to mobile plants. These facilities were partially portable and could be moved on a trailer within a site or to a different location. The quality of end products from semi-mobile plants is superior to that from mobile units. However, these plants are unable to process mixed types of C&D waste that comprises components encompassing plastic, wood, as well as metal.

1.6. Informal stakeholders

In the Indian economy, recycling C&D waste can be greatly aided by informal stakeholders. They have often been regarded as the backbone of the recycling industry, making significant contributions to environmental sustainability and the circular economy. Their involvement also helps alleviate the economic burden on urban local bodies.

Typically, high-quality waste is collected by the informal sector after it has been segregated. These stakeholders include mobile waste buyers, individual or group waste collectors, waste traders involved in secondary sorting, and small shop owners. Additionally, waste pickers who work at dumpsites and communal waste collection points, along with owners of waste warehouses or storage facilities, are essential components of this sector.

Integrating informal stakeholders into the formal waste collection process is essential, as it can cost-effectively optimize the efficiency of waste collection and processing. India has a vast workforce in the informal sector that could be formally engaged in the segregation and transportation of waste, especially where current waste management practices are deficient, leading to missed recycling opportunities. Promoting C&D waste segregation at source might be beneficial, and institutional mechanisms involving the informal sector could be established for waste collection. This sector can be trained to categorize waste and participate in repurposing and recycling, including making tiles out of crushed building waste (Gayakwad & Sasane, 2015).

2. A sustainable C&D waste business model

Management of C&D waste, one of the major global challenges, as it depletes natural resources needed for construction. However, sustainability can be achieved through changes in institutional frameworks. Five parameters are essential for fostering sustainability: a) civil society, which drives both individual and social innovation; b) appropriate government policy instruments; c) a strong financial system; d) entrepreneurs contributing to sustainable products through greener and fairer production methods; and e) the role of individual consumers. The sustainability approach is generally based on three principles: a) efficiency, b) consistency, and c) sufficiency.

The current study highlights three approaches for developing a sustainable business model, all aimed at reducing resource consumption. The efficiency and consistency approaches focus on production, while the sufficiency approach addresses resource consumption. The sufficiency approach involves three primary strategies: reduction, adaptation, and substitution. The efficiency approach in a business unit focuses on reducing production costs, aiming to align economic and environmental interests. An ideal sustainable business model should integrate all three approaches.

Consistency strategies do not aim to increase the number of resources or efforts, as efficiency approaches do. Instead, they concentrate on using infinite, renewable resources or preventing resources from becoming unusable (Manuel et al., 2023).

The first step for any business model is conducting comprehensive market research to understand the quantity of waste generated, along with the present challenges and opportunities within the city, region, and state. Effective C&D waste management prerequisites a strategic method to its implementation across India. Transforming C&D waste into a valuable resource necessitates sustainable construction practices, which include raising awareness of environmental impacts and enforcing strict regulations regarding waste management.

At the regional level, market investigation should evaluate the C&D waste management landscape, particularly composition and volume, as these aspects can vary from one region to another. Understanding the existing recycling plants, their capacities, locations within the city, and collection points is also essential. Furthermore, considerations should include the regulatory authority, existing policies, incentives for recycling products, market share of service providers, pricing structures for recycled products, and the supply and demand dynamics of these products. A sustainable business model requires thorough local market analysis for efficient management of C&D waste. The current investigation proposes a viable commercial strategy for local C&D waste management, as illustrated in the accompanying figure.

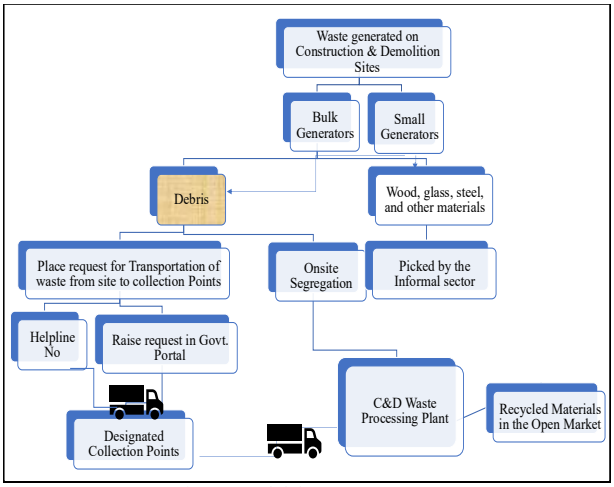

Fig. 1: A Business Model for C&D waste management.

Source: Author's creation.

In the suggested business model, construction and demolition waste will be systematically collected, sorted, recycled, and reused. The three main operational costs in the model above are labour, transportation, and equipment upkeep. Facilities, transportation, and machinery all demand capital investment. Marketing expenses are necessary to promote recycled resources. In addition, effective logistics such as prompt collection and transportation to cut expenses, advanced sorting technologies, strong regulatory compliance, such as the ability to receive incentives, avoid fines, and work with local governments, and spreading public awareness, are all essential to the model's success. Stakeholders (Government and regulatory authorities, construction and demolition firms, and recycling facilities) play crucial roles in ensuring the efficient, sustainable, and compliant handling of waste materials.

The proposed business model, an effective framework that includes three key approaches: efficiency, consistency, and sufficiency. Consumers should be encouraged to adopt more sustainable consumption patterns and to use natural resources more wisely. Waste can be minimized through practices like recycling as well as reusing. Applying the circular economy model, which seeks to eradicate waste, is crucial to the sustainability of waste management. However, transitioning from a linear to a circular economy presents both technical and organizational challenges.

The business model proposed in this study for C&D waste management offers an opportunity for utilizing recycled materials effectively. To enhance C&D waste management functionality, a digital platform is needed. Currently, there is no dedicated helpline or Management Information System (MIS) activated across cities for waste collection requests and complaints. Therefore, cities must establish a specific phone number for C&D waste collection alongside transportation. A robust digital infrastructure will assist Urban Local Bodies (ULBs) in managing C&D waste efficiently in the future.

3. SWOT analysis of C&D waste management in India

Based on secondary literature, the present study developed a SWOT analysis for the management of C&D waste to obtain a more profound and comprehensive condition of C&D waste management, as outlined below.

SWOT analysis of C&D waste management

3.1. Strength

The strength of Construction and Demolition (C&D) waste management lies in its ability to address environmental sustainability, economic efficiency, and social well-being when effectively implemented. Some strengths are:

- Effective methods of segregation and disposal reduce emissions, leachate production, and contamination of water or soil.
- Increase resource efficiency by turning waste into useful materials, aiding in the larger transition to a circular economy, in which waste is turned into a resource.
- Support the larger-scale future of urban planning. An approach to reaching the zero-waste goal.
- Reusing and recycling materials lowers the cost of building materials, and fewer landfill fees lower project costs overall. By acting as secondary raw materials, recycled materials can stabilise prices and lessen reliance on virgin resources.

3.2. Weakness

Construction and Demolition (C&D) waste management also faces several weaknesses that hinder its effectiveness and sustainability. Some of the main weaknesses are:

- Illegal dumping and non-compliance are frequently caused by the lack of enforcement of current legislation.
- Effective planning is hampered by incomplete or faulty data collection on the volume, types, and disposal of C&D waste.
- There is inadequate or obsolete infrastructure for processing and recycling C&D waste. Recovery is limited by the absence of specialized facilities for material sorting, processing, and reuse.

- Insufficient coordination and understanding among construction stakeholders regarding the significance and advantages of waste management.

3.3. Opportunities

Construction and demolition (C&D) waste management offers numerous opportunities to improve sustainability, reduce environmental impact, and enhance economic efficiency. Some key opportunities are:

- To expand the number of recycling facilities at the state level that will enhance environmental benefits and create job opportunities. Minimise waste, maximise recycling, reduce landfill usage, and reduce contamination of land and water.
- It is essential to have access to city-specific construction and demolition (C&D) permit data to precisely measure C&D waste, evaluate trash generation trends, and create efficient waste management plans.
- To increase consumer demand for recycled products, which are thought to be superior alternatives to virgin building materials.
- Cutting-edge technology, such as advanced equipment for effective C&D waste sorting and processing. Applications of digital tools for waste management and tracking optimisation.
- Waste as resource: converting construction and demolition waste into secondary resources, such as utilising recycled aggregates in new concrete or road base, or converting wood waste into chips or bioenergy.

3.4. Threat

Construction and Demolition (C&D) waste poses several environmental, economic, and social threats if not managed properly. Some of the threats are listed below:

- Long-distance C&D waste transportation increases carbon emissions.
- Air quality is impacted by dust and particulate matter produced during waste handling or demolition.
- Land degradation results from the large amounts of unmanaged construction and demolition waste that fill landfills.
- Improper disposal of paints, chemicals, or other hazardous items raises the danger of water contamination.
- There may be fines, penalties, and legal repercussions for breaking waste management laws.
- Construction workers and local inhabitants are at risk for health problems due to exposure to dust, asbestos, lead, or other toxic materials.
- There was less demand for recycled materials made from C&D waste. Natural reserves are depleted when materials are not recycled or reused, leading to needless virgin resource exploitation.

4. Resource efficiency of C&D waste recycling materials

Under the 2016 C&D Waste Management Rules, every city with a population exceeding one 1million must establish a C&D waste recycling plant (MoEFCC 2016). Recycled items from C&D waste might get transformed into green building materials, including various-sized aggregates, manufactured sand, paver blocks, concrete bricks, double-tee precast panels for boundary walls, manhole covers, water tanks, and more. These products, made from C&D waste, help conserve natural resources and serve multiple purposes in contemporary construction activities. They provide better environmental solutions and serve as effective replacements for virgin materials.

Recycled Concrete Aggregates (RCA) are commonly used in precast concrete products and civil maintenance work. Recycled aggregates offer a superior alternative to river sands, while recycled sand is utilized in brickwork, mortar, and road construction. Brick aggregates are often used in road sub-bases, lean concrete, and low-bearing concrete blocks. Street paving blocks (both steel and rubber-molded) and curbstones made from recycled aggregates are durable, customizable, and eco-friendly. These recycled products can also be used for street furniture, such as benches and planters, as well as for rainwater harvesting systems.

Numerous studies support efficiently utilizing C&D waste within the base of pavement as well as sub-base layers, addressing the growing virgin aggregates in road construction. The emerging concern regarding waste production might be alleviated if employing recycled materials in major highway construction projects is deemed acceptable (Parveen Berwal et al., 2024).

4.1. Major roadblocks for recycled materials

4.1.1. Weak market linkages

A thriving market for recycled materials is essential to the operations of C&D waste processing facilities. These plants produce various products, including recycled aggregates and paver blocks. However, they face significant challenges due to weak market linkages and a lack of awareness. Implementing legal requirements that require all construction activities to make the best utilization of recyclable resources could help boost and support the market. The construction permit system ought to be employed by all ULBs to safeguard a buyback policy for recycled materials from processing plants. The government should require that 20% of secondary or recycled materials be used in new construction projects and 40% in roads and highways.

4.1.2. High GST charges

Additionally, recycled materials are subject to a higher Goods and Services Tax (GST) than virgin construction materials, despite recycling plants being exempt from GST. This discrepancy raises the prices of recycled materials. C&D Waste Rules 2016 advocate utilizing recycled building materials in place of 10 to 20 percent of virgin ones, but only a few cities have implemented this rule as a mandate. A state or local government order could effectively require the application of recycled materials to all civic building activities. The current GST rate of 18% for recycled materials should be reduced to 5%.

4.1.3. Awareness among stakeholders

All stakeholders involved in construction and demolition activities must understand the relevant regulations, their responsibilities, and the potential penalties for non-compliance. Many waste generators, especially smaller ones, are often unaware of their obligations regarding

C&D waste management. Common violations encompass illegal dumping near highways, failure to properly segregate waste, and inadequate storage of waste outside building premises.

5. Way forward

Several environmentally friendly methods for handling C&D waste are recommended below:

5.1. Stakeholder coordination

Effective coordination among stakeholders, like recyclers, contractors, local authorities, as well as others, is crucial for a sustainable method of managing waste from C&D. By collaborating, the built environment can be made more resilient along ecologically friendly by these stakeholders.

5.2. Sustainable construction practices

Integrating sustainable practices like prefabrication and material optimization can greatly minimize waste generation at the source during different phases of C&D.

5.3. Efficient waste management

Good waste management techniques are essential. This involves segregating waste at the source and properly collecting and transporting it to designated collection points before sending it to recycling facilities.

5.4. Comprehensive planning

Cities should develop comprehensive plans for collection points and recycling facilities, ensuring strong coordination among them.

5.5. Dust control measures

Effective management of dust control measures at construction sites, during transportation, and at recycling facilities is essential. All parties involved in waste management should adhere to appropriate dust control measures.

6. Results & discussions

The present research found that accessible collection points were necessary to process C&D waste efficiently. Every city should establish designated collection points within a limited distance to minimize transportation challenges. Minimal fees should be imposed on all waste generators for processing, transportation, collection, as well as waste disposal, and these fees should be communicated by the relevant authorities. A robust digital infrastructure will aid urban local bodies (ULBs) in managing C&D waste efficiently and accurately estimate long-term data.

An efficient C&D waste management can help to preserve natural resources, lessen its effects on the environment, encourage regulatory compliance, and foster healthier communities. It becomes an essential part of sustainable urban expansion when it is successfully incorporated into construction methods.

All ULBs should implement a buy-back policy for recycled materials through a building permit system. Additionally, GST on recycled materials should be reduced from the current rate of 18% to 5%. To promote resource efficiency and circularity in C&D waste, the government ought to require the utilization of recycled materials as well as restrict the usage of virgin ones in new construction activities, as well as in roads as well as highways construction.

7. Conclusion

C&D waste had significant potential to enhance circularity, reduce emissions, and improve resource efficiency. Addressing climate change and the goal of achieving zero waste requires a switch to a circular model from the linear one of waste management. This transition can be facilitated through a decentralized approach, which will also create substantial employment opportunities.

A sustainable business model is vital for managing C&D waste in urban areas having populations surpassing 1 million. The dual benefits of recycling C&D materials include providing better substitutes for virgin construction materials and reducing environmental pollution. The products obtained from recycled C&D debris are durable, eco-friendly, and contribute to conserving natural resources. Transforming waste into wealth holds tremendous potential for addressing environmental challenges and improving resource efficiency.

8. Declaration

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