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Construction & Demolition (C&D) Waste Generation and Recycling Management Protocol of Bangladesh

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Abstract: Bangladesh is quickly growing urban areas and building new facilities, which has caused a large increase in Construction & Demolition (C&D) waste. Divisional cities, which are important for economic and population growth, have trouble sustainably handling waste. Poor management of Construction & Demolition (C&D) waste harms the environment, increases urban flooding, and poses major health risks to the public. The generation, composition, and current management policies of C&D waste in eight divisional towns in Bangladesh, such as Dhaka, Chattogram, Rajshahi, Khulna, Sylhet, Barishal, Rangpur, and Mymensingh, are investigated in this paper. While Rangpur generates roughly 0.12 million tons, Dhaka generates about 1.28 million tons of Construction & Demolition (C&D) debris yearly. Most of the garbage in Dhaka includes concrete and bricks; concrete accounts for 60% of the total, while bricks form 21%. Effective recycling schemes provide major financial advantages. From recycled goods, they might bring roughly USD 44.96 million yearly in Dhaka. Given the present shortcomings in recycling infrastructure and the inadequate application of laws, this study emphasizes the immediate need for evidence-based policies and strategic investments in sustainable waste management. While tabular forms summarize important results, data visualization tools, including bar charts and curves, powerfully show trends. The study ends with suggestions meant to change regulations, build infrastructure, and support public-private collaborations to raise recycling rates and sustainable waste management techniques.

Keywords: *C&D, Waste, Recycling, Management, Bangladesh.*

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I. INTRODUCTION

Particularly in the management of Construction & Demolition (C&D) debris, Bangladesh's fast urbanization and infrastructure development function as a double-edged sword, supporting economic growth but also posing major environmental and logistical problems. Driven by government megaprojects, private real estate development, and a growing population, urbanization in Bangladesh has lately sped up [7]. With divisional cities such as Dhaka, Chittagong, Khulna, and Sylhet leading the front stage in this change, the World Bank (2021) says that about 37% of Bangladesh's population lives in urban settings [9]. But this growth has led to a notable rise in Construction & Demolition (C&D) trash, a category sometimes overlooked in conventional municipal solid waste (MSW) control strategies.

- *The Growing Challenges of C&D Waste*

Along with non-inert hazardous elements, including paint and asbestos, Construction & Demolition (C&D) waste usually consists of inert materials, including concrete, bricks, wood, metals, and glass. Environmental damage is exacerbated in Bangladesh by the absence of separate garbage collection systems and by improper disposal techniques. With 20% to 30% of all garbage generated in developing nations coming from Construction & Demolition (C&D) debris, research indicates these industries significantly contribute to urban waste in these nations (Hossain & Islam, 2020) [6]. Given Bangladesh's strained urban infrastructure and limited waste management resources, the data there raise serious questions.

- *Urban Growth & Expansion of Infrastructure*

Urban and infrastructure development is being led by Bangladesh's divisional cities. The capital, Dhaka, is seeing notable vertical expansion as tall buildings replace more

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traditional single-story homes. [4] Large-scale projects like the Padma Bridge and the Karnaphuli Tunnel simultaneously create a great demand for building materials, which fuels an amazing volume of Construction & Demolition (C&D) trash. Renowned as the commercial center of the country, Chattogram has seen a significant rise in building activity, particularly in its port and industrial areas (Rahman & Karim, 2019) [7]. Smaller cities like Rajshahi and Barishal have these difficulties even if their population is growing more slowly. These metropolitan regions' absence of integrated building and demolition waste management systems creates a significant problem that emphasizes the need for a comprehensive and sustainable approach to solve it.

➢ *Environmental and Public Health Implications*

A range of environmental effects follow from the poor management of building and demolition (C&D) waste. Unchecked trash disposal into water bodies has been connected in Dhaka to the pollution of the Buriganga and Shitalakhya rivers, which are vital supplies of irrigation and drinking water. Many times, large amounts of building and demolition debris are dumped in open areas or used in landfills without treatment, contaminating the soil and interfering with the natural drainage systems. Affecting millions yearly, the activities listed contribute to urban floods (Alam & Ahmed, 2021) [1]. The decomposition of waste products releases harmful chemicals into the atmosphere that aggravate the urban heat island phenomenon and increase respiratory problems for the surrounding people. [2]

➢ *Global Perspective and Bangladesh's Standing*

Sustainable urban development depends on the management of Construction & Demolition (C&D) waste. Creating complex recycling programs, advanced nations such as Germany, Japan, and the United States have achieved rates of Construction & Demolition (C&D) waste recycling above 70%. These countries improve resource recovery by using advanced technology, including automated mixed waste sorting systems and mobile concrete crushers (Singh et al., 2018) [8]. But Bangladesh trails far behind, with recycling rates predicted to be under 10% (Hossain & Islam, 2020) [6]. Two main obstacles to improvement are limited technological adoption and a lack of a clear legislative framework.

➢ *Economic Opportunities in Recycling*

For Bangladesh, the reuse of building and demolition (C&D) waste has a significant financial potential. Studies show that building with recycled concrete and bricks might be a reasonably affordable substitute for new building materials, cutting material costs by as much as 40% (Rahman & Karim, 2019) [7]. Recycling programs can create major employment possibilities, especially in cities where processing operations and trash management are focused. The recycling of building and demolition trash might provide Dhaka with over USD 44.96 million yearly (Alam & Ahmed, 2021) [1]. The financial benefits highlight how recycling can be a double-edged tool, promoting environmental sustainability and economic development.

➢ *Barriers to Effective Management*

Bangladesh's Construction & Demolition (C&D) waste recycling suffers from many difficulties, even if it has significant promise. An important challenge in most divisional towns is the lack of specific recycling facilities. The present waste processing plants lack the capacity to handle the unique composition of building and demolition (C&D) waste and deal largely with municipal solid waste (MSW) [5]. The inadequate application of environmental regulations contributes to aggravating the ongoing issue of illegal dumping. Stopping development without enough information is among the building businesses and local authorities about the benefits of recycling. The budgetary constraints and lack of public-private cooperation that impede the growth of recycling initiatives intensify the problems.

➢ *Research Objectives and Scope*

This study bridges the knowledge gap by analyzing C&D waste generation, composition, and management in the eight divisional cities of Bangladesh: Dhaka, Chittagong, Rajshahi, Khulna, Sylhet, Barisal, Rangpur, and Mymensingh. By analyzing data from government reports, peer-reviewed journals, and case studies, the research tries to:

- Measure the annual C&D waste generation in each city.
- Identify the primary components of C&D waste and their recycling potential.
- Evaluate the environmental and economic impacts of current waste management practices.
- Recommend actionable improvements for recycling and sustainable management.

➢ *Structure of the Paper*

The rest of this paper is organized: Section 2 provides a comparative literature review of Construction & Demolition (C&D) waste management protocols in the European Quality Association for Recycling (EQAR) and India. Section 3 discusses the method, including data collection techniques and analysis frameworks. Section 4 presents the findings, focusing on waste generation rates, composition, environmental impacts, and recycling potential. Section 5 concludes with policy recommendations and future research directions.

By addressing the above goals, this research provides a roadmap for policymakers, urban planners, and stakeholders to transform C&D waste management in Bangladesh's divisional cities. The findings have broader implications for other developing countries facing similar challenges, making this study a valuable contribution to the global discourse on sustainable urban development.

II. LITERATURE REVIEW

➢ *Comparative Analysis of EQAR C&D Waste Management Protocol and Indian C&D Waste Management Protocol, with Recommendations for Implementation in Bangladesh*

Waste management in Construction & Demolition (C&D) has become a priority for environmentally friendly urban growth. While the European Quality Association for Recycling suits the infrastructure and socioeconomic reality of a developed nation, India's C&D waste management system fits

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that of a developing nation. Advanced recycling criteria and circular economy ideas are stressed in EQAR (EUROPEAN QUALITY ASSOCIATION FOR RECYCLING) policies. Emphasizing their advantages and drawbacks, evaluating the two models gives Bangladesh a customized implementation plan.

- *EQAR (European Quality Association for Recycling) C&D Waste Management Protocol*

The European Quality Association for Recycling (EQAR) approach creates a guideline for sustainable Construction & Demolition (C&D) waste recycling throughout Europe. It seeks to maximize recycling rates by giving technical innovation a priority, along with quality standards.

- ✓ Sorting is necessary: From the source, waste must be divided into groupings comprising concrete, wood, metal, and hazardous products.
- ✓ Advanced Recycling Technology: Mobile crushers, automated sorting, and material recovery facilities that effectively handle goods represent advanced recycling technologies.
- ✓ Quality Assurance: Recycled products must satisfy rigorous building criteria if they are to be put onto the market.
- ✓ Circular Economy Integration: The protocol emphasizes designing easily separable constructions that reduce waste by allowing one to separate elements.
- ✓ Policy and Monitoring: Strict rules and continuous inspections guarantee that everyone applies the recommendations.

➢ *Strength*

With rates above 70%, certain member states, including Germany and the Netherlands, show outstanding recycling performance. Promoting recycling practices inside companies depends much on the strategic use of financial incentives.

➢ *Limitation*

Major capital investments in infrastructure and technology pose a great difficulty, especially in contexts with limited resources. Often found in poor nations, the lack of robust administration and enforcement adds still another level of complication to this problem.

- *Indian C&D Waste Management Protocol*

The Indian Construction & Demolition (C&D) waste management system is meant to solve problems resulting from inadequate waste management infrastructure and increasing urbanization.

➢ *Key Features*

- Decentralized Systems: Cities like Delhi and Bengaluru have implemented recycling facilities to manage garbage locally.
- Required Regulations: Construction projects must submit waste management plans detailing expected waste volumes and disposal strategies.
- Implementation of Recycled Materials: Regulations require the use of recycled aggregates in governmental construction initiatives to establish a consistent demand.
- Community Engagement: Awareness initiatives and monetary incentives promote garbage segregation at the origin.

➢ *Strength*

Using localized solutions and cheap technologies improves adaptation in many urban environments. The Swachh Bharat Abhiyan (Clean India Mission) increases public involvement.

➢ *Limitation*

Recycling rates are persistently low, ranging from 25% to 30%, attributable to inadequate infrastructure and ineffective enforcement. The dominance of the informal sector in waste collection results in operational inefficiencies and heightened safety risks.

III. METHODOLOGY

This research uses a thorough mixed methods approach to examine the generation, content, and management of Construction & Demolition (C&D) debris in the eight divisional cities of Bangladesh. The method combines data collection, representation, and analysis to yield practical insights into the existing Construction & Demolition (C&D) waste management landscape and to pinpoint opportunities for the adoption of sustainable methods.

➢ *Research Design*

This study uses an exploratory and descriptive design, incorporating both qualitative and quantitative data collection methodologies. It encompasses all eight divisional cities of Bangladesh: Dhaka, Chattogram, Rajshahi, Khulna, Sylhet, Barishal, Rangpur, and Mymensingh. These cities were selected for their distinct urban attributes and differing degrees of economic and infrastructural advancement.

➢ *Data Acquisition*

- *Collection of Primary Data:*

- ✓ Field Observations: Observations were performed at construction sites, waste disposal sites, and recycling facilities (where applicable) to evaluate existing procedures and estimate waste production.
- ✓ Stakeholder Interviews: Interviews were conducted with construction workers, local authorities, and waste management professionals.

- *Collection of Secondary Data:*

- ✓ Literature Review: We reviewed peer-reviewed publications, government papers, and environmental studies to collect pertinent data on Construction & Demolition (C&D) trash in Bangladesh and similar environments.
- ✓ Official Statistics: Data from entities such as the Bangladesh Bureau of Statistics (BBS) [2] [3] and municipal records offered quantitative insights into waste generation and composition.

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➢ *Representation of Data*

To illustrate and convey results proficiently:

- Bar Diagrams and Curves: Used to illustrate patterns in trash generation and composition among cities.
- Tables: Compiled quantitative data, including annual trash generation, material composition, and recycling possibilities.
- Flow Diagram: Created to illustrate the technique and procedures used in the study.

➢ *Analysis of Data*

The analytical framework comprises the subsequent steps:

- Measurement of Trash Production: Assessing the yearly Construction & Demolition (C&D) trash creation in each city using construction activity and demographic data.
- Composition Analysis: Classifying trash into primary components (e.g., concrete, bricks, metals, wood) and evaluating their respective proportions.
- Comparative Analysis: Emphasizing disparities in trash generation and composition among cities to discern region-specific trends.
- Recycling Potential Assessment: Evaluating the economic value and environmental advantages of recycling essential waste components.
- Barrier Identification: Assessing obstacles to efficient waste management, encompassing infrastructural, legislative, and awareness-related issues.

➢ *Flow Diagram of Methodological Framework*

Below is the flow diagram representing the methodological steps:

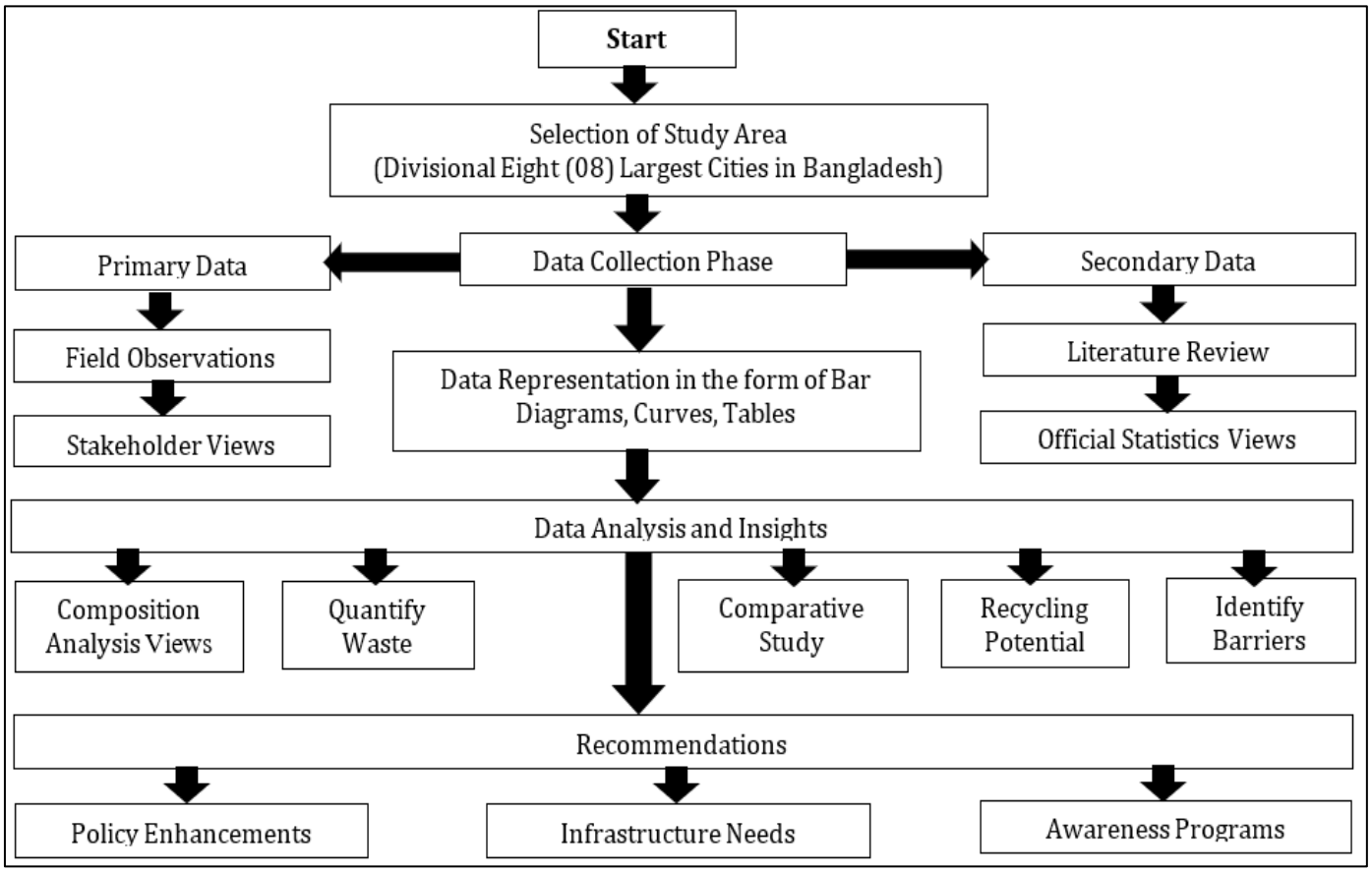

Fig 1 This Flow Diagram Delineates the Methodical Stages of the Research Process, Ensuring Clarity in Scientific Advancement.

➢ *Validation of Outcomes*

To guarantee the dependability and accuracy of the results:

- Triangulation: The process of cross-referencing primary and secondary data to validate trends and findings.
- Expert Evaluation: Involving waste management specialists to assess the viability of suggested recommendations.
- Sensitivity Analysis: Evaluating the influence of data variability on critical conclusions, especially in evaluating recycling potential.

➢ *Ethical Considerations*

The research meets ethical standards by securing informed consent from participants during interviews.

- Confidentiality of participants and entities.
- Clarity in data acquisition and dissemination.

➢ *Limitation*

This study offers substantial insights, yet certain drawbacks are present:

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- Restricted access to disaggregated data about Construction & Demolition (C&D) waste.
- Disparity in municipal record-keeping methodologies among cities.
- Challenges in gaining access to certain private construction sites for observation purposes.

IV. RESULTS AND DISCUSSIONS

This study analyzes C&D garbage generation, composition, environmental consequences, and recycling potential in the eight divisional cities of Bangladesh. This section is organized into topical divisions, each examining various aspects of the issue, supplemented by tables, bar charts, and infographics for elucidation

➢ *Waste Generation Rates (WGR) by Municipality*

Comprehending the annual trash volume is essential for resource distribution and infrastructure development. Table 1 encapsulates the annual waste generation rates (WGR) for each city, extracted from municipal records and construction activity reports.

Table 1 Annual C&D Waste Generation in Divisional Cities

City	Annual C&D Waste (Tons)	Primary Components
Dhaka	1,280,000	Concrete (60%), Bricks (21%)
Chattogram	850,000	Concrete, Metals
Rajshahi	350,000	Bricks, Mortar
Khulna	400,000	Concrete, Wood
Sylhet	200,000	Concrete, Tiles
Barishal	150,000	Bricks, Mortar
Rangpur	120,000	Concrete, Bricks
Mymensingh	180,000	Bricks, Mortar

Sources: Municipal Construction Records (2023), Interviews with city Waste Management Authorities

- Dhaka produces the largest quantity of waste because of its accelerated urbanization and elevated construction density.
- Chattogram, the second-largest city, significantly contributes to the national Construction & Demolition (C&D) waste owing to its port-related infrastructure expansion.
- Smaller cities such as Rangpur and Barishal generate relatively lesser amounts, indicative of their sluggish economic development.

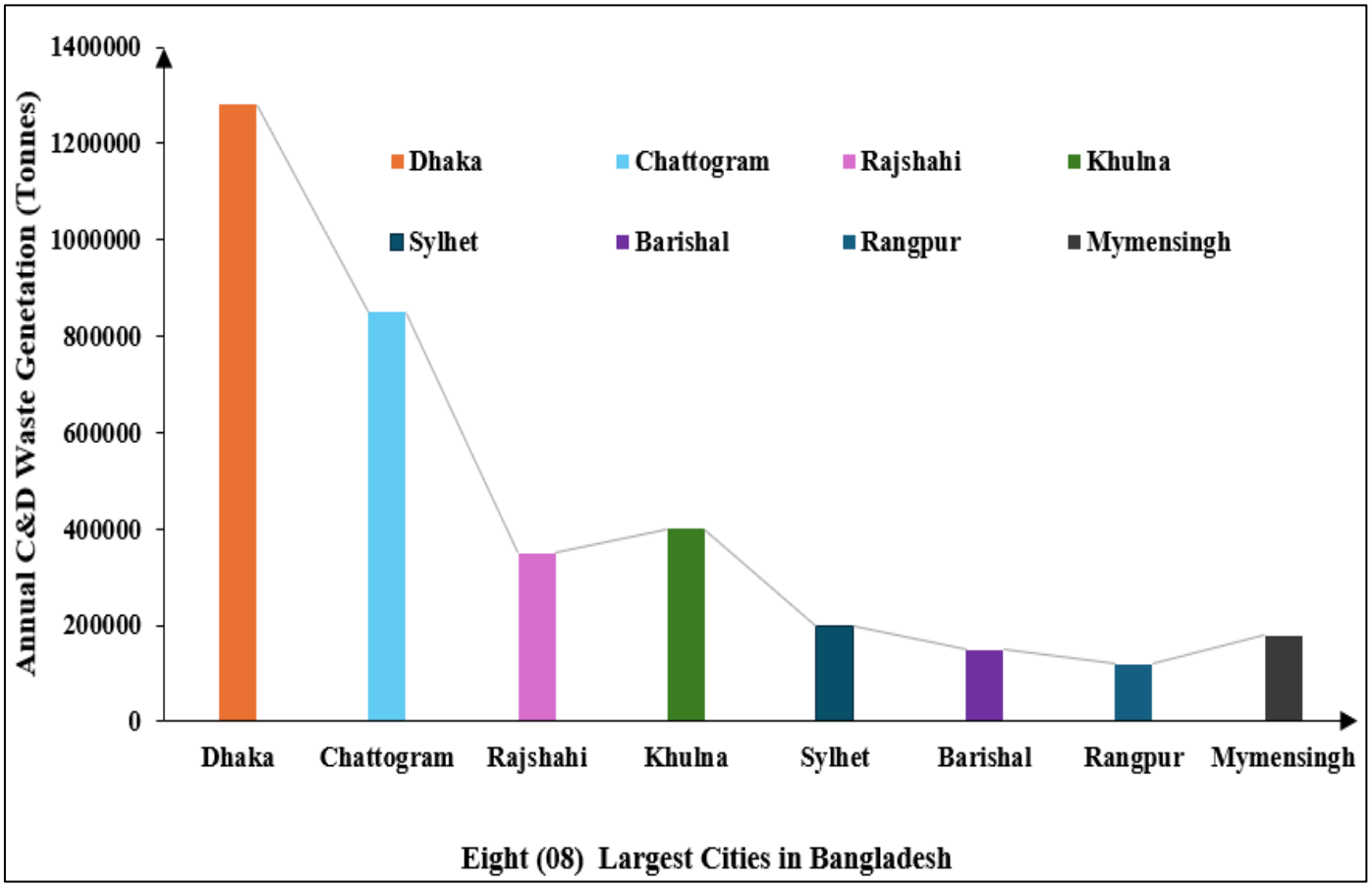

Fig 2 Bar Diagram of Annual C&D Waste Generation by City

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➢ *Composition of C&D Waste*

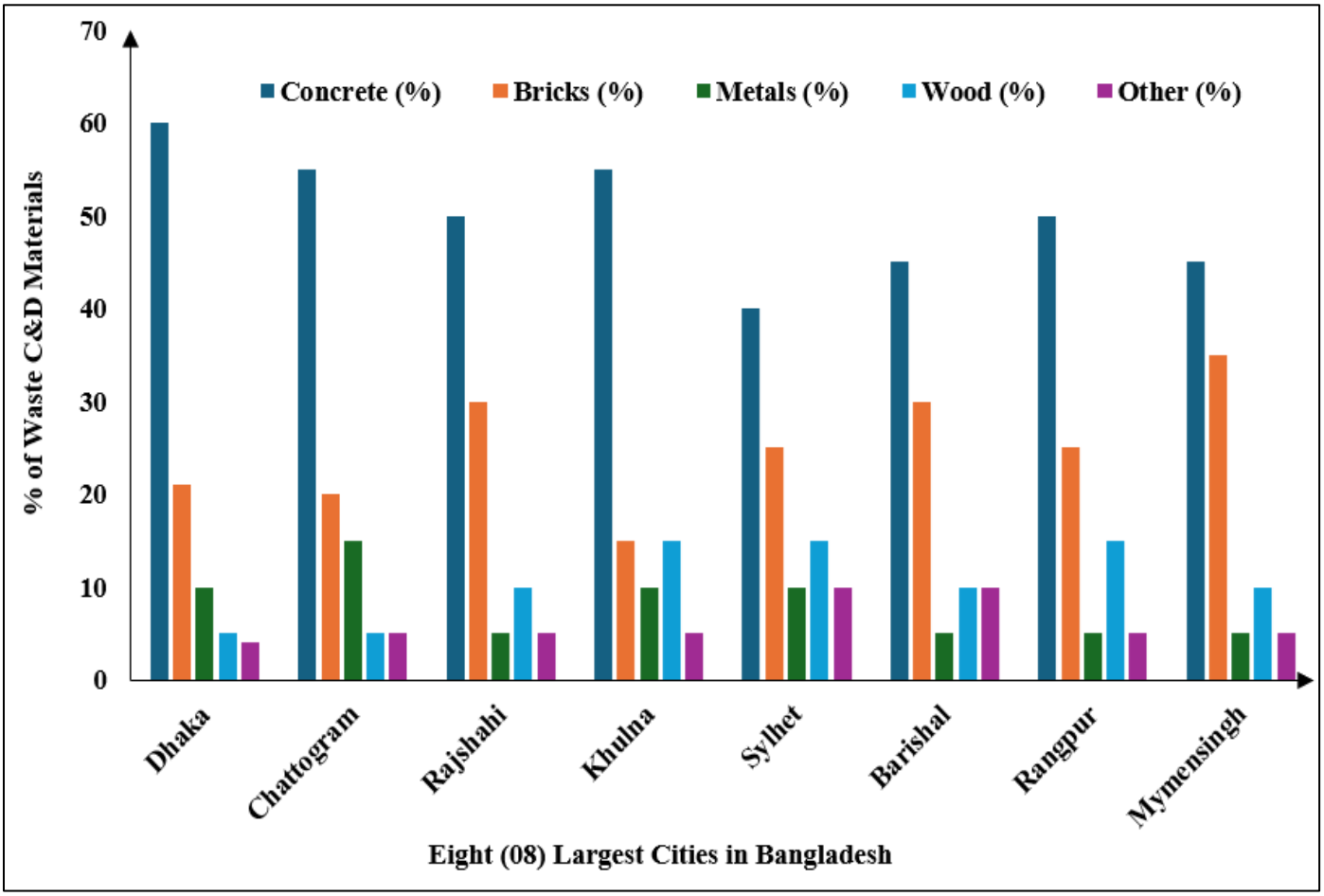

Fig 3 Composition of C&D Waste by Percentage

Sources: Data from Construction site Observations, Published Case Studies (Hossain & Islam, 2020; Rahman & Karim, 2019).

- Concrete and bricks are the predominant components of garbage in all cities, suggesting their extensive use in building.
- Chattogram exhibits an elevated concentration of metals attributable to industrial operations.
- Sylhet and Khulna have considerable wood content, shaped by regional construction methodologies.

➢ *Environmental Impacts of C&D Waste*

The improper disposal of Construction & Demolition (C&D) debris has considerable environmental repercussions, such as soil contamination, water pollution, and urban flooding.

- *Key Features*

✓ Urban Flooding: In Dhaka and Chattogram, indiscriminate waste disposal in low-lying regions impedes natural drainage.

✓ Soil and Water Contamination: The leaching of heavy metals from carelessly discarded metals and paints pollutes adjacent soil and aquatic environments.

✓ The Urban Heat Island Effect: Extensive garbage piles elevate surface temperatures, intensifying urban heat challenges (Alam & Ahmed, 2021) [1].

➢ *Potential for Recycling*

The economic and environmental advantages of recycling Construction & Demolition (C&D) waste are substantial. Table 3 encapsulates the recycling potential regarding economic value and CO_2 mitigation.

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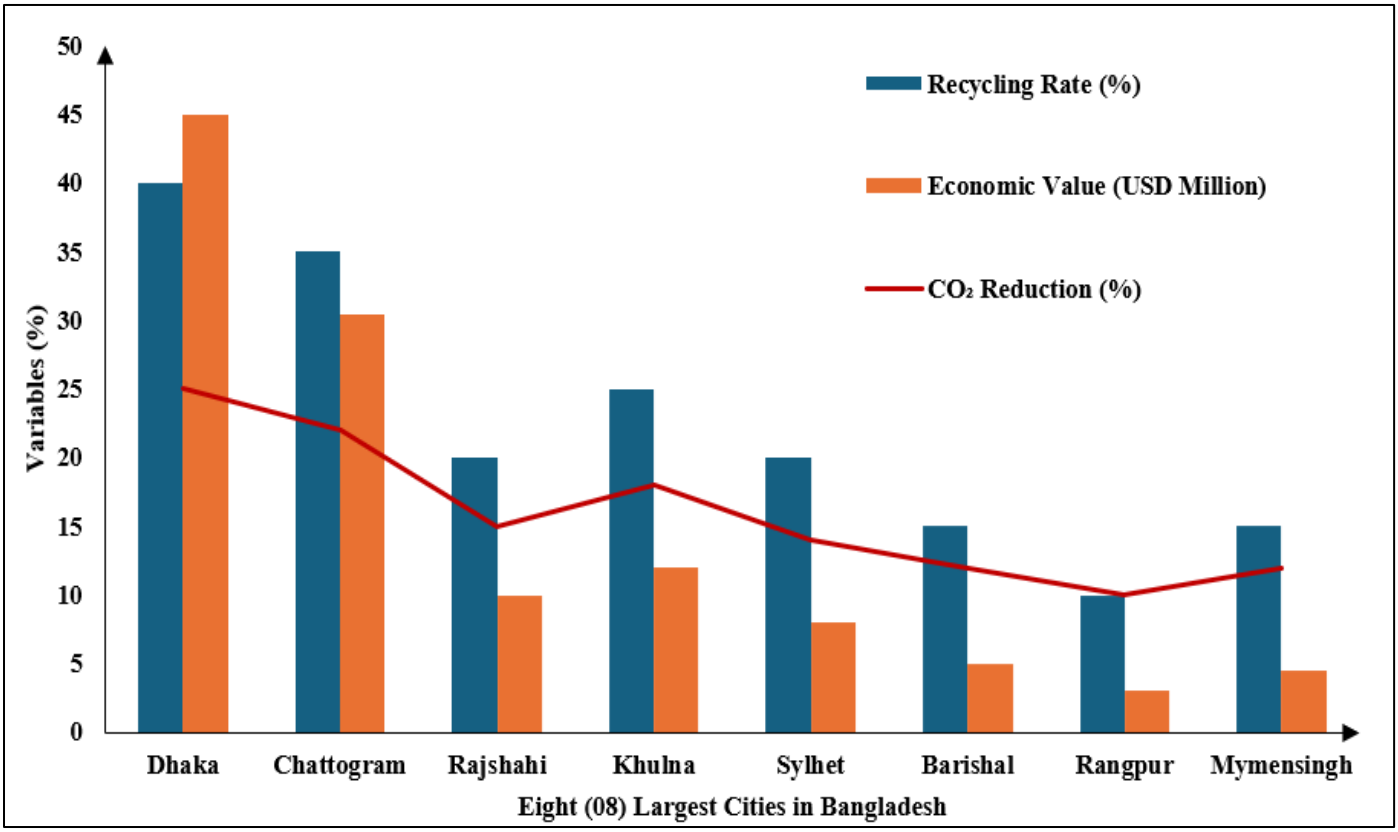

Fig 4 Economic Value of Recycling C&D Waste

- Dhaka has the greatest potential for economic gains from recycling, owing to its substantial trash volume.
- Smaller cities such as Rangpur have lower recycling rates due to inadequate infrastructure.
- Recycling initiatives can substantially reduce CO_2 emissions under national climate goals.

➢ *Obstacles to Recycling:*

Notwithstanding its potential, recycling encounters many challenges:

- Insufficient Facilities: Recycling units lack most cities, constraining capacity.
- Regulatory Deficiencies: Insufficient enforcement of waste management legislation helps with unlawful disposal.
- Stakeholder Awareness: Many building firms are uninformed about the advantages of recycling (Hossain & Islam, 2020) [6].

➢ *Prospective Forecasts:*

The study forecasts a 25% rise in Construction & Demolition (C&D) trash production over the next ten years, assuming current urbanization patterns continue. Effective waste management is essential for reducing related environmental hazards.

➢ *Construction & Demolition (C&D) Waste Management Protocol for Bangladesh*

Bangladesh encounters distinct issues in Construction & Demolition (C&D) waste management, such as accelerated urbanization, inadequate infrastructure, and feeble regulatory enforcement. Based on insights from EQAR and India, these recommendations are put forth:

- Decentralized Recycling Infrastructure: Establish small to medium-sized decentralized recycling facilities in divisional cities, including Dhaka, Chattogram, and Rajshahi. Use mobile crusher and sorting machines to reduce transportation expenses and enable on-site garbage processing.
- Regulatory Framework: Establish a comprehensive policy requiring source separation and the submission of waste management plans for large-scale projects. Impose sanctions for unlawful trash disposal and offer incentives for adherence to regulations.
- Technology Integration: Utilize economical, contextually suitable technologies, encompassing manual sorting techniques and semi-automated crushing machinery. Collaborate with global organizations to implement pioneering recycling technology.
- Public-Private Partnerships (PPP): Promote private sector participation in waste management to stimulate investment and enhance operational efficiency. Provide tax incentives to enterprises that incorporate recycled materials in construction initiatives.
- Capacity Development and Awareness Raising: Design and execute training initiatives for municipal staff and contractors, focusing on sustainable waste management methodologies. Initiate public awareness efforts that emphasize the economic and environmental advantages of recycling.
- Tracking and Assessment: Establish a consolidated database to methodically track Construction & Demolition (C&D) waste production, recycling efficacy, and

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associated environmental effects. Perform routine inspections of recycling plants to guarantee compliance with quality and safety regulations.

Bangladesh can create a strong and effective building Construction & Demolition (C&D) waste management system by combining the contextual adaptability of India's protocol with EQAR's technical precision. Reaching the greatest results calls for strategic investments in recycling infrastructure, strict regulatory compliance, and aggressive community involvement. These initiatives will reduce environmental problems and generate financial possibilities and support sustainable urban development.

V. CONCLUSION

The immediate need for sustainable management strategies for building Construction & Demolition (C&D) waste in Bangladesh's divisional cities is underlined in this paper. The rapid urbanization and large-scale infrastructure development have aggravated the problems with building and demolition waste generation, therefore causing significant effects on public health, the environment, and the economy. Mostly made of concrete and bricks, millions of buildings and demolition waste produced yearly by Dhaka, Chattogram, and other fast-expanding metropolitan areas come from Modern management techniques that aggravate metropolitan flooding, soil and water contamination, and greenhouse gas emissions through uncontrolled garbage disposal and insufficient recycling campaigns.

Recycling provides a practical and efficient alternative, yielding significant economic and environmental benefits. The establishment of effective recycling systems in Dhaka may generate about USD 44.96 million per year while simultaneously decreasing CO_2 emissions by 25%. Still, inadequate infrastructure, poor regulatory enforcement, and little stakeholder knowledge pose substantial obstacles to the actualization of this potential.

➢ *This Paper Presents a Thorough Plan to Address these Difficulties, Concentrating on these Essential Areas:*

- Policy Enhancement: Implement and strictly enforce regulations that require the recycling of Construction & Demolition (C&D) waste.
- Infrastructure Enhancement: Establish and implement specialized recycling facilities in all urban centers in the division.
- Public Education Initiatives: Execute focused efforts to inform stakeholders about the benefits of recycling waste management practices.
- Public-Private Partnership: Create strategic connections to support advanced waste management practices.

➢ *Scope for Future Study*

This study investigates the development of Construction & Demolition (C&D) waste in Bangladesh and the recycling management techniques, even though many problems require further investigation.

Advanced Waste Processing Technologies: Future studies aimed at Bangladesh's urban setting should assess the viability of implementing modern technologies such as automated sorting systems, advanced material recovery facilities, and mobile recycling units.

Life Cycle Assessment (LCA): Comprehensive life cycle studies of virgin and recycled materials would offer a more complex assessment of the financial and environmental advantages of recycling.

- Social and Behavioral Dynamics: Developing successful, customized awareness campaigns and incentive programs depends on first looking at the behavioral elements affecting stakeholder acceptability of sustainable waste management techniques.
- Integration of Circular Economy Principles: Examining the incorporation of circular economy principles into urban development strategies to reduce waste production at the source would greatly enhance the discipline.
- Comparative Analyses with Comparable Nations: Comparative assessments with developing countries with similar issues could yield useful transferable learning and best practices.
- Impact of Climate Change: Investigating the impact of climate change on the composition and management of Construction & Demolition (C&D) waste would yield essential information for the formulation of robust waste management systems.
- Economic Feasibility of Public-Private Partnerships: Comprehensive case studies of successful public-private partnerships in waste management from other locations could guide the formulation of effective policies for Bangladesh.

Subsequent research addressing these deficiencies can substantially enhance the creation of innovative, economical, and sustainable solutions for the management of Construction & Demolition (C&D) waste.

➢ *Conflict of Interest*

The publication of this manuscript presents no conflict of interest.

➢ *Author Contribution*

The authors of the manuscript titled "Construction & Demolition (C&D) Waste Generation and Recycling Management Protocol of Bangladesh" contributed to the research work as follows: Study conception and design: Mohammad Abdul Awal, Md. Mahadi Hashan. Data collection: Mohammad Abdul Awal, Md. Mahadi Hashan, Avizit Biswas. Analysis and interpretation of results: Mohammad Abdul Awal, Md. Mahadi Hashan, Avizit Biswas. Draft manuscript preparation: Mohammad Abdul Awal, Avizit Biswas.

Every author checked the data and approved the last draft of the book. Every author assumes accountability for the work's integrity and accuracy.

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