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Evaluating The Effectiveness Of Construction And Demolition Waste Management System Of Bhubaneswar

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Abstract: This paper evaluates the effectiveness of Construction and Demolition (C&D) waste management practices in Bhubaneswar, Odisha. With rapid urban growth driven by government initiatives and infrastructure development, the city generates significant quantities of C&D waste, the research is structured around three core objectives: (1) to assess the current practices of C&D waste management in Bhubaneswar; (2) to estimate the quantity of C&D waste generated in the city; and (3) to analyse existing gaps in implementation of national-level policies and propose an improved management framework. The study uses a combination of primary surveys, stakeholder interviews, secondary data analysis, and gap assessment. Results highlight major deficiencies in segregation, collection, recycling, and enforcement mechanisms. Based on the findings, the paper proposes a structured approach to enhance C&D waste governance aligned with sustainable urban planning principles. Through assessment of current practices, policy implementation, data analysis, and stakeholder engagement, this study highlights key challenges, such as low awareness, weak regulatory enforcement, and limited infrastructure. Recommendations include improving waste segregation, expanding recycling capacity, and enforcing the C&D Waste Management Rules, 2016. The paper advocates for sustainable urban planning by integrating circular economy principles in C&D waste handling.

Index Terms **– Construction Waste, Demolition Waste, Waste Management, Urban Planning, Bhubaneswar, Recycling**

I. INTRODUCTION

1.1 GENERAL

Construction and demolition waste" means the waste comprising of building materials, debris and rubble resulting from construction, re-modelling, repair and demolition of any civil structure. The primary method is adopted in waste handling is carried through by interviewing professionals like project managers, architects, civil engineers, contractors and government officials.

India's construction sector, growing at 10% annually, generates approximately 150-500 million tons of C&D waste annually. However, official estimates from the Central Pollution Control Board (CPCB) put it around 165- 170 million tons per year. Only about 1% of the total waste is processed, while the rest is either dumped illegally or used for land filling. Major contributors to C&D waste: Demolition of old buildings (40-50%), New construction (30-40%) & Repair and renovation activities (10-20%). Construction and Demolition waste accounts for a large portion of urban waste, often unmanaged or illegally dumped, posing environmental hazards.

The waste material generally consists of non-biodegradable materials such as

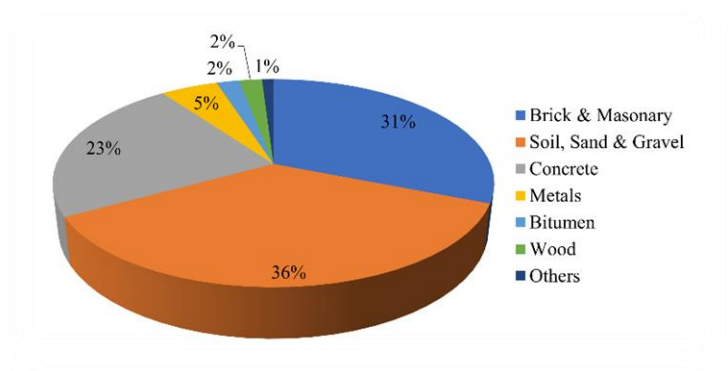
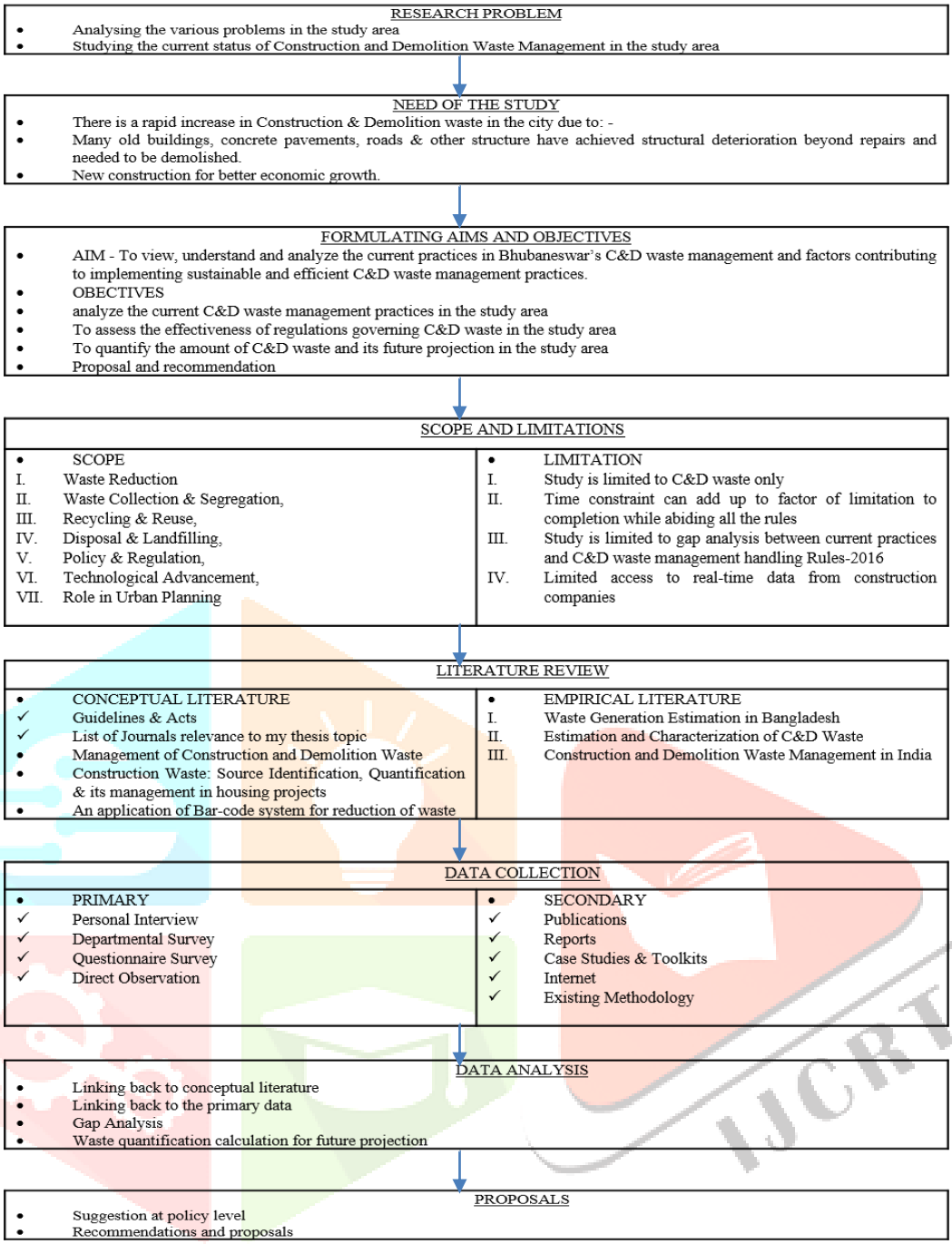


Fig.1 Typical Composition of C&D Waste Composition

Bhubaneswar, as a Smart City, faces increasing pressure from infrastructure projects that result in substantial C&D waste. The absence of robust implementation of waste management rules and low adoption of recycling technologies exacerbates the issue. This paper investigates current management practices in Bhubaneswar and evaluates regulatory effectiveness to propose sustainable solutions.

II. METHODOLOGY

The study used primary surveys, field visits, stakeholder interviews, and data collection from Bhubaneswar Municipal Corporation. It adopted a mixed-methods approach, combining qualitative insights and quantitative techniques to evaluate Bhubaneswar's C&D waste practices:



2.1 ANALYSIS OF EXISTING PRACTICES

To evaluate the practical challenges in Construction and Demolition (C&D) waste management in Bhubaneswar, a comprehensive gap analysis was conducted. The analysis assessed key determinants such as policy implementation, operational mechanisms, and spatial monitoring practices. Data from the Bhubaneswar Municipal Corporation (BMC) was examined against regulatory requirements, stakeholder responsibilities, and best practices. The table below summarizes the findings, highlighting existing determinants, current practices, and the critical gaps identified in policy, collection mechanisms, and GIS-based monitoring.

Table-1: Analysis of Existing C&D waste Management Practices

Particular	Determinant	Gap Identified
1. Policy & Regulatory Framework Review	1. Existing policies on C&D waste management.	- No guidelines on storage standards (e.g., covered containers, space allocation).
		- No mention of incentives for responsible disposal.
		- Lack of post-approval monitoring and audits. - No integration with circular economy principles (e.g., reuse, recycling incentives).
		- Lack of provision for temporary storage within construction premises. - No incentive for on-site waste minimization or reuse.
	2. Compliance with Solid Waste Management Rules, 2016, and C&D Waste Management Rules, 2016.	- No accountability mechanism for timely completion. - No mention of stakeholder consultation. - Lack of interim milestones for tracking progress.
		- No criteria specified for site selection. - No provision for public participation in site identification. - Risk of land acquisition delays.
		- No clarity on funding sources and investment structure. - No penalties or alternative solutions if the deadline is missed. - No mention of operational guidelines and monitoring post-implementation.
	3. Review BMC bylaws on waste segregation, collection, transportation, and disposal.	- Lack of mandatory segregation at the source for small and bulk generators. - No penalty or incentive structure for compliance. - No guidelines on the type of segregation (e.g., reusable, recyclable, inert materials). - No tracking system for collection efficiency and service transparency. - No specific bylaws defining transportation standards (e.g., covering waste during transit). - No environmental or safety compliance guidelines for transport vehicles.
2.Waste Collection & Disposal Mechanisms	1.Assess how C&D waste is collected and transported	- No penalty for non-compliance or false reporting. - No provision for periodic monitoring during construction.
		- No details on service response time and collection frequency. - No incentives for regular users of the service.
		- No transparency on complaint resolution timelines. - No mention of action against repeat offenders. - No data on public awareness and usage of the platform.
		- No alternative for small-scale generators (high fixed cost). - No concessions or incentives for bulk generators adopting sustainable disposal methods. - No details on penalties for non-payment.
	2.Identify official disposal sites and unauthorized dumping locations.	- No mention of environmental impact assessment (EIA) for these sites. - No details on the waste processing or recycling plan at these sites.
	3.Analyze waste processing & recycling facilities whether the city has dedicated C&D recycling plants.	- The current processing capacity may be insufficient given the rapid urbanization of Bhubaneswar. - No details on plant efficiency, operational challenges, or expansion plans. - No incentives for waste generators to send materials for processing.

		- No information on market demand or adoption rate of recycled products. - No policy for mandatory use of recycled materials in public or private projects.
3. GIS Mapping of Waste Generation & Disposal Sites	1. Use QGIS/ArcGIS to create spatial distribution maps of C&D waste hotspots, collection centres, and illegal dumping sites.	- Lack of real-time data on C&D waste hotspots. - Inconsistent data sources for collection centres and illegal dumping sites (e.g., relying on citizen reporting or surveys). - Unstructured data for hotspots (e.g., no standardized format or incomplete records). Limited access to updated or complete construction permit data. - Lack of a direct link between waste generation estimates (from construction data) and actual waste hotspots. - No standardized methodology for identifying which construction activities lead to the highest waste generation. - Inadequate granularity in waste hotspot analysis (i.e., only using large spatial zones, rather than examining specific streets or blocks). - Lack of integration between construction activity and waste generation data at a micro-level. - Limited capacity to visualize temporal trends in C&D waste generation and disposal. - No system for continuous data updates or feedback loop from waste collection centers.
	2. Overlay with construction permit data to identify high-waste-generation zones.	
	3. Spatial Analysis for High-Waste Zones	
	4. Data Sharing and Accessibility	
	5. Monitoring and updating the GIS Database	

2.2 ASSESSMENT OF REGULATORY COMPLIANCE

To evaluate the operational efficiency and compliance with C&D waste management protocols in Bhubaneswar, an assessment framework was developed. This framework focuses on key determinants such as regulatory enforcement, stakeholder perception, and field-level monitoring. It integrates qualitative and quantitative data collection methods and defines evaluation metrics like compliance and recycling efficiency. The following table summarizes the assessment structure, data collected, and indicators of compliance and non-compliance observed during the field study.

Table-2: Assessment of C&D waste Management Compliance

Particular	Determinant		Data Collected	
1. Key Aspects of Assessment	Regulatory Framework Analysis:	Reviewing how well existing regulations are implemented.		
	Compliance Levels:	Examining how strictly builders, contractors, and residents adhere to guidelines.	Builders, contractors	
			- Clarity of regulations on C&D waste disposal.	A capacity building workshop is required
			- Ease of compliance with waste management plans.	
			- Challenges in using designated collection & disposal services.	
			- Costs & incentives for proper waste management.	
			Residents	
			- Awareness of C&D waste disposal regulations.	A capacity building workshop is required
			- Accessibility of reporting mechanisms (public grievance portal, helplines).	

			- Responsiveness of BMC in addressing illegal dumping complaints.	
			- Impact of C&D waste on the local environment.	
	Monitoring & Enforcement:	Evaluating BMC's capacity to track and penalize non-compliance.	For the management of C&D waste, BMC has 3 zonal teams (1 for each of the 3 zones) and 1 central team. Each team has 8–10 people. The central team is responsible for the management of C&D waste. Zonal enforcement teams have 2 tippers and 2 JCB for C&D waste collection and the central enforcement team has 4 tippers and 2 JCB. Their role is to patrol the city daily to check for any illegal construction and stockpiles along roadsides, and issue notices and penalties for the same.	
	Waste Processing & Recycling Efficiency:	Measuring how much C&D waste is properly collected, segregated, and recycled.	Avg. daily count = 20 to 25 trips. 1 trip = 7 ton Avg. volume of waste collected = 140 to 175 ton per day Volume of waste go to land fill site = 18 to 22 trips = 126 to 154 ton Volume of waste go to processing plant = 2 to 3 trips = 14 to 21 ton	
	Stakeholder Perception:	Gathering feedback from builders, contractors and residents on regulatory effectiveness.	Builders, contractors	
			- Complexity of regulatory compliance.	A capacity building workshop is required
			- Clarity of waste disposal guidelines.	
			- Cost and feasibility of waste collection services.	
			- Availability of waste recycling facilities.	
			Residents	
			- Awareness of C&D waste regulations.	A capacity building workshop is required
			- Impact of illegal dumping on public spaces.	
			- Ease of reporting violations & response from authorities.	
			- Quality of waste collection services.	
2. Data Collection Methods	Field Surveys & Inspections:	Conducting site visits to check compliance.	Inspection Focus	Compliance Criteria / Non-Compliance Indicators
			On-Site Waste Storage	C&D waste must be stored separately from other waste on-site. / Waste mixed with municipal solid waste or dumped openly.
			Waste Collection & Transportation	Waste must be transported to designated collection centres / No record of waste collection requests, use of

				using authorized vehicles.	unauthorized vehicles.
			Illegal Dumping	No construction waste should be dumped in public spaces.	Waste found in vacant plots, along roads, or near water bodies.
			Submission of Waste Management Plans	Builders (especially bulk generators) must submit a solid waste management plan during permit approval.	No record of submitted waste management plans or plans not followed on-site.
			Usage of Processing Facilities	C&D waste must be sent to recycling units or processing plants.	Lack of records on waste sent for processing; waste is dumped instead of recycled.
	GIS & Data Analytics:	Mapping illegal dumping sites and waste hotspots.			
3. Evaluation Metrics	Compliance Rate (%):	Percentage of projects following C&D waste regulations.	5% - 10%		
	Recycling Efficiency (%):	Proportion of waste sent to authorized recycling facilities.	Avg. daily count = 20 to 25 trips. 1 trip = 7 ton Avg. volume of waste collected = 140 to 175 ton per day Volume of waste go to land fill site = 18 to 22 trips = 126 to 154 ton Volume of waste go to processing plant = 2 to 3 trips = 14 to 21 ton		

2.3 QUANTIFICATION AND PROJECTION OF WASTE

To understand the scale and impact of C&D waste in Bhubaneswar, it was essential to quantify the volume of waste generated over time. Waste quantification serves as the foundation for designing management infrastructure, estimating recycling potential, and proposing regulatory interventions.

In this study, waste generation was estimated using standard construction norms, built-up area data, and approved building permits collected from Bhubaneswar Municipal corporation. The methodology adopted ensures a context-specific and data-driven estimate of C&D waste produced within the city.

2.3.1 QUANTIFICATION OF WASTE GENERATED FROM NEW RESIDENTIAL BUILDING CONSTRUCTION

2.3.1.1 TOTAL NUMBERS OF NEW RESIDENTIAL BUILDING PLANS APPROVED (2019-2024)

To estimate the quantity of construction and demolition (C&D) waste generated in Bhubaneswar, data on residential building activity over the past six years was analysed. The Bhubaneswar Municipal Corporation (BMC) provided records of sanctioned building plans categorized by typology—ranging from single-storied to multi-storied structures. The total built-up area and plot area approved annually serve as key indicators for estimating construction volume and corresponding C&D waste generation. The following table presents the

yearly distribution of residential building permits and their associated built-up and plot areas from 2019 to 2024.

Table-3: Approved Building Plans Year wise

YEAR	Building Categories (Residential Only)						TOTAL NUMBERS OF BUILDINGS	TOTAL BUILT-UP AREA (Sqm)
	Single Storied	G+1&S+1	G+2&S+2	G+3&S+3	S+4	Multi-Storied Building		
	NUMBER OF BUILDING PLANS APPROVED							
2019	3	21	51	1	2	--	78	25778.03
2020	29	152	270	7	11	--	469	156165.89
2021	13	191	522	33	34	6	799	344721.4463
2022	50	213	748	114	90	16	1231	750024.2387
2023	32	141	448	83	14	2	720	407672.0441
2024	27	92	605	122	108	18	972	692810.722
							4269	**2377172.371**

- Number of Building plans approved (2019-2024) - 4269 (New Construction)
- Total Built Up Area- 2377172.371 Sqm ~ 2.377 million Sqm
- To calculate the material intensity for a new construction with a total built-up area of 2377172.371 sqm ~ 2.377 million Sqm

2.3.1.2 TOTAL QUANTITY OF C&D WASTE GENERATED FROM NEW RESIDENTIAL BUILDING CONSTRUCTION (2019-2024)

Using the **TIFAC estimate of 40–60 kg of C&D waste per square meter for new construction**, we can calculate the total waste generation for **2377172.371 sqm** as follows:

- Minimum waste estimate:
  40 kg/Sqm × 2377172.371 Sqm = 95086.89 Tons
- Maximum waste estimate:
  60 kg/Sqm × 2377172.371 Sqm = 142630.34 Tons

So, the estimated **C&D waste** generation for project is between **95086.89 Tons and 142630.34 Tons.**

2.3.2 QUANTIFICATION OF WASTE GENERATED FROM RENOVATION

2.3.2.1 TOTAL NUMBERS OF RENOVATION BUILDING PLANS APPROVED (2022-2024)

To support accurate estimation of construction and demolition (C&D) waste, recent data on sanctioned residential building plans was analyzed for the years 2022 to 2024. This data includes the total built-up area and plot area for each year. It reflects a shift in urban development patterns and provides critical inputs for calculating projected waste volumes. The table below summarizes the number of residential building permits issued, along with the corresponding built-up and plot areas recorded by the Bhubaneswar Municipal Corporation (BMC).

Table-4: Approved Building Plans Year wise

YEAR	Building Categories (Residential Only)						Total Numbers of Buildings	TOTAL BUILT-UP AREA
	Single Storied	G+1&S+1	G+2&S+2	G+3&S+3	S+4	Multi-Stored Building		
	Number Of Building Plans Approved							
2022	--	2	10	--	--	--	12	4086.904
2023	--	11	53	--	--	--	64	17250.5407
2024	2	19	108	2	--	1	132	63195.3249
							208	84532.7696

- Number of Building plans approved (2022-2024)- 208 (Addition & Alteration)
- Total Built Up Area- 84532.7696 Sqm
- To calculate the material intensity for a renovation with a total built-up area of 84532.7696 sqm

2.3.2.2 TOTAL QUANTITY OF C&D WASTE GENERATED FROM RENOVATION (2022-2024)

Using the **TIFAC estimate of 40–50 kg of C&D waste per square meter for building renovation**, we can calculate the total waste generation for **84532.7696 Sqm** as follows:

- Minimum waste estimate:
  40 kg/Sqm × 84532.7696 Sqm = 3381.31 Tons
- Maximum waste estimate:
  50 kg/Sqm × 84532.7696 Sqm = 4226.64 Tons

So, the estimated **C&D waste** generation for project is between **3381.31 Tons and 4226.64 Tons**

2.3.3 QUANTIFICATION OF WASTE GENERATED FROM DEMOLITION ACTIVITY

To establish a baseline for construction and demolition (C&D) waste estimation in Bhubaneswar, reported data from the State Pollution Control Board (SPCB) and a approximate truck load data was collected from Bhubaneswar Municipal Corporation (BMC). These figures, expressed in tons per day (TPD) and extrapolated to annual values, reflect the increasing burden of C&D waste on the city's solid waste management system. The following table presents officially reported waste quantities for the years 2022 to 2024.

Table-5: Approved Building Plans Year wise

As per SPCB report - 2022	
C&D waste generated (TPD)	120 Ton
Total C&D waste generated in the year 2022	120 x 365 = 43800 Ton
As per SPCB report - 2023	
C&D waste generated (TPD)	150 Ton
Total C&D waste generated in the year 2023	150 x 365 = 54750 Ton
As per BMC - 2024	
C&D waste generated (TPD)	175 Ton (Approx.)
Total C&D waste generated in the year 2024	175 x 365 = 63875 Ton (Approx.)

2.3.4 ANALYSIS OF YEAR WISE QUANTIFICATION OF C&D WASTE GENERATED FROM NEW CONSTRUCTION

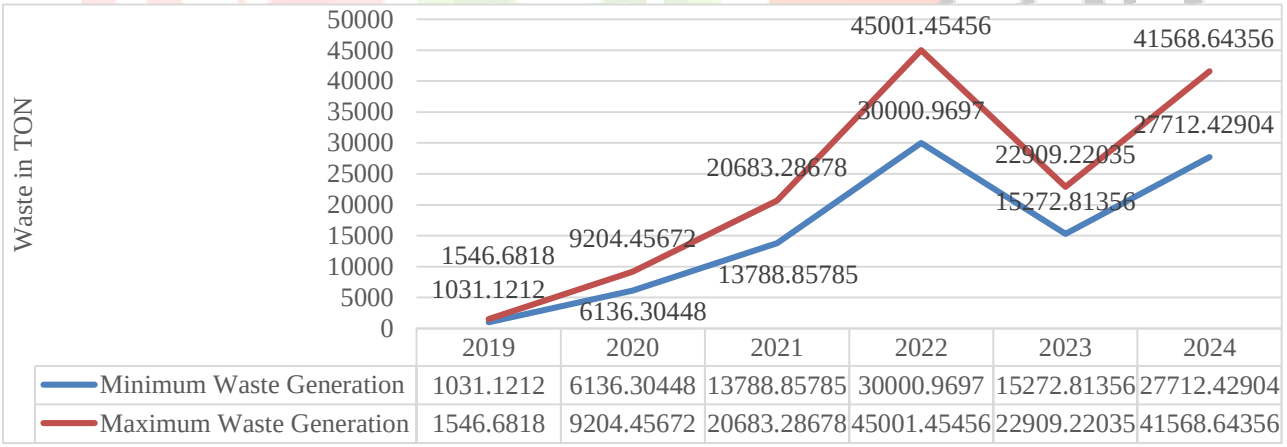


Fig. 2 Year Wise C&D Waste Generation from New Construction

2.3.5 ANALYSIS OF YEAR WISE QUANTITY OF C&D WASTE GENERATED FROM RENOVATION

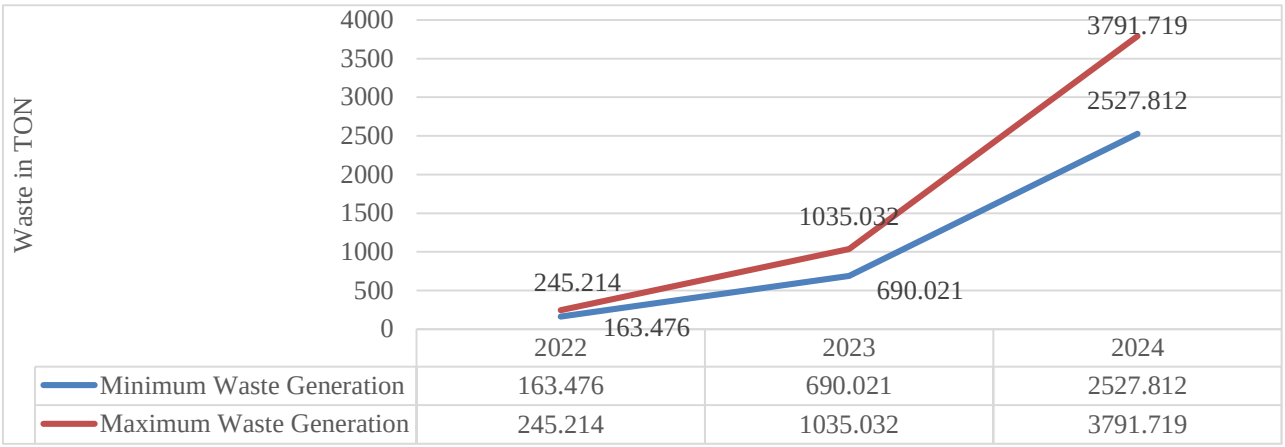


Fig. 3 Year wise C&D Waste Generation from Renovation

2.3.6 FUTURE PROJECTION OF C&D WASTE COLLECTION

Understanding the future scale of C&D waste generation is essential for planning infrastructure capacity, processing facilities, and regulatory interventions. Based on data provided by the State Pollution Control Board (SPCB) and extrapolated using historical growth patterns, the following estimates present projected waste volumes for Bhubaneswar from 2022 to 2029. The waste generation is expressed in tons per day and tons per year, with associated annual growth rates. The graph below visually illustrates the steady increase in waste load, highlighting the urgent need for proactive policy enforcement and investment in C&D waste management systems. The future projection calculation is based upon the data collected from State Pollution Control Board (SPCB) as there is no availability of concrete data in BMC, Bhubaneswar.

Table-6: Projection OF C&D WASTE Collection

ESTIMATION OF C&D WASTE				
Year	**Waste Collected (Tons/Day)**		**Waste Collected (Tons/Year)**	**Growth Rate (%)**
2022	120	SPCB	43800	--
2023	150		54750	25.00%
2024	175	APPROX.	63875	16.67%
2025	211		77146	20.75%
2026	255		93172	20.75%
2027	308		112444	20.75%
2028	371		135722	20.75%
2029	448		163844	20.75%

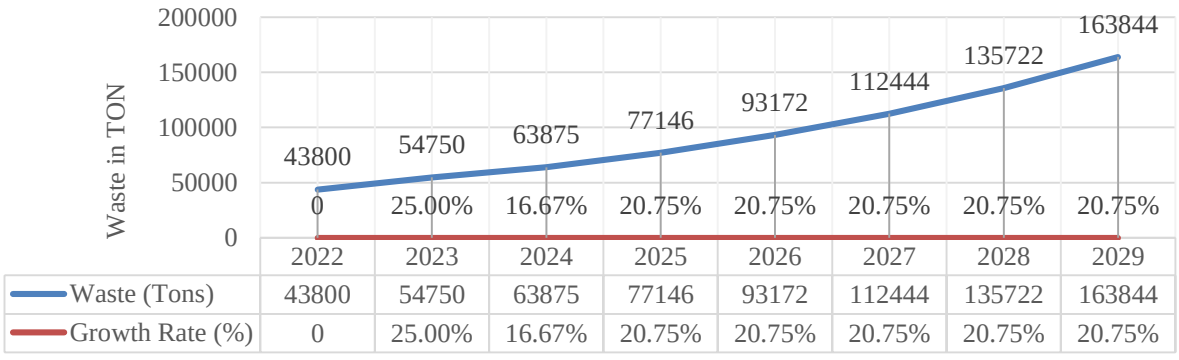


Fig. 4 Future Projection of C&D Waste Collection

3. RESULTS AND DISCUSSION

Findings reveal that Bhubaneswar generates approximately 150–200 tons of C&D waste daily. However, the city has only one operational processing plant and limited infrastructure for waste segregation. Only a small fraction of recyclable waste is recovered. Interviews with city officials highlighted enforcement issues and public unawareness. There is limited adherence to mandatory waste management plans by contractors and developers. Technologies for processing recycled aggregates remain underutilized.

The also study reveals that Bhubaneswar generates a substantial volume of construction and demolition (C&D) waste, primarily from new construction, renovations, and infrastructure expansion. Key findings include:

- **Waste Generation Volume**: Between 2019 and 2024, a significant amount of C&D waste was generated, with projections indicating a rising trend due to upcoming construction projects.
- **Material Composition**: Major components include concrete, bricks, debris, steel, and wood. A large portion of this waste is recyclable, but current infrastructure does not support widespread reuse.
- **Gaps in Implementation**:
  - Lack of post-approval monitoring by Bhubaneswar Municipal Corporation (BMC)
  - No structured incentives for waste minimization or use of recycled materials
  - Absence of clear operational guidelines for processing facilities

4.PROPOSAL & RECOMMENDATION

A cradle to grave approach has to be adopted for proper management of C&D waste according to the national standards (C&D Waste Management Rules, 2016) where a properly implemented system exists. The system should contain proper collection of segregated C&D waste from the polluter, proper transportation of waste, storage of waste occurs at designated transfer stations or collection points followed by proper processing of waste into recycled or reusable products that have market value and where minimal rejects are produced which get deposited in designated landfills. A properly implemented management system also needs to contain proper quantification and classification system for C&D waste at different stages of handling and a properly implemented monitoring system with a neat documentation process.

To address the identified gaps, the thesis proposes a eleven-part action framework for effective C&D waste management

i) Policy and Regulatory Strengthening

- Mandatory segregation of waste onsite.
- Clear EIA norms for processing sites.
- Defined roles and regular audits for site operators.
- Strict penalty and compliance structure.

ii) Awareness and Capacity Building

- Regular training for workers and stakeholders.
- Mass awareness campaigns.
- Integration with community groups like Mission Shakti.

iii) Monitoring, Tracking, and Reporting

- Real-time GPS tracking for waste transport.
- Online registration for generators and collectors.
- Independent monitoring cell and regular audits.

iv) Waste Management Onsite

- Encourage on-site reuse (e.g., backfilling).
- Store and transport non-reusable waste to recycling plants.
- Mandate space for waste segregation in building permits.

v) Waste Transportation Standards

- Covered and sealed transport vehicles.
- GPS-enabled and color-coded vehicles.

- Use of dust suppressants.

vi) Collection Points

- Intermediate transfer stations to reduce travel distances.
- Minimum one collection point per 25,000 people.
- Not to be mixed with municipal solid waste.

vii) Site Development

- C&D waste facilities to follow strict location, access, and environmental norms.
- A 750 TPD plant projected to be required by 2029.
- Facility design to include safety, utilities, and dust/noise control.

viii) Waste Processing Technology

- Standard equipment: crushers, screens, presses, etc.
- Mobile recycling units for small-scale onsite processing.
- Use of GIS and AI for hotspot detection and route planning.

ix) C&D Waste Products

- Recycled Concrete Aggregates (RCA), M-sand, paver blocks, tiles, etc.
- Applications in roads, housing, landscaping, and sub-bases.
- Use of eco-labelling and green certification to enhance acceptance.

x) Recommendations

- Preferential procurement by government.
- GST relaxation.
- Expanded marketing to all infrastructure sectors.
- Online platforms for product marketing, ordering, and awareness.

xi) Waste Minimization and Recycling Techniques

- Source Reduction: Renovation and preservation strategies.
- Reuse: Direct reuse and raw material substitution.
- Recycling: Converting waste into new construction materials.
- Design: Sustainable and reusable design practices.
- Technology: Adoption of flexible equipment and efficient layouts.
- Best Practices: Segregation, material handling, and loss prevention

5. CONCLUSION

C&D waste poses a major challenge for urban sustainability in Bhubaneswar. The city must enforce existing rules, increase investment in waste processing infrastructure, and raise awareness among stakeholders. The use of recycled aggregates, incentives for sustainable practices, and integration with urban planning strategies can create a circular economy model. The study contributes by outlining a roadmap for effective C&D waste governance in Bhubaneswar.

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