

Construction and demolition waste recycling

Construction and demolition waste (C&D waste) recycling is the recovery of materials from the waste consisting of building materials, debris, and rubble, resulting from the construction, re-modeling, repair, and demolition of any civil structures (CPCB 2016). The state of Odisha generated 455 tonnes per day (TPD) of C&D waste in 2022-23 (OSPCB 2023). Odisha has limited C&D waste recycling facilities (Forest, Environment & Climate Change Department 2023); most of the C&D waste is either used for filling low-lying areas or disposed of in solid waste dumpsites (OSPCB 2023), leading to no resource recovery. Recycling C&D waste is critical to recovering recyclable materials, thereby reducing the burden on and demand for virgin construction materials.

Opportunities for 2030

Jobs overview

- A total of **2,000¹** direct full-time equivalent jobs can be generated through recycling **3,000² kilo tonnes** of cumulative C&D waste generated in Odisha during 2024-2030. These estimates are based on an ambitious scenario, which assumes that Odisha will reach a C&D waste recycling rate of 100 per cent by 2030.

Market opportunity

- **10³ million USD** is the revenue potential for Odisha from recycling 1,000⁴ kilo tonnes of C&D waste in 2030 in the ambitious scenario.

Investment opportunity

- **10 million USD** is the investment potential⁵ (capital expenditure except the cost of land) to set up the recycling capacities of 1,000⁶ kilo tonnes per annum in Odisha under the ambitious scenario.

Annexure I contains the detailed methodology.

¹ Rounded up from 1,515 jobs

² Rounded up from 3,312 kilo tonnes

³ Rounded up from 9.5 million USD; Market opportunity considers the maximum recovery of materials from C&D waste and their sale.

⁴ Rounded up from 1,160 kilo tonnes

⁵ Investment potential herein includes plant and machinery costs for setting a wet and dry C&D waste processing plant. It does not include land costs. Here, it is assumed that the land will be provided by the local body for the private entity to set up the facility under a public private partnership model.

⁶ Rounded up from 1,170 kilo tonnes

Why should Odisha invest in C&D waste recycling?

- **Reduced dependency on virgin materials:** The annual consumption of construction materials in India, such as stone aggregates, is estimated at 2 billion tonnes and 750 million tonnes of sand (Niti Aayog 2018). It is projected that the demand for sand will be 1,567 million tonnes by 2025 (Prakash Chandar and Loganathan 2022). Sand is the second most exploited natural resource in the world, after water (European Commission 2023). It faces issues of supply and prices due to the ban on mining river sand during specific periods (PIB 2023) and the hike in prices of manufactured sand (Jaisankar 2023). Sand was also being imported to the country earlier to meet the demand (Roychowdhury, Somvanshi, and Verma 2020). In this context, recycled C&D waste materials, such as sand, recycled aggregates, and concrete, could reduce reliance on virgin materials and minimise the related ecological impact due to their extraction and mining. With policies such as the Odisha Rural-Urban Transition Policy being notified, where Odisha plans to provide amenities and infrastructure to the fast-growing rural and peri-urban areas, a part of the demand for construction materials can be met through recycled materials.
- **Avoiding greenhouse gas emissions (GHG) and environmental degradation:** Some studies suggest that recycled coarse aggregates produced from C&D waste generate up to 65 per cent less GHG emissions compared to natural coarse aggregates (Hossain et al. 2016). Further, the use of recycled materials, when produced closer to construction sites for consumption, reduces the carbon footprint of transporting natural aggregates and related costs. Proper C&D waste management will also help mitigate air pollution by abating the usual generation of dust particles from unmanaged or dumped C&D waste, which is one of the major sources of local air pollution (CPCB 2017).
- **Improving land availability:** C&D waste is bulky in nature and is generally deposited on identified sites or dumped in low-lying areas or roadside or in landfills. Land is a scarce resource needed for practically all plausible activities. Proper C&D waste management will allow land parcels to be used for necessary purposes and improve local aesthetics (Purchase et al. 2021). Additionally, landfills in India are already operating at or exceeding their capacity. Recycling C&D waste will divert it from landfills and free the area for disposing of solid inert waste from which no resources can be recovered (Jain, Singhal, and Kumar Jain 2019).

Inspiration from a success story

New Delhi's C&D waste recycling plant⁷ Burari, which was **India's largest** plant, had a processing capacity of 2,000 TPD (Roychowdhury, Somvanshi, and Verma 2020). It was a public-private partnership between the North Delhi Municipal Corporation (NDMC) and Indo Enviro Integrated Solutions Private Limited (IEISL). NDMC provided the land while IEISL was responsible for building and operating the plant (Biswas et al.



2021). It was an integrated plant with machinery for wet and dry processing. It produced ready-mix concrete, hollow bricks, pavement blocks, kerbstones, concrete bricks, and sand. Initially, due to the prior poor uptake of recycled C&D materials, the Delhi government had to mandate the use of recycled products in government and municipal contracts to build confidence and encourage usage of such materials (Roychowdhury, Sareen, and Singh 2023). The plant has supplied over 1.8 million recycled C&D blocks for the construction of the Supreme Court Extension (Roychowdhury, Somvanshi, and Verma 2020).

Who could support in scaling C&D waste recycling?

1. Role of departments:

- **Local bodies** play a key role in setting up and scaling C&D waste recycling. Some of the key responsibilities for local bodies to scale the C&D waste recycling include:
 - Conducting baseline assessment to assess existing infrastructure, estimating waste generation and composition, and future projections. This information is critical for waste management planning.
 - Depending on the baseline assessment and the mapped areas of C&D waste generation, identifying or expanding intermediate C&D waste collection points or debris sites and the vehicles required for transportation. For example, the erstwhile North Delhi Municipal Corporation had designated collection points in every ward, which increased waste collection and optimised the trips to the centralised processing facility (Roychowdhury, Sareen, and Singh 2023).
 - Issuing tenders for C&D waste recyclers to set up and operate recycling plants as per the current and projected requirements. In parallel, identifying land for setting up the plant, in compliance with C&D Waste Management Rules, 2016 (C&D Rules) (Niti Aayog 2018). Identifying sustainable and economically viable business models for recyclers through assessment mechanisms such as feasibility studies. For instance, these may include local bodies waiving off the profit sharing or fees from the recyclers on the sale of recycled products (Niti Aayog 2018).

⁷ Note: The original plant was established in 2009 and has now been dismantled. A new C&D recycling plant with more efficient technology has been inaugurated in its place in 2023 with the same capacity. Singh, Parag. 2023. "Kejriwal inaugurates 'India's largest C&D waste plant' in Delhi's Burari." Accessed on May 01, 2024. <https://www.hindustantimes.com/cities/delhi-news/kejriwal-inaugurates-india-s-largest-c-d-waste-plant-in-delhi-s-burari-101696787904867.html>

- Tying up smaller local bodies with bigger ones to channel their C&D waste to their recycling facility or collectively forming clusters to set up combined C&D waste recycling plants.
 - Organising interactive awareness campaigns for the general public, developers, and bulk generators⁸ on their duties and promotion of recycled products.
 - Building the capacities of the municipal staff, such as sanitary officers and inspectors, facilitating C&D waste management, organising field visits to cities and facilities where best practices are being adopted, and implementing demonstration exercises. The above actions to be undertaken collectively to avoid a fragmented and inefficient approach (Roychowdhury, Sareen, and Singh 2023).
 - Compliance verification with C&D Rules and the respective waste management plans of the bulk generators by the local development authority.
- The **Housing and Urban Development Department (H&UDD)** to issue and notify the state policy on C&D waste as required under the C&D Rules. Minimum procurement and use of recycled materials by the local bodies, authorities, and government departments in their construction (Government of NCT of Delhi 2016) and in implementing schemes such as Pradhan Mantri Awas Yojana and Swachh Bharat Mission infrastructure to be mandated. A C&D waste recycling facility should be piloted with provisions of a minimum offtake of recycled materials. Further, this data should be made public to encourage recyclers to view Odisha as a potential destination for setting up recycling facilities. In addition, specific incentives under the Odisha Development Authorities (Planning and Building Standards) Rules, 2020 to be set out for buildings that have green rating certificates such as the Green Rating for Integrated Habitat Assessment (GRIHA), Indian Green Building Council (IGBC), etc.
 - The **Odisha State Pollution Control Board (OSPCB)** to issue directions as and when required for effective implementation of the C&D Rules, as mismanaged C&D waste has several environmental effects including air pollution (DPCC 2018). Regular inspections and monitoring of the C&D waste management facilities must be undertaken to ensure compliance with the C&D Rules, dust pollution control measures, terms of authorisation, among others.
 - The **Works Department, Odisha** to mandate the use of minimum recycled C&D waste products, preferably locally procured, in accordance with the standards set out by the Bureau of Indian Standards (BIS) in building construction, road works, etc., and include recycled materials and products in the schedule of rates for construction materials.
 - **Government agencies**, which may be bulk generators such as the Works Department, city development authorities, public sector utility companies, etc., to tie up either with the local bodies for C&D waste recycling or develop in-situ mechanisms and use recycled materials as mandated, in accordance with the BIS requirements. This utilisation should be on a regular basis

⁸Bulk generators are waste generators who generate more than 20 tonnes or more in one day or 300 tonnes per project in a month as provided under the Construction and Demolition Waste Management Rules, 2016. It is provided that these generators have to pay for the processing and disposal of C&D waste generated by them, apart from the payment for storage, collection and transportation. The rate shall be fixed by the concerned local authority or any other authority designated by the State Government.

and not only in a few selected projects. This uptake will build confidence in the private sector to use recycled materials for construction purposes.

- The local **traffic police ensure** that the vehicles transporting C&D waste are covered to avoid dust pollution and also conduct random checks if authorised vehicles are carrying the C&D waste (Roychowdhury, Sareen, and Singh 2023).
- The **Bureau of Indian Standards (BIS)** to regularly update existing standards are for using recycled C&D waste based on changing construction practices and materials. BIS to provide specifications for testing the waste and the products as may be necessary. Additionally, standards to be created to allow for more proportional use of recycled materials based on verified research and development.

2. Role of the private sector:

- **Industry associations** such as the Confederation of Real Estate Developers' Associations of India (CREDAI) take the responsibility of facilitating the adoption of more sustainable construction practices in the construction industry. They should identify challenges from the construction industry in using recycled materials and disseminate successful examples and best practices to create awareness around the same.
- **Builders and developers** play the most critical role in managing waste and becoming market linkages for recycled materials. Builders and developers that are bulk generators can reuse C&D waste generated on their sites to minimise waste generation and either tie up with local bodies or set up their own recycling mechanism depending on the quantum of waste generated.
- **Recyclers collaborate** with industry associations and conduct sessions and demonstrations to address doubts and queries about the durability and functionality of recycled materials.
- Green building **rating systems** such as GRIHA and IGBC to raise awareness of government incentives for obtaining green ratings for construction.
- **Private stakeholders such as manufacturers** of construction materials or recyclers of C&D waste to extend grants to academic institutions or funding for research and development of technology and recycling processes, as well as products made from recycled C&D waste that function close to their natural counterparts.

Overcoming challenges to scale C&D waste recycling

- **Supply chain challenges and lack of consumer awareness:** There is low awareness among the waste generators on the authorised manner of depositing C&D waste. While the Swachh Bharat Mission, with its robust awareness campaigns, has made people aware of solid waste management, C&D waste management lags behind on that front. The lack of awareness is one of the major reasons formal recyclers face supply chain issues since the waste generators then unintentionally give the waste to the informal sector. The informal players collect the waste in exchange for a fee and dump the waste in dump sites or vacant plots or fill low-lying areas again

in exchange for money.⁹ This is despite the fact that in many jurisdictions, small waste generators are not required to pay fees for the collection and transportation of C&D waste to encourage them to deposit the waste. Moreover, bulk generators are required to pay for C&D waste management under the C&D Rules. However, many bulk generators dump the waste at unauthorised points or dumpsites or landfills to avoid such costs. In such scenarios, the requisite quantity of waste does not reach the authorised C&D waste facility.

Way forward: In this context, the local bodies must undertake awareness campaigns for different stakeholders on aspects of the collection, user fees, use of recycled products and materials, penalties, reduction of illegal dumping, etc., and encourage generators to deposit waste for resource recovery. The awareness of different types of waste generators and related penalties for non-compliance should be undertaken repeatedly for effective implementation. For instance, it can be undertaken separately for builders in association with CREDAI, private waste generators, public utility service providers, etc. Field visits can also be arranged to sensitise these stakeholders on the repercussions of mismanaged waste. Odisha's collaboration with Mission Shakti self-help groups on solid waste can be extended to awareness campaigns for C&D waste on collection and compliance requirements.

Moreover, the local bodies create a robust collection mechanism whereby waste can be collected on call or deposited into decentralised collection centres. The aggregated waste at the centre can then be channelled to the recycling facility. The vehicles should be equipped with GPS for traceability and identifying instances of dumping. There are various collection and transportation models practised by cities across the country. The local bodies in Odisha identify an effective model in their local context based on the waste generation quantum, mapping of collection points and routes and awareness levels, among others.

- **Need of enforcement of regulation:** Despite being notified over seven years ago, the C&D Rules have not been implemented effectively. There continues to be unauthorised collection and dumping of C&D waste and meagre collection of user fees and penalties. The non-implementation of the C&D Rules directly affects the operations of the recyclers, leading to mismanagement of waste and related environmental issues.

Way forward: The H&UDD to notify the state policy on C&D waste under the C&D Rules, setting forth broad roles and responsibilities of different stakeholders to facilitate the C&D waste management and use of recycled products. Under the policy, periodic market potential assessments from C&D waste recycling to be undertaken to showcase the market size of the state and encourage the private sector to invest in recycling facilities. The local bodies to notify the bye-laws for C&D waste clearly laying down the process of collection, transportation, storage and channelisation to the facility for processing. The bye-laws should also mention the duties of local bodies, authorised service providers, small and bulk generators, recycling facilities, etc. The user charges for collection, transportation and processing of C&D waste, at least for bulk generators, should be notified along with penalties for specific non-compliances such as unauthorised collection and dumping of waste. Moreover, a robust grievance redressal mechanism should be created and promoted where citizens can raise complaints.

⁹ Stakeholder consultations

Inspiration can be taken from cities such as Delhi that have made fortnightly self-audits mandatory on an online platform, where developers have to register C&D projects larger than 500 sq. m. for records and better accountability (DPCC n.d.). Similarly, there can be mechanisms set out under the Odisha Development Authorities (Planning and Building Standards) Rules, 2020 that promote transparency, such as (i) a show of proof of channelising C&D waste from demolition to an authorised facility prior to giving approval for a new building plan or (ii) compliance of C&D waste management plans submitted by bulk generators can be verified prior to issuing occupancy certificate. A common monitoring system between the sanitation department of the local body and the development authority can ensure such compliance and record keeping.

- **Low uptake of recycled materials and products:** Recyclers are dependent on making their revenue from the sale of recycled materials. However, generally, recycled materials are perceived to be of an inferior quality, and therefore, their market uptake remains a challenge. Further, the awareness on C&D waste recycled materials and range of products and their varied use-case is limited. Its general assumed utility is rubble for filling.

Way forward: Obtaining a recycled product certification from a recognised independent third party and listing them on product catalogues of entities such as GRIHA or GreenPro Ecolabel will improve market acceptability and exposure (Niti Aayog 2018).

The C&D Rules require procurement of materials made from C&D waste to be made mandatory, up to an extent, in government contracts. For ease in market uptake, recycled C&D material and products with potentially better uptake in the local context to be identified by the state and promoted pertaining to its use case. The state departments, Works Department and local bodies mandate use of minimum recycled C&D waste products in building construction, road works, etc., as may be apt in the local context. The clauses of C&D waste management and minimum use of recycled materials to be included in their construction contracts. This will not only increase uptake in the public sector but also provide private parties the confidence to use such products. For instance, the Delhi Public Works Department has issued an advisory to all government departments to incorporate clauses in tenders that mandate the use of 2 and 10 per cent of recycled materials in buildings and road works, respectively (Government of NCT of Delhi 2018). In addition, targets for the off-take of recycled C&D materials can be set out for different departments and local bodies (National Green Tribunal 2019; DPCC 2022). For instance, the construction of toilets under the Swachh Bharat Mission with minimum use of recycled C&D waste materials can be mandated with specified design and quality control.

Further, the state provides incentives and encourages builders to rate their buildings through building rating certifications. IGBC has criteria for green procurement of construction materials and products (including those made from C&D waste) and recycling of C&D waste generated. In order to encourage rating systems like IGBC, several state governments have provided incentives such as an additional 10 per cent floor area ratio (FAR) for rated projects (IGBC n.d.). This also helps incentivise uptake of recycled materials.

Risk-proofing the scale-up of C&D waste recycling

- **Environmental risks:** Risks include air and land pollution due to unauthorised collection (Masrath 2023) and dumping of waste. The local bodies ensure that the collection and transportation agencies and recycling facilities regularly comply with their contractual obligations and conditions of registration. In instances of unauthorised collection and dumping, penalties should be imposed, and enforcement should be stringent.

Annexure I

Scoping of the C&D waste recycling value chain

The scope of the C&D waste recycling value chain is limited to jobs generated from recycling operations that include partial transportation of waste to recycling plants,¹⁰ and different stages of recycling such as screening, sorting, and recycling of C&D waste, along with its storage and utilisation of recycled materials to produce products. These jobs are created at or by a recycling plant.

The activities before recycling, including primary collection from construction sites and aggregation of C&D waste, are not included in the scope of the current analysis due to data unavailability. The scope excludes corporate functions of the recyclers, such as accounts, human resources, legal, etc., and ancillary activities related to insurance, banking, chartered accountants, etc. These functions are not directly linked to the operational capacity of the recycler. Hence, only direct jobs from recycling operations are estimated in this analysis.

Jobs

- Direct jobs are converted to a full-time equivalent (FTE). The full-time equivalent or job year is defined as simply a ratio of the time spent by an employee on a particular task/project in a given year to the standard total working hours in that particular year. The FTE formula translates short-term or one-time employment into a full-time equivalent or job-year (Tyagi et al. 2022).
- In this analysis, FTE for recycling operations is the number of workers engaged in the recycling operations in a year divided by the quantity of waste recycled in a year.
- Key informant interviews (KIIs) were conducted with identified players in the C&D waste recycling ecosystem in order to arrive at the FTE. The interviews focused on the number of people employed for recycling operations, challenges and risks for the ecosystem, skilling requirements, etc.

Market opportunity

- The market opportunity is estimated as the revenue accrued by selling materials and products (made from such materials), recovered from C&D waste recycling.

Investment opportunity

- The investment opportunity refers to the capital expenditure for setting up the C&D waste recycling facilities. This includes the cost of plant and machinery.

¹⁰ The transportation is partial herein since occasionally the C&D waste supplier or the local bodies transport the C&D waste to the recyclers. In this context, we have accounted for employment by the recycler towards partial/limited transportation of waste to the recycling facilities. Any jobs created by other than the recyclers have not been included in this study.

Detailed methodology for market, employment, and investment opportunity

Three scenarios were developed for estimating the market, investment and employment opportunity. These are business as usual (BAU), policy, and ambitious, each having a different recycling target.

FTE estimation

KIIs were conducted with identified players to calculate the C&D waste recycling FTE and estimate jobs.

- A mix of purposive and convenience sampling strategy was used to identify the stakeholders for KII.
- Three KIIs were conducted, representing daily recycling capacities between 300 to 1000 tonnes. However, out of these three, data from two respondents was used to calculate FTE. These two respondents provided data for five C&D waste recycling facilities. The activities performed by the respondents were partial transportation of waste to the recycling facility, storage, screening and sorting and recycling of the C&D waste along with producing products from the recycled C&D waste materials.
- Questionnaires were used to gather information and data from the respondents. The broad heads under the questionnaire included specifications of the recycling plants such as capacity, area, workers deployed for different activities, etc., and stages of recycling. There were also qualitative questions on skill requirements at different stages of recycling, risks associated with the recycling ecosystem, prevalent challenges in the ecosystem, and interventions that can potentially solve them.

Annual FTE for C&D waste recycling is computed as:

$$\text{Full time equivalent (per kilo tonne)} = \frac{\text{Total number of workers employed for recycling operations}}{\text{Total waste recycled in the year (in kilo tonne)}}$$

Annual FTE for producing products from recycled material:

$$\text{Full time equivalent (per kilo tonne)} = \frac{\text{Total number of workers employed for producing products from recycled materials}}{\text{Total recycled material made into products in the year (in kilo tonne)}}$$

Table 1: Annual FTE calculated using data received from the KIIs

FTE (workers per kilo tonne)				
	Recycling			Products
Recycling facilities	Collection of waste to the facility (includes loading, partial transportation, and unloading)	Storage in the facility	Screening, sorting, and recycling of C&D waste	Utilisation of recycled material into value-added products - bricks, pavers, etc.
Facility 1	0.222	0.255		15.72
Facility 2	0.225	0.381		-

Facility 3	0.157	0.405	8.71
Facility 4	0.060	0.240	1.07
Facility 5	0.300	0.380	1.07
Average (per kilo tonne)	0.525		6.64

FTE for recycling (per kilo tonne)	0.52
FTE for products (per kilo tonne)	6.64

Source: Authors' analysis based on stakeholder consultations

- It should be noted that this analysis does not consider any reduction in employment due to increased automation of various recycling operations.

Market opportunity

The market opportunity has been estimated from the sale of recovered materials and products made from such materials. The following methodology was used to calculate the market opportunity under the three scenarios.

- First, Odisha's C&D waste was projected till 2030. Thereafter, recycling rates under these scenarios were applied to calculate the C&D quantum to be recycled. Next, this number was multiplied with recovery rates, applicable for the chosen recycling process, to calculate the quantum of recycled materials recovered from C&D waste. Lastly, the quantum of recycled materials was multiplied with market prices to estimate the revenue from recycling. The market opportunity is, therefore, a summation of the quantum of product and price of all recoverable materials from C&D waste:

$Market\ opportunity\ (USD) = \sum (Recovered\ material\ from\ C\&D\ waste\ (kg))_i * (market\ price\ (USD/kg))_i$

i indicates the recoverable materials from the C&D waste

USD to INR = 83

- The following sections detail out these three stages:

i. C&D waste generation:

The C&D waste generated in the state was calculated as a proportion of the solid waste generated therein (MoHUA 2021). The solid waste generation data was obtained from secondary sources (CAG 2022; OSPCB 2023). 10.3 per cent of the solid waste generated from 2016 to 2023 was estimated as the C&D waste generation for that period (*refer to Annexure II*). Using a CAGR (compound annual growth rate) on C&D waste from 2016-2023, i.e., 32.8 per cent, C&D waste was estimated from 2024-2030.

Table 2: Estimated C&D waste generation and projection till 2030

Year	Data taken from CAG reports for the years 2016-17 to 2019-20 and from OSPCB for the years 2020-21 to 2022-23							Projected data (using CAGR of 32.8%)							
	2016-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	24-25 ¹¹ (2024)	25-26	26-27	27-28	28-29	29-30	30-31 ¹² (2030)
Total solid waste generation in Odisha (tonnes per day/ TPD)	583	1,382	2,564	2,209	2,133	2,103	3,199								
C&D waste is calculated as 10.3% of total solid waste (TPD) (refer to Annexure II)	60	142	264	227	219	216	329	437	580	770	1,023	1,358	1,803	2,395	3,180
CAGR (2016-23)							32.8%								
Number of days in a year	365	365	365	366	365	365	365	366	365	365	365	366	365	365	365
C&D (tonnes per annum)	21,876	51,850	96,195	83,074	80,010	78,895	119,996	159,792	211,625	281,039	373,222	496,998	658,212	874,109	1,160,820

Source: Authors' analysis based on data from CAG 2022 and OSPCB 2023

The composition of C&D waste was determined using the information provided by Technology Information, Forecasting and Assessment Council's (TIFAC) on segregation of C&D waste. The same is shown in tables below.

Table 3: Composition of C&D waste

Components of C&D waste	Composition (In per cent)
Soil, sand and gravel	36
Bricks and masonry	31
Concrete	23
Metal	5
wood	2
others	3

Source: Roychowdhury, Somvanshi, and Verma 2020

Table 4: Further categorisation of C&D waste

Segregation into components	In per cent
Metal, wood, others (plastics, carry bags) ¹³	10
Concrete waste	23
Mixed C&D waste (Soil, sand gravel, bricks and masonry)	67

Source: Roychowdhury, Somvanshi, and Verma 2020 (based on the above table)

¹¹ Considered as calendar year 2024 herein.

¹² Considered as calendar year 2030 herein.

¹³ After sorting, these materials are usually sent to third parties for recycling or to the landfill.

ii. Recycling and recovery rates: The recycling rates were different for each scenario and are discussed in the upcoming sections. The C&D waste to be recycled is then multiplied by the recovery rate of materials from recycling as per secondary sources and KILs.

Table 5: C&D waste recycling recovery rate

C&D waste recycling process technology	Recovery rate
Centralized C&D waste recycling plant(dry,wet process)	95 per cent

Source: Stakeholder consultations and ILFS n.d.

Post-recycling C&D waste, the following materials are recovered: recycled concrete aggregates, recycled aggregate, recycled sand, and silt or soil. The proportions of the recovered materials are based on the information received from the KILs shown in the tables below.

Table 6: Recycled materials obtained from concrete and mixed C&D, as per KILs

Recycled materials obtained from C&D waste	
(i) Concrete waste direct product	
RCA (recycled concrete aggregates)	13.75 per cent
(ii) Mixed C&D waste (soil, sand gravel and bricks and masonry) direct product	
Manufactured sand	17.5 per cent
RA (recycled aggregates)	13.75 per cent
Soil/ landfill soil	55 per cent

Source: Stakeholder consultations

From these recovered materials, under both scenarios, it is assumed that 50 per cent of the RAs and RCAs recovered will be used to produce products such as concrete blocks and paver bricks. The market opportunity for these products is calculated by multiplying the number of products made from RA and RCA with the price of each product unit. Table 7 below shows the specifications of concrete blocks and paver bricks taken into consideration for the analysis.

Table 7: Specifications of concrete blocks and paver bricks

Secondary products	Ratio	Weight per block (in kg)	Weight of RA/RCA in each block (in kg)	Average Dimensions	Grade	Price per piece (in INR)
CC Blocks (made from RA)	1 part cement, 2 parts sand, and 4 parts RA 1:2:4	16	9.1	400*200*100 mm ³	M10	32
Paver bricks (made from RCA)	1 part cement, 1 part sand, and 2 parts RCA 1:1:2	4.5	2.3	300*150*60 mm ³	M25	10

Source: Stakeholder consultations, MoHUA 2021, Makkar and Panwar n.d., Sekhar, Chandran, and Rathi 2016

The remaining 50 per cent of the RAs and RCAs will be sold as recycled raw material along with recycled sand and silt or soil on a per tonne basis.

The current prices of the materials recovered and products are an average of data on prices from secondary sources and verified with primary consultations. The secondary sources include recycled materials’ price list from C&D plants, the Delhi Public Works Department (PWD) schedule of rates, and Indiamart. These prices were then confirmed through stakeholder consultations. These prices are kept constant for the assessment period (2024 to 2030), and any change in them will directly impact the market opportunity.

Table 8: Price of the recycled materials and secondary products

Price of the recycled materials and secondary products	Prices (in INR)
RA/ RCA (per tonne)	393
Manufactured sand (per tonne)	459
Soil (per tonne)	125
CC blocks (per piece)	32
Tiles (per piece)	10

Source: Indiamart, stakeholder consultations, CPWD 2021

Scenarios for market opportunity

1. Business as usual (BAU) scenario

BAU assumes a nominal recycling rate of about 1 per cent for C&D waste recycling in Odisha. The state has a cumulative C&D waste recycling capacity of 341 tonnes per day as per the Swachh Bharat Mission (Urban) website (SBM (U) n.d.). However, generally, the C&D waste generated is disposed of in low-lying areas or solid waste dumpsites (OSPCB 2023). In this regard, due to the varied operational capacity as per sources, India’s C&D waste recycling rate, which is at 1 per cent (Roychowdhury, Somvanshi, and Verma 2020), is taken into account for the BAU scenario for Odisha. In this context, the cumulative C&D waste to be recycled under the **BAU scenario** for the assessment period of 2024-2030 is 40.5 kilo tonnes and the cumulative market opportunity is **0.33 million USD**.

2. Policy Scenario

Under the **policy scenario**, the recycling rate is projected to reach 50 per cent by 2025 and 75 per cent by 2030 based on the targets under the Draft National Resource Efficiency Policy, 2019.¹⁴ In this context, the cumulative C&D waste to be recycled under the **policy scenario** for the assessment period of 2024-2030 is 2,578 kilo tonnes and the cumulative market opportunity is **21 million USD**.

¹⁴ We have reviewed secondary literature and related documents until March, 2024 for the purpose of this report. The Draft Construction and Demolition Waste Management Rules, 2024 were issued on July 29, 2024, and therefore, have not been considered in this analysis and therefore do not reflect in the market opportunity estimation.

3. Ambitious scenario

The **ambitious scenario** considers the recycling rate to reach 100 per cent by 2030. The scenario is inspired by Delhi's C&D waste recycling capacity, which is at 80 per cent of the total C&D waste generated, and soon to reach a 100 per cent recycling rate. In this context, the cumulative C&D waste to be recycled under the **ambitious scenario** for the assessment period of 2024-2030 is 3,312 kilo tonnes and the cumulative market opportunity is **27 million USD**.

Jobs

There are two FTEs for C&D waste value chain; one for recycling and other for manufacturing of products from the recycled C&D waste materials. Therefore, the jobs are calculated as a sum of the above two sets of jobs.

- As mentioned above, under each scenario, depending on the recycling rate, the quantity of C&D waste to be recycled is calculated. Therefore, the total number of jobs for recycling are calculated using the below formula:

$$\text{Recycling jobs} = \text{FTE} * \text{waste to be recycled in tonnes}$$

- Similarly, under each scenario separately, the jobs for producing products are calculated by multiplying the FTE with 50 per cent of the quantity of RA and RCA recovered, of which products will be made.

$$\text{Products jobs} = \text{FTE} * \text{market opportunity (50 per cent of RA and RCA recovered from recycling in tonnes, from which products will be made)}$$

On this basis, jobs are estimated for three scenarios as follows:

- Under the BAU scenario, the total cumulative jobs for the assessment period 2024-2030 is **15** for recycling **40.5 kilo tonnes** of C&D waste and producing products of **4.7 kilo tonnes** of RA and RCA over the assessment period 2024-30.
- Under the policy scenario, the total cumulative jobs for the assessment period 2024-2030 is **1,137** for recycling **2,578 kilo tonnes** C&D waste and producing products of **303 kilo tonnes** of RA and RCA over the assessment period 2024-30.
- Under the ambitious scenario, the total cumulative jobs for the assessment period 2024-2030 is **1,515** for recycling **3,312 kilo tonnes** C&D waste and producing products of **389 kilo tonnes** of RA and RCA over the assessment period 2024-30.

Investment opportunity

The investment opportunity is the capital expenditure (capex) to be incurred in setting up the C&D waste recycling facilities under different scenarios. The number of facilities and their recycling capacity are sized to the maximum waste generated in Odisha, that is, waste generated in the year 2030, and indicative to showcase the investment potential. The capex required under different scenarios is mentioned below:

Table 9: Capex required under different scenarios

Scenario	Annual waste to be recycled in 2030 (in tonnes)	Per day recycling capacity (assuming 300 working days)	Number of facilities required	Per annum capacity (in tonnes)
BAU	11,608	39	1 facility 50 TPD	15,000
Policy	870,615	2,902	4 facilities -500 TPD	600,000
			3 facilities-300 TPD	270,000
				870,000
Ambitious	1,160,820	3,869	4 facility-500 TPD	600,000
			1 facility- 400 TPD	120,000
			5 facilities-300 TPD	450,000
				1,170,000

Source: Authors' analysis

- For the BAU scenario, where a 39 TPD plant is required, it is suggested that a 50 TPD C&D waste stone crushing unit is set up for this purpose. The machinery cost of a 50 TPD C&D waste stone crushing unit is Rs.12,00,000 i.e., 0.014 million USD (Sekhar, Chandran, and Rathi 2016).
- For the policy and ambitious scenarios where various facilities of different capacities are required, we have used the capex range from a primary consultation. As per the consultation, the capex for setting up a 200 - 500 TPD is approximately Rs. 5 to 9 crores. This includes plants and machinery. It is assumed that the land will be provided by the local body for setting up the facility under a public-private partnership model.
- Thereafter, a per tonne capex was calculated as below:

Assuming that the plant is operational for 300 working days, the average per tonne capex was calculated:

Table 10: Capex: Average per tonne

Capex (in crores)	Daily capacity (in tonnes)	Annual capacity (in tonnes)
5	200	60,000
9	500	1,50,000

Source: Stakeholder consultations and analysis

Per tonne capex (in USD) = {Average[(5,00,00,000/60,000)+(9,00,00,000/1,50,000)]}/83
 where, 1 USD = Rs. 83.

In this regard, when considering the annual capacity of a C&D waste plant, approximately, 8.6 USD is the estimated capex on a per tonne basis.

- Using the per tonne capital expenditure, investment opportunity for the policy and ambitious scenario were calculated.

*Investment opportunity under each scenario = Per annum capacity of C&D facilities (as set in the table above) * per tonne capex.*

- In this context, the investment opportunity under the policy scenario is **7.5 million USD**, and under the ambitious scenario, it is **10.1 million USD**.

Annexure II: C&D waste generation

Based on the urban local body (ULB) population, C&D waste is considered as a percentage of the total solid waste generated by the ULB (MoHUA 2021):

Table 11: C&D waste as a percentage of solid waste generated by the ULB

Population categories	C&D waste generation
More than 10 million	Approximately 25% of the Total solid waste generated
1-10 million	20-25% of the Total solid waste generated
0.5-1 million	15-20% of the Total solid waste generated
Less than 0.5 million	10% of the Total solid waste generated

Source: MoHUA 2021

Estimating the composition of C&D out of the total solid waste based on the population of ULBs as set out above:

Table 12: C&D percentage of the total solid waste for Odisha

The total population of Odisha in 2023	47,099,270 (India Census 2023)
Number of ULBs with a population greater than 0.5 million (India Census 2023)	2
Bhubaneswar	946,381
Cuttack	684,693
Total population for 2 ULBs (2023)	1,631,074
Number of ULBs with population lesser than 0.5 million	112
Total population (for the 112 ULBs) (2023)	45,468,196
Categories	C&D waste as a percentage of Total Solid waste
Population between 0.5 million to 1 million	15-20% (Average 18%)
Population lesser than 0.5 million	10%
Calculation of the weighted average (percentage)	0.103 [(1,631,074*18% + 45,468,196*10%)/47,099,270]
The percentage of C&D out of the total solid waste for Odisha	10.3%

Source: India Census 2023, Authors' analysis

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