FINANCIAL SUSTAINABILITY OF CONSTRUCTION AND DEMOLITION WASTE RECYCLING PLANTS

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The annual construction and demolition (C&D) waste generated in India has been estimated to be 150 million tons. Currently, with only about 16 C&D waste recycling centers in India, with most of them having a capacity less than 500 tons per day, only an estimated 1% waste is recycled, a small proportion of waste is used for filling and levelling, and the rest simply goes to landfills, is left in place, or else dumped by roadsides. It may be noted that though the technology for recycling C&D waste and producing useful products is available, the idea has not really taken off in India. Some entrepreneurs have been forced to abandon their efforts to start recycling plants due to lack of profits and/or absence of policy support and regular customers. This research seeks to formulate a simple model for financial sustainability of C&D waste recycling plants in India and examine it in the context of available data for revenue and expenditure. Data was collected from various reports, research papers, and personal interviews. The study also provides insight into the barriers and possible solutions for improved financial sustainability of such plants and shows that C&D waste recycling can be easily sustainable through simple changes in the overall C&D waste management processes.

Keywords: Landfills, CPWD guidelines, Revenue, Operating expenditure.

1 INTRODUCTION

Even after the publication of the C&D Waste Management Rules by the Ministry of Environment, Forest, and Climate Change (MoEFCC) in 2016, India recycles only 1% of its C&D waste (Centre for Science and Environment (CSE) 2020). According to the Building Material Promotion Council (BMPTC), India generates an estimated 410,959 tons of C&D waste every day (CSE 2020), but the official recycling capacity is only 6,500 tons per day (tpd) (CSE 2020). Though 53 cities were expected to set up C&D waste recycling facilities by 2017, only 13 cities had done that by 2020 (CSE 2020). Contrary to this, C&D waste reuse and recycling rates in the European Union, USA, and Singapore are 79%, 70%, and 90%, respectively and the number of C&D waste recycling plants in these is much higher (BMTPC 2018, Roychowdhury et al. 2020). One of the major reasons behind the small number of C&D waste recycling plants is the lack of established viable business models for C&D waste recycling businesses due to which entrepreneurs are hesitant to open recycling facilities (CII 2020). There is practically no literature on this aspect in the Indian context, and this study seeks to provide a framework for that on the

1 The number of C&D waste recycling plants per country are: Germany, 220; UK, 120; Netherlands, 70; Belgium, 60; France, 50; Italy, 43; Denmark, 20; India, 16
basis of discussions with professionals in some of the existing plants and suggests possible changes in regulatory policies to facilitate financial viability.

2 LITERATURE REVIEW

In 1999, Youth for Unity and Voluntary Action (YUVA) in Navi Mumbai began recycling C&D waste (Roychowdhury et al. 2020), as perhaps the first such formally organized attempt in India but ran into financial difficulties as the waste had to be bought, which pushed the cost of recycled products higher than other products available in the market. Also, absence of tax benefits for the eco-friendly products and initiative were not forthcoming, causing the venture to be closed in 2012. Delhi opened a C&D waste recycling facility with an initial capacity of 500 tpd in 2010, which was increased to 2000 tpd (NITI Aayog 2019). The Infrastructure Leasing & Financial Services Limited (IL&FS) initiative too incurred a loss of ₹117.6 million till March 2018 due to lack of buyers for recycled products (Hindustan Times 2019). Ahmedabad also started a C&D waste recycling plant in 2014 with an initial capacity of 300 tpd, which was increased to 600 tpd in 2016 and 1000 tpd in 2018 (NITI Aayog 2019).

There have been several studies regarding the technical viability of C&D waste recycled products. One such analysis of properties of recycled aggregates (RA) and recycled aggregate concrete (RAC) showed that RAC can easily be used in lower end applications of concrete (Rao et al. 2007). The study also identified lack of appropriately located recycling facilities, absence of appropriate technology, lack of awareness, lack of government support, and lack of proper standards, as some of the barriers in promoting RA and RAC (Rao et al. 2007).

In 2014, CPWD Guidelines for Sustainable Habitat also mentioned the need for special provisions in Bureau of Indian Standards (BIS) and Indian Roads Congress (IRC) codes for use of RA in combination with naturally occurring aggregates (CPWD 2014). In 2016, MoEFCC (2016) established C&D waste management rules and defined duties of various stakeholders such as waste generator, service provider and contractors, local authorities, State Pollution Control Board, State Government, BIS, and Central Government, etc. These guidelines also mentioned the criteria for site selection for the C&D waste management plants, and application of materials and products created. The standard for coarse and fine aggregate in concrete also added the provision that use of manufactured aggregates could be permitted in plain, lean, and reinforced concrete (BIS 2016a). The National Building Code of India (2016) also mentions use of RA in concrete for bulk fills, bank protection, base/fills of drainage structures, pavements, sidewalks, kerbs and gutters, etc. (BIS 2016b). The Indian Roads Congress (IRC:121-2017) also added provisions regarding use of C&D waste in the road sector. These guidelines deal with the use of RA and recycled concrete aggregate for road works such as embankment, sub-base and base course, and for replacing a part of aggregates in different types of cement concrete pavements.

It is clear that even though several steps have been taken to create a framework of rules for better management of C&D waste over the last ten years, the suggested C&D waste management practices are far from real implementation. Technical viability of recycled products has been confirmed by many research organizations, however there is a need to verify and confirm the financial viability of recycling facilities.

3 CURRENT C&D WASTE MANAGEMENT PRACTICES IN INDIA

Most cities in India do not have systems for formal demolition permits and developers generally hire local contractors for demolition (NITI Aayog 2019). Government agencies like Public Works Department (PWD) invite bids for demolition based on what contractors would pay for recovered items with some value, such as pipes, fixtures, metal rods, and wooden frames, etc.
Removal of these items leaves behind rubble comprising concrete, stones, bricks, and mortar, and it is estimated that only 10-30% of this rubble is used for back-filling and land leveling at construction sites (NITI Aayog 2019), with the remaining being disposed in landfills or dumped without authorization in places such as low-lying areas and roadsides. This is despite there being specific provisions for proper handling and disposal of the C&D waste.

4 PROPOSED FRAMEWORK FOR FINANCIAL SUSTAINABILITY

4.1 Collection Points for C&D Waste

A simple model for C&D waste management in a city is schematically shown in Figure 1, where for an illustration, the city is divided into 7 segments, each having one local collection point (LCP), and two recycling plants (RP) located at the boundary of the city. The waste collected in segments 1 to 3 could be sent to RP I, while that in segments 4 to 7 could be sent to RP II for processing. It is further suggested that whereas the cost of transporting the waste to the LCP could be borne by the waste generator, the cost of the onward transportation to the plant could be borne by the plant. The following paragraphs discuss basic details of the costs and revenue for a plant in the framework suggested by the MoEFCC.

![Figure 1. Schematic representation of location of collection points.](image)

4.2 Cost Analysis for C&D Waste Recycling Facility

4.2.1 General assumptions about recycling facility

Let us consider a recycling facility with the following parameters:

- Capacity of plant = Z tpd
- Annual operation days = N days

The following paragraphs briefly discuss the components of fixed and variable cost in the operation, (sources of) revenue for the facility, which finally enables the computation of parameters to evaluate the financial viability of the plant.

4.2.2 Fixed costs

Total fixed cost is calculated using Eq. (1),
\[ F = F_L + F_D + F_B + F_M + F_V + F_A + F_W + F_P \] (1)

where, \( F_L, F_D, F_B, F_M, F_V, F_A, F_W \) and \( F_P \) are cost of land, cost of site development, cost of building and civil works, cost of machines and apparatus, cost of vehicles (excavator, wheel loader, JCB, tractor, tipper, etc.), cost of auxiliaries (power connection, weighbridge, CCTV, DG sets, etc.), working capital and pre-operative expenses (designing/planning, licenses, etc.) respectively.

### 4.2.3 Operating costs

Total operating cost per ton, \( OC (\text{\₹/ton}) \) and total annual operating cost, \( O (\text{\₹/year}) \) are calculated as given in Eq. 2 and Eq. 3:

\[
OC = O_E + O_M + O_S + O_{T1} + O_{T2} + O_A + O_W + O_B + O_C + O_D + O_O
\] (2)

\[
O = N \times Z \times OC
\] (3)

where, \( O_E = \) Energy cost (\text{\₹/ton})

\( O_M = \) Maintenance and servicing cost (\text{\₹/ton})

\( O_S = \) Salaries of workers (\text{\₹/ton})

\( O_{T1} = \) Collection and transportation cost from waste generation points to LCPs (\text{\₹/ton})

\( O_{T2} = \) Collection and transportation cost from LCPs to RP (\text{\₹/ton})

\( O_A = \) Cost of chemical additives (e.g. Polyelectrolyte) (\text{\₹/ton})

\( O_W = \) Cost of water (\text{\₹/ton})

\( O_B = \) Dumping cost of rejected material (\text{\₹/ton})

\( O_C = \) Cost of rehandling of C&D waste (\text{\₹/ton})

\( O_D = \) Depreciation cost (\text{\₹/ton})

\( O_O = \) Others (insurance, administrative office costs, marketing expenses, etc.) (\text{\₹/ton})

### 4.2.4 Revenue

Revenue to the recycling facility comes primarily from the waste input gate fees, which is paid principally by the waste generator, and the sale of products. As far as the former (say \( R_W \text{\₹/ton} \)) is concerned, it may, at times, not be received depending on the waste generator (e.g. Municipal Corporations), and thus only a fraction (say \( y \), which could be about 40% to 60%) of the total waste contributes to this revenue. Value-added products such as recycled concrete blocks, pavers, kerbstones, tiles, etc. can be manufactured from RA which can increase the revenue and also help in utilization of RA in case they are not sold. The average unit price of all value-added products is assumed \( P_{i,1} \text{\₹/ton} \). The revenue from recycled and value-added products is formulated as given in Table 1. There could be large variations in the C&D waste composition, which affects the proportion of the different products, which in turn affects the revenue.

Thus, the total revenue, \( TR (\text{\₹/day}) \), for the plant using terms defined above can be given in Eq.(4)

\[
TR = Z \times y \times R_W + \sum_{i=1}^{11} (X_i \times P_i)
\] (4)

Hence, the total annual revenue, \( R \text{\₹/year} \), annual profit, \( P \text{\₹/year} \), and the payback period, \( T \) years, can be given by Eq.s 5-7.

\[ R = (N \times TR) \] (5)

\[ P = (R - O) \] (6)

\[ T = \frac{P}{P} \] (7)
4.3 Role of Various Stakeholders According to C&D Waste Management Rules 2016

These rules state that the waste generator is responsible for collection, segregation and storage of C&D waste generated. The waste is required to be kept within the premise or deposited at an LCP or handed over to the C&D waste processing facility. The waste generator is also expected to pay relevant charges for storage, collection, transportation, processing and disposal at a rate fixed by the concerned local authority. Also, the local authority is responsible for providing appropriate LCPs and periodically transferring the waste to the processing plants that may be operated by private operators. Following the terminology used in Eq. (1), in a PPP agreement, the cost F_L is shouldered by the government, as land is provided on lease to plant operator at nominal cost. Other fixed costs F_D, F_B, F_M, F_V, F_A, F_W and F_P are to be borne by the plant operator, besides all the operating costs, while cost of transportation to the LCP is to be paid by waste generator. The waste input gate fee R_W, can come from waste generator or local authority or both, depending on the contract.

Table 1. Revenue from recycled products.

<table>
<thead>
<tr>
<th>Recycled product</th>
<th>Quantity of products sold (tons/day)</th>
<th>Unit price (₹/ton)</th>
<th>Revenue (₹/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete coarse aggregates</td>
<td>X₁</td>
<td>P₁</td>
<td>X₁ × P₁</td>
</tr>
<tr>
<td>Concrete fine aggregates</td>
<td>X₂</td>
<td>P₂</td>
<td>X₂ × P₂</td>
</tr>
<tr>
<td>Ceramic coarse aggregate</td>
<td>X₃</td>
<td>P₃</td>
<td>X₃ × P₃</td>
</tr>
<tr>
<td>Ceramic fine aggregate</td>
<td>X₄</td>
<td>P₄</td>
<td>X₄ × P₄</td>
</tr>
<tr>
<td>Iron and steel</td>
<td>X₅</td>
<td>P₅</td>
<td>X₅ × P₅</td>
</tr>
<tr>
<td>Other metals</td>
<td>X₆</td>
<td>P₆</td>
<td>X₆ × P₆</td>
</tr>
<tr>
<td>Paper and cardboard</td>
<td>X₇</td>
<td>P₇</td>
<td>X₇ × P₇</td>
</tr>
<tr>
<td>Plastics</td>
<td>X₈</td>
<td>P₈</td>
<td>X₈ × P₈</td>
</tr>
<tr>
<td>Wood</td>
<td>X₉</td>
<td>P₉</td>
<td>X₉ × P₉</td>
</tr>
<tr>
<td>Gypsum</td>
<td>X₁₀</td>
<td>P₁₀</td>
<td>X₁₀ × P₁₀</td>
</tr>
<tr>
<td>Value added products</td>
<td>X₁₁</td>
<td>P₁₁</td>
<td>X₁₁ × P₁₁</td>
</tr>
</tbody>
</table>

4.4 Financial Viability of C&D Waste Recycling Plants

Balancing the expenses and revenue, parameters such as the ‘payback period’ can be worked out; and depending on what is ‘acceptable’ to an entrepreneur, the financial viability can be determined. Viability of such plants can be ‘promoted’ through systems by which the cost to the plant is reduced and revenue is ensured. Also, there has to be a fair distribution of risks (e.g., the variation in the composition of the raw waste) between the urban local body (ULB) and the plant.

4.5 A Case-Study of C&D Waste Recycling Facility in Delhi, India

The discussion in this section is largely based on the feedback from a 500 tpd plant operating in Delhi on PPP basis. The following contribute to the favorable conditions for the operation of this plant: (i) waste generation is high, which ensures a regular supply to the RP(s), which can then run almost throughout the year, (ii) the price of virgin aggregates is high which makes RA and value added products more attractive, (iii) a waste to energy plant is situated in Delhi, allowing the C&D waste recycling plant to sell its incinerable waste (paper, plastics, wood, etc.) generating additional revenue, (iv) there is lack of silt in Delhi, and the silt produced in the RP can also be sold and contribute to the revenue, (v) the government has provided land at nominal cost and, (vi) waste generators pay waste input gate fee to the plant. A summary of the collected data for the plant, operating 300 days annually, is given in Table 2.
Table 2. Data collected from operating plant in Delhi through personal interviews.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(i) Revenue from gate fee</td>
<td>₹165/ton</td>
</tr>
<tr>
<td>(ii) Working capital</td>
<td>₹25 million</td>
</tr>
<tr>
<td>(iii) Fixed cost</td>
<td>₹200 million</td>
</tr>
<tr>
<td>(iv) Interest on initial investment</td>
<td>₹50 million</td>
</tr>
<tr>
<td>(v) Operating cost</td>
<td>₹602/ton</td>
</tr>
<tr>
<td>(vi) Revenue from sale of products</td>
<td>₹385/ton</td>
</tr>
</tbody>
</table>

With the above, the payback period was worked out to be about 10 years, which could be seen as financially viable. Of course, this number can change with steps such as reduced taxation and/or assured market for value-added products, reduced power tariff. Also, the following risks could impact the viability from the operators’ point of view: (i) variation in the composition of waste over time, which affects both the processing cost and revenue, (ii) variation in the fraction of waste on which waste input gate fee is received.

5 CONCLUDING REMARKS

C&D waste recycling is in a nascent stage in India, and for successful C&D waste management, all stakeholders need to work together, and the C&D waste management Rules 2016 try to define their individual roles. This study presents a simple model incorporating the different parameters contributing to the cost and the revenue in the business and shows that the operation can be viable. However, the extent of profits would depend on risk sharing, and on policy initiatives such as rationalization of taxes on recycled products and assured consumption of these products.

Acknowledgement

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References


