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Author Suneel Pandey, Associate Director, TERI

Email: spandey@teri.res.in

Jai Kishan Malik, Research Associate, TERI

Email: jai.kishanmalik@teri.res.in

Reviewer Shri Prakash, Distinguished Fellow, TERI

Email: shri.prakash@teri.res.in

For more information

Project Monitoring Cell
T E R I
Darbari Seth Block
IHC Complex, Lodhi Road
New Delhi – 110 003
India

Tel. 2468 2100 or 2468 2111
E-mail pmc@teri.res.in
Fax 2468 2144 or 2468 2145
Web www.teriin.org
India +91 • Delhi (0)11

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1 Background

With increasing population, the management of municipal solid waste (MSW) in the country has emerged as a severe problem not only because of the environmental and aesthetic concerns but also because of the sheer quantities generated every day. According to the Central Pollution Control Board, 1,27,486 TPD (tons per day) of MSW was generated in India during 2011. Of the total waste generated, approximately 89,334 TPD (70%) of MSW was collected and only 15,881 TPD (12.45%) was processed or treated (CPCB, 2013). Segregation at source, collection, transportation, treatment and scientific disposal of waste was largely insufficient leading to degradation of environment and poor quality of life. This paper primarily focuses on the issues related to the management of municipal solid waste.

The key issues impacting proper management of MSW include the following:

- Limited primary collection at the doorstep
- Reluctance in public to take ownership
- Unavailability of adequate funds
- Lack of access to proper technology; and
- Unscientific disposal of MSW at dump sites

In addition, as per CPCB estimates, the class I[1] cities and class II[2] towns in the country generate around 38,254 MLD (Million Litres per Day) of sewage of which only 11,787 MLD (31%) is treated and balance is discharged untreated (Ref). The key issue regarding sewage collection treatment and disposal at the national as well as state level is inadequate provision of sewage treatment facilities which is one of the major cause of pollution of water bodies in the country.

As per the estimates of CPCB, annually around 7.66 million Metric Ton (MT) of hazardous waste is generated from 40,000 industries in the country, of which landfillable waste is 3.39 million MT (44.26%), incinerable 0.65 million MT (8.50%) and recyclable hazardous waste is 3.61 million MT (47.13%). (CPCB, 2010)

The mechanism of disposal of hazardous wastes lacks proper enforcement resulting in abandoned hazardous waste dumps. These abandoned disposal sites have the potential to cause soil and groundwater contamination due to heavy metals and other toxic compounds, some of which bio-accumulate through the food chain, thereby posing long-term health risks. The present treatment capacity for industrial wastewater is 1/6th (142 MLD) of total generation. So the total industrial wastewater generation can be pegged at around 850 MLD.

The rate of municipal waste generation in India in 2011 was 127458.1 T/day. This was divided by the then urban population to get the per capita waste generation rate of 0.356 kg/day. The amount of waste generated per capita is estimated to increase at the rate of 1-1.33% annually. (Pappu et al., 2007). Using the urban population projections in the year 2011, 2021, 2031 and 2041, the total amount of waste generated in India can be calculated as shown

[1] Class I: Population 100,000 and above
[2] Class II: Population 50,000 to 99,999

in the table 1 (Scenario B, PFI). As clear from the table the daily waste generation in urban areas is expected to rise by almost 146% by 2051.

Table 1: Projections of waste production in India at an all India level for 2011, 2021, 2031 and 2041

	India		
	Per capita waste generated (Kg/day)	Urban Population (x 1000)	Waste generated (T/day)
2011	0.356	358308.6	127458.1
2021	0.406	436690	17728107
2031	0.463	516372	239240
2041	0.529	593548.7	313839.7

Source: Population projections from Scenario B, Population forecast of India

2 Policy framework

The status of solid waste management is considered as a development indicator as it has direct link to issues like sanitation and public health. Thus, management of solid waste generated in a country must be one of the priorities while forming policies at national level. However, the situation of solid waste and sanitation in India has always been questionable. The major reasons, particularly in urban areas, are economic growth, migration from cities, unplanned land use and, most importantly, the lack of proper legislations on solid waste management.

One of the foremost regulations in the waste management sector was the Hazardous Waste (Management & Handling) Rules, 1989 followed by Bio-Medical Waste Handling Rules, 1998. However, the specifications regarding the roles and responsibility of waste management and the protocol to be followed in municipal waste collection, segregation, processing and disposal were missing. As a result, the sanitation standards in cities were not up to the mark. It was observed that often the waste from all over the city was dumped at the periphery of cities in low lying area which later got inhabited slums and unauthorized colonies for picking up recyclable waste. As the waste was not segregated and included bio-medical, industrial and e-waste, it was a serious threat to public health. Thus public interest litigation (PIL) was filed in the Supreme Court in 1996 against the Government of India and municipal corporations responsible for solid waste management; following which a committee was appointed to look into the matter. The committee submitted the final recommendation in 1999. The Ministry of Environment and Forest was then directed to act

on the recommendations and develop appropriate rules for management of municipal solid waste (Zhu, Asnani, Zurbrugg, Anapolsku, & Mani, 2008).

The institutional framework on solid waste management is still in development. Some of the major landmarks in the history of solid waste management (SWM) have been mentioned in table 2.

Table 2: Major landmarks in the history of waste management in India

Year	Rules/Policies/Schemes/Plans
1989	The Hazardous Waste (Management & Handling) Rules
1994-95	MSW Management – Strategy Paper by NEERI
1998	Bio-medical Waste Handling Rules, 1998
2000	MSW (Management & Handling) Rules, 2000
2005	Report of The Technology Advisory Group on Solid Waste Management 2005
2006	Strategy and action plan-use of compost in cities
2008	National Urban Sanitation Policy
2009	Draft document on E-waste handling Rules
2010	National Mission on Sustainable Habitat
2011	Plastic Waste Rules, 2011 & E-waste Rules,2011
2013	Draft Municipal Solid Waste Rules 2013
2014	Draft Manual on Municipal Solid Waste Management and Handling
2014	Swachh Bharat Mission
2015	Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

Source: (CPHEEO, 2014)

Municipal Solid Waste (Management and Handling) Rules 2000: The MSW rules were made effective in the year 2000. All the municipal authorities in country were directed to manage solid waste in their respective jurisdiction according to the rules. The MSW rules cover all the aspects of solid waste from collection to waste disposal. Some of the directions made are:

- *Collection/storage*: A door-to-door collection must be done by the municipal authorities including in unauthorized areas like slums. The collected waste must include both bio-degradable and non-bio-degradable waste. There must be no littering on the streets; separate bio-degradable and non-bio-degradable dustbins must be installed at convenient locations. Street sweeping drives must cover all kinds of areas and on all days.

- *Transportation*: The transportation of the waste must be in closed trucks.

- *Treatment*: The bio-degradable waste collected must be either composted or used in waste-to-energy plants.

- *Disposal*: Only the inert material or waste from treatment plants should end up in the landfills. The rule also specifies the standards for waste disposal in landfills.

National Urban Sanitation Policy: The policy was prepared by the Ministry of Urban Development in 2008. The objective of the policy is 'to transform urban India into community-driven, totally sanitized, healthy and livable cities and towns.' The policy stresses upon awareness and behavior change, open defecation free cities and integrating sanitation in all the other aspects of cities. (Ministry of Urban Development)

National Mission on Sustainable Habitat: Launched in 2010 under the National Action Plan for Climate Change, this mission will be implemented in the Twelfth Five Year plan. Apart from energy consumption in buildings and shift to public transport this mission focuses on technological intervention in the waste management and recycling. The mission will include major R&D programs in bio-chemical waste processing, recycling and, especially in, waste-to energy (Planning Commission, 2012).

Swachh Bharat Mission: The Swachh Bharat Mission was launched in 2014. The main objectives of the mission include elimination of open defecation, eradication of manual scavenging, modern and scientific municipal solid waste management, to effect behavioral change regarding healthy sanitation practices, capacity building for ULBs, and to create enabling conditions for private participation in capital investment and operation and maintenance. One of the overall objectives is to achieve scientific solid waste management in 4041 cities/towns for 30.6 crore persons.

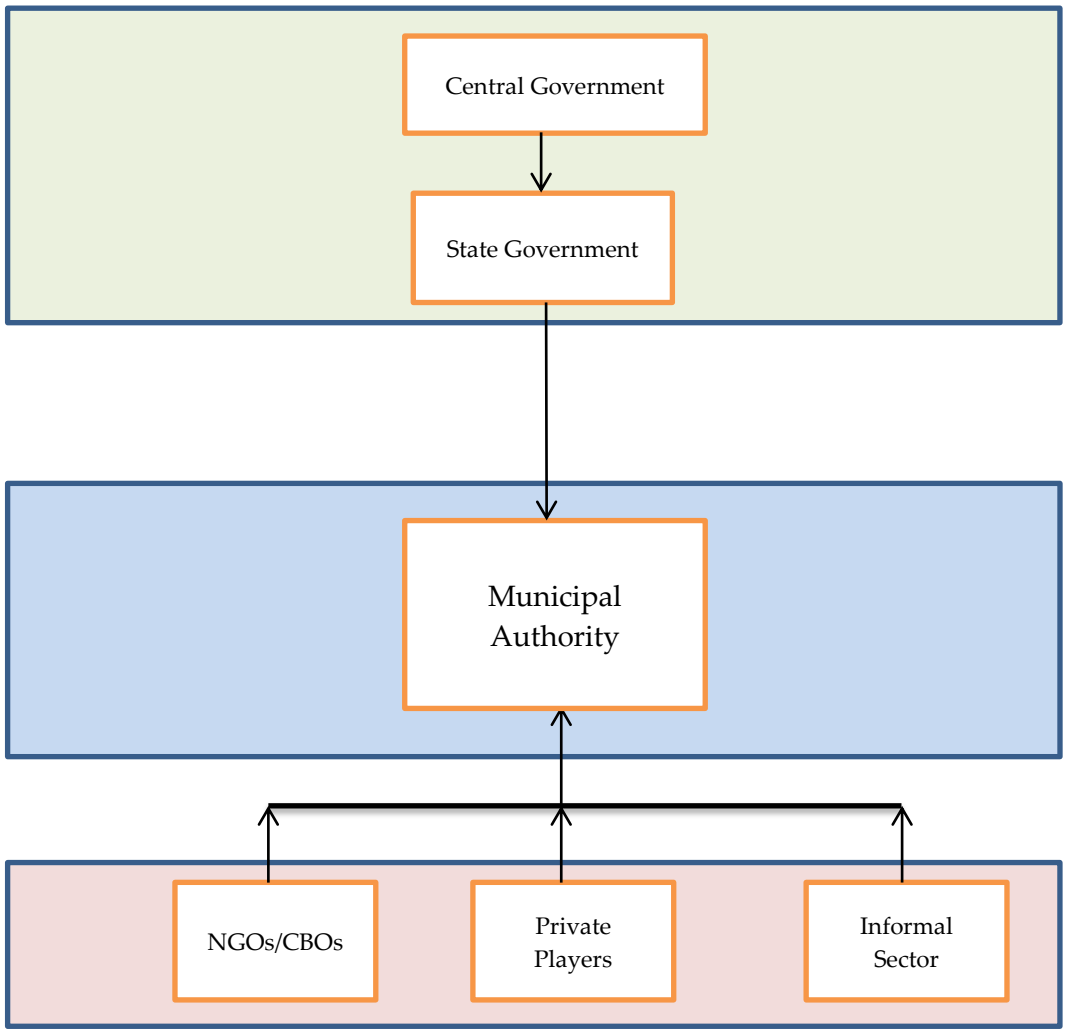
AMRUT: Launched in 2015, the Atal Mission for Rejuvination and Urban Transformation has an aim to ensure that every household has access to tap water and sewerage; increase the amenity value of the city by promoting greenery and well maintained open spaces; and to reduce pollution by promoting non-motorized and public transport. One distinguishing feature in AMRUT is that now the MoUD will approve an annual state action plan rather than giving project by project approvals.

3 Institutional Framework for Implementation

The framework of solid waste management in India is broadly divided into three tiers, which are, central, state and urban local bodies (UBL).

The main function at the central level is to make laws and rules, frame policies, financial support and to prepare guidelines and manuals. The state is responsible for implementing the rules, laws and guidelines set by the center at the state level. ULBs are responsible for the actual implementation and to prepare plans for collection, transportation, treatment and disposal of the solid waste (Bharat & Jaiswal, 2013)

Even though the major responsibility of MSW management lies with the governmental agencies and urban local bodies, there are other stakeholders which play a crucial role as well. These are households, businesses, industries, informal sector, non-governmental organizations (NGOs), community based organizations (CBOs), self-help groups (SHGs), secondary schools and college students. Involvement of all these stakeholders is necessary in planning of solid waste management. Figure 1 shows diagrammatically that the rules and policies are framed at the national and state level but the actual implementation is done by the ULBs. Other stake holders like private partners, CBOs, NGOs and informal waste collector execute certain aspects of waste management like waste collection, processing etc. Table 3 lists out responsibilities of stakeholders involved in the whole process.



: Make laws and rules; frame policies; prepare guidelines, manuals, and technical assistance; provide financial support; monitor implementation of laws and rules

: Involved in the actual collection, segregation, transportation, processing and disposal of waste

: Auxiliary agencies helping municipal corporation in waste management

Figure 1: Role of different agencies in waste management

Table 3: Role of different institutions in solid waste management

Role and responsibilities in SWM	Responsible Institution
Make laws and rules; frame policies; prepare guidelines, manuals, and technical assistance; provide financial support; monitor implementation of laws and rules.	Central government
Make state-level laws and rules; frame policies; prepare guidelines, manuals, and technical assistance; provide financial support; monitor implementation of laws and rules.	State government
Plan for SWM treatment facilities; Collect, transport, treat, and disposal of waste; Frame by laws; levy and collect fees; Finance SWM system	Municipal authorities
Mobile communities for waste collection, decentralized treatment, conduct waste related Information Education and Communication Strategy (IEC) activities and mobilize financial support for communities	NGOs and CBOs
Recycling at different stages like collection, transportation and final dump/disposal site	Informal Sector Waste Recyclers
Collection and transportation of waste, treatment plants on Build-Operate-Transfer (BOT) basis, technology providers collection vehicles and equipment manufacturers	Private Partners

Source: World Bank Institute. (2008)

4 Challenges

The key challenges in achieving efficiency in waste management sector at the national level include non-segregation of waste at the source; the ULBs lack funds and are inadequate to address the existing identified problems in waste management. The institutional arrangement is not adequate and there is no community participation towards management of waste and sanitation. The ULBs are also unable to recover user charges from residents for solid waste service provision.

In order to address these challenges, it has been suggested that informal arrangement of rag pickers and NGOs/CBOs must be strengthened for an effective door-to-door collection, guidelines from the state must be followed while acquiring land for projects and SWM solutions must be developed according to the regional requirements and constraints.

A report by National Plastic Waste Management Task Force in 1997, looked at social and environmental status of rag pickers and waste collectors in informal sector. In the same year, the Ministry of Urban Affairs and Employment, under the clean city campaign, discussed about the creation of waste recycling centers in a scientific manner. Following this in 2001, Ranganath Mishra Committee on Plastic Waste Disposal suggested that the retrieval of packaging for disposal must be the responsibility of the plastic industry.

The Indian government has realized that for national sustainable development, active participation of all the stakeholders including environmental NGOs is necessary. The development programs must take place at the grass root level for the sake of sustainability. Waste Minimization Circle (WMC) for ensuring maximum resource recovery from industrial waste is one such example (Planning Commission, 2012).

Under the National Action Plan for Climate Change in the Eleventh Five Year Plan (FYP), Sustainable Habitat Mission was launched. One of the objectives of this mission is to achieve efficient solid waste management.

The Twelfth FYP has suggested some recommendations for an efficient waste management system. This includes the development of National Waste Management and Recycling Program which will primarily focus on a more organized framework for waste management and recycling, development of guidelines for recycling industries synchronized with the existing waste management rules and development of industry and sector specific recycling standards. The recommendations also suggest promotion of public–private partnership (PPP) model for waste management and development of technologies. Recently launched programs like Swachh Bharat Mission and AMRUT are also steps taken to tackle the issue in a systematic manner.

Due to absence of segregation of waste at source, the waste processing technologies essentially handle mixed waste which not only increases the cost of waste processing but also produces products with poor quality (e.g. compost contaminated with heavy metals). Such products cannot be sold market at competitive price hence affect the financial viability of the project. Mixed waste also causes wear and tear in the waste handling equipment and also is source of emission of toxic pollutants when the waste is combusted.

Efficient management of waste cannot take place in isolation of the ULBs due to unavailability of land and financial viability of the projects. The state government has a crucial role to play in co-ordination between ULBs of the state and promoting a regional waste management approach. Box 1 gives the example where the state government of Gujarat had played an important role in improving the waste management situation of the state.

Box 1: Regional waste management approach in Gujarat

The government of Gujarat realized the importance of an integrated approach to waste management in 2005. It was understood that little progress would be made if the ULBs keep working independently. Thus centralised co-ordination has to be established. In this regard, the Gujarat Urban Development Company (GUDC) was made the state nodal agency for municipal waste management. The GUDC was to come up with a new plan for waste management with grants 12th finance commission to the state.

GUDC conducted a series of workshops and realized that the main focus for regional approach on waste management should be waste processing and disposal. The gap in the funds had to be met through private investments or other sources like CDM (Clean Development Mechanism). The state was divided into 20 clusters and scientific landfill facilities were constructed at the regional level for disposal. The clusters were designed in such a manner that the distance between landfill site and any of the ULBs was not more than 50 km. Private technical companies were hired to develop processing facilities like vermin-composting at the ULB level.

Source: (GoI)

5 Learnings from international good practices

This section describes international (Brazil and Europe) best practices in case of solid waste management. These examples and the lessons learnt could be helpful for policy makers in India while framing policies related to municipal solid waste management.

5.1 Brazil

The specific objectives of Brazilian national policy for solid waste management and the Law include:

- Adherence to waste hierarchy - a) reduce b) reuse c) recycle d) disposal of treated solid waste in an ecological manner must be promoted.
- The industries must be incentivized to use recycled products.
- Environmental impacts must be minimized by adopting, developing and improving clean technologies.
- Integrating reusable and recyclable material collectors in actions that involve joint liability for product life cycle.
- Preference to green procurement i.e. purchase of recycled and recyclable products, goods, services and so on, such that it promotes social and environmental sustainability. (al, 2013) The Brazilian government, in 2014, decided that all the unregulated landfills must be shut down. Moreover, individual or entities not complying with policies and are responsible for damage to environment are required to compensate the government for remedial actions.

5.2 Europe

Many initiatives have also been taken by the European governments to ensure the safe disposal of solid waste to promote sustainability. Improvement in the efficiency of waste treatment and disposal facilities, diversion of bio waste from landfills to reduce greenhouse gas (GHG) emissions, replacement of mineral fertilizers with organic fertilizers (compost) and an improvement in the output from recycling units to reduce natural resource consumptions are some of the steps taken.

The bio-degradable waste management (BMW) systems[3], in Netherlands, Austria and United Kingdom, focus on building separate collection systems like specific bins which would eventually lead to BMW treatment systems. In addition, some economic instruments like Pay-As-You-Throw (PAYT)[4] and organic waste tax have been used as an incentive so that the residents' themselves divert BMW from the regular waste. Landfill Allowance

[3] Bio-degradable waste management system (BWMS) refers to the systems in place which are designed to separate Bio-degradable waste from the municipal waste stream
[4] PAYT is very similar to user fee charges. The only difference is that PAYT is levied according to quantity of waste generated

Trading System (LATS), another such initiative by the United Kingdom government, provided the local authorities the flexibility to manage waste more efficiently.

In 1990 another waste management system – 'Duales (Dual) System Deutschland DSD', was introduced in Germany and then later replicated all over Europe. The main idea behind this was to transfer the responsibility of collection and recycling of main packaging on the producer itself. The packaging is typically marked with a 'green dot' to identify that it belongs to the DSD system. However, in Denmark, it was observed that there was no responsibility of producers in handling the packaging waste; this increased the uncertainty in the estimation of waste and then consequently resulting in higher waste management cost for the local bodies. In the Danish waste management system, all types' wastes, irrespective of the type and origin, are to be handled by the local bodies. The segregation of the waste is done at source itself. The financing of the system is through the polluter-pays-policy. (Pires, Martinhi, & Chang, 2010)

6 Measures for adopting green growth

6.1 Integrated Solid Waste Management

Integrated Solid Waste Management (ISWM) is a system which defines a hierarchy while managing solid waste. According the ISWM, solid waste must be managed in the following hierarchy with the first strategy being most desirable and the succeeding strategies to be followed only when a particular strategy cannot be employed:

- *Reduction at source and reuse:* The most logical and preferred option is minimizing the waste production. This can be done by using better technologies, efficient packaging, reusing the waste produced at each level in some other process or activity.
- *Recycling:* Recovery of material from the waste and reusing it again in manufacturing of some other product is recycling. Although recycling helps in recovering the material waste, energy is used in the process.
- *Waste to Compost:* Decomposition of organic municipal waste to produce manure.
- *Waste-to-Energy*: Production of heat, electricity or fuel from the waste using bio-methanation, waste incineration or Refuse Derived Fuel (RDF).
- *Waste Disposal:* Inert waste or the residual waste produced in the other waste management process must be disposed in engineered landfills.

Another aspect of ISWM is the integration of informal sector, to include rag pickers and private door-to-door waste collectors. The informal waste sector plays an important role in waste collection and segregation and this is done at a minimal cost. It has been observed that developing countries spend almost 80%-90% of the allotted waste management budget on waste collection (Marshall & Farahbakhsh, 2013). Thus, integration of informal sector through NGOs, resident welfare association (RWAs), SHGs and CBOs will help in reducing

the waste collection cost. Moreover, this will also protect them from exploitation (CPHEEO, 2014).

Table 4 and 5 summarize the significant knowledge gaps and administrative challenges. The tables also suggest intervention which could fill the knowledge gaps and overcome the challenges.

Table 4: Knowledge barriers and interventions

Barriers	Interventions
Unavailability of database on waste streams generated – quantity and composition	Municipalities must maintain a database of waste generated and handling activities.
Waste handled by unskilled labor	Regular training and capacity building programs for labor directly involved in waste handling
Lack of proper monitoring and inspection techniques	Capacity building of the officers responsible for administering waste in municipalities
Lack of coherence and learning from experiences and developments in municipalities	Maintenance of nation or state wide portal to highlight achievements or best practices
Ignorance in general public	• Public awareness drives • Waste management in school curriculum

Table 5: Administrative/ policy barriers and interventions

Barriers	Interventions
Waste generation is directly influenced by economic growth, i.e. large quantities of waste generated.	• Establishing a benchmark of the quantity waste to be produced by a household. • Use of alternate packaging – jute/cloth • Encouraging products with longer life cycle. • Designing products which can be re – manufactured or recycled at the end of life
No ownership of waste	Introduction of EPR[5](extended producer responsibility) and PAYT (pay as you throw)

[5] EPR means that the manufacturer of a product is responsible to safely dispose the waste produced at the end of its life.

Ignored informal sector working out of coherence	Integration of the informal sector within the formal waste management system
Lack of accountability of waste management authorities	Establishing a unit in every municipality to receive and act upon complaints/suggestions from the general public
Lack of enforcement of rules	Establishing special courts for dealing with non compliance of waste management rules
Waste mostly handled by ULBs	Involvement of RWAs, NGOs, CBOs, private players and/or informal sector in waste management
Centralized decision making	Local communities must have a say in the waste management of their locality
Majority of waste in landfills	Increasing the entry fee at landfills

6.2 Financing Mechanisms

In order to ensure the practicality and sustainability of the Solid Waste Management programs being developed, it is very important to understand the financial aspect of it. In India, the implementation of the SWM programs is usually done by the ULBs. The central and state governments provide grants to the ULBs. Besides these grants other sources of funds are internal revenues through taxes, loans and private partners.

While budgeting the costs of solid waste management a holistic understanding of the process is necessary. The planners must take into account all the aspects of SWM including collection, segregation, transportation, disposal, employee salary and other hidden costs. Increase in population and waste quantity in future must be considered while planning a long term project or constructing a facility. These costs are majorly met through grants from government, taxes and user fee charges (in only small fraction of cases). Studies have suggested that there is a scope of improvement in the management of the money allocated for waste management. Most of the funds available are spent on the salaries of the employees. 70-75% of the funds are spent on street sweeping, 25-30% on collection and only 0-5% percent on disposal. In an efficient waste management system, the majority of the funds must be spent on waste treatment and disposal. The sections below discuss finance availability and requirements for effective solid waste management.

Grants from state/central government: The ULBs themselves seldom have enough funds to meet the financial requirements of the Solid Waste Management projects. Thus, the government at both national and state levels provides grants to ULBs for implementing projects. Some such examples are:

- Central funds
    - Finance Commission Grant
    - JnNURM-UIG grants
    - JnNURM-UIDSSMT grants
- State funds
    - State Finance Commission grants

The centrally sponsored mega city scheme was launched in 1993/94 for Mumbai, Calcutta, Chennai, Bangalore, Hyderabad and Ahmedabad. The scheme was launched to develop the urban infrastructure of the city which included aspects of water, sanitation, sewerage and solid waste management. 50 percent of the funds were met by the contribution of central and the respective state governments. Remaining 50% of the funds were financed by market institutions.

In the 12th Finance Commission, the government allotted INR 2500 crore to the ULBs for the improving waste management facilities and services. (Department of Economic Affairs, Ministry of Finance , 2009). That means 50% of the grants allocated for class I cities (Rs 5000 crores) were dedicated to solid waste management. Even the 13th finance commission stipulates that 50% of the funds allocated to the ULBs should be earmarked for solid waste management.

According to the planning commission report five year plan 2012-2017. The Government of India had set up National Clean Energy Fund in 2010. A sum of INR 10,000 crore is expected to be collected under this fund which will be invested in projects and programs supporting clean energy technologies including waste management. (Planning Commission, 2012)

The Sustainable Habitat Mission focuses on solid waste management along with energy efficiency in buildings and cleaner transportation technologies. A total of INR 1000 crore were sanctioned for the mission out of which 50 Crore were incurred in the Eleventh Five Year Plan and the remaining INR 950 Crore shall be incurred in the Twelfth FYP. (Planning Commission, 2012)

It is also decided that solid and liquid waste management will come under nirmal grams and grant of INR 500000 will be given per 1000 people. (Planning Commission, 2012)

6.2.1 Subsidies

Waste-to-energy projects like refuse derived fuels; biomethanation, biogas and gasification are highly encouraged by providing financial incentives. The Ministry of New and Renewable Energy (MNRE) gives incentives to both private and public sector companies. On an average a subsidy of INR 15 million to INR 30 million per MW is given. Also, INR 15 lakh per MW of incentive is given to ULBs for providing garbage free of cost and facilitating the needs of waste to energy projects. Whereas, the state nodal agencies are provided an

incentive of INR 5 lakh/MW for the promotion and co-ordination of projects. Ministry of Environment Forest and Climate Change and Ministry of Agriculture provides a subsidy of upto 50% of capital cost of compost plants.

6.2.2 Loans from government or other financial institutions

The ULBs can approach private or public banks if loans are required for funding projects at low rates of interests. Some of such financial institutions are Housing and Urban Development Corporation Limited (HUDCO), Infrastructure Development Finance Company Limited (IDFC), Infrastructure Leasing & Financial Services Limited (IL&FS), National Bank for Agriculture and Rural Development (NABARD), Indian Renewable Energy Development Agency Limited (IREDA), Industrial Development Bank of

In March, 2006, the Indian government borrowed 3,584 million yen (INR 6,254 crore) from JICA (Japan International Cooperation Agency) for the 'Kolkata Solid Waste Management Improvement Project). The aim of the project was to promote healthy and hygienic living conditions in Kolkata by developing a sustainable regional solid waste management system including sanitary landfills.

6.2.3 Incentives to invest in waste sector

The government of India has provided certain incentives to promote the investment in the solid waste management sector; some of these have been listed below:

- Tax exemption of certain bonds selected by the local authorities.
- Tax holiday for the projects involved in solid waste management.
- Exemption of taxes on the income of the companies which have invested in the projects of infrastructural development, including solid waste management infrastructure.
- India was part of the Kyoto protocol in 1997 -- industrialized countries which participated in this agreed to reduce their carbon emissions. In order to do that, these countries could also invest in the carbon mitigation project in developing countries. Since solid waste is a source of greenhouse gases, particularly methane; projects with an aim to capture methane emission from anaerobic decomposition of solid waste could be financed under this scheme. However, the international carbon market crashed after some time. (Zhu, Asnani, Zurbrugg, Anapolsku, & Mani, 2008)

In the financial year 2013-14, the government of India recommended the percentage investment in different aspects of solid waste management. Table 6 gives the details of these recommendations.

Table 6: Recommended cost sharing for MSWM activities

S.No	Activity	Total investment (INR crore)	Required investment (80%) (INR crore)	Share of central government (INR crore)	Share of state government (INR crore)	Share of private partners (INR crore)
1.	Segregation, Collection and Transportation	6,862	5,490	1,922(35%)	1,922(35%)	1,647(30%)
2.	MSW processing plants	11,951	9,561	3,824(40%)	956 (10% as viability gap funding)	4,780(50%)
3.	C&D waste Processing	500	500	150(30%)	100(20%)	250(50%)
4.	Support to non-functional plants	500	500	250(50%)	100(20%)	150(30%)
5.	Common regional Sanitary Landfill Facility (SLF)	3,878	3,102	1024(33%)	1024(33%)	1054(34%)
6.	Rehabilitation and capping of dumpsites	1,000	1,000	500(50%)	200(20%)	300(30%)
	Total	24,691	20,153	7,670	4,302	8,181

Source: (Planning Commission, 2014)

6.2.4 Challenges in the financial support to solid waste management

The municipalities in India are in a poor financial condition. The most important way for municipalities to raise money is through taxes, especially property tax. Property tax is deliberately kept low to avoid public outcry. Moreover, the collection method of property tax is questionable. There are many loopholes in the current collection system and more often than less, the taxed property is under assessed. The ULBs, thus, have to majorly depend on the grants from the government. Another big challenge in the solid waste sector is the manner in which the collected funds are utilized. Ideally, the majority of the share must be spent on the treatment and disposal of waste but the real situation in India is the exact opposite. Most of the funds are spent on the salaries of the staff (Zhu, Asnani, Zurbrugg, Anapolsku, & Mani, 2008). The challenges faced in funding the MSWM projects have been summarized in table 7. Private companies can be encouraged to spend the CSR (corporate social responsibility) funds in developing technologies for waste management or funding ULBs to carry out certain selected projects in the municipalities.

According to a report published by the High Powered Expert Committee (HPEC), total investment required for urban infrastructure over the period 2012 to 2031 amounts to be INR 31 lakh crore. In this estimate solid waste management has been allotted INR 48582 crore, that is, 1.6% of the total investment. The per capita investment cost in solid waste management comes out to be Rs 391 and the per capita annual operation and maintenance cost of the sector is INR 155.

Table 7 Financial Barriers and interventions

Barrier	Intervention
Operation of maintenance of waste management units dependent on grants	Waste treatment facilities can be made self sufficient if they produce products which can be sold in the market eg RDF, compost etc. Improvement in the quality of the final product from waste treatment/processing plants is required.
Poor collection of house tax, which is a major source of funds for waste management	Devising better ways to collect house tax in order to improve its coverage. Also, setting up of tax tariffs must not be influenced by external factors.
Absence of market for products from RDF units and MRFs	Enabling better market conditions to improve the sale of fuel/materials derived from waste
Lack of investments	Devising better schemes to attract private investors
Less involvement of waste producers, especially industries	Promoting CSR initiatives in waste sector
No motivation to limit waste produced	Providing incentives to households producing less waste and/or fine for household producing more waste
Limited scope of re-selling products out of use	Promoting weekly markets for selling second hand products

6.3 Use of Economic Instruments

A report by European Commission in 2012 recommended some economic instruments which may promote efficient waste management.

- Disposal of waste is the least preferred option in the waste management hierarchy, as mentioned earlier. Introduction of landfill taxes could be a way to discourage disposal of waste and promote reuse and recycling.

- The responsibility of management of certain mass produced products must be on the producers. The study reveals that arrangements like a private body specifically designed for collection and recycling of waste owned collectively by obligated producers are successful. The producers must be fully responsible for funding the schemes and then later recover the costs by marketing the recycled products. The success of EPR scheme in Belgium which achieves 92% collection and 95% recycling proves the efficiency of EPR.

- While managing solid waste priority must be on the hierarchy in which the management is preferred. The Pay As You Throw (PAYT) scheme promotes the hierarchy. The aim of PAYT is to structure charging system, at the collection level, in such a way that the residual waste in the waste stream in minimal. This will encourage the recycling of the waste.

- Imposing taxes on virgin materials will encourage re-use and recycling of the waste material. However, in practice, this scheme has many obstacles. For instance, the challenge to the implementation of this scheme in EU was the on-going trade within the EU countries and also between EU and other nations.

- The quantity of residual waste generated per inhabitant of a household is an indicator of consumption level and the degree to which the waste generated is recycled and reused. Establishing a benchmark of residual waste per inhabitant of a household and then imposing proportional taxes for exceeding the benchmark and re-imbursements for generating less waste could be employed to discourage waste generation.

- Existing VAT Directive (2006/112/EC) is another way of reducing the waste, for example, reduced VAT on repairing large household appliances is step towards promotion of re-use rather than increasing consumption.

The situation of waste management in India is certainly different from that of countries in Europe; however, India is heading the same direction. For example, the consumption rate of finished products had always been low on account repair and re-use of products. This trend is now changing because the facilities for repairing are slowly losing their market to cheap use-and-throw products. The government should take initiatives to ensure that market to repair goods should remain in business. This will not only promote the longevity of products (hence, reduced waste) but will also encourage employment in these sectors.

6.4 Public private partnership

In India, typically, the government has been responsible for provision of funds for public utility projects like roads, sanitation, health, water supply and so on. However, it was observed that the available funds for development purposes were not adequate. Thus, Public Private Partnership (PPP) was introduced as a financing solution to developmental activities.

It is believed that the PPP increase the efficiency of the operation, make use of latest technologies and provide an overall better service. The reasons being - financial and managerial autonomy, as well as, accountability. In case of municipal solid waste management, PPP has been practiced in door to door collection, street sweeping, secondary collection of waste, transportation of waste, composting and power generation from waste and disposal. The main challenges observed in practicing PPP in Indian scenario were lack of accurate estimation of quantity of municipal solid waste, the available technologies required segregations of highest orders and often some other material had to be added to the waste in order to process it with the available technologies. Moreover, projects like

RDF/Pellets did not have a market to sell the products produced by them. It was also observed that certain technologies like combustion of waste were causing damage to the air quality and required huge capital investment. (JNNURM, 2011). The projects involving PPP under JnNURM are tabulated below.

Table 8: Projects involving PPP under JnNURM

S.No.	Name of the project	Place	Project cost (INR Crs.)	Source of Financing	Remarks
1.	Solid waste upgradation system	Surat, Gujarat	99.00	ACA share: 26.25 Cr State Government's share: 10.50Cr ULB share: 15.75 Cr PPP share: 46.5	The project was carried out in three phases
2.	Design, development, operation & maintaenance of secured engineered landfill at Jumbua in Vadodara	Vadodara, Gujarat	30.98	ACA share: 15.49 Cr State Government's share: 6.19 Cr ULB share: 9.30 Cr PPP share: Nil	PPP without capital contribution
3.	MSWM Asansol-Durgapur Area	Asansol-Durgapur	43.57	ACA share: 21.79 Cr State Government's share: 8.71 Cr ULB share: 4.66 Cr PPP share: 8.41 Cr	
4.	Integrated solid waste management for Puducherry	Puducherry	108.00	ACA share: 39.73 Cr State Government's share: 9.93 Cr ULB share: Nil PPP share: 58.34 Cr	BOOT (Build Own Operate Transfer) type PPP
5.	Solid waste management fot 13 ULBs of Kolkata Metropolitan Area (KMA)	Kolkata, West Bengal	111.97	ACA share: 39.19 Cr State Government's share: 39.19 Cr ULB share: Nil PPP share: 33.59 Cr	BOT(Build Operate Transfer) model

S.No.	Name of the project	Place	Project cost (INR Crs.)	Source of Financing	Remarks
6.	MSWM in Agra	Agra, Uttar Pradesh	31.20	ACA share: 15.42 Cr State Government's share: 6.17 Cr ULB share: 9.25 Cr PPP share: 0.36 Cr	BOOT, management, service contract
7.	SWM for Kanpur	Kanpur, Uttar Pradesh	92.47	ACA share: 28.12 Cr State Government's share: 11.25 Cr ULB share: 16.87 Cr PPP share: 36.23 Cr	BOOT Type
8.	Integrated waste management	Dehradun, Uttarakhand	24.60	ACA share:19.68 Cr State Government's share: 2.46 Cr ULB share: 2.46 Cr PPP share: Nil	
9.	Integrated municipal solid waste Management Project	Alandur, Pallavapuram and Tambaram, Chennai	44.21	ACA share: 15.47 Cr State Government's share: 6.63 Cr ULB share: Nil PPP share: 22.11 Cr	BOT type arrangement
10.	Solid waste management of Chennai Corporation	Chennai, Tamil Nadu	255.32	ACA share: 12.77 Cr State Government's share: 5.47 Cr ULB share: 18.23 Cr PPP share: 218.85 Cr	BOOT type arrangement
11.	Integrated solid waste management in Madurai Corporation	Madurai, Tamil Nadu	74.29	ACA share: 37.15 Cr State Government's share: 14.85 Cr ULB share: 5.19 Cr PPP share: 17.1 Cr	BOOT type PPP model

Source: (JNNURM, 2011)

6.5 Use of technology

As shown in figure 2, out of the total waste generated in India 55% is organic waste, 15% is recyclable waste and the remaining 30% is residual waste (Zhu, Asnani, Zurbrugg, Anapolsku, & Mani, 2008).

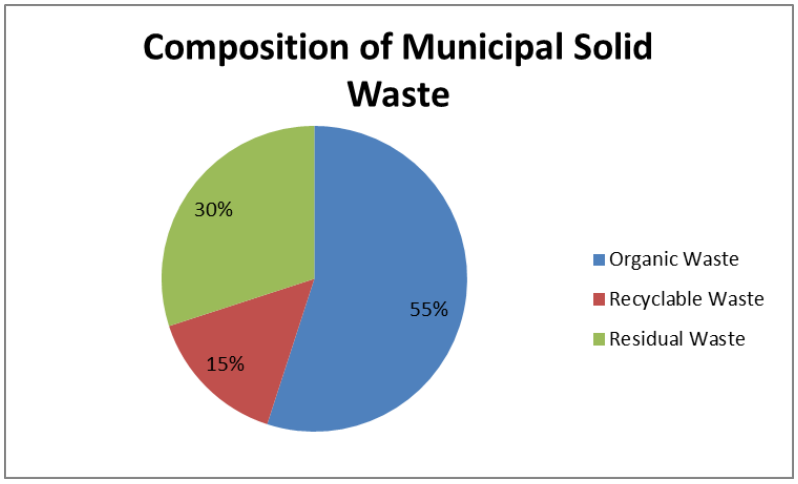


Figure 2 Composition of Municipal Solid Waste in India

(Zhu, Asnani, Zurbrugg, Anapolsku, & Mani, 2008)

This waste composition indicates that the waste generated in India has a high potential to be treated and re-utilized. The organic waste can be composted and recyclable waste can be used for material recovery. This implies that only 30% of the waste generated in India must be disposed in landfills. However, as mentioned earlier, the actual situation is opposite. Only 12.45% of the waste generated is treated, rest is either dumped into landfills without any treatment or remains uncollected.

Improving the waste collection efficiency and developing suitable technologies for waste segregation, transportation, treatment and disposal could be a step towards the solution of this problem.

6.5.1 Collection

As mentioned earlier, out of the total solid waste generated in India only 70% of waste is collected. The remaining waste remains in the streets creating unsanitary living conditions. This calls for an intervention in the collection system in India.

Collection of waste is generally divided in two categories, primary collection and secondary collection. The collection of waste from the source like houses, commercial establishments, markets and so on is primary collection. When waste is collected from storage places like bins and finally transported to processing units or disposal sites, it is termed as secondary collection.

In India, primary collection is usually a door to door collection from households facilitated by using push-carts, tri-cycles, mechanized vehicles or compactors depending upon the location of the area. It is usually noted that less influential areas with narrow lanes like

slums is not included in the collection drives. This leads to unsanitary living conditions in the urban areas.

Role of the informal sector: The informal sector plays a very important role in waste collection. Typically, the informal sector has two types of arrangements for waste collection – 'kabadi system' and rag pickers.

Individuals or small enterprises generally constitute the 'kabadi system'. This is a door to door collection service, where recyclable waste like plastics, paper, batteries and are collected from households and then later sold to a wholesaler. The wholesaler then sells this waste to recycling units. Even though unorganized and not legally registered, this system is highly efficient in collecting, as well as, segregating the recyclable waste. Since mostly the collection and segregation is manual, the GHG emissions are minimal.

Rag pickers on the other hand manually pick up waste from the streets and dumping sites which can be recycled and re-used but discarded by their previous owners. However, rag pickers are one of the most exploited groups in the society due to absence of laws to protect them. They are also exposed to health damage and infection while manually sorting the waste without any protection.

There is a need to integrate these informal arrangements into formal waste collection. This will increase the efficiency and optimize the resources spent on the waste collection and segregation in India. This can be done with the help of NGOs and self-help groups. Local frames and by-laws must also be framed to accommodate the needs and requirements of workers in informal sector.

Box 2: Case study on efficient collection system

Case Study: Unsatisfied with municipal solid waste management system local people in Shimla, Himachal Pradesh raised complaints against the municipal authority. As a result, the high court of HP issued directives to improve waste management which eventually led to establishment of Shimla Environment Heritage Conservation and Beautification Society (SEHB) in 2009.

The SEHB is headed by the Municipal Commissioner and the primary objective is to reduce littering by increasing the waste collection efficiency. A proper methodology of waste collection and daily routes of collection drives has been defined. A central system has also been dedicated to take complaints and feed backs from users. The SEHB workers are provided with uniforms, identity cards and regular health checkups.

So far, SEHB has more 90% coverage in 25 wards. The public complaints are regularly duly considered and remedial actions are taken in time. Since the users are charged for the collection facility the society is sustainable and self-sufficient.

The segregation of wet waste in composting plants usually requires manual labor. However, further segregation of dry waste can be done mechanically. Some of the processes utilized to further segregate dry waste are:

- **Screening**: Separation of waste stream according to size of the waste particles.
- **Ferrous metal separation**: Ferrous metals can be separated from the waste stream by using electro-magnets.

- **Air classification**: Waste can also be segregated on the basis of the difference in their weight by passing the waste through air stream of an appropriate velocity. Horizontal air classifier, Vibrating inclined air classifier and inclined air classifier are the three kinds of air classifiers.

- **Non-ferrous metal separation:** The difference in the electrical conductivity of the metal can be utilized in separating metals like zinc, aluminium, copper, lead and nickel. Usually, an eddy current separator is used for such purposes.

- **Detect and route system**: Nature of the material is usually determined using optical signals and then depending upon the signal received the desired waste is directed in a specific direction using air jets. This is used to separate different grades of paper, glass and plastics.

The separated waste is finally reduced in size and baled for further processing (CPHEEO, 2014).

6.5.2 Recycling

Recovery of the material from the waste is an important step in waste management. This not only reduces the volume of waste but also prevents over exploitation of natural resources. Paper and plastics are the most recycled waste products in India. However, other constituents of municipal wastes like metal scraps and glass can also be recycled. Box 3 shows an example of efficient recycling of paper waste.

Plastic forms 1-10% of total municipal solid waste. According to CPCB, India produces approximately 8 million tons of plastic every year (CPCB, 2012). Plastic waste maybe in the form of bottles, carry bags, cables, pipes, and tea cups. Recycling is the best strategy to handle plastic waste. However, virgin plastic can only be recycled 2-3 times. The strength and utility of plastic is reduced with every recycling cycle. There are safe ways to dispose plastic. It can either be converted to fuel using plasma pyrolysis or liquid fuel, or it can be used in construction of polymer blended bitumen roads.

Box 3: Case study on recycling of paper waste

Case Study: The amount of paper waste generated in India is increasing as the country is economically progressing. Production of paper has huge direct implication on forest and wildlife. Thus, recycling paper waste is the most logical option. 'Waste to Wealth' was an initiative started by the ITC in 2011. The focus area is south of India, particularly, Hyderabad, Bangalore, Coimbatore and Chennai. IT companies like Infosys, IBM and Wipro have agreed to sell their waste to ITC for recycling. They also plan to tie up with RWAs, NGOs and local bodies.

6.5.3 Composting

Biological decomposition of organic waste is known as composting. In India, majority if the waste produced is organic which makes composting a viable technique to handle waste. The technologies used for composting are:

- **Windrow composting:** In this type of composting, the organic waste is stacked into windrows. The windrows are stacked to maximize the exposure to air. They are also constantly turned using mechanical turners. The finished product is rich in organic matter and nutrients with C/N ratio of 20:1 and moisture content of 30 to 35%.

- **Aerated static pile composting:** The waste is placed over piles which are directly above a system of pipes connected to blowers. This helps ensure better aeration, hence, fermentation time and the fuel spent on mechanical turners (in windrow composting) is saved.

- **In-vessel composting:** The composting of waste is done inside a closed vessel like drum, silo, digester bin or tunnel. Conditions like air-flow, moisture content, agitation mechanism and temperature are controlled. This allows more waste to be decomposed in less time. Moreover, with proper care the odour and leachate production can be reduced.

- **Decentralized composting:** Since organic waste decomposes, it is better not to waste time in collection and transportation but rather treat it at the source itself. Decentralized composting is done either at community level in boxes with capacities of 3-5 tons or at individual household level in bins.

- **Vermi composting:** This is composting of bio-degrade able waste with help of earth-worms. The resultant compost is rich in nutrients and can be used as a soil conditioner. Ideally, the vermin-compost beds must have a moisture content of 30-40% and a temperature range of 20-30°C.

6.5.4 Waste to Energy

The waste unfit for recycling and composting must be utilized in waste to energy plants. Waste with low moisture content and high calorific value is suitable for waste to energy plants. Thus, segregation of waste is a necessity for optimal functioning of such plants. The most common waste to energy technology used in India is Refuse Derived Fuel (RDF). Other waste- to- energy techniques include pyrolysis and gasification.

RDF comprises of the non-recyclable municipal solid waste which is processed in order to obtain waste with high calorific value. The objective is to utilize this segregated waste as fuel to generate electricity or any other form of usable energy. The MSW Rules 2000 and Electricity act 2003 provide some guidelines for RDF projects. Moreover, permission and regular monitoring by respective SPCBs is necessary for RDF plants.

The table 9 gives the list of 5 waste-to-energy plants under implementation. All of these projects have received funding from Ministry of New & Renewable Energy (MNRE).

Table 9: Projects which received funding from MNRE

S.No	Place	Private Partners	Status	Technology	Waste Processed	Production
1.	Timarpur-Okhla, Delhi	M/s Jindal ITF Ecopolis	Plant commissioned in 2012	RDF, Incineration	1300 TPD	450 TPD of RDF 16MW of energy
2.	Ghazipur, Delhi	M/s ILFS	Project Under Construction	RDF, Incineration	1300 TPD	433 TPD of RDF 12 MW Energy
3.	Bangalore	M/s Srinivas Gayithri Resource Recovery Ltd and Bruhat Bangalore Mahanagar Palika(BBMP)	Not yet operational.	Incineration	-	8 MW of power
4.	Pune	-	Under Construction	Gasification	700 TPD	10 MW of Electricity
5.	Nalagonda, Hyderabad	-	Under Construction	RDF, Incineration	1000 TPD	11 MW power

Source: (CPHEEO, 2014)

Besides the above mentioned technologies to convert waste into energy, biomethanation is another viable option in the Indian scenario. Biomethanation, is anaerobic decomposition of anaerobic matter with an aim to recover methane which can be used as a source of energy. Box 4 covers an example of successful bio-methanation plant.

Box 4: Case study for biogas technology

Case Study: The Nisarguna Technology developed by the Babha Atomic Research Centre (BARC) is an improvement over the traditional Gobar Gas plants to generate methane for energy purposes. The improvement in the design prevents choking and allows the plant to treat a variety of waste feed. In 1998, the Municipal Corporation of Greater Mumbai, Stree Mukti Sanghatana, Bhabha Atomic Research Centre, Waste pickers cooperatives and Navi Mumbai Municipal Corporation collaborated together to manage the municipal waste by incorporating The Nasirguna Biogas Technology.

Table 10 points out some technical challenges face by the ULBs while executing waste management projects. One of the major challenges is low collection efficiency in almost all of the ULBs. Apart from the institutional interventions if one was to look at the technological solution then sensors installed at the collection site could be an option. The sensors would

send a signal to collection vans when full. The GPS system installed in the vans would then help in optimizing the collection route.

Table 10: Technological barriers and interventions

Barriers	Intervention
Low collection efficiency	Installation of technologies like GPS in collection trucks to monitor and improve the route to increase the amount of waste collected
Long distance transportation of decomposable organic waste	Promoting decentralized composting plants to manage organic waste on the spot
Ground water contamination at landfill sites	Construction of sanitary landfills to contain the flow of leachate and to tap the methane emissions
Lack of waste inventory	Use of IT tools like GIS, remote sensing, optical sensing in central bins and collection vans to create an inventory of the daily waste collected

6.5.5 Deployment of technology

Smart Waste Management System: The major problem with the waste management system in India is inefficiency is waste collection and transportation. A nationwide intervention is required in collection and transportation system.

SM-WMS is providing logistic solutions and constantly developing the mechanism according to needs and previous learning. These solutions are usually a combination of hardware and software developed by IT professionals. The basic objective is to minimize time consumption and investment, and maximize the quality of the service provided. For instance, the collection system can be improvised if the quantity and quality of the waste collected is regularly monitored. This knowledge will eventually help in better planning of collection routes, types of vehicles to be used and identification of critical areas which, probably, need special attention. Technologies like optical sensors could be used for high quality segregation of waste which will minimize the economic losses and provide a better input for specialized processing units.

The municipal corporation of Coimbatore is using an online waste truck monitoring system using radio frequency identification linked with waste transfer stations and processing units. The Bhopal Municipal Corporation saved up to 2000-3000 liters of diesel per day only by installing GPS devices in about 50 waste trucks.

Information Communication Technology: Integrating the information technology with the existing waste management system can have a huge impact on the condition of the waste sector in India. Technologies like GPS, GIS, remote sensing, online web services and cloud computing can find some real time application in waste management. For example, trucks and bins can be installed with remote optical sensors which can constantly record the data of type and amount of waste collected at various locations and create a database. This database

can be instrumental in understanding, analyzing and predicting the waste production patterns, and eventually manage waste more efficiently. (Ion & Gheorghe, 2014) (Planning Commission, 2014).

7 Ways forward

Greening the waste sector is expected to generate substantial economic, environmental and social benefits. They include: 1) natural resource and energy saving; 2) creation of new businesses and jobs; 3) compost production supporting organic agriculture; 4) energy production from waste; 5) reduced GHG emissions; and 6) contributions to equity and poverty eradication. Improved health, avoided health costs, avoided water contamination, and the consequent cost of alternative water supply are also important streams of benefits.

Though the figures for job creation while greening the sector is not available as of now for India; similar experiences in other developing countries show that the activity does create better quality of jobs. Over half a million waste pickers have been reported in Brazil and the country has close to 2,400 companies and cooperatives involved in recycling and scrap trading (UNEP 2008). In Buenos Aires, an estimated 40,000 waste scavengers are estimated to have an economic impact of US$1.78 million per year, close to 0.05% of the city's GDP (Medina 2008). Other estimates put the number of waste scavengers in India at least at a million, while in China up to 10 million workers are reportedly involved in recycling activities (UNEP 2008). Scheinberg et al. (2010) studied informal recyclers in six cities: Cairo, Egypt; Cluj-Napoca, Romania; Lima, Peru; Lusaka, Zambia; Pune, India; and Quezon City (part of Metro Manila), the Philippines, and found that more than 75,000 individuals and their families are engaged in recycling about 3 million tonnes of waste per year with an economic value of more than US$ 120 million.

The situation of solid waste management has certainly improved over the years. However, there is still a long way to go. Instead of following the usual end of pipe approach, waste management must be looked at holistically and preference must be given to reduction of waste at the source. The waste management system is blocked at collection stage, which is inefficient and consumes most of the funds and time. Instead of working against the informal sector, it is important to recognize the importance of informal sector and incorporate it into the formal waste collection system. Waste processing and disposal deserve more strategic and financial importance. There is need to maximize resource recovery from waste and waste recycling to reduce the land requirement for waste disposal.

As regards to municipal solid waste and other urban waste streams like e-waste, construction and demolition debris, partnership of various stakeholders viz. ULBs, private formal and informal waste managers, waste generators, and regulatory agencies need to evolve to ensure that waste management is carried out in most efficient manner. The ULBs in India are running low on funds. The current mechanisms to raise funds for waste management must be improvised. Also, it must be realized that municipalities can no longer 'provide' all the waste management services in isolation. The aspects of waste management which the municipalities can handle efficiently must be identified and private players must be given a chance to manage the remaining aspects. The government must alter policies in

such a way that private sector is encouraged to invest, establish and operate facilities in the waste management sector. The key strategies for efficient management of waste as part of greening the waste sector would include:

- **Waste reduction strategies:** Waste reduction strategies involve lesser generation of waste at source and using alternative material which generate waste of lesser hazard as compared to traditionally used ones. It is necessary to decouple the waste generation process from the growth of economy and population. Various ways in which this can be achieved are:

    a. Alternative packaging – use of fabric or jute packaging instead of traditionally used polythene bags which are difficult to collect and recycle (reviving of jute sector)

    b. Designing products like cell phones and other electronic goods for longer shelf life so that they enter the waste stream a little later

    c. Designing products for disassembly so that majority of their components can be recycled at the end-of-life

    d. Developing re-manufacturable products to increase their life cycle

- **Waste inventory:** In absence of dynamic waste inventory, long term planning for waste management becomes difficult. Each municipality should maintain a complete database for its waste management activities, particularly generation of waste (daily data), characteristics of waste (monthly data), processing facilities actually installed and operated and their performance (monthly data) and final disposal in a sanitary landfill (monthly data).

- **MSW to composting:** Excessive use of chemical fertilizers and resulting run off is resulting in pollution of soil and water bodies and is key non-point source of pollution. The top soil as a result of over irrigation is also getting depleted in organic carbon which affects soil fertility. As stated earlier, MSW in India comprises of around 50% organic or food waste with high moisture content. This waste (food waste, agricultural residues, etc.) can be composted either aerobically or anaerobically. This process not only treats the waste, diverting it from landfill (thus saving on cost of disposal) but also the compost produced can enrich the top soil with organic carbon which is key to soil fertility. The process is net GHG saver as compared to open dumping of waste which results in uncontrolled emission of methane. Decentralized, community composting options should be explored wherever feasible (away from residential areas to avoid community conflicts)

- **MSW to energy:** Viability of producing energy from MSW (woody waste, agricultural residues, food waste, waste papers and plastics) and extraction of landfill gas from 'open but soon to be closed waste dumps' can not only treat the waste but also provide renewable source of energy to 'energy starved' cities. Technologies like anaerobic digestion (producing power as well as compost), use of refuse derives fuel and landfill gas will be explored for processing such waste. These

processes also would be net GHG saver as compared to open dumping of waste which results in uncontrolled emission of methane. Decentralized biomethanation options as implanted in Pune should be explored for other cities as well. The Ministry of New and Renewable Energy (MNRE) estimates that there is potential of generating around 2500 MW of energy from processing of waste in the country.

- **Material recovery and recycling:** India reportedly salvages and recycles around 70% of MSW, though most of it is collected and recycled by informal sector using rudimentary technologies. It is reported that in developing countries around 15-20 million people are engaged in waste recycling activities – in some cities 2% of the population. More than 1 million people are engaged in waste recycling activities in India. It is also reported that informal sector (waste pickers) remove around 10-15% of waste every day from city streets and are key to solid waste management system in any city. There should be efforts to institutionalize informal sector and modernization of recycling technologies. Informal waste recyclers can be trained to collect the waste from households, do decentralised waste processing (composting or biogas) and trade recyclable waste as is demonstrated by Stree Mukti Sangathan in Mumbai.

The goals of greening the waste sector cannot be achieved without increased investment. Minimising waste generation requires changes to product design and production processes upstream. Downstream recovering, remanufacturing, recycling, and final treatment require new facilities or upgrading of existing facilities. Investment is also needed to train the labour force in the sector as well as to formalise the informal sector.

Cities in India typically spend more than half of their waste budget in collection alone (mainly on labour and fuel), although the collection rate remains low and the transport of waste inefficient. Spending on other segments of the waste management chain such as appropriate treatment, recovery and disposal technologies and facilities is generally rather low. Increased investment in basic collection services, the transport of waste and cleaning up dumpsites is a starting point for greening the sector. Investment can be targeted, for example, at techniques such as route optimisation and transfer stations, which can bring down the capital and operational costs of providing waste services.

The incentives commonly prevalent in the waste sector include: 1) taxes and fees; 2) recycling credit and other forms of subsidies; 3) deposit-refund; and 4) standards and performance bond or environmental guarantee fund. Volumetric landfill taxes can encourage the reduction of waste and are easy to implement. Their effectiveness, however, depends on the tax rate per tonne of waste and on the existence of adequate monitoring and enforcement measures. It is also important to ensure that the tax does not result in increased illegal dumping rather than encouraging 3Rs.

Pay-as-you-throw (PAYT) is another way of discouraging waste generation. Precaution against illegal waste dumping or misuse of recycling facilities is however needed. Full financing of the waste-management infrastructure has to be assured and sufficient awareness-raising is necessary. PAYT has a positive impact on recycling. For example,

PAYT increased the recycling rate from 7% to 35% in Portland, Oregon and from 21% to 50% in Falmouth, Maine in just one year of implementation (Shawnee Kansas 2009).

Waste avoidance can also be achieved by assigning a disincentive for items such as plastic bags. For example, Nagoya city in Japan, after extensive consultation with retailing companies and two years of piloting, assigned a charge for plastic shopping bags in April 2009. The scheme was adopted by 90% of the shopping market. The initiative reduced plastic-bag usage during shopping by 90% as of December 2009. About 320 million bags weighing 2,233 tonnes were estimated to have been saved between October 2007 and October 2009 (Environmental Affairs Bureau 2010).

The following enabling conditions are important:

- *Finance:* Investing in greening the waste sector requires substantial financial resources for both capital expenditures and operation. Such resources may be found from: 1) private investments; 2) international funding 3) cost recovery from users; and 4) other innovative financing mechanisms.

- *Incentives and disincentives:* Economic incentives and disincentives serve to motivate consumers and businesses to reduce waste generation and dispose of waste responsibly, thereby contributing to increased demand for greening the waste sector.

- *Institutional arrangement between formal and informal sectors:* It is important to formalise the informal sector enterprises and support them through incentives in order to develop local markets and small and medium formal recycling enterprises. Incentivising formal recycling activities, providing micro-finance and access to the markets could help in shifting the informal sector to formal regime. In addition, raising awareness on the social and health related benefits of formalisation may help in understanding importance of intangible benefits.

- *Policy and regulatory measures:* The most common types of policy and regulatory measures include:

    - Regulated targets for minimisation, reuse, recycling; and required targets for virgin materials displacement in production inputs;

    - Regulation relevant to the waste management 'market', i.e. permitting/licensing requirements for waste handling, storage, treatment and final disposal; and recycled materials standards; facilities standards, including pollution control technologies; and

    - Land-use policies and planning for siting waste processing and disposal infrastructure.

8 References

Jaiswal, A., & Bharat, A. (2013). Assessing Institutional and Regulatory Framework for Solid Waste Management in India. *International Journal of Regulation & Governance*, *13*(2).

de Sousa Jabbour, A. B. L., Jabbour, C. J. C., Sarkis, J., & Govindan, K. (2014). Brazil's new national policy on solid waste: challenges and opportunities. *Clean Technologies and Environmental Policy*, *16*(1), 7-9.

Pires, A., Martinhi, G., & Chang, N.-B. (2010). Solid waste management in European countries: A review of systems analysis techniques. *Journal of Environmental Management* , 1033-1050.

JNNURM. (2011). *Municipal Solid Waste Management: Treatment Process and Prospects of Public Private Partnership.* GoI

Planning Commission . (2012). *Twelfth Five Year Plan (2012–2017) Faster, More Inclusive and Sustainable Growth.*.GoI

Zhu, D., Asnani, P., Zurbrugg, C., Anapolsku, S., & Mani, S. (2008). *Improving Municipal Solid Waste Management in India.* The World Bank.

Asnani, P. U. (2006). India Infrastructure Report. *Oxford Press*

Ministry of Urban Development. *National Urban Sanitation Policy.*

Marshall, R. E., & Farahbakhsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management*, *33*(4), 988-1003.

CPHEEO. (2014). *Municipal Waste Management Manual.* Ministry of urban Development.GoI

JNNURM. (2012). *Toolkit for Solid Waste Management.* MoUD.GoI

CPCB. (2012). *Status report on municipal solid waste management.* CPCB.

CPCB. (2012). *Annual Report:Implementation of Plastic Waste Management.* CPCB.

Department of Economic Affairs, Ministry of Finance . (2009). *Position paper on solid waste management in India* . GoI.

Planning Commission . (2014). *Report of the Task Force on Waste to Energy (Volume I).* GoI

Ion, I., & Gheorghe, F. F. (2014). The innovator role of technologies in waste management towards the sustainable development. *Science Direct* .

High Powered Expert Committee. (2011). *Indian Urban Infrastructure and Services.* New Delhi: Ministry of Urban Development.

CPCB. (2013). *Status od municipal solid waste management.* CPCB.

About TERI

A unique developing country institution, TERI is deeply committed to every aspect of sustainable development. From providing environment-friendly solutions to rural energy problems to helping shape the development of the Indian oil and gas sector; from tackling global climate change issues across many continents to enhancing forest conservation efforts among local communities; from advancing solutions to growing urban transport and air pollution problems to promoting energy efficiency in the Indian industry, the emphasis has always been on finding innovative solutions to make the world a better place to live in. However, while TERI's vision is global, its roots are firmly entrenched in Indian soil. All activities in TERI move from formulating local- and national-level strategies to suggesting global solutions to critical energy and environment-related issues. TERI has grown to establish a presence in not only different corners and regions of India, but is perhaps the only developing country institution to have established a presence in North America and Europe and on the Asian continent in Japan, Malaysia, and the Gulf.

TERI possesses rich and varied experience in the electricity/energy sector in India and abroad, and has been providing assistance on a range of activities to public, private, and international clients. It offers invaluable expertise in the fields of power, coal and hydrocarbons and has extensive experience on regulatory and tariff issues, policy and institutional issues. TERI has been at the forefront in providing expertise and professional services to national and international clients. TERI has been closely working with utilities, regulatory commissions, government, bilateral and multilateral organizations (The World Bank, ADB, JBIC, DFID, and USAID, among many others) in the past. This has been possible since TERI has multidisciplinary expertise comprising of economist, technical, social, environmental, and management.

The Energy and Resources Institute
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