# Sustainable Waste Management Issues in India

Shikha Saxena*, R K Srivastava** and A B Samaddar***

Solid waste management (SWM) has become a global issue and is of a major concern, especially in developing countries, due to various environmental problems, such as pollution of air, soil and water and generation of greenhouse gases from landfills. Municipal authorities generally fail in fulfilling their adequate services due to insufficient funds and ineffective legislation. The present work shows the current waste management practices of municipal solid waste management (MSWM) of India, including collection, transportation, treatment and disposal systems. It also highlights the possible improvement for sustainable solid waste management considering the technological, institutional and financial factors. A conceptual framework for upgrading the technological aspects is also provided.

***Keywords:*** Open dumps, Solid waste, Urban Local Bodies (ULBs), Waste generation, Waste treatment

## Introduction

Human activities create waste, and these wastes are handled, stored, collected and disposed of, which can pose risks to the environment and to public health (Zhu *et al*., 2008). Rapid urbanization and industrialization in India have resulted in overstressing of urban infrastructure services, including municipal solid waste (MSW) services. Civic bodies are facing considerable difficulties in providing adequate services, such as supply of water, electricity, roads, education and public sanitation, including MSWM (Joseph, 2002). The management of MSW is going through a critical phase due to the nonavailability of suitable facilities to treat and dispose of the increasingly large amount of MSW generated daily in metropolitan cities. The MSW amount is expected to increase significantly in the near future as the country strives to attain industrialized nation status by the year 2020 (Shekdar *et al*., 1992; and CPCB, 2004). Major portion of the problem of solid waste management (SWM) arises from urban areas of India. Unscientific disposal causes an adverse impact on all components of the environment and human health (Gupta *et al*., 1998; Kansal *et al*., 1998; Singh and Singh, 1998; Kansal, 2002; Jha *et al*., 2003; and Rathi, 2006). To ensure better human health and safety, there is a need for effective SWM systems which should be both environmentally and economically sustainable. The present paper

* Research Scholar, Department of Civil Engineering, MNNIT, Allahabad 211004, India. E-mail: Shikha_alld@yahoo.com

** Professor, Department of Civil Engineering, MNNIT, Allahabad 211004, India; and is the corresponding author. E-mail: rksciv@yahoo.com

*** Director, Department of Civil Engineering, MNNIT, Allahabad 211004, India. E-mail: director@mnnit.ac.in

highlights the waste management practices in India including the generation, collection, segregation, treatment, transportation and final disposal. Recommendations for achieving sustainable SWM are provided.

Augmentation of SWM facilities and their operation and maintenance in a sustainable manner by the urban local bodies would not only require huge capital investment, but also introduction of latest and cost-effective technologies. These approaches can all be integrated in the four aspects covered in this paper. These aspects are technological, institutional and financial. Further, it has been mentioned in the present work that incorporation of GIS technologies can highly upgrade the technological aspects of sustainable SWM by using GIS as an effective tool for data storage and handling.

## Indian Waste Management Scenario

### Waste Generation

The quantity of MSW generated (Table 1 and Figure 1) depends on a number of factors, such as food habits, standard of living, degree of commercial activities and seasons. Data on quantity variation and generation are useful in planning for collection and disposal systems. The increasing urbanization and changing lifestyles have increased the waste generation rate of Indian cities. In India, the amount of waste generated per capita is estimated to increase at a rate of 1-1.33% annually (Shekdar, 1999).

**Table 1: Municipal Solid Waste Generation Rates in Different States in India**

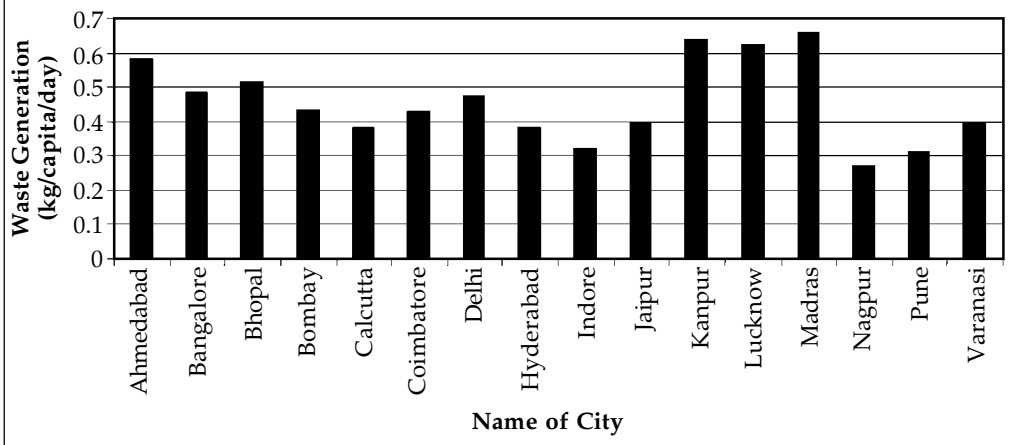
| Name of State | No. of Cities | Municipal Population | MSW (t/day) | Per Capita Waste (kg/day) |
|---|---|---|---|---|
| Andhra Pradesh | 32 | 10 ,845,907 | 3,943 | 0.364 |
| Assam | 4 | 878,310 | 196 | 0.223 |
| Bihar | 17 | 5,278,361 | 1,479 | 0.280 |
| Gujarat | 21 | 8,443,962 | 3,805 | 0.451 |
| Haryana | 12 | 2,254,353 | 623 | 0.276 |
| Himachal Pradesh | 1 | 82,054 | 35 | 0.427 |
| Karnataka | 21 | 8,283,498 | 3,118 | 0.376 |
| Kerala | 146 | 3,107,358 | 1,220 | 0.393 |
| Madhya Pradesh | 23 | 7,225,833 | 2,286 | 0.316 |
| Maharashtra | 27 | 22,727,186 | 8,589 | 0.378 |
| Manipur | 1 | 198,535 | 40 | 0.201 |
| Meghalaya | 1 | 223,366 | 35 | 0.157 |

Table 1 (Cont.)

| Name of State | No. of Cities | Municipal Population | MSW (t/day) | Per Capita Waste (kg/day) |
|---|---|---|---|---|
| Mizoram | 1 | 155,240 | 46 | 0.296 |
| Orissa | 7 | 1,766,021 | 646 | 0.366 |
| Punjab | 10 | 3,209,903 | 1,001 | 0.312 |
| Rajasthan | 14 | 4,979,301 | 1,768 | 0.355 |
| Tamil Nadu | 25 | 10,745,773 | 5,021 | 0.467 |
| Tripura | 1 | 157,358 | 33 | 0.21 |
| Uttar Pradesh | 41 | 14,480,479 | 5,515 | 0.381 |
| West Bengal | 23 | 13,943,445 | 4,475 | 0.397 |
| Chandigarh | 1 | 504,094 | 200 | 0.475 |
| Delhi | 1 | 8,419,084 | 4,000 | 0.295 |
| Pondicherry | 1 | 203,065 | 60 | 0.376 |

*Source: Status of MSW generation, collection, treatment and disposal in Class-I cities, (CPCB, 2000b)*

**Figure 1: Per Capita Generation Rate of MSW for Indian Cities**



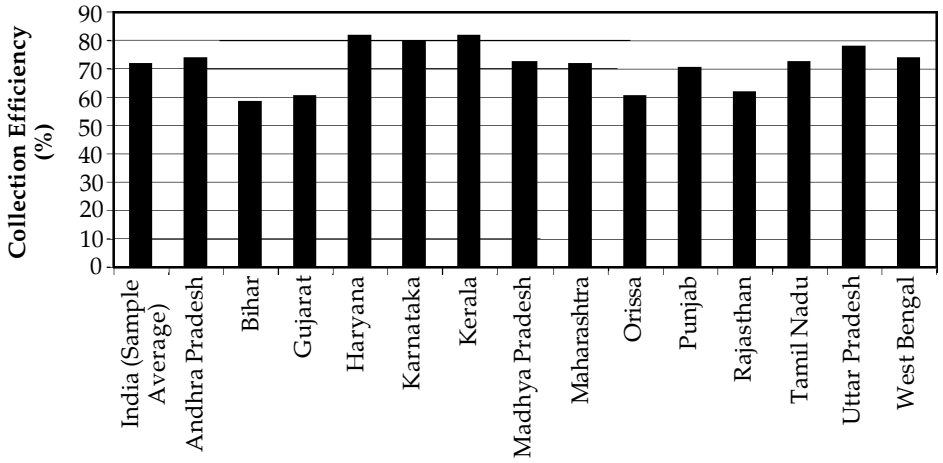

*Source: CPCB (2004)*

## Waste Collection

The waste collection in India is very unorganized. The collection bins used in various cities are neither properly designed nor properly located and maintained. This has resulted in the poor collection efficiency. The average collection efficiency for MSW in Indian cities and states is about 70% (Khan, 1994; Maudgal, 1995; Gupta *et al*., 1998; Nema, 2004; Rathi, 2006; and Siddiqui *et al*., 2006). Figure 2 shows the collection efficiency of MSW in the Indian states. The Central Pollution Control Board (CPCB) has collected data for the

299 Class-I cities to determine the mode of collection of MSW. It has been observed that manual collection comprises 50%, while collection using trucks comprises only 49% (CPCB, 2000b).

**Figure 2: Per Capita Collection Efficiency of MSW for Indian States**




## Transportation

Most of the Indian cities are lacking proper transportation system for SWM. Transport capacity to carry municipal solid waste in 44 Indian cities is shown in Table 2. It is clear that about 70% of Indian cities do not have such capacity. The figure might be higher, considering that the fleet in most cities is old and its performance very poor. The collection, transportation and disposal of waste are labor-intensive activities because modern, automated systems are not used. In recent years, the number of cities that are short of municipal workers has increased (Table 3). The prime reason for this is the government's

**Table 2: Transport Capacity to Carry Municipal Solid Waste**

| Capacity (Cubic Meters/ Million Population) | Cities (%) (44 cities) |
|---|---|
| <100 | 4.5 |
| 100-200 | 34.1 |
| 200-300 | 29.6 |
| 300-400 | 25.0 |
| >400 | 6.8 |

*Source: Bhoyar et al. (1996)*

**Table 3: Manpower for Solid Waste Management**

| No. of Workers/Million Population | Cities (%) | |
|---|---|---|
| | For Year 1971 (40 Cities) | For Year 1989 (155 Cities) |
| 1,000-2,000 | 47.5 | 25.2 |
| 2,000-3,000 | 27.5 | 11.0 |
| 3,000-4,000 | 18.5 | 5.2 |
| 4,000-5,000 | 7.5 | 1.3 |
| >5,000 | – | 1.3 |

*Source: Bhide and Sundaresan (1984), "National Institute of Urban Affairs 1989"*

policy to restrict employment. As a result, on an average, less than three-fourths of the waste is collected.

## MSW Treatment

In India, the treatment option that is widely accepted and also suitable for Indian MSW is composting. Though other treatment options, which include incineration, pelletization and biomethanation, are also adopted at some places, there are also many examples of their failure, while successful stories are only a few.

### *Composting*

As far as large-scale composting is concerned, many mechanical compost plants with capacities ranging from 150 to 300 tons/day were set up in the cities of Bangalore, Baroda, Mumbai, Calcutta, Delhi, Jaipur and Kanpur during 1975-1980 under the central scheme of MSW disposal (Sharholy *et al*., 2006). MSW composting in India was carried out in Indore and the processing name was also named after it. Now, about 9% of the MSW is treated by composting (Rao and Shantaram, 1993; Dayal, 1994; Gupta *et al*., 1998; Kansal *et al.*, 1998; Reddy and Galab, 1998; CPCB, 2000a and 2000b; Kansal, 2002; Malviya *et al*., 2002; Sharholy *et al*., 2006; and Gupta *et al*., 2007).

### *Incineration*

Incineration has not been found to be a successful option except at a few places. Further, chances of environmental pollution increases due to toxic emissions if proper measures are not taken. Indian waste has a low calorific value between 700 and 1,000 kilocalories. Therefore, it is not suitable for incineration (Zhu *et al.*, 2008). A large incineration plant was set up in Delhi in 1986, failed, and had to be closed down. However, two power plants using refuse-derived fuel are in operation in Andhra Pradesh—Hyderabad and Vijayawada. Both produce 6.5 megawatts of power, but those plants may be using more agro waste than MSW.

### *Biomethanation*

Anaerobic digestion is the process used for the biological decomposition of organic waste. The organic wastes are hydrolyzed, liquified and gasified with the help of methanogenic bacteria. There exists a large potential for generating power from urban and municipal waste and also from industrial waste in India. The potential is likely to increase further with economic development.

### *Pelletization*

Fuel pellets, also referred to as refused derived fuel (RDF), are small cubes/cylindrical pieces made out of garages. Its calorific value, 4000 Kcal/kg of the product, is quite close to the coal; therefore, it can be a good substitute for coal, wood, etc. Studies were carried

out in India on a plant to process 150 tons per day MSW to 80 tons per day pellets. The plant was funded by the Department of Science and Technology (DST) and was set up in Mumbai in 1991. The plant was closed down due to various reasons and was operated only for a short period.

*Gasification*

This process can be used for MSW treatment after drying, removing the inerts and shredding for size reduction (Sharholy *et al*., 2006). There are two designs of gasifiers that exist in India, the first one is installed in Rajasthan by Narvreet Energy Research and Information (NERI) and the second unit is installed in New Delhi by Tata Energy Research Institute (TERI) (CPCB, 2004; Ahsan, 1999).

A total of 27 waste-to-energy projects had been completed as on March 31, 2005 in India, with an aggregated installed capacity of 45.50 MW. Table 4 gives the state-wise cumulative achievements as on March 31, 2005 and Table 5 shows the relative capital cost of MSWM technological comparison.

**Table 4: Cumulative Achievements as on March 31, 2005**

| State | Achievement (MW) |
|---|---|
| Andhra Pradesh | 25.10 |
| Gujarat | 2.95 |
| Karnataka | 1.00 |
| Madhya Pradesh | 2.73 |
| Maharashtra | 1.90 |
| Orissa | 0.03 |
| Punjab | 1.75 |
| Tamil Nadu | 1.98 |
| Uttar Pradesh | 8.00 |
| **Total** | **45.43** |

*Source: Main Application: Energy Recovery from Wastes (National Science and Technology Entrepreneurship Development Board, 2008)*

**Table 5: Relative Capital Cost of MSWM Technological Comparison**

| Technology | MSW Quantity (T) | Land Required (acres) | Cost (cr.) |
|---|---|---|---|
| Biomenthanation | 150 | 6-7 | 6-7 |
| Pelletization | 125 | 3-4 | 4-5 |
| Incineration | 100 | 2-3 | 6-7 |
| Composting | 150 | 7-8 | 1.5-2 |

*Source: The world bank report (Improving Management of Municipal Waste Solid Waste in India – Overview and Challenges by David Hanrahan, Sanjay Srivastava & A Sita Ramakrishan)*

## Disposal Practices

Disposal system is a matter of what is available than what is suitable. It is observed that dumping sites in many cities are near to river systems, which might result in surface and groundwater contamination, for example, Sabarmati river in Ahmedabad and Rispana river in Dehradun. Some sites which have fulfilled their capacity have just been left to be

used as the home for rodents, birds, flies and scavengers. This is the story of the Indian dumping sites, but steps are being taken for upgrading these sites with the use of landfill mining concept, for example, in Delhi and Mumbai. Only seven cities and towns in India had established sanitary landfill facilities as of 2006 year-end (JNU, 2004). These are Surat, Pune, Ahmedabad, Puttur, Karwar, Navi Mumbai and Bangalore. Steps being taken by the government to improve the situation of SWM system in the municipalities are under progress. The stakeholders are willing to participate and cooperate in the activities for SWM. The Nammakal municipality and Suryapet municipality, India, are the successful examples of zero garbage cities.

## Initiatives Taken by the Government of India for MSWM

Looking at the pathetic situation of SWM practices being adopted by urban local bodies in the country and lack of action plan to solve the problem, the following actions have been initiated by the Government of India to provide technical and financial assistance to the ULBs in management of MSW in a scientific and hygienic manner:

- The Ministry of Environment and Forests, Government of India, notified the 'Municipal Solid Waste (Management and Handling) Rules, 2000' with specific directives to the local bodies, district administrations and the urban development department of the state government for proper and scientific management of municipal solid waste.
- The Ministry of Urban Development published the manual on MSWM in May 2000 to assist Urban Local Bodies (ULBs) in the management of MSW. The manual provides detailed guidelines/methodology for planning, designing, executing and operation and maintenance of SWM schemes. It also provides comprehensive guidelines for processing, treatment and disposal and resource recovery (compost/ energy) from municipal waste.
- Pursuant to the recommendations of the Committee on SWM for Class-I cities constituted by the Hon'ble Supreme Court of India, the Ministry of Urban Development, Government of India, constituted a Technology Advisory Group on Solid Waste Management in August 1999. The Committee finalized its report and the Ministry published the same in May 2005 and circulated the same to all states for reference.
- The Ministry of Urban Development formulated and forwarded a scheme to the 12$^{th}$ Finance Commission, requesting them for devolution of funds to the tune of Rs. 24,455.50 mn for SWM in 423 Class-I cities. The 12$^{th}$ Finance Commission has accordingly recommended devolution of Rs. 25,000.00 mn over a period of five years, starting from April 1, 2005 to March 31, 2010, for providing appropriate

collection and transportation system, compost plants and sanitary landfill for SWM in 423 Class-I cities and state capitals as per 2001 census.

- The Ministry has also launched two programs, i.e., Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT), with a view to provide infrastructure facilities in all the urban areas of the country, including SWM projects with a reform-oriented agenda. Under JNNURM since its inception, 22 SWM projects for 22 cities have been sanctioned so far at a total estimated cost of Rs. 13,902.70 mn by the Ministry of Urban Development.
- Ministry of Non-Conventional Energy Sources is the nodal Ministry for assisting waste-to-energy projects.

## Municipal Solid Waste (Management and Handling) Rules 2000

Realizing the need for proper and scientific management of solid waste, the Municipal Solid Waste (Management and Handling) Rules, 2000 were notified by the Ministry of Environment and Forests, Government of India (Table 6). These rules were framed in order to make the municipalities well aware of their responsibilities so that they can implement the same. Municipal authorities must meet the deadlines laid down in Schedule-I (Table 7) of the rules and must follow the compliance criteria and procedure laid down in Schedule-II. Hence, municipal authorities are responsible for implementing provisions of the year 2000 rules. They must provide the infrastructure and services with regard to collection, storage, segregation, transport, treatment and disposal of MSW. The CPCB is responsible for coordinating the implementation of the rules among the state boards. The municipalities were mandated to implement the rules by December 2003, with punishment for municipal authorities that failed to meet the standards prescribed;

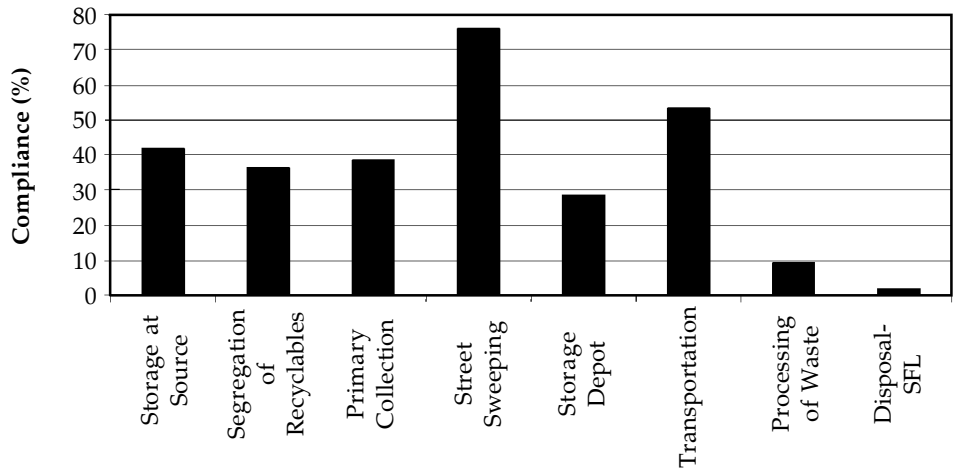
**Table 6: Schedule for Municipal Solid Waste (Management and Handling) Rules**

| | |
|---|---|
| Schedule-I | Relates to implementation schedule. |
| Schedule-II | Specifications relating to collection, segregation, storage, transportation, processing and disposal of MSW. |
| Schedule-III | Specifications for landfilling indicating site selection, facilities at the site, specifications for landfilling, pollution prevention, water quality monitoring, ambient air quality monitoring, plantation at landfill site, closure of landfill site and post-care. |
| Schedule-IV | Indicates waste processing options, including standards for composting, treated leachates and incinerations. |

| Table 7: Four Steps of Schedule-I of 2000 Rules | |
|---|---|
| **Step** | **Completion Date** |
| Set up waste processing and disposal facilities | December 2003 or earlier |
| Monitor the performance of processing and disposal facilities | Once in every six months |
| Improve existing landfill sites as per the provisions of the rules | December 2002 or earlier |
| Identify landfill sites and make sites ready for operation | December 2002 or earlier |
| *Source: Ministry of Environment and Forests (2000)* | |

nevertheless, most municipalities did not meet the deadline. The status of MSW compliance is mentioned in Figure 3 and reasons for noncompliance are given in Table 8. Municipal authorities are required to meet the specifications and standards specified in Schedules III and IV.

**Figure 3: Status of Compliance of MSW Rule 2000 by Class-I Cities as on April 1, 2004**




*Source: Asnani (2004)*

| Table 8: Reasons for Noncompliance of the MSW 2000 Rules | |
|---|---|
| **Area of Compliance** | **Reasons of Noncompliance** |
| Storage of waste at source | • Lack of public awareness, motivation, and education.<br>• Lack of civic sense and bad habits of people like littering.<br>• Lack of cooperation from households, trade, and commerce. |

Table 8 (Cont.)

| Area of Compliance | Reasons of Noncompliance |
|---|---|
| | • Lack of stringent penel provision.<br>• Lack of powers to levy spot fines.<br>• Lack of litter bins in the city.<br>• Long distance between community bins.<br>• Resistance to change in attitude. |
| Segregation of recyclable waste | • Lack of wide publicity through electronic and print media.<br>• Lack of public awareness and motivation, resulting in poor response from citizens.<br>• Lack of citizens' understanding of how to use separate bins for storage of recyclables.<br>• Lack of sufficient knowledge of benefits of segregation.<br>• Lack of cooperation and the negative attitude of people.<br>• Lack of finances to create awareness.<br>• Difficulty in educating slum-dwellers.<br>• Lack of effective legal remedy. |
| Collection of waste from doorstep | • Lack of awareness and motivation.<br>• Unavailability of primary collection vehicles and equipment.<br>• Insufficient response from citizens.<br>• Lack of financial resources.<br>• Difficulty in motivating slum-dwellers.<br>• Lack of personnel for door-to-door collection.<br>• Lack of suitable containers. |
| Daily sweeping of streets | • Excessive leave and absenteeism of sanitary workers.<br>• Unavailability of workers on Sundays and public holidays.<br>• Kuchha (unpaved) roads.<br>• Lack of financial resources. |
| Abolition of open waste storage depots and placement of containers | • Lack of financial resources for placement of containers. |

Table 8 (Cont.)

| Area of Compliance | Reasons of Noncompliance |
|---|---|
| | • Lack of planning for waste storage depots.<br>• Inaccessible areas and narrow lanes that do not allow sufficient space for containers. |
| Transportation of waste in covered vehicles | • Old vehicles that are difficult to replace. |
| Processing of waste | • Lack of financial resources.<br>• Lack of technical know-how.<br>• Lack of skilled personnel.<br>• Unavailability of appropriate land.<br>• Lack of basic facilities to set up treatment plants.<br>• Lack of institutional capacity. |
| Disposal of waste at the engineered landfill | • Lack of financial resources.<br>• Lack of technical personnel.<br>• Lack of technical knowledge for scientific disposal of waste.<br>• Unavailability of appropriate land.<br>• Lack of institutional capacity. |
| *Source: Asnani (2004)* | |

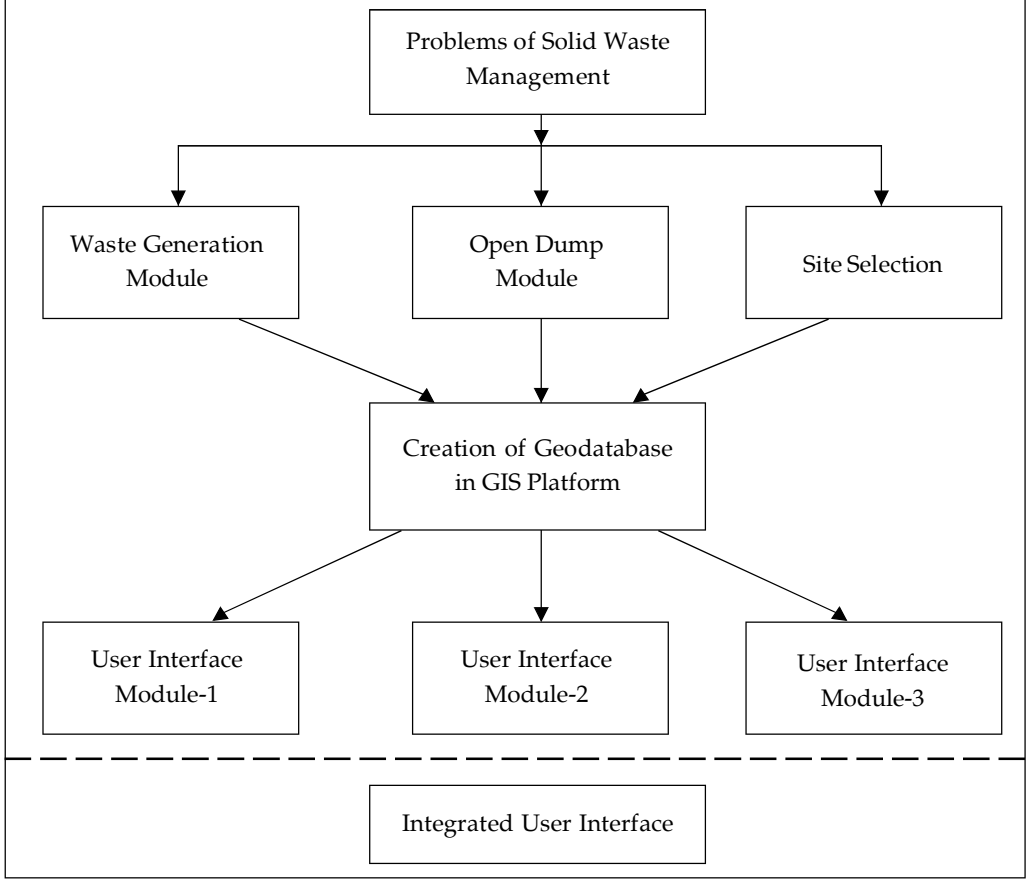
## Different Aspects Considered for Sustainable Solid Waste Management

The sustainability of SWM lies in its integrated sustainable approach, which means that the overall aspects, which include technological aspects, institutional aspects and financial aspects should be taken into consideration.

### Technological Aspects

The present SWM system lacks the use of the latest and cost-effective technologies. Thus, technological aspects include the incorporation of latest technologies into various levels of SWM, for example, use of Geographic Information System (GIS). A conceptual framework (Figure 4) has been proposed for the upgradation of technical aspects of present SWM scenario, which contains the use of GIS in the management of overall data of waste generation, management of open dumps and site selection for MSW disposal. It has been proposed in the conceptual framework that a user interface can be developed with the integration of GIS platform and a computer model. The problems of SWM, which are addressed here for management with the usage of GIS tools, are waste generation management problem, open dump management problem and site selection problem.

**Figure 4: Proposed Conceptual Framework for Upgrading Tehnological Aspects**




***Waste Generation Module***

Different waste generation data (ward-wise) of the city comprising biodegradable component, recyclable component, inert waste and other relevant information can be stored in GIS geodatabase and the same can be retrieved while taking decisions, for example, designing of composting facilities, recycling facilities and various other decisions for SWM purposes.

***Open Dump Module***

Location of various dump sites can be digitized in GIS and the attributes of all the dump sites can be provided regarding the waste reaching to the dumpsite, area of site, water quality, depth of water table, geotechnical properties of the contaminated soil and analysis of various contaminants along with their concentration. Thus the site, which has the maximum risk, can be found and measures can be taken accordingly, like landfill reclamation and their engineered closure.

*Site Selection Module*

In this module, GIS-based constraint mapping can be employed to eliminate the environmentally unsuitable sites and to narrow down the number of sites for further consideration (Figure 5). Different constraints can be considered as per the site selection criteria provided by CPCB, MoEF, Government of India. This results in the finding of candidate sites from which the best site can be chosen by creating various thematic layers of the candidate sites and overlaying them using weighted overlay techniques of GIS. Table 9 shows various possible input layers for overlay analysis.

**Figure 5: Site Selection Criterion Using GIS**

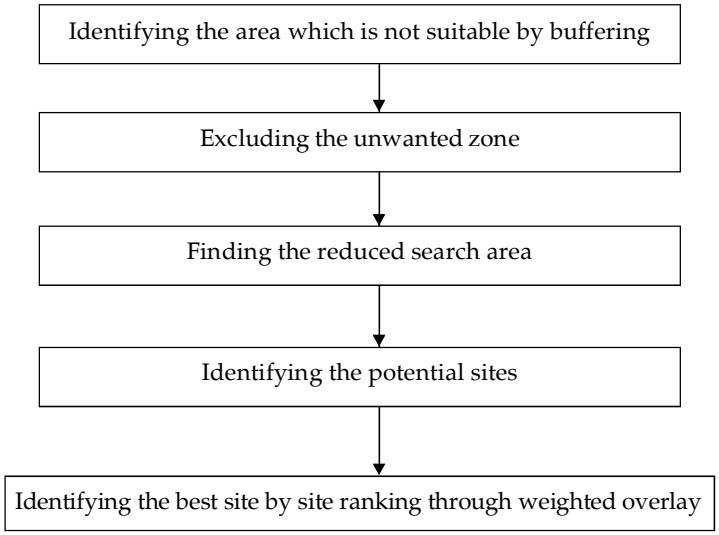



**Table 9: Summary of the Important Layers for the Thematic Maps and Their Possible Sources**

| Layer Name | Source Map |
|---|---|
| Lake/Pond | Topographic Maps |
| River | Topographic Maps |
| Highway | Topographic Maps |
| Critical Habitat | Topographic Maps |
| Airport | Topographic Maps |
| Power Lines | Topographic Maps |
| Water Table | Report from Ground Water Board |
| Bedrock Depth | Report from Ground Water board |
| Slope | Report from Ground Water board |

## Institutional Aspects

| Table 10: Three-Tier System of ULBs |
|---|
| Municipal corporations |
| Municipalities |
| Transition areas such as nagar panchayats and town panchayats |
| *Source: 74th Amendment of Indian Constitution* |

In the institutional setup of SWM, it is the central government which has powers to enact laws and frame rules for environmental protection. The subject of solid waste monitoring, implementation and authorizing the municipal authorities, setting of treatment and disposal facilities is left to State Pollution Control Boards (SPCBs) and passed to the ULB. The ULBs is a three-tier system (Table 10). The functions of solid waste institutions are given in Table 11.

| Table 11: Solid Waste Institutions and Functions | |
|---|---|
| Central Government | Roles and responsibilities in SWM. |
| Central Government | Make laws and rules; frame policies; prepare guidelines, manuals, and technical assistance; provide financial support; monitor implementation of laws and rules. |
| State Government | Make state-level laws and rules; frame policies; prepare guidelines, manuals, and technical assistance; provide financial support; monitor implementation of laws and rules |
| Municipal Authorities and State Government | Plan for SWM treatment facilities. |
| Municipal Authorities | Collect, transport, treat and dispose of waste. |
| Municipal Authorities with the Approval of State Governments | Frame bylaws; levy and collect fees. |
| Municipal Authorities and State and Central Governments | Finance SWM systems. |
| *Source: Zhu et al. (2008)* | |

For institutional strengthening, a SWOT analysis of the institutions involved in SWM is proposed. After identifying the strength, weaknesses, opportunities and threats (SWOT), the decision makers can decide which part should be strengthened and which area should be given less importance. In India, in most of the areas, the health officers who are medical professionals are responsible for the functioning of SWM department. Obviously, they lack technicalities of SWM and thus are not able to look at the technical aspects of SWM and give more importance to preventive health services. Institutions are lacking in their responsibilities of collection and disposal system. The experience shows that private sector partnership can do this work more efficiently. Involvement of NGOs has shown

good results in several cities like Ahmedabad, North Dum Dum, New Barrackpore, Bangalore, Surat, Jaipur, Delhi and Chennai. On the contrary, it has been found that there is potential risk in public private partnership. Some examples of the characteristics of the private sector that offer possible opportunities and threats for solid waste institutions are given in Table 12. Thus SWOT analysis should be done to fulfill the gaps in the present institutional setup.

**Table 12: Opportunities and Threats for SWM Institutions on Involving Private Sector Partnership**

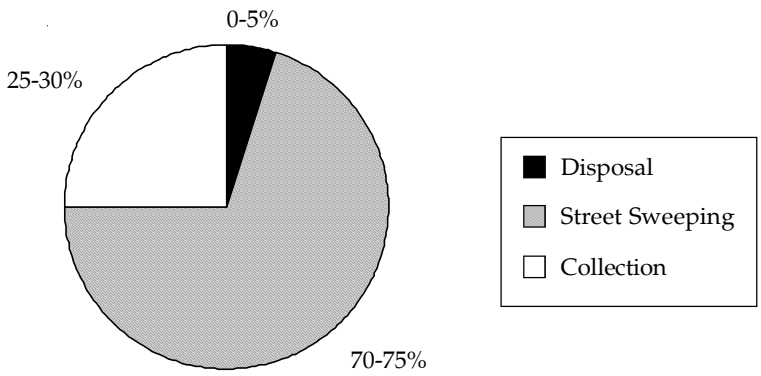
| | |
|---|---|
| **Flexibility**<br>• The private sector can easily hire qualified staff members and pay the salaries.<br>• Salaries and bonuses can be based on staff performance, thus also providing incentives for efficiency and good work.<br>• Employment is easily terminated when performance is unsatisfactory.<br>• More effective administration with fewer bureaucratic delays will result.<br>• Responsibilities will be more clearly defined, with no interdepartmental overlaps and no cross-departmental coordination needs.<br>• A faster and simpler decision-making process can be implemented.<br>**Increased Efficiency**<br>• New equipment or spare parts for equipment maintenance can easily be acquired.<br>• The private sector has ready access to technology and expertise.<br>• The private sector has easy access to financial resources for new investments.<br>• Adapting technology to the context and situation will be easier, thus increasing equipment performance.<br>• Full cost accounting and incentives for the lowest possible unit cost can be implemented.<br>**Contestability**<br>• Incentives for good performance and efficiency can be offered through competition.<br>• Less political interference will occur with private sector involvement. | **Operational Risk**<br>• Delay in construction<br>• Cost overrun<br>• Quality and performance<br>• Failures<br>• Increasing operation<br>• Costs<br>**Demand Risk**<br>• Change in demand<br>• Cost increase for resources<br>• Change of tariffs<br>**Financial Risk**<br>• Delayed or canceled payment<br>• Fluctuation of foreign exchange rates<br>• Fluctuation of interest rates<br>**Country Risk or Political Risk**<br>• Expropriation, breach of contract, or war<br>• Cancellation of credits<br>• No refund of profits |

*Source: SECO (2005)*

## Financial Aspects

Like any system, SWM too requires availability of financial resources for its efficient functioning. The annual requirement of funds for efficient SWM reveals that when the principle of full cost pricing is applied, the total annual requirement is often 2-3 times the amount being allocated at present (CPHEEO, 2000). Municipalities spend only 10% of their budget on SWM because they have to manage a large number of other activities. The percentage of expenditures for various solid waste services (Figure 6) shows that the expenditure is not appropriate and well-distributed. Areas of priority are not decided and extra investments are made where it may not be required.

**Figure 6: Percentage of Expenditures for Various Solid Waste Services**




*Source: Supreme Court (1999)*

The municipal agency has to depend on financial support from the state government. Funds for SWM activity are assigned in the general budget. Since SWM is given a low priority, these funds are often inadequate, and consequently whenever additional expenditure has to be incurred for specific renovation or as a fresh capital expenditure, generally, municipalities prepare their budgets using an incremental approach that is based on the previous year's budget. Annual budgeting should include the projections and SWM works to be undertaken in the next financial year. Municipal authorities need to take into consideration whole project costs when preparing their budgets and then breaking up the project costs into costs for yearly activities (Zhu *et al*., 2008).

A part of the revenue for SWM services can be met from tax/cess from the waste generators (Table 13). It can be based on the family size, assessment of location of building and its value and the income of the occupant. The tax rate can vary according to the variation in the amount of waste generated by different commercial establishments. The minimization of SWM service costs by enhancing community, nongovernmental organization (NGO), and private sector participation can also be done.

| Table 13: Examples of User Fees | |
|---|---|
| **City or State** | **Monthly User Fee (Rs.)** |
| North Dum Dum | Rs. 10 per household |
| New Barrackpore | Rs. 5 per household |
| Gandhinagar | Rs. 15 to Rs. 25 per household |
| Shimla | Rs. 35 to Rs. 225 per household or shop |
| Kerala State (Kudumbshree Scheme) | Rs. 30 per household |
| *Source: Asnani (2006)* | |

## Conclusion

The explosion in world population is changing the nature of SWM from mainly a low priority, localized issue to an internationally pervasive social problem. Risks to public health and environment due to solid waste in large metropolitan areas are becoming uncontrollable. There is a pressing need for sustainable approaches for SWM. Steps are being taken by the government, but still a more systematic approach is required along with the usage of latest and cost-effective technologies at various possible levels.

## References


1. Ahsan (1999), "Solid Waste Management Plan for Indian Megacities", *Indian Journal of Environmental Protection*, Vol. 19, No. 2, pp. 90-95.
2. Asnani P U (2004), "Status of Compliance of Municipal Solid Waste (Management and Handling) Rules 2000 in 127 Class 1 Cities in India as on 1-4-04", Paper presented at the National Training Program on Design, Construction, and Operation of Sanitary Landfills, jointly organized by the Government of India, the Central Pollution Control Board, the United States–Asia Environmental Program, and the Water and Sanitation Program of the World Bank, at Panaji, Goa, India, May 24-28.
3. Asnani (2006), "Solid Waste Management", in Anupam Rastogi (Ed.), *India Infrastructure Report 2006: Urban Infrastructure*, 16089, Oxford University Press, New Delhi, available at http://www.3inetwork.org/reports/IIR2006/solid_waste.pdf
4. Bhide A D and Sundaresan B (1984), "Street Cleaning and Waste Storage and Collection in India", in Holmes Chichester J R (Ed.), *Managing Solid Wastes in Developing Countries*, John Wiley, p. 304.
5. Bhoyar R V, Titus S K, Bhide A D and Khanna P (1996), "Municipal and Industrial Solid Waste Management in India", *Journal of Indian Association of Environmental Management*, Vol. 23, pp. 53-64.
6. CPCB (2000a), "Status of Solid Waste Generation, Collection, Treatment and Disposal in Metrocities", Series: CUPS/46/1999 2000.

7. CPCB (2000b), "Status of Municipal Solid Waste Generation, Collection, Treatment and Disposal in Class I Cities", Series: ADSORBS/31/1999 2000.
8. CPCB (2004), "Management of Municipal Solid Waste", Ministry of Environment and Forests, New Delhi, India.
9. CPHEEO (2000), "Manual on Municipal Solid Waste Management", Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, Government of India, New Delhi.
10. Dayal G (1994), "Solid Wastes: Sources, Implications and Management", *Indian Journal of Environmental Protection*, Vol. 14, No. 9, pp. 669-677.
11. Gupta S K, Prasad M, Gupta R K and Kansal S (1998), "Solid Waste Management in India: Options and Opportunities", *J. Resource, Conservation and Recycling*, Vol. 24, pp. 137-154.
12. Gupta P K, Jha A K, Koul S *et al*. (2007), "Methane and Nitrous Oxide Emission from Bovine Manure Management Practices in India", *Journal of Environmental Pollution*, Vol. 146, No. 1, pp. 219-224.
13. Jha M K, Sondhi O A K and Pansare M (2003), "Solid Waste Management a Case Study", *Indian Journal of Environmental Protection*, Vol. 23, No. 10, pp.1153-1160.
14. JNU (2004), "Summary Report of the Study on "Comparative Environmental Statistical Study of Municipal Solid Waste from Selected Cities in India", Conducted by School of Environmental Sciences Jawaharlal Nehru University, Delhi, India.
15. Joseph K, Nagendran R and Palanivelu K (2002) "Open Dumps to Sustainable Landfills", CES ENVISION, Monthly Newsletter of the ENVIS Node Under EMCBTA Project at CES (AU/CES/NL-02), Supported by Ministry of Environment and Forests, Government of India, Vol. 1, No.2
16. Kansal A (2002) "Solid Waste Management Strategies for India", *Indian Journal of Environmental Protection*, Vol. 22, No. 4, pp. 444-448.
17. Kansal A, Prasad R K and Gupta S (1998), "Delhi Municipal Solid Waste and Environment an Appraisal", *Indian Journal of Environmental Protection*, Vol. 18, No. 2, pp. 123-128.
18. Khan R R (1994), "Environmental Management of Municipal Solid Wastes", *Indian Journal of Environmental Protection*, Vol. 14, No. 1, pp. 26-30.
19. Malviya R, Chaudhary R and Buddhi D (2002), "Study on Solid Waste Assessment and Management – Indore City", *Indian Journal of Environmental Protection*, Vol. 22, No. 8, pp. 841-846.
20. Maudgal S (1995), "Waste Management in India", *Journal of Indian Association for Environmental Management*, Vol. 22, No. 3, pp. 203-208.
21. Ministry of Environment and Forests (2000), The Municipal Solid Waste (Management and Handling) Rules 2000, New Delhi.

22. Nema A K (2004), "Collection and Transport of Municipal Solid Waste", *Training Program on Solid Waste Management*, Springer, Delhi, India.

23. NIUA (1989), "Upgrading Municipal Services: Norms and Financial Implications, New Delhi", National Institute of Urban Affairs, p. 197.

24. Rao K J and Shantaram M V (1993), "Physical Characteristics of Urban Solid Wastes of Hyderabad", *Indian Journal of Environmental Protection*, Vol. 13, No. 10, pp. 425-721.

25. Rathi S (2006), "Alternative Approaches for Better Municipal Solid Waste Management in Mumbai, India", *Journal of Waste Management*, Vol. 26, No. 10, pp. 1192-1200.

26. Reddy S and Galab S (1998), "An Integrated Economic and Environmental Assessment of Solid Waste Management in India – The Case of Hyderabad, India", Unpublished Report, Centre for Economic and Social Studies, Andhra Pradesh, India.

27. SECO (State Secretariat for Economic Affairs) (2005), "Public-Private Partnerships in Infrastructure Services: An Instrument for Poverty Reduction and Economic Development", SECO, Berne, Switzerland.

28. Sharholy M, Ahmad K, Mahmood G and Trivedi R C (2006), "Development of Prediction Models for Municipal Solid Waste Generation for Delhi City", Proceedings of National Conference of Advanced in Mechanical Engineering(AIME-2006), Jamia Millia Islamia, New Delhi, India, pp. 1176-1186.

29. Shekdar (1999), "Municipal Solid Waste Management – The Indian Perspective", *Journal of Indian Association for Environmental Management*, Vol. 26, No. 2, pp. 100-108.

30. Shekdar A V, Krshnawamy K N, Tikekar V G and Bhide A D (1992), "Indian Urban Solid Waste Management Systems Jaded Systems in Need of Resource Augmentation", *Journal of Waste Management*, Vol. 12, No. 4, pp. 379-387.

31. Siddiqui T Z, Siddiqui F Z and Khan E (2006), "Sustainable Development Through Integrated Municipal Solid Waste Management (MSWM) Approach: A Case Study of Aligarh District", Proceedings of National Conference of Advanced in Mechanical Engineering (AIME- 2006), Jamia Millia Islamia, New Delhi, India, pp.1168-1175.

32. Singh S K and Singh R S (1998), "A Study on Municipal Solid Waste and Its Management Practices in Dhanbad Jharia Coalifield", *Indian Journal of Environmental Protection*, Vol. 18, No. 11, pp. 850-852.

33. Supreme Court (1999), "Report of the Supreme Court Appointed Committee on Solid Waste Management" and "Report on Waste Dump Sites in Banglore (2006)", *J. Waste Management*, Vol. 26, pp. 640-650.

34. Zhu D, Asnani P U, Zurbrugg C, Anapolsky S and Mani S (2008), "Improving Solid Waste Management in India", *A Sourcebook for Policy Makers and Practitioners*, World Bank Institute, WBI Development Studies, The World Bank.

*Reference # 63J-2010-02-04-01*