Discussion Paper No. 2/2016 (43)

December 2016

Solid Waste Management Service and Its Delivery Mechanism: with special reference to West Bengal

Dipankar Bhattacharjee

Centre for Urban Economic Studies
Department of Economics
University of Calcutta

Solid Waste Management Service and Its Delivery Mechanism: with special reference to West Bengal

Dipankar Bhattacharjee

December 2016

Centre for Urban Economic Studies
Department of Economics
University of Calcutta
1 Reformatory Street
Kolkata 700 027
India
cuescu@gmail.com
+91-33-2479-0156

First Published: December 2015

Publisher: Mahalaya Chatterjee
CUES
1 Reformatory Street
Kolkata 700027

Printer: Suban
33/A, Biplabi Pulin Das Street
Kolkata – 700009
Mobile : 9874555986

Preface

An urban area emerges and grows for many reasons. Whatever be the initial reason for its emergence and subsequent growth, an urban area implied a higher density of population and a move away from the natural environment. Both of these call for arrangement of some basic amenities like water supply, sewerage and drainage and solid waste management. These amenities add to the quality of life of the citizens and also have impact on the surrounding areas. Traditionally, these amenities are being provided by the local urban bodies and India is not an exception. In fact, one of the reasons of the introduction of local self-government in the urban areas was the recommendations of the Sanitary Commission, appointed for the three Presidency cities (Calcutta, Bombay and Madras) in 1864. Scavenging was the primitive form of solid waste management with dumping of waste in nearby vacant lands. From that, we have moved a long way. Not only, there was mechanisation in different steps of the management process but application of modern management techniques also paved the way to efficiency. Apart from end of the pipe control, the application of three 'R's - reduce, reuse and recycle – also became the keywords for SWM. The passing of the MSWM rues in 2002 was also a landmark in urban solid waste management in the country. The recent launch of the Swacch Bharat Mission by the Government of India and the proposed application of Information Technology are two important steps towards cleaner and greener environment of the urban India.

In this discussion paper, Dipankar Bhattacherjee, senior research fellow at the Centre for Urban Economic Studies, has looked into various aspects of SWM, specifically with the state of West Bengal. I hope this discussion paper will open up more debates and discussions on an important urban amenity.

Mahalaya Chatterjee

Professor & Director

Centre for Urban Economic Studies

Table of Contents

Abbreviations

SWM	Solid waste management
MOUD	Ministry of Urban Development
CPHEEO	Central Public Health and Environmental Engineering Organisation
MSWM	Municipal Solid Waste Management
DSWA	Delaware Solid Waste Authority
CWJSC	Canterbury Waste Joint Standing Committee
GUDU	Gujarat Urban Development Company
JICA	Japan International Cooperation Agency
HIDCO	Housing Infrastructure Development Corporation
ULB	Urban Local Bodies
FYP	Five Year Plan
FC	Finance Commission
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
GPS	Geographical Positioning System
CPCB	Central Pollution Control Board
TERI	The Energy and Resources Institute
USAID	United States Agency for International Development
PPP	Private Public Partnership
D-D	Door to door
MT	Metric Ton
OLS	Ordinary Least Squares
NSDP	Net State Domestic Product
AC	Average Cost
TC	Total Cost
MC	Marginal Cost
LFS	Landfill Site
SLB	Service Level Benchmarking
KMC	Kolkata Municipal Corporation
ADB	Asian Development Bank
UNDP	United Nations Development Program
WHO	World Health Organization
TPD	Tons per Day

Abstract

A city is an urban space (area) where social and economic systems integrate with each other in such a way that it becomes a hub of growth generating economic activities. As a result of this, the population of the city increases, and this increase in population requires an adequate level of urban services, such as the Solid Waste Management services, in order to maintain the public health, hygiene and economic prosperity. A good waste management requires the support of a certain level of budget and management machinery of the Municipal Bodies which govern the city. Since the level of service cannot immediately adjust to the growing rate of population, a gap is often created. The aim of this discussion is study that gap through uncovering the level of coverage of the service, the cost requirement and the possibility of incorporating the 'Green City'structure for some selected cities of West Bengal.For the purpose of conducting this reseach, data were collected from Service Level Bench Marking report of the Ministry of Urban Development, Central Public Health and Environmental Engineering Organization (GOI), Ministry of Labour & Employment (GOI), Labour Bureau of India (GOI), Labour Commission of West Bengal, prices from infrastructure development companies and suppliers, Central Pollution Control Board of India Report and a primary survey of Kolkata. Simple econometric tools were applied that involved the use of Ordinary Least Squares technique and Transcendental Logarithmic Function. The overall analysis revealed that the service delivery largely depended on population density, volume of waste generation, the economic profile of the areaand coverage of other services in that area. On the other hand, cost estimation showed economies of scope existed for Municipal waste management service in West Bengal. The case study revealed an important aspect for improving the service delivery mechanism. The study also discusses the existing pattern of waste processing in Indian cities and the actions and efforts that might be required to build *green cities.*

Keywords: Solid Waste Management services, coverage, cost, economies of scope, green cities

1. Background

A good solid waste management system indicates a good health of a city; if we have it we don't see the need for itbecause waste is not around, but, if this service is inadequate, then the deficiency is felt. The MSWM possesses such a characteristic and is so essential a service that it affects not only the health but also the wealth of a region. In India, per capita waste generation was increasing by approximately 1.3 percent per annum. In 2011-12, the Central Pollution Control Board of India estimated that 127486 tons of waste was generated each day. With a rate of growth of urban population at staggeringly 3 to 3.5 percent per year, the annual increase in the waste can be assessed at almost 5 percent. Quite understandably, the efficiency of the 'collection to the disposal of waste' service must match the pace of it's production. Urbanization is an inevitable outcome of the economic development of a region, however, the by-products are not always desirable (Sridhar and Venugopal Reddy, 2007). As the concentration of people increased over time, the available urban resources and infrastructures got over-exploited.

This study concentrates on the state of West Bengal which is one of the premium urbanized state of India. The urban population in West Bengal increased from 22,427,251 to 29,093,002 and this was associated with growth in a number of urban areas from 376 to 911. The increase may be ascribed to the evolution of 530 new Census Towns[1]in the state. The new towns that got added to the list are mostly of Classes[2] IV and V types. This rapid urbanization necessitates an increased level of urban services. Since this paper discusses the SWM, the justification to increase this service is as follows: firstly, as an outcome of modernization per capita waste generation will increase, and secondly, volume of waste increases as the number of people increases. The accumulated waste needs to be collected every day from the locality to maintain Public Health, hygiene and economic productivity. The duty to collect the waste rests in the hands of the different municipal bodies, designated to the different types of urban areas. In Bengal, the urban local governments are manifested in Municipal Corporations, Municipalities, Town Area Committees and Notified/ other Area Committees. At present, there are 6 Municipal corporations, 120 Municipalities, 4 Notified Areas and 780 towns in the state.

A substantial empirical literature exists on the question of scale economies in local services and provided evidence of economies of scope in favour of local bodies. Institutions play the vital role in delivering the services, which are not demand-led good and the supply is not determined by the price of the good/ service. In India, we can find very few places where a price is charged against the supply of such services. In the case of SWM, the municipal bodies are committed to collecting and disposing of waste in the area that comes into its jurisdiction. At times, trans-Municipal arrangements or state supported nodal agencies are formed to increase the efficiency of service, like the DSWA[3] in Delaware (United States), CWJSC[4] in Canterbury (New Zealand) and GUDU[5] in Gujarat (India). India had also observed that a few private companies, like JICA and HIDCO, had been putting in some investments in this sector. These companies which are expected to be driven by profit motive, were found to have entered into partnership with government bodies, albeit with no or very small market for recycled wastes. However, in the world an estimate 1.3 billion market already exists for recycled products and it still slowly showing up in India.

The seventy-fourth Amendment (1992) of the Indian Constitution has endowed the responsibility of catering urban services to the ULBs through the Twelfth Schedule (Article 243W) of the Indian Constitution. The list includes the provisioning of drinking water, SWM, Drainage and sanitation amenities along with other formal duties such as roads and electricity.

In the Tenth and Eleventh Five Year Plans drinking water and sanitation amenities were accorded highest priority. Accordingly, several Central Government Sponsored schemes were launched to support the initiative and the Thirteenth Finance Commission had also revised the loans and share of funds to ensure an efficient system of operation. Programmes such as JNNURM was designed to improve the housing condition of the urban poor and overall improvement in drinking water, SWM, drainage & sewerage, road and traffic conditions, etc. The programme was supposed to end by2012 but was extended for two more years and the final conclusion came inMarch 2014. At that time, only seventeen projects were completed in West Bengal out of a total of more than eighty projects. After the closer of JNNURM, some of the new programmes were launched by the Union government with similar intension, such as AMRUT, Smart Cities Programme, etc. The Smart Cities initiatives have emphasized on incorporating technologies, such as Geographical Positioning System (GPS)and Wireless Communications to collect and dispose wastes efficiently by saving on cost and time.

Broadly, the steps involved in SWM are collection, transportation, processing and disposal, all of which are inter-linked with each other processes, such that deficiency in one stream of action lead to inefficiency of the other. Usual collection points are house doors, market places and office areas, and the waste collected from here are transported to community vats and transfer stations. This is called the primary stage of collection and is carried out by push-carts and tricycles. Each of these primary collection vehicles cover 200 to 300 households depending upon the density of population. The second stage of transportation and disposal at the dumpsites are carried out by trucks, compactor vehicles and dumper placer vehicles, which carries the volume of waste equivalent to the volume generated by 2000 households or more. After dumping recycling and composting of waste is carried out. The entire process could be supported by adopting of advanced technology, such as GPS at the collection and transportation stage. 'Smart Bins' or wireless sensor fitted bins, were also found to be effective is enhancing the delivery mechanism. The Swatch Bharat Mission is a specially designed SWM initiative of Indian government which have proposed to adopt such technologies into the process.

This paper aims at exploring and discussing some major aspects of the service: level of coverage of the service, the cost requirement and the possibility of incorporating the 'Green City' structure for some selected cities of West Bengal. The study also covers a case study on Kolkata which would highlight some important facts of the service delivery. The analysis begins with coverage of SWM by studying the waste collection against the generation, and then explains the various stages involved in the process with reference to the State's scenario. The next part will estimate a cost function and analyse the scale economies. The third section includes the case study and the forth discusses the relative aspects of *Green Cities* with reference to selected cities of India.

2. A Brief Review of Literature

George Tolley (1978) used demand functions and cost functions to build a solid waste's extended demand and supply model of Chicago city, through which he found out Optimum cleanliness/ spaciousness (the optimum market for solid waste collection and disposal) by equating marginal cost and marginal Willingness-to-Pay. Schüebeler (1996) presented an extensive conceptual SWM base and discussed in details the inter-linkages between different actors and partners of the system, and also explained how private players can be involved in the process. The process starts at the household level, and good management at the household management level or the backdoor collection could eventually increase the efficiency of the system (Sarkhel, 2006). A comprehensive review (Sharholy, Ahmad, Mahmood and Trivedi, 2007) of service delivery showed 90 percent of the waste in India was unscientifically disposed of. In India, a large informal secondary market for wastes exists that trades in reusable and recyclable products, and it includes street pickers, rag pickers, itinerant buyers, retailers and wholesalers 'Kabariwalas' (Mahadevia and Wolfe, 2008).Empirical findings from two studies based on Bardhdhaman Municipality (Ghosh and Maji, 2010) and Saltlake City (Maity et al, 2011), and elaborated the ground realities that felt apart from theoretical conjuration.

Morris and Halthausen (1990) predicted that recycling the waste through proper household management could increase the household welfare gains. Another aspect of increasing efficiency was by introducing tariffs and tipping fee (Asnani, 2006). The concept *Integrated and Sustainable (solid) Waste Management* (UNDP, 2009) identifies three key elements of improving the economic system: Public Health by good waste collection, environmental protection through waste chain for efficient treatment and disposal and resource management through reuse and recycle. Likewise, it was also found that in smaller cities of China, the introduction of such fees had led to behavioral changes and had reduced the quantum of wastes. One of the most discussed concepts of bringing about the efficiency of the system was through waste processing (CPCB India, 2016). The Municipal Solid Waste handling reports published by Central Pollution Control Board of India emphasized much on waste processing and composting and adoption of the concept of waste to energy. India have already witnessed the setting up of 595 waste treatment and composting plants and 666 waste to energy units.

Sridhar and Mathur (2009) observed data from six large cities of India and estimated the cost function from operations and management expenditures. While estimating the cost of waste sector, Bel and Fageda (2009) showed that private players are more efficient than public authorities. The process of increasing efficiency or finding a secondary market would require an assessment of cost (World Bank, 2008), (Kinnaman, 2010), (Parthan, Milke, Wilson and Cocks, 2012), (Annepu, 2012), (TERI, 2015)]. Some recently published articles of USAID and World Bank also emphasized upon this concept, but in India, that arrangement did not worked quite well.The JNNURM final reports published after March 2014, showed that most of the projects under PPP motive had either failed or remained incomplete.

3. Research gap and question

Most of the literature described the operational process, formulated the models of efficiency of the system, some empirical works comprehended general aspects and the cost assessments addressed the accounting costs or policy related concept. The economic perspective of SWM service and delivery did not get much importance in the literatures.

The following questions were addressed in the study:

(i) What factors responsible for the solid waste collection to disposal service, in the (selected) municipal areas of West Bengal?

(ii) How the existing scale economies and delivery mechanism advanced technology can provide an insight into improving the system for some selected cities of West Bengal and India?

(iii) What is the relevance of adopting the concept of *Green Cities* in some selected cities of India?

4. Data and Methodology

This study used both secondary and primary data for research. The *Analytical* part consists of three sections. The first and second section of this paper used secondary data for analysis. The third part, which is a case study of SWM in Kolkata, extensively used information collected from personal interviews of the Senior Officers of Kolkata Municipal Corporation, workers at the Transfer Stations and officers of Dhapa Landfill site. The secondary data were obtained from the manuals and reports of Central Public Health and Environmental Engineering Organization, Service Level Benchmarking (SLB) reports of the Ministry of Urban Development (India), Labour Commission and Labour Bureau (India) websites, Ministry of Labour & Employment, infrastructure development companies and suppliers, and Central Pollution Control Board of India Report (for review of 2014-15, published in April, 2016).The Service activities were recorded from the SLB and the wage rates from the Office of the Labour Commissioner of West Bengal. The requirements of labour and capital for effective SWM was observed from CPHEEO's MSWM 2014 manual. The prices of vehicles and other capital equipment were obtained from infrastructure development companies' websites. The major techniques involved for the purpose of the study were Ordinary Least

Squares Linear Regression Coverage gap and Transcendental Logarithmic Cost Function for the state of West Bengal.

5. Analytical Framework

Efficiency and cost analysis of Urban Solid Waste Management Services delivery is carried out in the following sections. For this purpose, secondary data of 85 Municipalities (including the Municipal Corporations) of West Bengal was considered.

5.1. Section 1: Coverage and Service delivery of Municipal Waste Management in West Bengal.

This section has considered the following sub-sections:

- An account of stage of SWM activities undertaken in selected cities
- An account of coverage and proportion of waste collection service in the Municipal areas
- Factors affecting the delivery of the Service

5.1.1. A brief account of SWM activities in selected Cities of West Bengal.

In the state of West Bengal, collection and disposal was given utmost priority; while each of the indicators, segregation, recovery and scientific disposal facilities, had the service available in 12 out of 85 municipal areas (see Annexure). Around one-third of the ULBs allowed for complaints, which means that, not all communities or individuals had a chance to participate in the SWM process, who could warn the authorities regarding the accumulation of wastes in various corners of their areas. One of the notable facts was that, only few of the municipalities in West Bengal could earn some revenues from MSWM services, and even lesser number of municipalities could collect any type of tipping fees or service charges.

For the development, and also to be economically viable, a sector or a government department must earn revenues to meet its expenditures and to function at will. If it cannot, then its economic freedom could be heavily constrained. The findings from the above table indicated that MSW service in most of the cities of West Bengal were neither developed and nor self-resilient. More than two and a half thousand metric tons of waste was not scientifically disposed. Since, hygiene happens to be directly proportional to the productivity of an individual, such a level of service would generate lower economic productivity than its absolute potential.

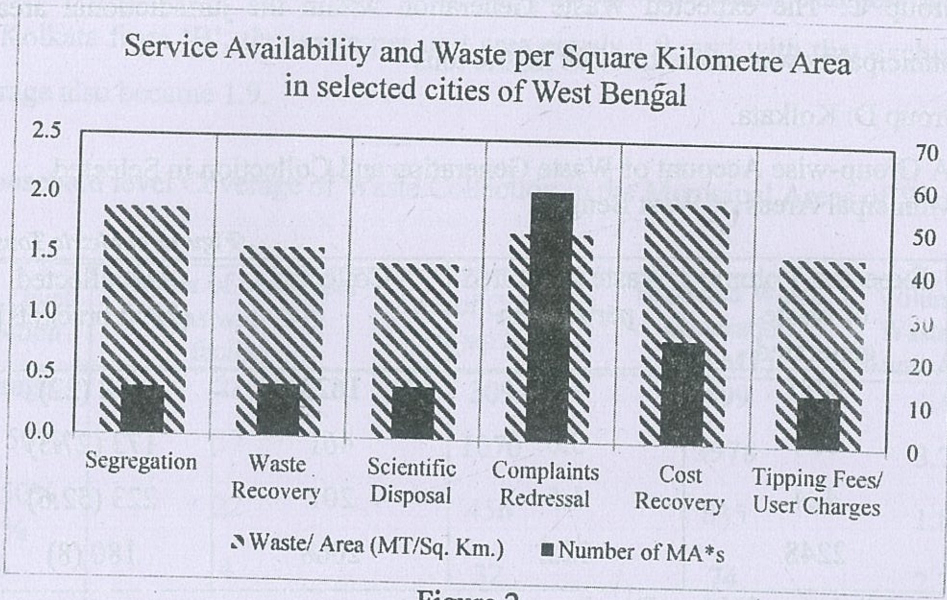


Figure 2.

On an average, in only 31 percent areas had the service availability. The figure represented Availability of Service, and Waste per unit of Area under each type of service coverage, in the secondary and primary axes, respectively. 'Complaint redressal' was found to have been 'most available' service in state. The mean of 'waste per square kilometre' was 1.7 and visually with a low variance. Segregation, recovery and scientific disposal were 'poorly available' services.

5.1.2. Coverage of the service.

The demand for solid waste collection to the disposal of an area is equivalent to the level of service which ensures 100 percent collection and disposal of waste from the locality. Thus, the demand for the service may be estimated by the expected volume of waste generated in an area with a given population. Another way of looking into the quantum of demand is the volume of waste generated per square kilometer of the area(Table 1). Against the demand for the service, the supply of the service is indicated by collection efficiency. For the purpose of representation and understanding, the selected ULBs were divided into four groups:

- Group A: The expected Waste Generation within the jurisdictional area of each municipalities was less than 100 metric tons

- Group B: The expected Waste Generation within the jurisdictional area of each municipality lied between 100 to 200 metric tons
- Group C: The expected Waste Generation within the jurisdictional area of each municipality was more than 200 metric tons
- Group D: Kolkata.

Table 1: A Group-wise Account of Waste Generation and Collection in Selected Municipal Areas of West Bengal

(Figures in Metric Tons)

Groups	Expected Volume of waste generated	Waste generated per sq. Km	Collected	Uncollected [% in brackets]
A.	2081	1.7	1623	458 (22)
B.	634	3.6	461	173 (27.3)
C.	424	1.5	201	223 (52.6)
D.	2248	12.2	2068	180 (8)

Data source: Ministry of Urban Development (India);
Census of India, 2011

Among the 85 samples cities, 77 of them belongs to the first group, 5 of them in 'B', 2 in 'C' and Kolkata as 'D'. Kolkata generates more waste than the 77 smaller towns taken together.In 'C' there weretwosamples and both are corporation areas; namely, Asansol and Durgapur, where the service varied immensely. In Asansol, 80 percent of the waste was collected, and on the other, only around 16 percent is collected from Durgapur area, which made the overall collection to reach to 50 percent.Group B is a set of 5 densely populated cities of Barddhaman, Panihati, Bhatpara, Rajpur Sonarpur and Maheshtala, whose waste generation per unit area was 3.6. For 'A', waste per unit area was 1.7, and this is because the density of population in these areas is low. Therefore, the simple analogy that smaller regions had been generating lower waste per unit area, implied that the demand for service must be higher for larger and densely populated areas. However, when it comes to estimating the service efficiency, the resourceful larger cities generally did better than others. In thecase of Kolkata, the collection efficiency was more than 90 percent (uncollected waste accounts for 8%), which was more than the rest (see Table 1).

This leads us to the question of coverage at the household level - the door-to-door (henceforth D-D) coverage (Table 2). Interestingly, out of the 85 selected urban areas, authorities of 22 area do not provide D-D facilities, which covers an area of 309 square kilometres. Kolkata entered the second group (in Table 2, below) because 25 percentage of households received this facility, although 92 % of city's waste got collected. One explanation for such a result could be the presence of slums in large numbers where D-D might not be always possible. The wastes from those areas were generally collected in waste bins, dumpers and vats. Excluding Kolkata from 'B', the waste per unit area equals 1.9, and with that exclusion the overall average also became 1.9.

Table 2: Household level Coverage of Waste Collection in the Municipal Areas of West Bengal

Household Level D-D Collection	Number of Municipal Areas with D-D facility	Area of Coverage (in sq. Km.)	Expected Waste Generation (in MT)	Volume of Waste per unit Area
No Coverage	22	309	499	1.6
Less than 50%	37	1070	3978	3.7
Between 50% and 99 %	22	456	835	1.8
100 %	4	32	74	2.3

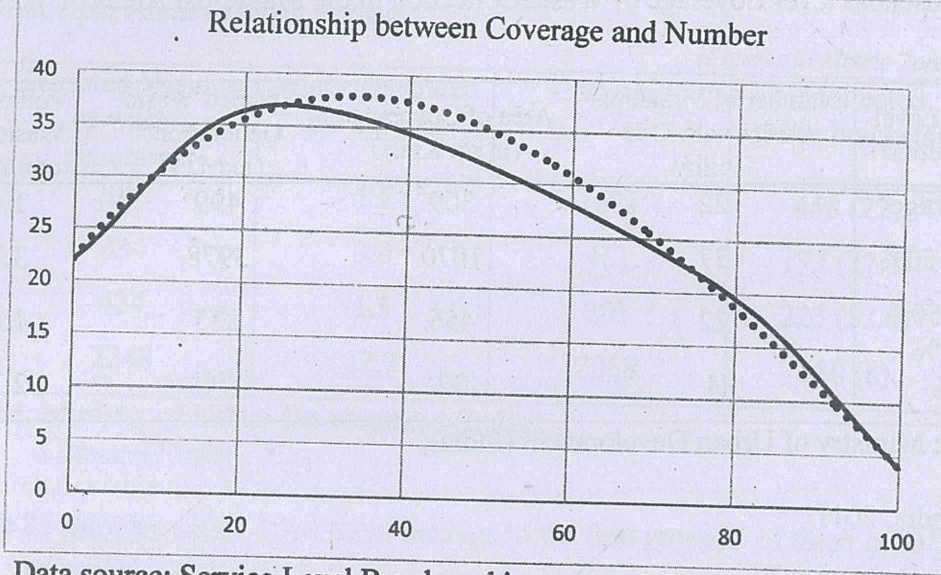
Data source: Ministry of Urban Development (India);

Census of India, 2011

The 100%D-D collection facility was found in 4 urban areas only, where all areas together generated74 metric tons of waste. Those areas include Mal and Dinhata in the North Bengal, New Barrackpore in the vicinity of Kolkata and Uttarpara-Kotrung across the Hooghly River, adjacent to North Kolkata. One notable fact was that despite generating more waste per unit area than others, the collection was optimal. In West Bengal, the two most influential cities are Kolkata and Darjeeling. The resonance of development created from these two points slowly diffuses across state, with a preconceived theory that the ones lying closer to the source enjoy greater externalities due to scale economies. Except Dinhata, which lie near the border of Bangladesh, all the other three might fall in line with the argument placed in the previous lines.

While tracing the relationship between Area, Population and Waste Generation separately with *coverage*, a unique pattern was observed. More number of Municipalities neither had zero coverage nor did they have full coverage. Similarly, more area coverage belonged to the middle groups and so did the other two. The coverage depends upon the financial resources of the Municipalities, which had been experienced to have been limited by revenue earning options. Therefore, the coverage seemed to be improving up to the limit at which the

Municipalities could serve sufficiently, and after that, with further increase in any of the parameters the coverage decreases. When the coverage (in percentage) was plotted against the number of areas that provided the facility, the relationship gave a unique dome-shaped curve. The trend line was skewed, which peaked below the 50 percentage mark, which indicated that more ULBs have less than 50 percent D-D facility.



Data source: Service Level Benchmarking report, Ministry of Urban Development (India);
Census of India, 2011
Graph reference: Table 2and Annexure A1.

Figure 1.

Around four thousand tonnes of waste is generated in the area where less than half is collected from houses. Therefore, it could be found that around two thousand MT of waste is either thrown at Vats, Bins or open dumpsites. Any unscientific arrangement for that waste might have harmed the economy, public health and environment. In addition to that volume, another few hundred tonnes must be added from the third group, which might have exerted same burden on community.

5.1.3. Factors affecting the volume of Collection of Solid Waste Management Services.

In order to study the factors responsible for collection of waste by municipalities, linear OLS Regression was performed with the range of demographic, socio-economic, economic and spatial explanatory. The 'collection' variable (dependent/ regressand) is obtained from the 'collection efficiency' variable of SLB report of MOUD. The term 'collection efficiency' meant the amount of waste collected against the amount generated in any area, given in the percentage form. For this study, the *collection efficiency* variable was inflated to obtain the actual amount of waste collected from the area, and then it was used as the regressand in the model.

The Model

(1) $Y_i = b_0 + b_{i1}X_1 + b_{i2}X_2 + b_{i3}X_3 + b_{i4}X_4 + b_{i5}X_5 + u_i$

The detailed description of the regressand (dependent variable) and regressors (explanatory variables) are given in the results table (see Table 3). The 'u_i' is the random term that captures all the other factors those were not explained by X's in equation 1. The first variable – 'population per square kilometre' represented the density of population of the area, and it is obtained by simply dividing the Total Population of the city by the Area covered under the jurisdiction of the city. The waste generation was taken as the volume of waste generated in metric tons per day by the city's population. The 'X_3' is a derived variable which was calculated as follows:

Derived Domestic Product by Urban proportion equivalent(urb_prop_dp) $= \dfrac{\text{Total Population of the city}}{\text{Total Population of the district where the city is located}} \times$ Net Domestic Product of the District where the city is located

The X_4 is the 'Main Working Population' of the area that actually represents the working population of the area who had been working for at least six months. The logarithmic transformation was necessary because it showed multicollinearity with the other explanatory variables is raw form. The last variable was the number of households being supplied with water by the municipalities, i.e the number of households having water supply connections at home. Water supply being one of the very vital public utilities for the citizens, it was considered as the representative of other urban services provide by the municipalities.

Estimated Model:

(2) $Y_i = 121.24 + 0.0008X_1 + 0.8483X_2 - 0.000008X_3 - 13.55X_4 + 0.0007X_5$

The model seemed fitted well with high value of R^2. After fitting the model, and estimating the OLS parameters and coefficients, multicollinearity and heteroskedasticity was tested with the help of three common tests: Variance inflation factor, Breusch-Pagan test and White's Information Matrix test, respectively.

Table 3: Result of Regression Analysis

Variables	Description	Coeff.	t (sig)
Dependent variable: eff_col(Y_i)	Solid Waste Collected by municipal bodies		
Explanatory Variables:			
pn_sqkm (X_1)	Population per square Kilometre	0.0008	1.79*
ex_wst_mt(X_2)	Waste generated in the city	0.8483	24.14***
urb_prop_dp (X_3)	Net State Domestic Product equivalent to Urban population proportion of the city	-0.000008	-0.34
ln_mn_wkr (X_4)	Natural Logarithm of Main Workers of the area	-13.55	-4.13***
ws_cov (X_5)	Coverage of water supply – number of households receiving water supply in the area	0.0007	4.38***
_cons (β_0)	Constant	121.24	3.98***
Model Summary			
1. *F (dof) = 2609.33 (5)* 2. *Prob > F = 000* 3. *R^2 (Adjusted R^2) = 0.9936 (0.994)* 4. *Variance Inflation Factor test* for multicollinearity *Mean VIF = 9.95* 5. *Breusch-Pagan / Cook-Weisberg test* for heteroskedasticity *Chi^2 (Prob > Chi^2) = 1.33 (0.2491)* 6. *White's test for Ho: homoscedasticity; H_0: unrestricted heteroskedasticity* *Chi^2 (Prob > Chi^2) = 80.61 (000)*			

Source: own calculation

The population density represents the class of a city, and higher class or status of city is associated with better functional machinery of the Urban Local Bodies (ULBs). Therefore, as the population per square kilometre increased, the waste collection service improved. Say, a Municipal Corporation has the capability to perform better than the other Municipalities of lower class cities. This is because the resource available to the Municipal Corporation bodies are more than the other smaller Municipalities, which enables the former to work more efficiently than the latter. Interestingly, it was due to the same reason that waste generation (given in metric tons) also had a positive causality with the collection mechanism. Another reason behind such extraordinary finding was that – when the waste volume increased, the liable authorities urged a better management system that might have helped in overcoming the crisis situations. The above findings lead to an important assessment that economic profile of the ULBs determine the level of waste collection, and even if waste production increases along with the population, a more able ULB, in terms of budget in its treasury and the management machinery in its possession, would provide better waste management service.

The domestic product equivalent to city-district population proportion was found to be an insignificant factor for determining the collection level. The result showed that the general economic profile of the citizens, given by the proportion of the domestic product they produces, exerted less impact on the service level. For example, Haldia is Class I port city that lies below all the Municipal Corporations in status but produces more output than any other city except Kolkata. Contai is another Class II city with a small local body, but produces more output than as many as 30 Class I cities in the group of 85 selected cities.

Another important variable that had a negative and significant effect on the collection was the working population. The working group comprising the Main Working population, along with their dependents, is expected to be economically better off. The income of households has direct relation to consumption pattern of an area, which is further associated with the trading and market activities. As these activities increases the waste in the form of packaging materials, plastics, metals etc. also increases, and that leaves some portion of the waste uncollected.

The coverage of other services (here water supply) was positively related to the collection service. The services are often bundled together by the ULBs. Therefore, improvement in one service leads to the improvement of the other. Together they indicate the functioning capacity of the ULBs.

5.2. Cost Estimation of MSWM for West Bengal

In economics cost can be classified into the accounting costs and analytical costs. The accounting costs can be studied with the help of opportunity costs, business costs and full costs, or implicit and explicit costs. Analytical costs can be fixed and variable costs; total, average and marginal costs; incremental and sunk costs; social and private costs; orhistorical and replacement costs. For the purpose of this study analytical costs were considered, and total, average and marginal cost functions and curves were used for understanding the scale economies. After deriving the total cost (TC) function from the expenditure on labour and capital, the average (AC) and marginal costs (MC) can be derived from the TC function. The cost curves are important in determining the optimal service level choices.

A cost function is the relationship between the cost and quantity of goods produced, and is often represented in the form of a mathematical function that shows how production expenses will change at different levels of output. This is the TC function. The AC is cost per unit of output, or in other words, it is defined in terms of minimum cost achievable at a given level of output. The MC is the rate of change in cost due to a unit change in output. The relevance of this information is that the Municipal Bodies may adjust and optimize the service level. In general, the TC is upward rising and the AC and MC are u-shaped. When the AC and MC curves are *falling* with higher level of output (here service) we may infer that economies of scope (positive scale economies) are operating, otherwise, when the curves are *rising* upward then diseconomies operate. These costs can be estimated for short run period and long run periods. For this study the short run was considered because of its analytical relevance. The cost function was used for understanding the scale economies of the waste management service of selected cities.

Institutions play a vital role in service delivery, quite reasonably because, they pay for the service. In economics, a trade off existed between decisions based on revenue-cost comparison, and the public expenditure on basic services. Here, the former argument does not stand because, whether revenue is available to pay off the cost or not, the service must be delivered. It was seen earlier in the paper that the quantum of service was not adequate due to the lack of capacity of the Municipal Bodies to generate profit from the service. However, *Central Public Health and Environmental Engineering Organization* of India provided manuals for delivering four important services for the Municipalities to follow, which in turn would enable these bodies to optimize the service levels in their respective localities. In that regard, this paper estimated cost function of SWM for selected cities of the state.

In case of SWM, there are two types of inputs: labour and capital, allotted within the entire supply chain of service. A typical supply chain would engage primary collection and transportation, secondary collection and transportation, transfer station and processing, and disposal/ landfilling. At the primary collection stage, two different activities are taken – street sweeping and D-D collection. Both these are labour intensive process, and the cost of capital is low. The next stage is secondary collection, which in many cases overlap with *transfer* *station and processing* process. This secondary stage along with the transfer station processing and compaction, are capital intensive. The last stage is disposal and landfilling, which must be considered separately, and is not considered for estimating cost.

The operating expenditures of labour and capital used for estimating the cost function is given below.

Table 5: Operating Expenditures of Municipal Waste Management Supply Chain.

Sl. No.	Cost	Unit price (in Rs.)	PRIMARY COLLECTION	SECONDARY COLLECTIN	TRANSFER STATIONS & PROCESSING	TRANSPORTATION
	Labour					
1.	Waste Collector (Zone: A/ B)	241/ 218	●			
2.	Truck Driver	230				●
3.	Workers & Helper	241/ 218		●	●	
4.	Sweeper	241/ 218	●			
	Capital					
5.	Pushcart/ Tricycle	17,250	●			
6.	LCV/ Tata Ace	550,000				●
7.	Dumper Placer	70,000	●	●	●	
8.	Dumper Placers Vehicles/ Truck	1,200,000				●
9.	Static Compactor	2,500,000			●	
10.	Roll-on-roll-off	500,000			●	
11.	Hook Loader/ Skip Loader	950,000			●	
12..	Blackhole Loader	2,522,575			●	
13.	Compactor Vehicles	1,200,000				●

Given these operating expenditures(unit prices) and the nature of their use, a short run cost function could be estimated. This study assumed a quadratic cost function because a function of quadratic nature allows for estimation of u-shaped curves, i.e., the ones with increasing, constant and decreasing cost conditions. A second order function of such a nature was thought to be ideal for reading the scale economies from cost functions.

The Cost Function

(3) $C_i = f(Q_i)$

Where C_i = Cost; Q_i = Quantity of waste

The second assumption regarding the functional form was that Transcendental Logarithmic function. The constant elasticity cost functions does not allow for the possibility of estimating the Average Costs that first falls and then rises, as $Q_i$changes from low to high values. The Transcendental Logarithmic (translog) Cost Function postulates a quadratic relationship between natural log of Total Cost and natural logarithm of input and out prices, which allows for the possibility of estimation of such scale effects. Another useful property of Translog function is that the exact functional form need not be assumed prior to the estimation of model (cost) function.

(4) $\ln C_i = \alpha_{0i} + \alpha_{1i}[\ln(Q_i)] + \alpha_{2i}[\ln(Q_i)]^2$

In order to estimate the values and the sign of coefficients Ordinary Least Squares technique was applied. Firstly, the operating expenditures of labour and capital was used to find out the cost elasticities of input prices, and then total cost was estimated. Such a form was homogeneous of degree 1. After that Linear Regression was run to find out the values and signs of the coefficients (see table below), which represented the Cost Function for SWM services in West Bengal.

Table 6: Estimation of Translog Cost Function

Variables	Description	Coeff.	Sign.
(C_i)	Total cost of services (Labour + Capital)		
Explanatory Variables:			
$\ln(Q_i)$	Natural Log of *Quantity of Waste* in Metric tons	0.225	+
$[\ln(Q_i)]^2$	Square of Natural Log of *Quantity of Waste* in Metric tons	0.053	+
_cons	Constant	9.956	+
	Model Summary		
1. *Number of observations = 85* 2. *F (dof) = 34.59 (2)* 3. *Prob > F = 000* 4. *R^2 (Adjusted R^2) = 0.4546 (0.4415)*			

Source: own calculation

Therefore, the short run Cost Function for the Municipal Solid Waste Management Services for the state of West Bengal could be written as:

(5) $\ln C_i = 9.956 + 0.225[\ln(Q_i)] + 0.053[\ln(Q_i)]^2$

The (positive) signs and values of the coefficients indicated the existence of the economies of scope. The Average Cost (AC) and Marginal Costs (MC) were then calculated from C_i (Total Cost: TC). The graphical representation of the cost curves are given in the figure below, where panel A and B represented the Total Cost (TC), and the AC and the MC, respectively.

The Total Cost function was rising upward, without any sign of diminishing downward. The AC and MC were both falling and MC lying below AC. The AC curve revealed a hyperbolic trend, and both AC and MC were converging with a tendency to become parallel to the *Quantity* axis. Such a trend was observed due to the fact that the signs of all the coefficients were found to be positive. This was a typical case of positive scale economies, where the externalities arising out of scale effects had made the AC (and MC) to decrease indefinitely without any inflexion point.

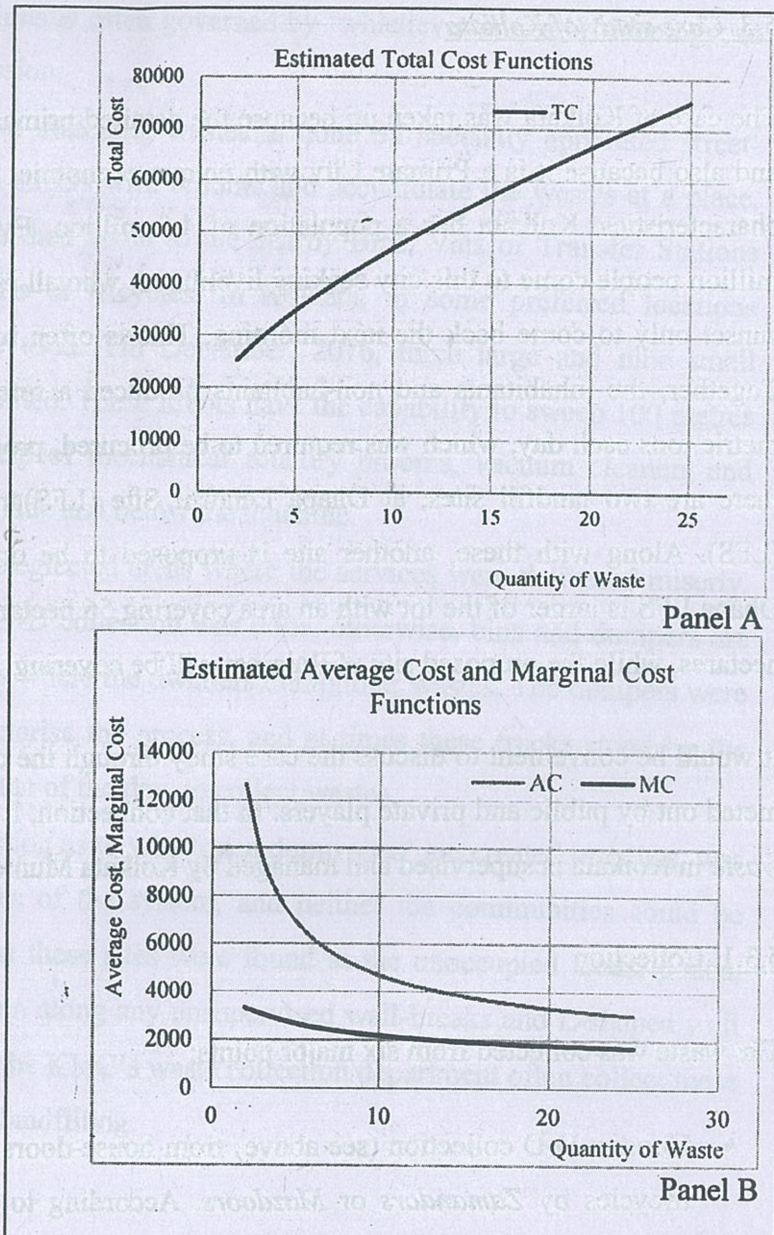


Figure 3: Cost Function for West Bengal.

The above condition refers to the situation where an increase in output reduces the cost, and hence the Municipal Bodies may increase the cost of SWM service until the diminishing returns appear. Thus, the state had ample opportunities from economies of scope. The capital and machineries, stipulated to be used for the service delivery, might create a significant level of productive capacities. If efficiency is defined as the ratio of output to input, then under such circumstances an increase in input would increase efficiency of the system. At present, any investment in this sector would only generate positive returns, and such a stage could be regarded as anearly stage of development of the solid waste service sector. Another explanation of this finding would be that the productive capacities were remaining un-utilized so far. Therefore, efforts on the part of municipalities are required to effectively reap the benefits of the system.

5.3. Case study of Kolkata

The case of Kolkata was taken up because the detailed primary survey was done for the city, and also because it is a Primate City with unique economic, spatial, social and ethnographic characteristics. Kolkata has a population of 4.5 million. Every day an additional 3.5 to 4 million people come to this city seeking livelihood, who all return back to their homes by the sunset only to come back the next morning. This is often regarded as 'Flying Population'. Together, the inhabitants and non-habitants produced a refuse volume of more than 4000 metric tons each day, which was required to be procured, processed and dumped. At present, there are two landfill sites, at Dhapa Landfill Site (LFS)and Garden Reach Landfill Site (LFS). Along with these, another site is proposed to be opened very shortly at Rajarhat. Dhapa LFS is larger of the lot with an area covering 56 hectare, and Garden Reach is only 20 hectares, while the proposed site of Rajarhat will be covering 18 hectares.

It would be convenient to discuss the case study through the chain of activities of the service meted out by public and private players. In that connection, it should be kept in mind that the *waste* in Kolkata is supervised and managed by Kolkata Municipal Corporation.

5.3.1. Collection

The waste was collected from six major points:

- Houses: D-D collection (see above) from house-doors with the help of Pushcarts and tricycles by *Zamandars* or *Mazdoors*. According to schedule, every morning D-D collection is done between 8-9 am from all the houses of the areas which is presently covered by the facility. It was observed that in 2011 (SLB), 25 percentage of houses came under the said facility.
- Market: Mostly comprising of vegetable and packaging waste, is generally collected in Dumper Placer containers and Bins. Pushcarts and tricycles are allotted with duty to collect these wastes in a scheduled time and empty them at local Transfer Stations or Vats (whichever is available). However, some part of the market waste had to be street-swept. Market wastes have rich contents for recycling.
- Office Areas: These wastes are collected in Bins located on street-side. A large part of these wastes are littered around and had to be regularly street-swept, and collected at community Vats, often located close to a market, or in dumper containers placed in

that locality. This collections is often governed by 'whichever is nearer' ideology, to get rid of wastes in possession.

- Streets: This task of street sweeping wastes is done by specially appointed street-sweepers who sweeps the streets with brooms and accumulate the wastes at a place. The accumulated waste is then taken to the nearby Bins, Vats or Transfer Stations with the help of pushcarts or tricycles. In Kolkata, in some preferred locations Mechanical Sweepers are used. Till December, 2016, three large and nine small Mechanical Sweepers operated. These robots have the capability to sweep 100 metres in 2 minutes, with the help of mechanical rotatory brooms, vacuum cleaners and waters sprayers, fitted to a side and below the machine.
- Slums: These are still the neglected areas where the services were delivered miserly. In some registered slums D-D collection was done, otherwise, bins and dumpers are placed in outskirts of slums where the dwellers dump their wastes. The dumpers were cleared by trucks that regularise the process, and at times these trucks stood by the slum entrances, for some time of the day, to collect wastes.
- Open Dumpsites: One question as to why 'open dump sites' are created or exists, was not entirely due to fallacies of the system, and neither the communities could be entirely blamed. Most often these sites were found at the unoccupied lands, ponds, along Tolly's Nulla and even along any unsupervised wall-breaks and L-shaped wall constructions. Trucks from the KMC's waste collection department often collect these wastes and take it away for landfilling.

5.3.2. Waste Collectors

The city is regularly served by staff strength of 12,000, including Permanent and Contractual conservancy *Mazdoors*, sweepers, etc. The permanent category receives around Rs. 12,000 a month, while the contractual category receives either Rs.183 or Rs.157 per day, depending upon their nature of their engagement. The so called – *'100 days workers'* (workers engaged by some scheme or Central Program) are often paid Rs.157 for each manday, and the others receive Rs.183 daily.

5.3.3. Transportation

The Primary collection vehicles are Push carts, tricycles and some new motored tricycles with automated unloader. The transportation from secondary points are carried out by KMC and Private Agency trucks and Compactor Vehicles. The KMC vehicles operate from 7 am to 5 pm while Agency vehicles operate from 8 am to 7 pm, every day, carrying the wastes to the Landfill Sites. On the other, the KMC Compactor Vehicles operate from 8 am till 4 pm, and the Agency Compactors start working by the same hours but work till 7 pm. A five (5) day study on the activities of the Dhapa LFS was carried out for the period between 1st to 5th December, 2016.For details see Annexure. A summary table and its corresponding graphical representation is given below. For the purpose of the study, the hourly record of vehicles' movement for dumping was collected from the Dhapa LFS Office, and personal interview of the Officers was conducted. The summary of the average of hourly records are given in Table 7, below.

Table 7: Hour-wise Movement of different types of Vehicles at Dhapa LFS

Vehicles	Hours of the Day												
	700	*800*	*900*	*1000*	*1100*	*1200*	*1300*	*1400*	*1500*	*1600*	*1700*	*1800*	*1900*
KMC_VEHI	8	22	45	71	99	126	148	161	166	169	170	170	170
AGENCY_VEHI	0	20	105	176	239	299	365	447	500	547	569	571	572
KMC_COMPAC	0	0	2	4	10	17	21	22	22	23	23	23	23
AGENCY_COMPAC	0	1	9	27	46	64	85	97	104	110	112	113	114

Data source: Primary Survey. See Annexure 4.

Note:

KMC_VEHI : Kolkata Municipal Corporation Vehicles, such as Trucks and Dumper Placer Vehicles
AGENCY_VEHI : Private Agency Vehicles, such as Trucks and Dumper Placer Vehicles
KMC_COMPAC : Kolkata Municipal Corporation Mobile Compactor Vehicles
AGENCY_COMPAC : Private Agency Mobile Compactor Vehicles

Record shows that four types of vehicles regularly dump wastes at Dhapa, which starts operation at 7 am in the morning (se details of the vehicles in *Notes* below the table). In the first hour only KMC vehicles were seen, and in the next hour all the other three starts moving in. The hourly cumulative account of incoming vehicles was noted row-wise against the different types of vehicles. The summary is diagrammatically represented in the figure below.

Largest service providers were the Private Agency Vehicles; and almost 66 percent (i.e. 2/3rd) of work was done by these trucks and dumper vehicles (see figure). It was seen that around 270 such vehicles (see Annexure) regularly takes part in the waste management service, which dumps an average of around 3400 metric tons of waste, i.e. equivalent to 71 percentage of total wastes being dumped at that site every day. Around 68 to 70 KMC vehicles makes 170 trips carrying almost 450 metric tons of waste to the dumpsite, and each of the vehicles make 2 to 3 trips each day.

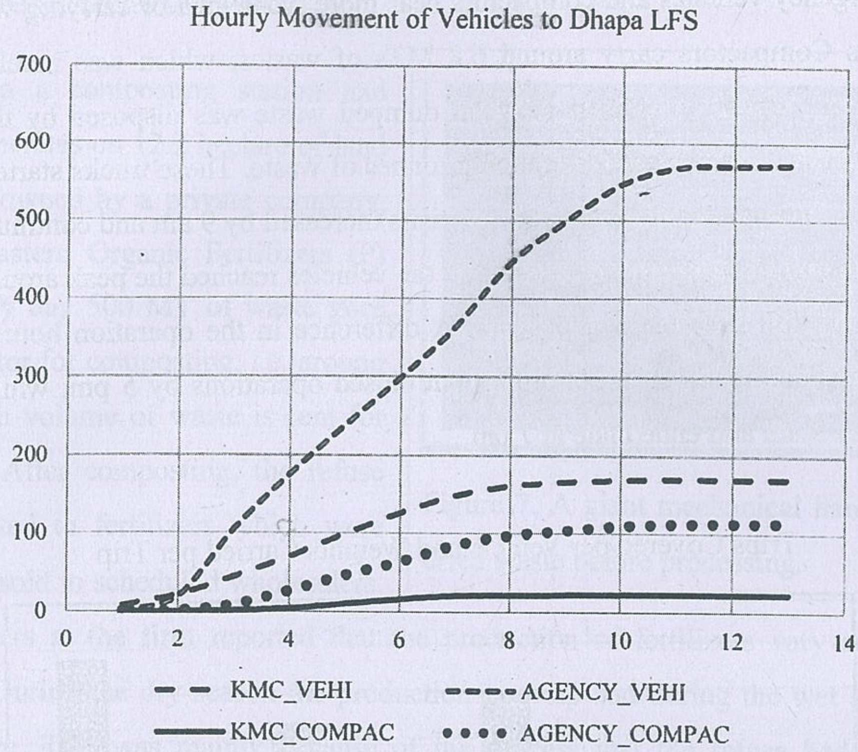


Figure 4.

It was recorded from the official data of the Dhapa LFS that a total of 70 Compactor Vehicles were registered dumpers at the site: 53 belonged to Private Agencies and 17 to KMC. It was also noted that more number of Private Agency Compactors appear at the site than the KMC owned ones. According to the KMC policy, the body had outsourced the major proportion of the service responsibilities to the private agencies. The study observed that around 70 percent of the transportation and dumping works are done by the private agencies.

The following table studied effectiveness of the vehicles.

Table 8: Vehicle's Efficiency in Waste Transportation to Landfill Site.

Vehicles	NET WT.	TOT_TRIP	TOT_VEHI	TRIP/VEHI	WT./TRIP (in MT)
KMC_VEHI	448852	170	68	2.5	2.6
AGENCY_VEHI	3400454	572	270	2.1	5.9
KMC_COMPAC	123118	23	17	1.4	5.4
AGENCY_COMPAC	772880	114	51	2.2	6.8
TOTAL	*4745304*	*880*	*406*		

For notes refer Table 7, Notes.

MT = Metric Tons; TOT_TRIP = Total Trips per Day; TOT_VEHI = Total Vehicles making Trips; TRIP/VEHI = Total trips per Vehicle; WT./TRIP = Weights (in metric tons) carried per Trip per Vehicle.

Overall, the Agency vehicles and compactors bear more work load of carrying wastes to the site. Agency's Compactors carry around 6.8 MTs of wastes, which was much above the others. However, largest volume of the total dumped waste was disposed by the privately owned trucks, each of which carries around 6 tonnes of waste. These trucks started operation by 8 am in the morning, and the frequency of visits increased by 9 am and continued till 3 – 4 pm in the afternoon. In general, activities of all the vehicles reached the peak around the same time (9 am), and fell between 3 and 4 pm. A difference in the operation hours was seen: KMC vehicles started early in the morning but closed operations by 5 pm, while the other group started by 9 am and ended late at 7 pm.

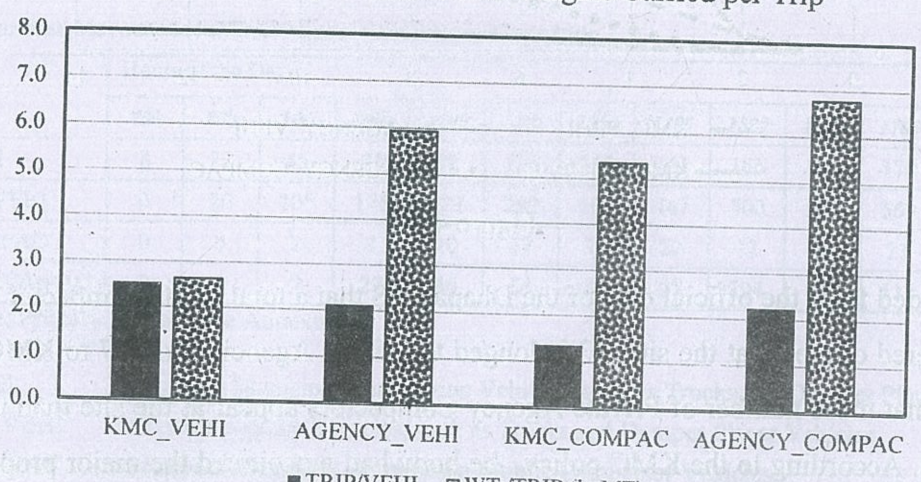


Figure 5.

It was found that KMC trucks carried less amount of waste than the other. At the same time these KMC trucks made more trips than the others.

Figure 6. Pushcart unloading collected waste into the compactor truck.

However, if the carrying capacity could be increased, the fuel cost due to greater frequency of trips. Trip frequency was least in case of KMC Compactors, which also had the least duration of operation. Out of 17 KMC owned compactors, less than half of the vehicles make onlyone trip per day.

5.3.4. Processing and Composting

At Dhapa a composting station and factory operates on 12.2 hectare of land which is owned by a private company, named Eastern Organic Fertilizers (P) Ltd. Every day 500 MT of waste goes to the factor for composting, i.e. around one-eighth volume of waste is sent for recycling.After composting, the refuse is converted to fertilizers which were regularly sold to scheduled wholesalers.

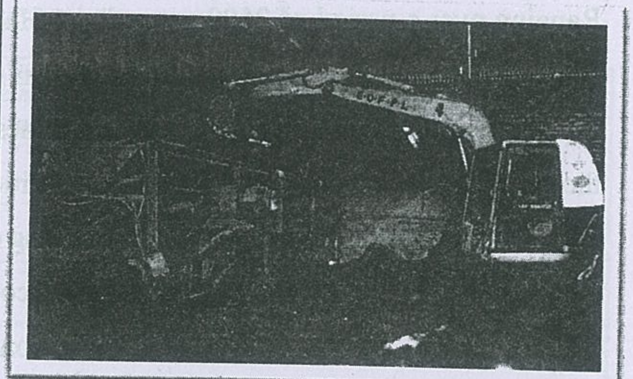


Figure 7. A giant mechanical hand working with dried waste before processing.

The officers at the firm reported that the production of fertilizers vary according to the seasons. During the dry season the production goes up and during the wet season the same goes down. This was mainly because of the process that the refuse had to go through: primarily, after procuring the waste from LFS it had to be dried in sun. After drying the processing starts and the entire process, up to packaging, was done by giant machines with minimum labour support.

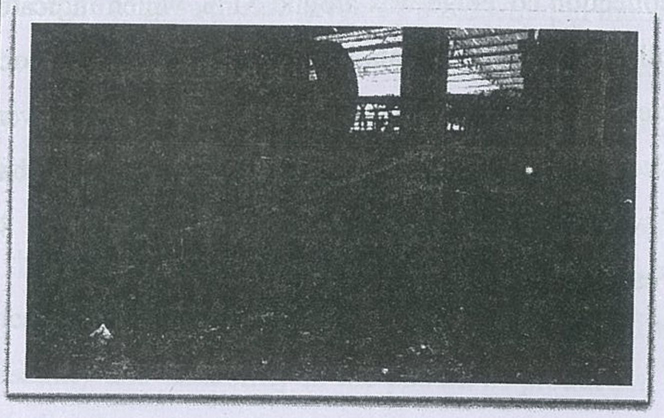


Figure 8. Composting Machine at the factory.

Figure 9. Packed Fertilizers before delivery.

6. Green Cities and Solid Waste Management

Ranging over a period of 2500 years, Peter Hall's elaborate description of transition of cities in his classic work, 'Cities in Civilization', spoke about positive forces of the cities experienced through the history. Edward Glaeser's 'The Triumph of the City' (2010) noted the efficiency and innovative properties of cities, and found out that the cities were greener than it looked; the positive externalities arising out of the cities created wealth for that region. Cities had been the driving forces for the economies and pulled millions of people out of poverty (ADB, 2012). However, the environmental consequences arising out of speedy economic development cannot be ruled out.

According to UN Habitat, cities were major contributors to climate change: although covering (approximately) 2 % of the earth's surface, cities consume 78% of world's energy and produce more than 60% of Carbon Dioxide and Green House Gasses, through energy generation, transportation, exhaust from industries and biomass use. In recent study held by WHO (2016), 22 Indian cities found their names among the top 50 most polluted cities in the world. Interactive Air Pollution map showed that India lied in the hazardous (air quality) zone. The Environmental Stress due to waste deposition is recorded in the waste atlas in d-waste website at 76.2 tons of Municipal Solid Waste per Km., which was high indeed. Waste management performance in terms of collection coverage was around 51%, which indicated half of the waste might have gone uncollected. However, Kala Sitharam Sridhar in her book "State of Urban Services in Indian Cities" stated that around 30 percentage of waste went uncollected. According to the Service Level Handbook of the Ministry of Urban Development report, 74 percentage of waste was actually collected, for the sample of 85 selected Municipalities (see above)of West Bengal.

7. Where India Stand?

The waste generation of 22 selected cities of India is typified in the figure below, and the table from which the figure was derived is given in the Table A7 of Annexure. In 2015-16, Mumbai (11,000 TPD) topped the list, followed by Delhi (8,700 TPD) and Chennai (5,000 TPD). Like Kolkata, Bangalore also produces a volume of around 4000 TPD of waste. The rate of growth of waste generation was highest in Lucknow (13.9), followed by Bangalore (11.1), for the period 2004-05 to 2015-16. Over the period 2010-11 to 2015-16, highest jump in accumulation of waste volume was recorded for the two greatest cities of India, namely, Mumbai and Delhi. In contrast to that, waste volume fell in some cities, and they were Hyderabad,Bangalore, Lucknow and Kanpur.

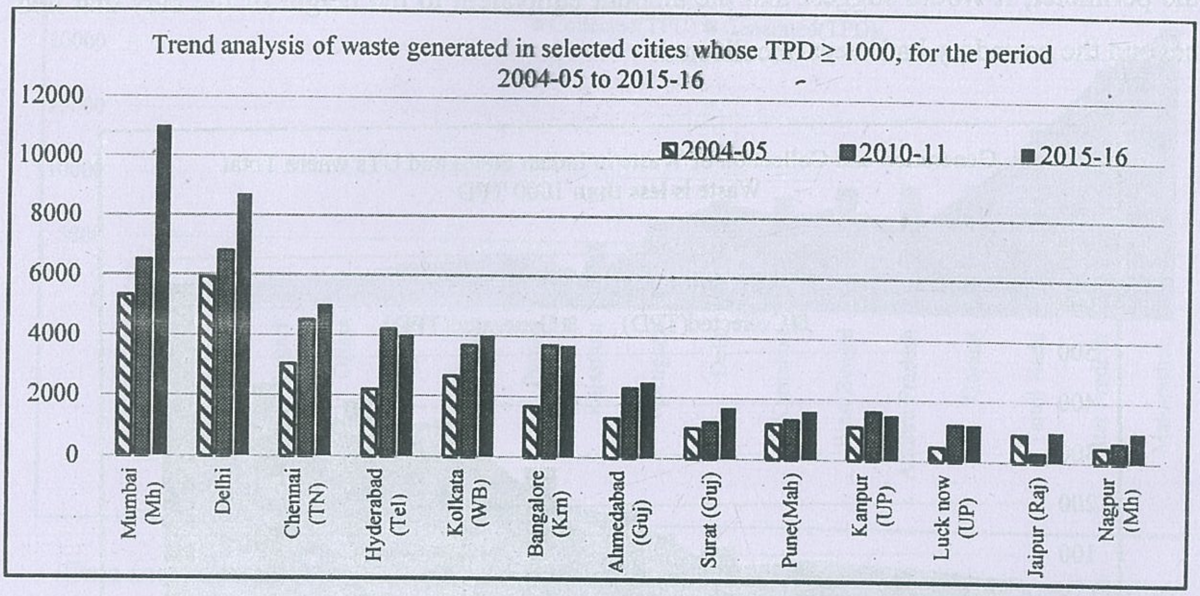


Figure 11.
Data source: "Solid Waste Generation in 46 Metrocities", Central Pollution Control Board (India), *www.cpcb.nic.in*

The figure considered only 13 cities out of 22 cities (Table A7) which had the per day waste generation of more than 1000 tons. Among the rest of the cities, Vishakhapatnam and Patna had negative growth rate given by a reduction in the waste volume over the years. Those two cities along with Madurai recorded a generation of less than 500 TPD, while five other cities had waste generation of more than 500 TPD; and they were Indore, Ludhiana, Coimbatore, Bhopal, Vadodara and Varanasi.

In the next part, a relative and comparative analysis of waste generation, collection and the extent of treatment is done for selected states of India. This country is characterised by versatility and variability in the pattern of production technology, market and consumption, and therefore, the indicators of waste management bound to vary. For the purpose of understanding, four comparative figures were drawn below that would reveal the state-wise variation in waste generation, collection and treatment. Firstly, the states were divided into two groups according to the quantum of waste generated i.e., one with less than 1000 TPD, and another with more than 1000 TPD. Figures 12 and 14 present the data for the first group, and figures 13 and 15 for the second. In figures 12 and 13, the area shown by grey stood for the volume which were collected, and the height of the vertical bars for the amount generated. If the height of the bars coincided with the perimeter of area, then the situation denoted that the entire waste was collected from the area, otherwise, if the bars broke through the perimeter, it would suggest that the amount equivalent to the height of the bars that lied beyond the boundary had went uncollected.

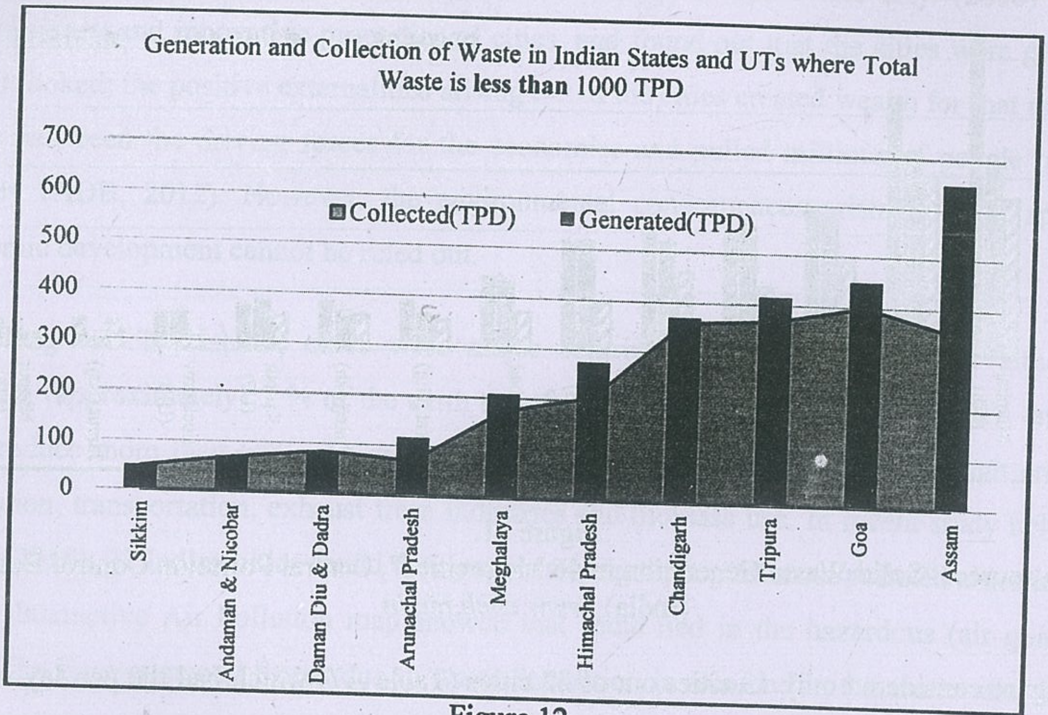


Figure 12.

Data source: "Annual Review Report: 2014-15", Central Pollution Control Board (India), *www.cpcb.nic.in*

The figure 12 comprised all the smaller States and Union Territories, where the small State of Sikkim and the two UTs had the best record of collecting 100 percent waste, and Chandigarh did well enough to be complimented with 97 percent collection. Except Assam, all the bars stayed close to the boundary line.

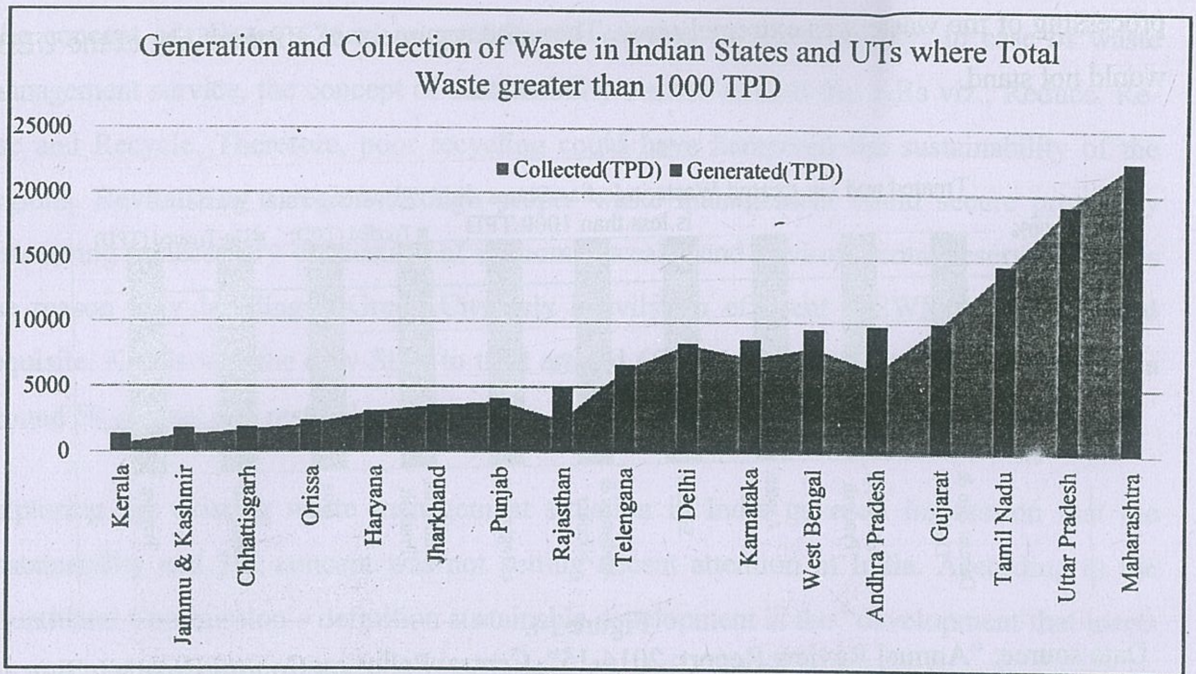


Figure 13.
Data source: "Annual Review Report: 2014-15", Central Pollution Control Board (India), *www.cpcb.nic.in*

In figure 13, four out of seventeen States had 100 percent collection rate, which was more than 90 for seven, in between 50 and 90 for four and two had the same below 50 percent. The half of Maharashtra's exorbitant 22500 TPD was attributed to Mumbai alone, but amazingly the entire volume is collected every day. Even Uttar Pradesh reported itself clean with 100 percent collection in spite of generating a heavy amount of 19180 TPD. On that note, Rajasthan and Kerala might be placed as poorer performing ones, while Delhi, Gujarat and Tamil Nadu were very close to achieving optimal point (See Table A8, Annexure). Maharashtra is 207 times larger than Delhi in terms of surface areas, but volume of waste accumulated each day was just 2.7 times more. Thus, among them, the intensity of waste accumulation was much higher in Delhi than in Maharashtra. In contrast to the above study, the collection of wastein West Bengal was found to be higher than the study's mean value of collection (as recorded by CPCB).

Treatment and processing of the refuse was absent in the four States and UTs from the right, and in the rest of the smaller regions some part of the waste was treated. The machinery for the treatment and capital arrangement is a costly set-up, and therefore, the financial resources might not have permitted the budget of the Municipalities of those smaller regions to allocate some amount for the process. However, in case of larger regions too, the treating and processing of the waste was extremely low. Then, the argument of affordability of the ULBs would not stand.

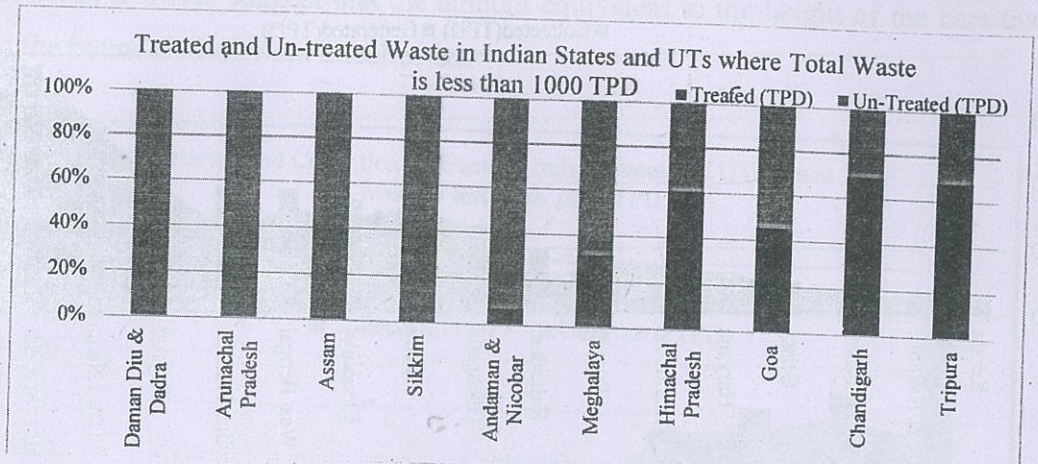


Figure 14.

Data source: "Annual Review Report: 2014-15", Central Pollution Control Board (India), *www.cpcb.nic.in*

The larger states have relatively larger population, and greater population density. The waste volume depends upon the population, and so the waste volume is expected to be high. On the other hand, the treatment of waste involves a considerable amount of investment of money. As the volume increases, the treatment cost increases, and this limits the functioning of local bodies. As a result of this, waste treatment becomes unpopular in the bigger states of India.

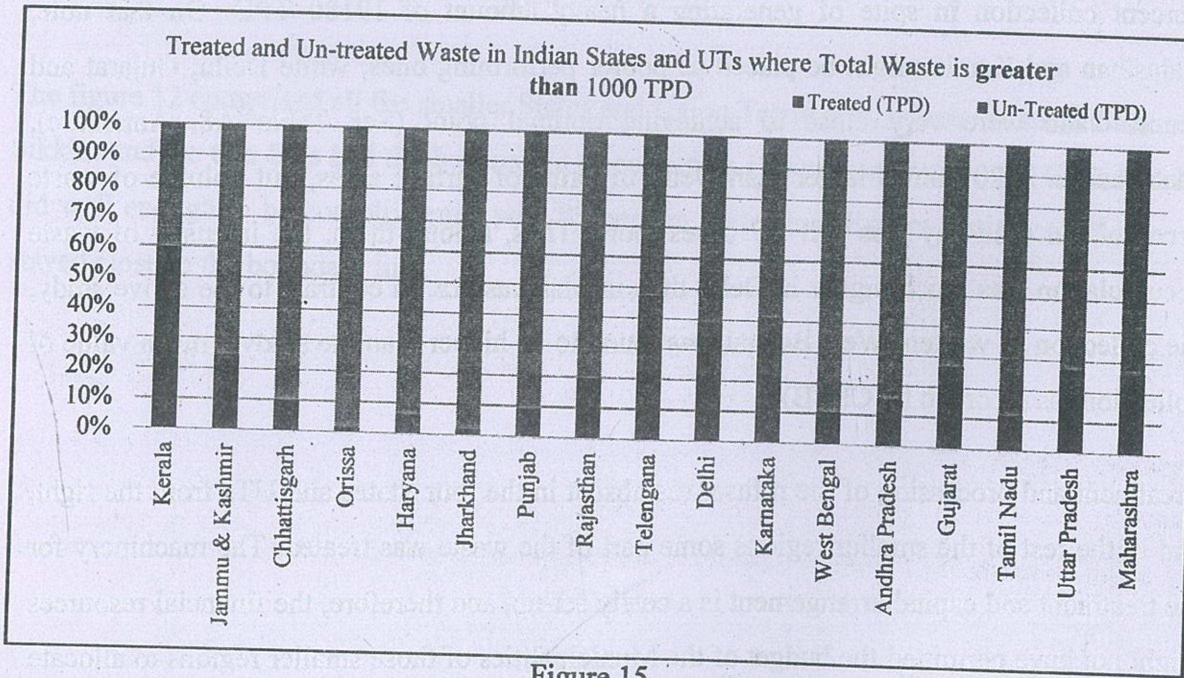


Figure 15.

Data source: "Annual Review Report: 2014-15", Central Pollution Control Board (India), *www.cpcb.nic.in*

The concept of *'Green Cities'* arises from the concept of sustainability. In case of waste management service, the concept of sustainability centres around the 3-Rs viz., Reduce, Re-use and Recycle. Therefore, poor recycling could have hampered the sustainability of the regions. Revitalizing a region through proper waste management could secure prosperity conserving unnecessary exhaustion of economic wealth and environmental reserves. This is the reason why building a Green City rely heavily on efficient MSWM as an essential requisite. Kerala was the only State to treat around 60 percent of collected waste, Telengana around 50 percent and rest below 40 percent.

Exploring the existing waste management situation in India gave an impression that the sustainability and 3-R concept was not getting decent attention in India. According to the Brundtland Commission's definition sustainable development is the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Simply stating, accumulated waste is highly detrimental to any society because it attacks sustainability of a region. Proper management would ensure less waste goes to the bins, of which the *recyclable* part is recycled, only the residue after full extraction is left landfilled. Since, in India the sector lacked attention, the sustainability, in terms of both economic and environment, is jeopardized.

8. The 'Green' Concept

The term 'green' seemed to get associated with purity, cleanliness, etc., and when it gets tagged with a city, the immediate message that is communicated is that the region must be clean and tidy in appearance. The concept of Green Economy gives rise to the concept of Green Cities, which got considerable weightage in 1989 through the publication of "Blue Print for a Sustainable Economy" by Pearce, Markhandya and Barbier. Just two years before that, UN published "Our Common Future", commonly known as Burndtland Commission, emphasized on multilateralism and interdependence of nations to achieve sustainability. Since the UN Conference on Environment and Development (UNCED) in 1992, the international

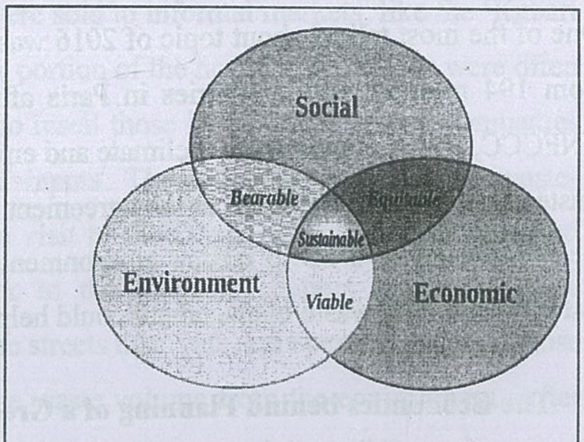


Figure 16: Concept of Green Economy arising from the concept of Sustainable Development.
Picture courtesy: *Johann Dréo, 'Sustainable development'". Date: March 9 2006; translated January 21 2007. Website: http://greenplanetethics.com*

communities, led by UN, were becoming increasingly concerned with the sustainability of the regions across the world. Recent publications on green economy or green growth by the United Nations Environment Program (UNEP), the UN Department of Economic and Social Affairs (UNDESA), the United Nations Conference on Trade and Development (UNCTAD), the International Labour Organisation (ILO), the World Bank, the Organisation for Economic Cooperation and Development (OECD), the Global Green Growth Institute (GGGI), the Green Economy Coalition,

Stakeholder Forum, the Green Growth Leaders and many others had brought to the light the concept and explained the different aspects of *Green* economy. The texts of G20 communiques had been frequently clubbing the two concepts together, and the concept 'Green' virtually floated ahead in the agenda list. The United Nations Environment Programme (UNEP) defined the Green Economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (2010).

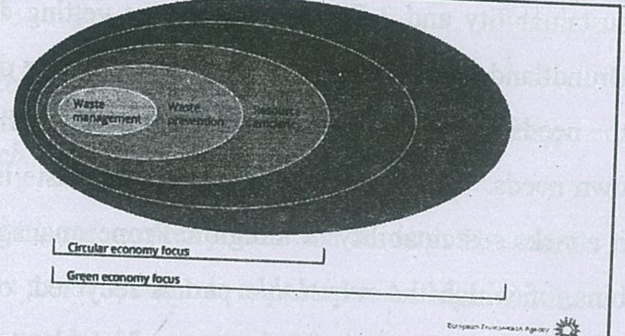


Figure17. Importance of Waste Management
Picture Courtesy: European Environment Agency
Website: http://www.eea.europa.eu/soer-2015/europe/green-economy

One of the most talked about topic of 2016 was the climate agreement adopted by consensus from 194 representative countries in Paris after the 21st Conference of the Parties of the UNFCCC, which voiced against climate and environmental hazards. Although, nothing about waste management was there in the agreement but the debates arising out of it clearly stated the importance of 3-Rs to ensure environmental sustainability. David Newman[7] reinstated that efficient solid waste management could help mitigate the climate change.

9. The Economics behind Planning of a Green City

A city is a small economy that drives growth of a region by transmitting positive externalities arising out of economies of scope created inside that city. A Green City is a Green Economy that must ensure sustainability to its inhabitants through efficient allocation of its resources. The theory of Public Economics had put forth allocation, distribution and macroeconomic stabilization as the prerequisite functions for the governing authorities. Since the resources had always been scarce, especially for the Municipal Bodies, good management and gainful returns from the services might become a key to attain sustainability. In that regard, SWM service could be placed higher up the priority list because of the following two important outcomes: firstly, an efficient service had always assured sustainable condition, and secondly, every refused product could be recycled into a new one. If a Municipality could own the recycling unit, then it would create a recurrent revenue earning opportunity for the municipality.

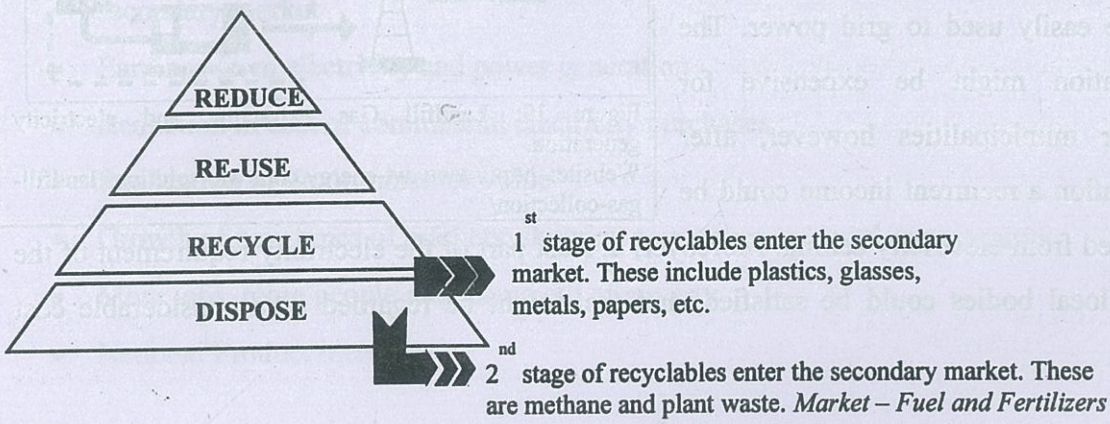


Figure 18. Derivation of the concept of how recycling of waste can enter the process.

The recycling can enter the hierarchical structure of 3-R in two stages: before disposal and after disposal. Several studies across the world showed that a large volumes of recyclable materials, such as paper, plastics, metals, etc., were sold to informal markets, like the 'Kabari walas' of Kolkata (see case study of Kolkata). A portion of the household's scraps were often found to be procured by these scrap-traders, who resell those items to the private companies which uses the refused items as intermediate inputs. There is another group of waste-collectors, and they are rag-pickers. During the visit to the Dhapa ground, it was observed that everyday 200 rag-pickers regularly work in the area and collect resalable items. Furthermore, the rag-pickers are often seen in the streets near vats and open dumpsites. Those pickers had been doing the work of reducing the waste volume from the environment. After procurement processing follow: the entire collection is segregated into different types of items, such as plastics, papers, metals, etc., which were then send to different types of factories for processing.

Another type of recycling might be done through Landfill Gas (LFG) Extraction and treatment, and generate electricity. The plant for extraction is required to be installed at the Landfill sites that treat LFG through extraction, condensation, treatment (filtration), compression and, at last, the generators generate electricity (see figure). The end product can be easily used to grid power. The installation might be expensive for smaller municipalities however, after installation a recurrent income could be expected from electricity selling. Moreover, at least part of the electricity requirement of the urban local bodies could be satisfied, and that might be regarded as a considerable cost saving.

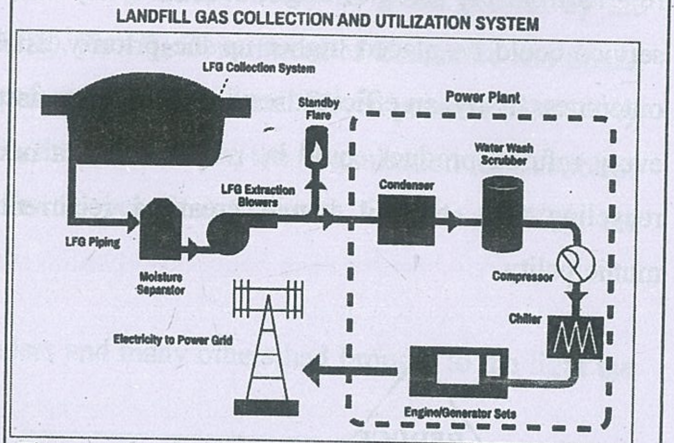


Figure 19: Landfill Gas extraction and electricity generation.
Website: http://www.wt-energy.com/wte-solutions/landfill-gas-collection/

Composting of waste was one of the most talked about topics after the World had started becoming conscious about sustainability of the environment. Composting had always been known well and appreciated for the innovative nature of the process. The food, vegetables and plant wastes are good sources of manure, and hence, fertilizer manufacturing by composting becomes the second option for earning a return from refuse.

10. Return from Waste

The concept of 'zero waste' had been adopted and tried by many countries around the world, especially in Europe. This is because, with proper machinery and perfect segregation process, every bit of waste can be processed that offers immense returns.

Expenditures => Costs

- Waste disposal system of the city: including collection, segregation, transportation and landfilling
- Fuel costs of vehicles
- Installation of Landfill Gas Treatment Unit: including methane extraction unit, compression, liquefaction, and treatment unit, and Generators

- Composting Plant

Earnings =>Benefits

- Improvement of Public Health: budget realizes
- Tidiness of environment attracts tourists: earnings from the Tourism Industry increases
- Cost realization from reduced landfilling: for the volume of waste that goes to secondary market
- Earnings from electricity and power generation
- Reduction in cost of commercial electricity purchases
- Realization of Environmental Value
- Growth of new types of markets: showing new entrepreneurial opportunities
- More jobs, more people may come out of poverty
- National Product increases

11. Emerging Market

According to the report of the market analyst, Frost & Sullivan, MSW market will generate approximately $300 billion by 2020. In 2013, the Global Waste Market earned a revenue of $160.52 billion. Ritu Marya of Franchise India believed that India has great potential for waste market to grow, predictably around $13 billion industry by 2025. Swachh Bharat Mission is supporting this industry to grow, and have also encourage few tie-ups of Indian companies with foreign ones. B.K. Soni of India's first e-waste management company, Eco Recycling Ltd. (Ecoreco), have pointed out that 50 percent of expensive e-waste carrying gold, silver, platinum and other expensive materials goes out of India, and sold back (after extraction) at 50 percent higher rates. Thus, it may be generalized that there exists a large untapped waste market in India, which till date had not been given due attention.

A selected list of the Indian 'Waste to Energy' companies is given below.

Biomethanation		**Combustion /Incineration**	
M/S Asia Bio- energy Pvt Ltd (ABIL)	Chennai	A2Z Group of Companies	Gurgaon
Cicon Environment Technologies	Bhopal	Hanjer Biotech Energies	Mumbai
Bermaco/WM Power Ltd	Navi Mumbai	SELCO International Limited	Hyderabad
Sound craft Industries	Mumbai	East Delhi Waste Processing Company Pvt Ltd	New Delhi
Hydroair Tectonics Limited	Navi Mumbai	**Gasification**	

Ramky Enviro Engineers Ltd	Hyderabad	Zanders Engineers Limited	Mohali
Mailhem Engineers Pvt Ltd.	Pune	UPL Environmental Engineers Pvt Ltd	Vadodara

Most of the companies were set up in Maharasthra, two in Karnataka and one each in Tamil Nadu, Madhya Pradesh, Haryana, Delhi and Gujarat. The Swachh Bharat Mission has emphasized much on these types of plants and had recently proposed six more such plants with a total installed capacity of 73.6 MW. The plants will come up at Ghazipur (12 MW), Narela-Bawana (24 MW), Jabalpur (11 MW), Hyderabad (11 MW), Nalonga (12.6 MW) and Chennai (3 MW). In order to boost their financial viability of the power generated from waste-to-energy plants, the Central Electricity Regulatory Commission (CERC) is also working to determine the chargeable tariff.

One of the mentionable initiative is found in Kolkata, where segregated waste is collected and recycled. The figure below makes an elaborate description of how it works. A portion of the waste paper is collected from segregated refuse and reprocessed into files, cards, and other craft items. More than 300 workers earn their living by getting engaged in the job.

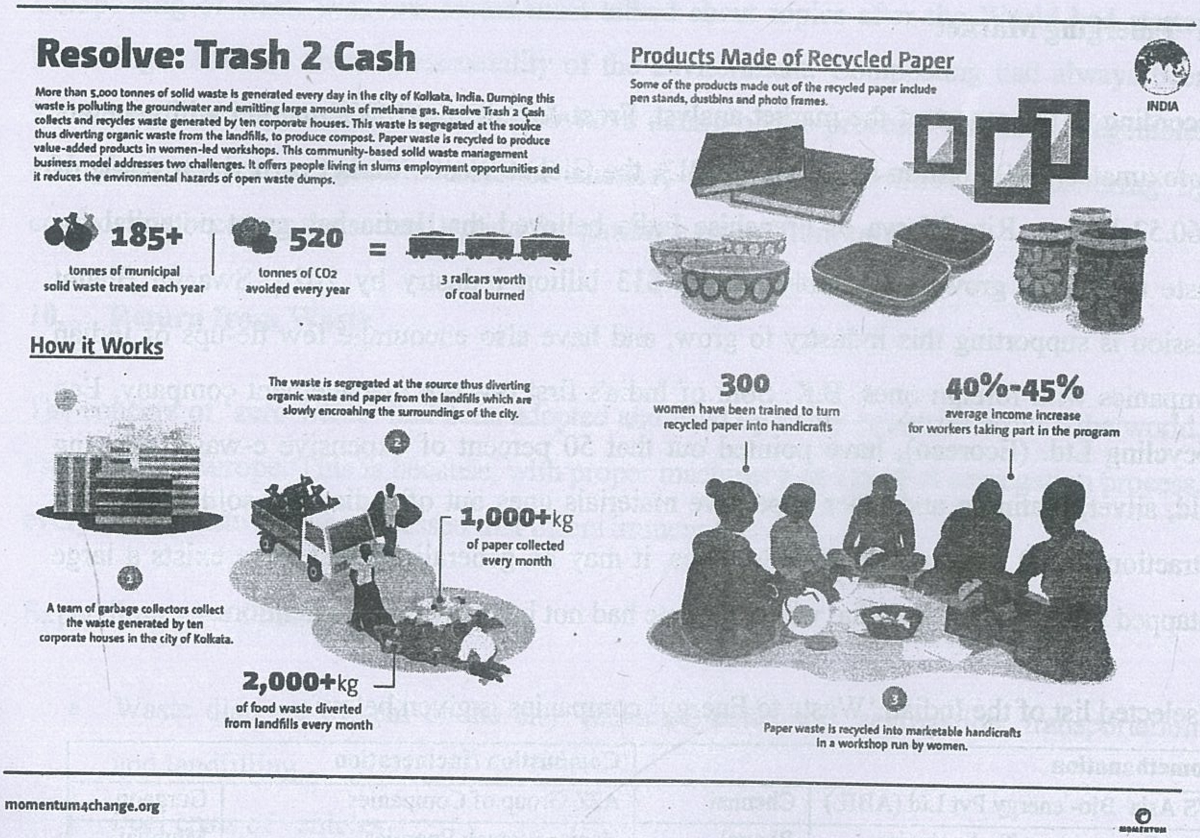


Figure 20. Trash to Cash Initiative of Kolkata
Source: Website: momentum4change.org

12. Discussion

Figure 21. Rag-pickers at the Dhapa LFS.

Waste Management service may be regarded as an important Urban Service that ensures economic productivity of a region by maintaining an optimum level of Public health and hygiene. It is desirable for a region that whatever waste is produced is collected. However, in the selected cities of West Bengal waste collection and disposal falls much short of that 100 percent limit. The entire MSWM process is carried out in chain activities, where much of the activities are not addressed well by the Municipal Authorities. The analysis of such findings shows that the budget of the ULBs put limits on the performance of those activities. Again, the Class Status of the cities, along with the nature of economic activities of the people, may prove to be vital factors that determine SWM carried out by ULBs of that area. However, there exists high scope of improving the service because economies of scope operate in those cities of the considered state of India. Two possible prescriptions may be put forward for improvement and development of MSWM: development of a recycled-product market, and technological advancement. Recycling would reduce the quantity of waste to be deposited, and it will also create an opportunity for the Municipal Bodies to earn some revenue. The world has witnessed a growing market for wastes, and in India too, a large informal market for 'Kabaris' or refuses exists. Thus, there is a large volume of untapped resources for the development of the said market. Another suggestion can be stated for the 'rag pickers' of Dhapa. The recent concept of green jobs can be made applicable to engage this section in the same job but in a hygienic and scientific way.

The sector is slowly imbibing in technology through adoption of Compactors, Mechanical Sweepers, Vehicle Tracking System (VTS) and Smart Bins. Betterment of technology is both time and cost-saving. In Kolkata, after the introduction of Compactor Vehicles, more than 250 Vats were shut down, and number of trucks got reduced from around 700 to 380. The only question regarding buying technology is money resource. In West Bengal, even the larger Corporations are falling way back in upgrading the system with technology. The journey towards 'Green Cities' would bring about economic stability and cleaner hygienic environment.

At the Dhapa LFS, the private vehicles were more effective in carrying out waste service than the Public vehicles. Thus, outsourcing management activities becomes another option to overcome the resource constraint and engage more capital than usual capacity of the Municipalities. Towards initiating a process, Kolkata had already started showing signs of an efficient system, albeit at a very early stage. Kolkata has all the potentialities to turn itself into a green city, and rest of the ULBs can follow suit.

13. Conclusion

A certain level of service determines the service itself, both in terms of quantum of service and delivery of service. When the services are caught up at a low level trap, a large push is required to make it self-sustaining. The 'push' may come in the form of capital investments in waste sector, creating market for selling the recycled products from where the money will come in, and privatizing the sub-sections of the system where the private players can perform better.

To conclude, this paper may add some insights into how the system of waste management may improve its delivery and volume of service. The discussions that will arise out of this paper may show more avenues for researches, not only in the waste management chain but also in other areas such as technology engagements, market features of recycled products, environmental issues, ULB's financial issues, empowerment of rag-picking people through generation of green jobs, and cost-benefit analysis of waste collection to transportation including the argument of privatizing a part of the system.

Reference

1. Alivelu, G. (2007). The Estimation of Indian Railway Cost Function. Zagreb International Review of Economics & Business, Vol. 10, No. 1, pp. 11-32. ISSN 1331-5609.

2. Annepu, R.K. (2012). Sustainable Solid Waste Management in India. Waste-to-Energy Research and Technology Council (WTERT), Colombia University.

3. Asian Development Bank (2012). Green Cities. www.adb.org. ISBN 978-92-9092-896-6 (Print), 978-92-9092-897-3 (PDF).

4. Central Pollution Control Board, Ministry of Environment, Forests & Climate Change, India. (2016) Consolidated Annual Review Report on Implementation of Municipal Solid Wastes (Management and Handling) Rules, 2000. Annual Review Report: 2014-15. cpcb.nic.in.

5. Central Pollution Control Board, Ministry of Environment, Forests & Climate Change, India. (n.d.). Solid Waste Generation in 46 Metrocities. www.cpcb.nic.in

6. Dixit, K. (2016). Tale of an untapped $13 billion waste management industry. The Economic Times, www.economictimes.com. Bennett, Coleman & Co. Ltd.

7. Finn, K.R. (2007). A Study of the Households' Willingness to Contribute to an Improved Solid Waste Management Program in Kratovo, Macedonia. Michigan Technological University.

8. Kinnaman, C.T. (2010). The Costs of Municipal Curbside Recycling and Waste Collection. Resources, Conservation, and Recycling. 864-871. dcadmin@bucknell.edu. DOI: 10.1016/j.resconrec.2010.01.005

9. McDavid, J.C. (1985). The Canadian Experience with Privatizing Residential Solid Waste Collection Services. *Wiley* on behalf of the *American Society for Public Administration.* Vol. 45, No. 5, pp. 602-608. DOI: 10.2307/3109936.

10. Merwe, C V D. (2010). Effective waste management could drive green economy. Engineering News, Creamer Media.

11. Parthan, S.R., Milke, M.W., Wilson, D.C. and Cocks, J.H. (2012). Cost estimation for solid waste management in industrialising regions – Precedents, problems and

prospects. Volume 32, Issue 3, Pages 584–594.
http://www.sciencedirect.com/science/article/pii/S0956053X11005010

12. Pfaff-Simoneit,W. (2012). Waste management: jobs, resources, environmental, climate and health protection. KfW Position Paper.

13. Ren, X. and Hu, S. (2014). Cost recovery of municipal solid waste management in small cities of inland China. Sage Journals. DOI: 10.1177/0734242X14526771.

14. Schübeler, P., Wehrle, K. and Christen, J. (1996). Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries. Working Paper 9. First Edition. Published by SKAT (Swiss Centre for Development Cooperation in Technology and Management).

15. Sharholy, M., Ahmad, K., Mahmood, G. and Trivedi, R.C. (2007). Municipal solid waste management in Indian cities – A review. Elsevier Ltd. DOI:10.1016/j.wasman.2007.02.008.

16. T E R I. (2015). Industrial and urban waste management in India. New Delhi: The Energy and Resources Institute. 34 pp. www.teri in.org.

17. The World Bank. (2008). Improving Municipal Solid Waste Management in India. ISBN: 978-0-8213-7361-3; eISBN: 978-0-8213-7362-0. DOI: 10.1596/ 978-0-8213-7361-3. www.worldbank.org.

18. The World Bank. (2012). Urban Development Series, Knowledge Papers. What A Waste. (http://www.worldbank.org/urban).

19. U. S. Environmental Protection Agency (2010). Methane to Markets. ASSESSMENT REPORT, No. 02205942.00. Kolkata Municipal Corporation.

20. U.S. Environmental Protection Agency (2014). Municipal Solid Waste Generation, Recycling, and Disposal in the United States. Office of Resource Conservation and Recovery, United States.

21. UNEP (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. www.unep.org/greeneconomy. ISBN: 978-92-807-3143-9

22. UN-HABITAT (2009). Solid Waste Management in the World's Cities. United Nations Human Settlements Programme. www.unhabitat.org.

23. Williams, R. (2014, April). Waste Management and the Green Economy. Paper presented in 2nd Africa Sustainable Waste Management Conference, ISWA/ APESB International Conference. Retrieved from www.iswa.org.

End Notes

[1] According to Census of India definition, a 'Census Town' is an Urban Area which has a minimum population of 5,000, at least 75 per cent of the *Male Main Working Population* engaged in non-agricultural pursuits; and has a density of population of at least 400 persons per sq. km.

[2] According to Census of India definition, classes of the cities are given as follows: Class I = 100,000 & above; Class II = 50,000 - 99,999; Class III = 20,000 - 49,999; Class IV = 10,000 - 19,999; Class V = 5,000 - 9,999; and Class VI = less than 5,000 but considered as Urban Areas.

[3] Delaware Solid Waste Authority (DSWA) is an independent agency which manages State's 'Waste' programmes. It was established through an Act and supported by State provided Seed Grant. This regional facility provides disposing facility in lieu of user charges from Urban Local Bodies, and also organizes recycling and Transfer Stations.

[4] Canterbury Waste Joint Standing Committee (CWJSC), comprising representatives from 10 Urban Local Bodies, established Transwaste Canterbury Limited (TCL) that had entered into a venture jointly with six councils and private companies

[5] Gujarat Urban Development Company (GUDU) is a nodal agency that provide state-wide MSW Management in consultation with Bhaskaracharya Institute of Space Applications and Geo-informatics (BISAG), IIM Ahmedabad, Institute of Solid Waste Management, Karnataka Compost Development Corporation, M/s Mahindra Acre, M/s SENES and Crisal Advisory Services Ltd.

[7]President, International Solid Waste Association's (ISWA)

Annexure

Table A1: Municipal Solid Waste Generation and Collection Service for Selected cities of West Bengal.

Town Name	Total HH	Total Population	Class	Area (sq. km.)	Household level coverage	Efficiency of collection (HH + other)	Waste generated (in MT)	Collected Waste (HH + other) (in MT)	Uncollected (HH + other) (in MT)
Mekliganj	2249	9127	V	3.71	4	0	2.28	0.00	2.28
Kharar	2643	12118	IV	8.43	0	81	3.03	2.45	0.58
Haldibari	3405	14404	IV	10.5	0	100	3.60	3.60	0.00
Tufanganj	5171	20998	III	3.88	88	100	5.25	5.25	0.00
Mathabhanga	5792	23890	III	44.18	75	83	5.97	4.96	1.02
Dainhat	5560	24397	III	10.36	0	41	6.10	2.50	3.60
Mal	5933	25218	III	21.5	100	100	6.30	6.30	0.00
Sonamukhi	6379	29085	III	21.8	25	28	7.27	2.04	5.24
Beldanga	6580	29205	III	3.98	57	95	7.30	6.94	0.37
Egra	6471	30148	III	17.21	25	40	7.54	3.01	4.52
Birnagar	6702	30799	III	5.52	10	0	7.70	0.00	7.70
Guskara	8119	35388	III	17.17	0	0	8.85	0.00	8.85
Dinhata	8739	36124	III	4.55	100	61	9.03	5.51	3.52
Dalkhola	6861	36930	III	15.95	0	98	9.23	9.05	0.18
Pujali	8587	37047	III	19.38	0	0	9.26	0.00	9.26
Dubrajpur	8145	38041	III	16.84	0	77	9.51	7.32	2.19
Taki	8919	38263	III	17.96	25	100	9.57	9.57	0.00
Memari	9638	41451	III	18.36	0	100	10.36	10.36	0.00
Murshidabad	9829	44019	III	3.88	14	76	11.00	8.36	2.64
Sainthia	10229	44601	III	24.99	0	100	11.15	11.15	0.00
Gobardanga	11502	45377	III	13.5	31	100	11.34	11.34	0.00
Jiaganj-Azimganj	11787	51790	II	3.85	18	82	12.95	10.62	2.33
Baduria	12058	52493	II	22.43	0	5	13.12	0.66	12.47
Baruipur	13226	53128	II	9.5	78	100	13.28	13.28	0.00
Kaliaganj	12347	53530	II	21.4	27	100	13.38	13.38	0.00
Islampur	11404	54340	II	51.74	70	83	13.59	11.28	2.31
Ghatal	11303	54591	II	10.4	12	76	13.65	10.37	3.28
Kandi	12237	55632	II	10.96	5	84	13.91	11.68	2.23
Kalna	13418	56722	II	11.67	0	96	14.18	13.61	0.57
Rampurhat	13077	57833	II	49.26	44	44	14.46	6.36	8.10
Gayespur	14304	58998	II	30	0	22	14.75	3.24	11.50
Jhargram	14235	61712	II	5.85	18	82	15.43	12.65	2.78
Alipurduar	15556	65232	II	9.8	0	69	16.31	11.25	5.06
Bishnupur	15074	67783	II	22.02	0	0	16.95	0.00	16.95
Ranaghat	17863	75365	II	15.83	0	45	18.84	8.48	10.36
Konnagar	19796	76172	II	8.19	29	92	19.04	17.52	1.52
New Barrackpore	19307	76846	II	11.55	100	95	19.21	18.25	0.96
Koch Bihar	18431	77935	II	10.26	94	97	19.48	18.90	0.58
Old Malda	16479	84012	II	12.61	54	99	21.00	20.79	0.21
Garulia	18122	85336	II	6.47	0	73	21.33	15.57	5.76
Jangipur	17418	88165	II	12.97	42	96	22.04	21.16	0.88
Contai	16760	92226	II	14.25	27	100	23.06	23.06	0.00
Chakdaha	23167	95203	II	15.65	0	0	23.80	0.00	23.80
Kalyani	24492	100575	I	9.16	15	19	25.14	4.78	20.37
Bhadreswar	23233	101477	I	8.28	26	100	25.37	25.37	0.00
Jalpaiguri	26205	107341	I	17.29	60	45	26.84	12.08	14.76
Bongaon	26332	108864	I	14.27	77	100	27.22	27.22	0.00
Champdani	24193	111251	I	6.54	11	97	27.81	26.98	0.83
Dum Dum	27702	114786	I	9.23	0	100	28.70	28.70	0.00
Puruliya	23754	121067	I	19.94	0	76	30.27	23.00	7.26
Ashokenagar Kalyangarh	30232	121592	I	20.5	25	92	30.40	27.97	2.43
Rishra	27906	124577	I	7.72	64	83	31.14	25.85	5.29
Halisahar	30381	124939	I	8.29	81	34	31.23	10.62	20.61
Basirhat	29276	125254	I	22.05	3	100	31.31	31.31	0.00
Nabadwip	30914	125543	I	8.84	98	100	31.39	31.39	0.00
North Barrackpore	32564	132806	I	12	0	100	33.20	33.20	0.00
Habra	36016	147221	I	21.8	36	69	36.81	25.40	11.41
Santipur	36506	151777	I	6.48	17	100	37.94	37.94	0.00
Barrackpore	37312	152783	I	10.61	44	100	38.20	38.20	0.00
Krishnanagar	38052	153062	I	185	62	90	38.27	34.44	3.83
Balurghat	37949	153279	I	10.76	78	84	38.32	32.19	6.13
Uttarpara Kotrung	40824	159147	I	2.49	100	100	39.79	39.79	0.00
Chandannagar	41347	166867	I	22.1	22	57	41.72	23.78	17.94

Medinipur	37392	169264	I	7.5	26	100	42.32	42.32	0.00
Serampore	42258	181842	I	10	65	88	45.46	40.01	5.46
Raiganj	35326	183612	I	14	52	100	45.90	45.90	0.00
Berhampore	43075	195223	I	31.42	85	88	48.81	42.95	5.86
Madhyamgram	48942	196127	I	96	48	94	49.03	46.09	2.94
Haldia	44065	200827	I	109.65	60	45	65.27	29.37	35.90
English Bazar	42867	205521	I	13.25	45	91	66.79	60.78	6.01
Kharagpur	44618	207604	I	12.97	85	80	67.47	53.98	13.49
Bidhannagar	48919	215514	I	33.1	85	95	70.04	66.54	3.50
Naihati	37167	217900	I	17.25	0	45	70.82	31.87	38.95
Baranagar	63387	245213	I	7.12	89	100	79.69	79.69	0.00
DumDum (N)	63256	249142	I	6.89	41	12	80.97	9.72	71.25
Barasat	69506	278435	I	34.5	19	74	90.49	66.96	23.53
TOTAL				***1487.31***			***2009.54***	***1528.20***	***481.34***
Barddhaman	71618	314265	I	26.3	82	100	102.14	102.14	0.00
Panihati	85985	377347	I	26.45	7	70	122.64	85.85	36.79
Bhatpara	87645	386019	I	34.69	0	70	125.46	87.82	37.64
Rajpur Sonarpur	106604	424368	I	10.76	32	37	137.92	51.03	86.89
Maheshtala	101453	448317	I	7.85	25	92	145.70	134.05	11.66
Siliguri	115957	513264	I	43.48	3	100	192.47	192.47	0.00
TOTAL				***149.53***	***149***	***469***	***826.3267***	***653.35***	***172.97***
Asansol	113739	563917	I	125.23	37	79	211.47	167.06	44.41
Durgapur	130944	566517	I	154.2	47	16	212.44	33.99	178.45
TOTAL				***279.43***			***423.91***	***201.05***	***222.86***
Kolkata	1024928	4496694	I	6.87	25	92	2248.35	2068.48	179.87

Data source: Ministry of Urban Development (India);
Census of India, 2011

Table A2: Municipal Solid Waste Management Service Activities for Selected cities of West Bengal.

City	Class	Area (sq.km.)	DD-coverage	Collection	Segregation	Recovery	Scientific Disposal	Complaint Redressal	Cost Recovery	Collection Charges	Water supply Coverage	Toilet Facility Coverage	Sewerage Coverage	Sanitation Coverage
Alipurduar	II	9.8	0	2	0	0	1	2	0	0	8867	6689	0	467
Asansol	I	125.23	42083	2	0	0	0	1	1	1	34122	113739	0	35259
Ashokenagar Kalyangarh	I	20.5	7558	2	0	0	0	1	0	0	7256	29325	0	4535
Baduria	II	22.43	0	1	0	0	0	2	0	0	723	8441	0	723
Balurghat	I	10.76	29600	2	0	0	0	2	1	0	379	37949	0	6072
Baranagar	I	7.12	56414	3	0	0	0	0	0	0	60218	0	0	3169
Barasat	I	34.5	13206	2	0	0	0	1	0	0	27107	0	0	2085
Barddhaman	I	26.3	58727	3	0	0	0	0	0	0	42971	0	0	0
Barrackpore	I	10.61	16417	3	0	0	0	0	1	1	24626	31342	0	373
Baruipur	II	9.5	10316	3	0	0	0	0	0	0	2910	9258	0	8861
Basirhat	I	22.05	878	3	0	0	0	2	1	0	586	29276	0	29276
Beldanga	III	3.98	3751	2	0	1	0	2	1	1	658	6580	0	2632
Berhampore	I	31.42	36614	2	0	0	0	2	1	0	4738	43075	0	75381
Bhadreswar	I	8.28	6041	3	0	0	0	0	0	0	7435	23233	0	23233
Bhatpara	I	34.69	0	2	0	0	0	2	0	0	26294	63981	11394	43823
Bidhannagar	I	33.1	41581	2	0	0	0	3	1	0	41581	48919	46962	978
Birnagar	III	5.52	670	0	0	0	0	0	1	1	1474	0	0	0
Bishnupur	II	22.02	0	0	0	0	0	0	0	0	3015	7085	0	12511
Bongaon	I	14.27	20276	3	0	0	1	2	1	0	0	23699	0	790
Chakdaha	II	15.65	0	0	0	1	0	2	0	0	6487	23167	0	9962
Champdani	I	6.54	2661	2	0	0	0	2	0	0	16209	23225	0	28306
Chandannagar	I	22.1	9096	2	0	1	1	2	1	0	27289	33078	6616	827
Contai	II	14.25	4525	3	0	0	0	0	0	0	168	5531	0	0
Dainhat	III	10.36	0	1	0	0	0	2	0	0	1501	4392	0	0
Dalkhola	III	15.95	0	2	0	0	0	3	0	0	0	0	0	274
Dinhata	III	4.55	8739	2	0	0	1	2	0	0	437	6729	0	8739
Dubrajpur	III	16.84	0	2	0	0	0	0	0	0	0	4887	0	1059
Dum Dum	I	9.23	0	3	0	0	0	0	0	0	17175	0	0	18006
Durgapur	I	154.2	61544	1	1	1	1	2	1	1	1309	0	0	0
Egra	III	17.21	1618	1	0	0	0	1	0	0	3236	0	0	0
English Bazar	I	13.25	19290	2	0	0	0	3	0	0	25720	41581	0	42867
Garulia	II	6.47	0	2	0	0	1	2	0	0	9242	0	0	24827
Gayespur	II	30	0	1	0	0	0	1	0	0	5865	14304	0	14304
Ghatal	II	10.4	1356	2	0	0	0	2	0	0	2374	8929	0	1695
Gobardanga	III	13.5	3566	3	1	0	1	2	1	1	230	10582	0	460
Guskara	III	17.17	0	0	0	0	1	2	0	0	568	0	0	0
Habra	I	21.8	12966	2	0	0	0	2	0	0	2161	20169	0	28092
Haldia	I	109.65	26439	1	0	0	0	2	0	0	26880	35252	0	11016
Haldibari	IV	10.5	0	3	0	0	0	0	0	0	443	2179	0	0
Halisahar	I	8.29	24609	1	0	0	0	2	1	0	21874	18229	0	18229
Islampur	II	51.74	7983	2	0	0	0	2	0	0	1140	9807	0	0
Jalpaiguri	I	17.29	15723	1	0	0	0	2	0	0	18344	20964	0	6551
Jangipur	II	12.97	7316	2	1	1	0	2	0	0	6619	17418	0	4355
Jhargram	II	5.85	2562	2	1	1	0	2	1	1	0	6263	0	1708
Jiaganj-Azimganj	II	3.85	2122	2	1	1	0	2	1	1	0	11433	0	7662
Kaliaganj	II	21.4	3334	3	0	0	0	3	0	0	0	7285	0	617
Kalna	II	11.67	0	2	0	0	1	1	1	0	5636	9661	0	134
Kalyani	I	9.16	3674	1	0	0	0	2	1	1	23757	22288	4409	23512
Kandi	II	10.96	612	2	0	0	0	1	1	0	2080	12237	0	857
Kharagpur	I	12.97	37925	2	0	1	0	2	0	0	31233	37479	37925	29002
Kharar	IV	8.43	0	2	0	0	1	2	0	0	502	925	0	0
Koch Bihar	II	10.26	17325	2	1	0	0	2	0	0	11612	17878	0	0
Kolkata	I	6.87	256232	2	0	0	0	1	0	0	286980	297229	0	0
Konnagar	II	8.19	5741	2	0	0	0	1	0	0	13659	19400	0	198
Krishnanagar	I	185	23592	2	0	0	0	0	0	0	9894	0	0	2664
Madhyamgram	I	96	23492	2	0	0	0	0	0	0	23003	0	0	0
Maheshtala	I	7.85	25363	2	0	0	0	1	0	0	63915	98409	0	0
Mal	III	21.5	5933	3	0	0	0	3	0	0	0	5458	0	1009
Mathabhanga	III	44.18	4344	2	0	0	0	2	0	0	0	4692	0	3128
Medinipur	I	7.5	9722	3	0	0	0	0	0	0	5235	0	0	0
Mekliganj	V	3.71	90	0	0	0	0	1	0	0	607	1957	0	0

Memari	III	18.36	0	3	0	0	0	0	0	0	2891	9638	0	9638
Murshidabad	III	3.88	1376	2	0	0	0	1	0	1	0	8846	0	1278
Nabadwip	I	8.84	30296	3	1	1	1	2	0	0	2473	0	18858	24113
Naihati	I	17.25	0	1	0	0	0	0	1	1	0	0	0	12637
New Barrackpore	II	11.55	19307	2	0	0	0	2	1	0	12163	19114	0	0
North Barrackpore	I	12	0	3	0	0	0	0	0	0	11723	23772	4233	16282
North DumDum	I	6.89	25935	1	0	0	0	0	0	0	2530	0	0	21507
Old Malda	II	12.61	8899	2	0	0	0	0	0	0	989	165	0	824
Panihati	I	26.45	6019	2	1	0	0	2	1	0	0	72227	0	6019
Pujali	III	19.38	0	0	0	0	0	0	0	0	0	0	0	0
Puruliya	I	19.94	0	2	0	0	0	2	0	0	950	14727	0	238
Raiganj	I	14	18370	3	0	0	0	2	0	0	0	0	0	2473
Rajpur Sonarpur	I	10.76	34113	1	0	1	0	0	1	0	5330	85283	0	53302
Rampurhat	II	49.26	5754	1	0	0	0	3	0	0	523	13077	0	131
Ranaghat	II	15.83	0	1	0	0	0	2	1	1	6073	12861	0	6073
Rishra	I	7.72	17860	2	0	0	0	1	0	0	20092	27627	0	27906
Sainthia	III	24.99	0	3	0	0	0	0	0	0	409	0	0	3478
Santipur	I	6.48	6206	3	1	1	1	0	0	0	2920	0	0	9127
Serampore	I	10	27468	2	1	0	0	0	0	0	37187	32539	10142	10565
Siliguri	I	43.48	3479	3	0	1	0	2	1	0	16234	0	0	0
Sonamukhi	III	21.8	1595	1	0	0	0	0	0	0	1212	4338	0	0
Taki	III	17.96	2230	3	0	0	1	0	0	0	0	0	0	89
Tufanganj	III	3.88	4550	3	0	0	0	2	0	0	1500	2999	0	2534
Uttarpara Kotrung	I	2.49	40824	3	1	0	0	3	0	0	16330	0	0	0

Data source: Ministry of Urban Development (India);
Census of India, 2011

Collection: 3 = 100 %; 2 = Coverage 50 % and more; 1 = Coverage less than 50 %; otherwise = 0
Segregation: 1 = Coverage; otherwise = 0
Recovery: 1 = Coverage; otherwise = 0
Scientific Disposal: 1 = Coverage; otherwise = 0
Complaint Redressal: 1 = Coverage; otherwise = 0
Cost Recovery: 1 = Coverage; otherwise = 0
Collection Charges: 1 = Coverage; otherwise = 0

Table A3: An Account of different Solid Waste Management Activities in the Selected Cities of West Bengal.

Parameters	Segregation of Waste		Waste Recovering facility		Scientific Disposal of Waste		Redressal of Complaints		Cost recovery *(Annual operating revenue)*		Tipping Fee, taxes and Cess taken	
	No Service	*Service Available*	*No Service*	*Service Available*	*No Service*	*Service Available*	*No Service*	*Service Available*	*No Service*	*Service Available*	*No Service*	*Service Available*
1.Number of MA*s	73	11	72	12	72	12	26	58	60	24	72	12
2.Population	8,904,422	1,887,152	11,086,120	8,604,105	9,297,446	1,494,128	3,375,652	7,415,922	6,596,061	4,195,513	8,851,615	1,939,959
3.Households	2,037,869	440,804	2,544,735	1,964,658	2,125,612	353,061	789,536	1,689,137	1,521,625	957,048	2,056,521	422,152
4.Area (sq. Km.)*2	1,376	304	1,916	1,615	1,373	307	407	1,273	1,029	651	1,269	412
5.Expected waste generation (MT*3s)	2,567	571	2,457	681	2,694	444	953	2,186	1,839	1,299	2,496	643
6.Waste/ Area (MT/Sq. Km.)	1.9	1.9	1.3	1.9	2.0	1.4	2.3	1.7	1.8	2.0	2.0	1.6

Data Source: Service Level Handbook, Ministry of Urban Development (India).

Note: *1 Municipal Area; *2 Square Kilometres; *3 Metric tons.

Table A4: Expenditure on Labour, Capital and Sweeping, used to find out Cost of Service.

Name	*Households*	*Population*	*Waste per day (in MT)*	*Cost per day in MT*			
				Labour	***Capital***	***Sweeping***	***Total Cost***
Alipurduar	15556	65232	16.31	13076.50	6906.79	180436.92	200420.21
Asansol	113739	563917	211.47	70507.37	40386.29	110432.13	221325.79
Ashokenagar Kalyangarh	30232	121592	30.40	15351.72	9364.28	187332.43	212048.43
Baduria	12058	52493	13.12	10136.05	5221.48	97905.48	113263.01
Balurghat	37949	153279	38.32	19499.80	12153.69	0.00	31653.49
Baranagar	63387	245213	79.69	36022.40	22134.49	142203.08	200359.97
Barasat	69506	278435	90.49	39340.72	23993.94	301846.15	365180.81
Barddhaman	71618	314265	102.14	44027.26	24949.93	250733.54	319710.72
Barrackpore	37312	152783	38.20	19176.33	12086.27	115794.89	147057.49
Baruipur	13226	53128	13.28	11117.88	5673.88	20793.85	37585.60
Basirhat	29276	125254	31.31	14866.26	9263.09	206543.26	230672.62
Beldanga	6580	29205	7.30	9163.54	2634.88	33357.35	45155.77
Berhampore	43075	195223	48.81	22811.92	15011.32	649304.62	687127.85
Bhadreswar	23233	101477	25.37	11797.65	7390.60	58571.57	77759.81
Bhatpara	87645	386019	125.46	50116.04	30960.91	33538.46	114615.41
Bidhannagar	48919	215514	70.04	28176.42	17365.34	214646.15	260187.91
Birnagar	6702	30799	7.70	9333.44	2641.06	0.00	11974.50
Bishnupur	15074	67783	16.95	7654.53	4883.17	69760.00	82297.71
Bongaon	26332	108864	27.22	13371.31	8129.57	101561.17	123062.05
Chakdaha	23167	95203	23.80	11764.13	7383.61	108664.62	127812.36
Champdani	24193	111251	27.81	12285.13	7492.21	50643.08	70420.42
Chandannagar	41347	166867	41.72	21225.29	13335.27	89883.08	124443.64
Contai	16760	92226	23.06	8510.68	5061.63	100615.38	114187.69
Dainhat	5560	24397	6.10	7743.05	2254.41	39904.06	49901.53
Dalkhola	6861	36930	9.23	9554.87	2649.12	12731.20	24935.19
Dinhata	8739	36124	9.03	12170.24	3401.84	55117.11	70689.19
Dubrajpur	8145	38041	9.51	11343.02	3042.97	60852.18	75238.17
Dum Dum	27702	114786	28.70	14066.99	7452.66	0.00	21519.65
Durgapur	130944	566517	212.44	75244.75	46517.90	40221.05	161983.69
Egra	6471	30148	7.54	9011.75	2300.58	7894.95	19207.28
English Bazar	42867	205521	66.79	24185.28	14430.56	154276.92	192892.76
Garulia	18122	85336	21.33	9202.30	5616.75	34209.23	49028.27
Gayespur	14304	58998	14.75	12024.05	6116.74	0.00	18140.80
Ghatal	11303	54591	13.65	9501.39	4812.80	113024.62	127338.81
Gobardanga	11502	45377	11.34	16018.09	4528.18	101956.92	122503.20
Guskara	8119	35388	8.85	11306.81	3041.65	0.00	14348.46
Habra	36016	147221	36.81	18518.23	11538.13	94598.58	124654.94
Haldia	44065	200827	65.27	24834.95	14142.27	0.00	38977.23
Haldibari	3405	14404	3.60	4741.92	1158.88	29936.43	35837.24
Halisahar	30381	124939	31.23	15427.38	9380.05	109804.92	134612.35
Islampur	11404	54340	13.59	9586.29	4823.49	26830.77	41240.55
Jalpaiguri	26205	107341	26.84	13306.82	8116.13	88541.54	109964.48
Jangipur	17418	88165	22.04	8844.81	5542.23	112689.23	127076.27
Jaynagar Mazilpur	6036	25922	6.48	8405.95	2278.54	35550.77	46235.25
Jhargram	14235	61712	15.43	11966.05	6109.44	36221.54	54297.03
Jiaganj-Azimganj	11787	51790	12.95	9908.24	5192.80	77943.38	93044.43
Kaliaganj	12347	53530	13.38	10378.99	5252.07	29735.20	45366.26
Kalna	13418	56722	14.18	11279.28	5694.20	58356.92	75330.40
Kalyani	24492	100575	25.14	12436.96	7523.86	181107.69	201068.51
Kandi	12237	55632	13.91	10286.52	5240.43	79150.77	94677.72
Kharagpur	44618	207604	67.47	25134.84	15020.82	162326.15	202481.81
Kharar	2643	12118	3.03	3680.74	1120.26	32196.92	36997.92
Koch Bihar	18431	77935	19.48	9359.20	5649.45	0.00	15008.66
Kolkata	1024928	4496694	2248.35	645289.66	377401.87	3649110.77	4671802.31
Konnagar	19796	76172	19.04	10052.35	6204.89	97932.31	114189.55
Krishnanagar	38052	153062	38.27	19552.10	12164.59	0.00	31716.69
Madhyamgram	48942	196127	49.03	25791.16	15632.31	209581.85	251005.31
Maheshtala	101453	448317	145.70	57604.10	35251.52	0.00	92855.63

Mal	5933	25218	6.30	8262.51	2273.32	0.00	10535.82
Mathabhanga	5792	23890	5.97	8066.15	2266.17	34175.69	44508.01
Medinipur	37392	169264	42.32	19216.96	12094.73	0.00	31311.69
Mekliganj	2249	9127	2.28	3132.04	771.52	25489.23	29392.79
Memari	9638	41451	10.36	13422.22	3776.17	12536.68	29735.07
Murshidabad	9829	44019	11.00	13688.22	3785.85	91895.38	109369.45
Nabadwip	30914	125543	31.39	15698.03	9436.47	1616.55	26751.06
Naihati	37167	217900	70.82	21803.33	14107.17	159515.63	195426.13
New Barrackpore	19307	76846	19.21	9804.03	6153.13	80834.40	96791.57
North Barrackpore	32564	132806	33.20	16535.90	10022.07	127446.15	154004.12
North DumDum	63256	249142	80.97	35951.36	22121.08	0.00	58072.43
Old Malda	16479	84012	21.00	8367.99	5031.89	107323.08	120722.95
Panihati	85985	377347	122.64	49215.83	30379.97	197876.92	277472.72
Pujali	8587	37047	9.26	11958.56	3394.14	62227.26	77579.96
Puruliya	23754	121067	30.27	12062.21	7445.74	79.15	19587.10
Raiganj	35326	183612	45.90	18877.00	12547.29	125453.97	156878.26
Rajpur Sonarpur	106604	424368	137.92	60397.48	36600.89	631864.62	728862.99
Rampurhat	13077	57833	14.46	10992.63	5658.10	52413.91	69064.64
Ranaghat	17863	75365	18.84	9070.78	5589.33	117384.62	132044.73
Rishra	27906	124577	31.14	14170.58	8707.13	70430.77	93308.48
Sainthia	10229	44601	11.15	14245.27	3806.13	16769.23	34820.63
Santipur	36506	151777	37.94	18767.05	11590.00	0.00	30357.04
Serampore	42258	181842	45.46	22397.05	14513.88	0.00	36910.93
Siliguri	115957	513264	192.47	66408.17	41024.36	0.00	107432.53
Sonamukhi	6379	29085	7.27	8883.62	2295.92	3353.85	14533.39
Taki	8919	38263	9.57	12420.92	3410.96	4091.69	19923.57
Tufanganj	5171	20998	5.25	7201.32	1905.93	38904.62	48011.86
Uttarpara Kotrung	40824	159147	39.79	20959.71	12868.95	97033.48	130862.14

Table A6: A Primary Survey recording the Movement of Vehicles at Dhapa LFS, for a period of 5-days.

VEHICLE	AGENCY	Disposal Date	7H	8H	9H	10H	11H	12H	13H	14H	15H	16H	17H	18H	19H	NET WT.	TOT_TRIP	TOT_VEHI
VEHI	KMC	1-Dec-16	9	22	42	66	99	123	148	165	173	174	176	176	176	472670	176	70
VEHI	KMC	2-Dec-16	8	23	46	77	99	127	149	161	166	167	169	169	169	454830	169	67
VEHI	KMC	3-Dec-16	9	22	46	66	102	127	149	165	169	174	176	176	176	459980	176	69
VEHI	KMC	4-Dec-16	8	25	50	82	111	138	162	173	177	180	181	181	181	457250	181	65
VEHI	KMC	5-Dec-16	6	18	40	62	85	.115	134	141	147	150	150	150	150	399530	150	67
VEHI	AGENCY	1-Dec-16	0	25	110	162	236	292	354	436	496	546	577	581	583	3440690	583	271
VEHI	AGENCY	2-Dec-16	0	11	102	183	233	295	368	466	493	544	563	566	568	3361500	568	269
VEHI	AGENCY	3-Dec-16	0	14	97	172	237	301	370	446	517	571	587	591	592	3577710	592	276
VEHI	AGENCY	4-Dec-16	0	20	107	181	249	315	374	452	501	537	552	552	552	3301300	552	262
VEHI	AGENCY	5-Dec-16	0	29	110	181	239	294	360	436	495	539	564	564	566	3321070	566	272
COMPAC	KMC	1-Dec-16	0	1	1	2	8	15	20	22	23	23	23	23	23	127150	23	17
COMPAC	KMC	2-Dec-16	0	0	2	6	12	18	22	22	23	23	23	23	23	122480	23	17
COMPAC	KMC	3-Dec-16	0	0	2	5	11	15	20	21	21	22	23	23	23	119690	23	17
COMPAC	KMC	4-Dec-16	0	0	1	6	13	18	21	22	22	23	23	23	23	123600	23	17
COMPAC	KMC	5-Dec-16	0	0	2	3	8	17	22	22	23	23	23	23	23	122670	23	17
COMPAC	AGENCY	1-Dec-16	0	0	8	21	41	53	72	88	95	106	110	111	112	767800	112	48
COMPAC	AGENCY	2-Dec-16	0	0	8	28	45	62	83	98	101	109	110	112	113	774360	113	51
COMPAC	AGENCY	3-Dec-16	0	0	10	24	47	66	87	97	107	112	115	117	118	821990	118	53
COMPAC	AGENCY	4-Dec-16	0	2	9	31	51	75	94	106	112	113	116	116	116	749550	116	53
COMPAC	AGENCY	5-Dec-16	0	3	9	29	48	63	87	97	103	108	110	110	110	750700	111	50

Table A8: State-wise Waste Generated, Collected and Treated (in TPD) during the year 2014-15.

States	Generated(TPD)	Collected(TPD)	Treated (TPD)	Percentage collected	Percentage treated
Maharashtra	22,570	22,570	5,927	100.0	26.3
Uttar Pradesh	19180	19180	5197	100.0	27.1
Tamil Nadu	14500	14234	1607	98.2	11.1
Gujarat	9988	9882	2644	98.9	26.5
Andhra Pradesh	9754	6340	975	65.0	10.0
West Bengal	9500	8075	851	85.0	9.0
Karnataka	8697	7288	3000	83.8	34.5
Delhi	8370	8300	3240	99.2	38.7
Telengana	6740	6369	3016	94.5	44.7
Rajasthan	5037	2491	490	49.5	9.7
Punjab	4105	3853	350	93.9	8.5
Jharkhand	3570	3570	65	100.0	1.8
Haryana	3103	3103	188	100.0	6.1
Orissa	2374	2167	30	91.3	1.3
Chhattisgarh	1896	.1704	168	89.9	8.9
Jammu & Kashmir	1792	1322	320	73.8	17.9
Kerala	1339	655	390	48.9	29.1
Assam	650	350	0	53.8	0.0
Goa	450	400	182	88.9	40.4
Tripura	415	368	250	88.7	60.2
Chandigarh	370	360	250	97.3	67.6
Himachal Pradesh	276	207	125	75.0	45.3
Meghalaya	208	175	55	84.1	26.4
Arunachal Pradesh	116	70.5	0	60.8	0.0
Daman Diu & Dadra	85	85	0	100.0	0.0
Andaman & Nicobar	70	70	5	100.0	7.1
Sikkim	49	49	0.3	100.0	0.6

Data source: Central Pollution Control Board, GOI.

22. Transportation Policy for the Control of Vehicular Air Pollution in Urban Areas: Applying Lessons from North to Calcutta, India – *Madumati Dutta* (September 2001)
23. Urbanisation in the Pre-colonial Bengal –*Biplab Dasgupta* (December 2001)
24. Emerging Issues in Bio-Medical Waste Management – *Sushma Wadhwani* (January 2002)
25. Urbanization and Agricultural Change in North-Eastern India – *J. B. Ganguly* (October 2003)
26. An Analytical Study of the Growth Experience in the Small Industries of Howrah and Burdwan Districts, 1988-2000 – *Nandita Basak* (October 2003)
27. Truck Terminals in Kolkata Metropolitan Area: Master Planning and Market Response – *Anis Mukhopadhyay* (August 2004)
28. Labour Market Segregation and Gender Bias –*Pampa Sengupta* (September 2004)
29. Urbanisation, Migration and Urban Society in Colonial Bengal - *Biplab Dasgupta* (December 2005)
30. The Growth Experience of the Small Scale Industries of North 24 Parganas and Medinipur Districts, West Bengal, 1988-2001- *Nandita Basak* (October 2007)
31. An Environmental Valuation of an Urban Wetland: A Case Study of the Jodhpur Park Lake – *Simanti Banerjee and Ashish K. Ghosh* (2007)
32. Evolution and Growth of Municipal Towns in Kolkata Metropolitan Area – *Mahalaya Chatterjee* (August 2008)
33. Polluting Behaviour of Different Modes of Transport in Big Cities and Policy Implications for Pollution Reduction: The Case of Kolkata, India – *Madhumati Dutta, Mohit Roy and Sudip K. Roy* (July 2009)
34. Spatial and Economic Changes in Asansol, 1951-2001(1/2011) - *Mousumi Ghosh*
35. Some Aspects of Urbanisation in Eastern India (2/2011)- *Somali Chakravorty & Malabika Dasgupta*
36. Modern Mobility, rejuvenation of Howrah and East-West Metro (1/2012)- *Anis Mukhopadhyay*
37. Kolkata Metro: A Study On Passenger Movement And Financial Health (1990-2010) (2/2012) - *Koyel Bhattacharjee*
38. Symbolic Urban Landscape: Science City, Kolkata (1/2014) – *Aditi Chatterji*
39. Use Of Pedestrian Bridge: A Case Study In Kolkata (2/2014) – Tarun Kumar Sarkar
40. Perspectives of Planned New Towns, Its Transformation, Evaluation, Challenges and Problems: Case of West Bengal (1/2015) – Joy Karmakar
41. Growth of Ports and Port Towns in India in the Post Independence Period: in the context of Trade and Urbanisation (2/2015) - Aparna Banerjee, Dr. Sudakshina Gupta, Dr. Uttam Kumar Bhattacharya