Chapter 11
Estimating Economic Costs of Municipal Solid Waste Management: Using Contingent Valuation Method

J. Sacratees and G. Hari Govindaraj

Introduction

Municipal solid waste management (MSWM) is one of the major environmental problems of Indian cities. Improper management of municipal solid waste (MSW) causes economic loss and health hazards to inhabitants. MSW is basically useless and unwarranted materials discharged as a result of human activity. Most commonly, they are composed of solids, semisolids or liquids found in containers disposed from houses and commercial or industrial premises (Nyangababo and Hamya, 1980).

The quality and quantity of MSW generated by a particular community will vary according to its socioeconomic status, cultural habits, urban structure, population and commercial activities. Asian countries are facing MSWM problems due to the rapid growth in MSW generation rate. The total quantity of waste generated by 23 metro cities in India was 30,000 t/day (tpd) in 1999, and has increased considerably to about 52,000 tpd in 2004 (Inanace et al. 2004). Government bodies at all levels (central, state and municipal) are taking proactive steps to improve the MSW scene in India. The Government of India issued new rules that regulate the MSWM at the local level (MoEF 2000).

Waste management is a problem in urban as well as rural areas. Many areas, particularly in developing countries such as India, still have inadequate waste management; poorly controlled open dumps and illegal roadside dumping remain a serious problem. Such dumping spoils scenic resources, pollutes soil and water resources and is a potential health hazard to plants, animals and people. According to the United Nations Centre for Human Settlements, only between 25 and 55 % of all waste generated in large cities is collected by municipal authorities. At least 60 % of

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the countries that submitted national reports to the United Nations before the 1992 Earth Summit said that solid waste disposal was among their biggest environmental concerns. The importance of proper solid waste management (SWM) is one of the primary functions of the civic body, as improper management of solid wastes is a cause of much discomfort. Since waste management is a fundamental requirement for public health, Article 48-A of the Indian Constitution affixes it to be the responsibility of the state to manage these wastes properly.

Realizing the need for proper and scientific management of solid waste, the MSW (Management and Handling) Rules, 2000, were notified by the Ministry of Environment and Forests, Government of India. The severity of solid waste management is crucial and inevitable in the modern world. Tirunelveli, the sixth largest municipal corporation in Tamil Nadu, has been generating more solid waste in recent days because of increasing urbanization and consequent urban growth coupled with the emergence of more and more new colonies and extension areas and the changing lifestyles of the people. The corporation found it difficult to clean all areas regularly. On the basis of the discussion in various forums, the corporation started the concept of promoting residential associations to take up sanitation in their colonies by engaging private sanitary workers. The increasing public awareness and concern over the solid waste management problem are the main factors that motivate this study that aims to provide research-based solution for promoting an effective and efficient way of maintaining solid waste management by the municipal corporation. This study aims to estimate the willingness to pay (WTP) for efficient solid waste management services by implementing a contingent valuation (CV) survey. The survey results would also significantly facilitate in fixing a tariff ceiling to every household based on the service provided towards solid waste management by the corporation.

Municipal Solid Waste in Tirunelveli City

As per the 2011 census, Tirunelveli district had a population of 30,72,880 with 15,18,595 (49.42%) males and 15,54,285 (50.58%) females. The decadal growth rate of population has increased from 8.9 to 13.7%. The city has an average literacy rate of 78%, which is higher than the national average of 59.5%; male literacy is 83% and female literacy is 73%. In Tirunelveli, 10% of the population is less than 6 years of age. Among the municipal corporations, Tirunelveli has been identified with a gender ratio for urban agglomeration of 20.22%. The city is spread over an area of 108.65 km^2. The population density of the city has increased from 3,781 persons/km^2 in 2001 to 4,370 persons/km^2 in 2011.

The main aim of the research is to assess the economic impact of solid waste management in Tirunelveli Corporation in general and its impact on human health in particular. The economic impact is evaluated in terms of work-days lost and health impact due to solid waste disposal by the corporation. The concept of environment in a developing nation brings about the vision of a society where settlements in urban area would be healthy and drinking water would be easily accessible and free from disease. Sanitary conditions would be at an acceptable level and the

urban society will be able to provide opportunities to its members to live healthy. All these complexities pose a greater challenge to the policymakers on how they would solve the crucial problem of solid waste management without affecting the environment. There is no proper solid waste management measure available. Existing legal measures are not effective in ensuring efficient solid waste management.

Table 11.1 shows the unit-wise solid waste collection by Tirunelveli Corporation during 2003–2010. MSW falls into many categories, such as food waste, rubbish, commercial waste, institutional waste, street-sweeping waste, industrial waste, construction and demolition waste and sanitation waste. MSW contains recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries and medicines), compostable organic matter (fruit and vegetable peels and food waste) and solid waste (blood-stained cotton, sanitary napkins and disposable syringes) (Jha et al. 2003; Reddy and Galab 1998; Khan 1994).

The quantity of MSW generated depends on a number of factors, such as food habits, standard of living, degree of commercial activities and seasons. Data on quantity variation and generation are useful in planning collection and disposal systems. With increasing urbanization and changing lifestyles, Indian cities now generate eight times more MSW than they did in 1947. Presently, about 161.44 t of solid waste is generated annually by the people of Tirunelveli Corporation. The amount of MSW generated per capita is estimated to increase from 340 g in 2011 to 355 g in 2015 owing to the changing lifestyle of the people in Tirunelveli city.

According to the United Nations Centre for Human Settlements, only between 25 and 55% of all waste generated in large cities is collected by municipal authorities. For instance, waste generation every day in Tirunelveli Corporation was estimated to be 170.94 t, out of which 61.5 t was left uncollected. Out of the total amount of waste generated, 35.98% remained uncollected while the rest 64.02% was collected. The remaining uncollected solid waste creates huge environmental problems for city dwellers, and this becomes a daunting task for the corporation. This study would propose a feasible solution to manage solid waste in an efficient way without affecting the environment.

Objectives of the Study

The overall objective of the study is to empirically study the solid waste management problem in Tirunelveli city using primary and secondary data and a methodology based on a contingent valuation (CV) technique. The specific objectives are as follows:

1. To study the existing practices of solid waste management and their environmental and health impacts in Tirunelveli city.
2. To estimate the cost incurred owing to solid waste management by Tirunelveli Corporation.
3. To estimate respondents WTP to improve solid waste management in Tirunelveli Corporation by using the contingent valuation method (CVM).

Table 11.1 Unit-wise solid waste collection by Tirunelveli Corporation during 2003–2010 (in tonnes). (Source: Compiled data from Municipal Corporation, Tirunelveli-1)

Year	Units																	Total
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	
2003	3,538	2,236	2,155	1,759	1,662	2,362	1,649	1,830	2,025	1,920	1,581	1,721	2,299	1,689	2,556	1,825	1,663	34,470
	(10.27)	(6.49)	(6.25)	(5.10)	(4.82)	(6.85)	(4.78)	(5.31)	(5.87)	(5.57)	(4.59)	(5.00)	(6.67)	(4.90)	(7.41)	(5.29)	(4.83)	(100)
2004	3,161	1,574	1,158	1,158	1,395	3,439	959	1,548	1,291	1,865	1,178	1,849	2,895	1,649	2,109	1,657	1,420	30,305
	(10.43)	(5.19)	(3.82)	(3.82)	(4.60)	(11.35)	(3.16)	(5.12)	(4.26)	(6.15)	(3.89)	(6.10)	(9.55)	(5.44)	(6.96)	(5.47)	(4.69)	(100)
2005	4,022	1,589	863	916	1,307	3,781	702	1,562	1,149	2,010	1,147	2,127	3,839	1,025	2,261	1,530	1,469	31,299
	(12.85)	(5.08)	(2.76)	(2.93)	(4.18)	(12.08)	(2.24)	(4.99)	(3.67)	(6.42)	(3.66)	(6.80)	(12.27)	(3.27)	(7.22)	(4.89)	(4.69)	(100)
2006	3,943	1,835	1,216	1,300	1,380	4,084	827	1,668	889	1,957	1,191	2,261	3,892	841	2,286	1,335	1,220	32,125
	(12.27)	(5.71)	(3.78)	(4.05)	(4.30)	(12.71)	(2.57)	(5.19)	(2.77)	(6.09)	(3.71)	(7.04)	(12.12)	(2.62)	(7.12)	(4.16)	(3.80)	(100)
2007	4,518	1,429	999	1,371	1,410	4,509	746	1,855	975	1,921	1,060	2,463	4,265	1,672	1,840	2,086	1,481	34,600
	(13.06)	(4.13)	(2.89)	(3.96)	(4.08)	(13.03)	(2.16)	(5.36)	(2.82)	(5.55)	(3.06)	(7.12)	(12.32)	(4.83)	(5.32)	(6.03)	(4.28)	(100)
2008	3,778	1,463	1,045	991	1,180	3,642	603	1,136	711	1,502	297	2,422	3,559	1,879	2,077	1,744	1,202	29,031
	(13.01)	(5.04)	(3.60)	(3.41)	(4.07)	(12.58)	(2.08)	(3.91)	(2.45)	(5.17)	(1.02)	(8.34)	(11.57)	(6.47)	(7.16)	(6.01)	(4.14)	(100)
2009	3,935	1,378	1,388	740	1,185	3,838	609	1,186	773	1,442	689	2,290	3,579	1,645	2,136	1,947	1,295	30,055
	(13.09)	(4.58)	(4.62)	(2.46)	(3.94)	(12.77)	(2.03)	(3.95)	(2.57)	(4.80)	(2.29)	(7.62)	(11.91)	(5.47)	(7.11)	(6.48)	(4.31)	(100)
2010	3618	2339	1884	1926	1709	4110	1078	2109	977	2164	1681	3001	3736	2648	2585	2124	1712	39401
	(9.18)	(5.94)	(4.78)	(4.89)	(4.34)	(10.43)	(2.74)	(5.35)	(2.48)	(5.49)	(4.26)	(7.62)	(9.48)	(6.72)	(6.56)	(5.39)	(4.35)	(100)

Methodology

Tirunelveli Corporation has been divided into four zones: Tirunelveli, Thatchanallur, Palayamkottai and Melapalayam. Further, these zones were divided into 55 wards. Each ward is divided according to the size of population not exceeding a maximum of 7,500 per ward. In order to give equal representation to every zone and to every ward of Tirunelveli Corporation, it was decided to cover 510 sample households (30 households for each unit) in Tirunelveli Corporation. A field survey was conducted in all the units by the researcher from October 2010 to March 2011. This study is based on both primary and secondary sources of data. Primary data were collected by administering appropriate questionnaires. The sample selection was executed on the basis of stratified random sampling of 510 household respondents. The researcher has used two types of questionnaires. The first type of questionnaire focused on the respondents' demography, environmental quality, the household's WTP, door-to-door collection, available infrastructure, frequency of garbage collection, level of satisfaction of consumers, improved solid waste management and health and environmental damage. The second questionnaire collected institutional responses from the corporation covering information, such as annual budget for solid waste maintenance, solid waste collection, transport and disposal during 2003–2010. In addition, data were collected about the staff employed for each unit, solid waste management regulations, bylaws, waste processing procedures, availability of incineration facility, waste collection, transfer, disposal and general policy issues regarding MSWM. Additionally, the health data were collected from Primary Health Centres (PHCs), the Deputy Director of Health Services, Palayamkottai, and the Joint Directorate of Health Services, Tenkasi, and the Directorate of Health Services, Chennai.

The literature review was performed by going through relevant books, national and international journals, reprints, monographs, working papers and various reports of national and international organizations. Additionally, some relevant sources have been collected from the Madras School of Economics (MSE), Chennai; Indira Gandhi Institute for Development Research (IGIDR), Mumbai; Institute of Economic Growth (IEG), New Delhi; and Tata Energy Research Institute (TERI), New Delhi.

CVM is a widely used nonmarket valuation method, especially in the areas of environmental cost-benefit analysis and environmental impact assessment.[1] Its application in environmental economics includes estimation of nonuse values (e.g. Walsh et al. 1984; Brookshire et al. 1983), nonmarket use values (e.g. Choe et al. 1996; Loomis and duVair 1993) or both (e.g. Niklitschek and Leon 1996; Desvousges et al. 1993) of environmental resources. In recent years, this method is commonly used in developing countries to elicit individual preferences for basic infrastructural projects, such as water supply and sanitation (see Whittington 1998;

[1] For detailed discussion in this context see Mitchell and Carson (1989) and Cummings et al. (1986).

Merrett 2002). Although a popular nonmarket valuation method, a group of academicians has criticized this method for not being proper for estimating nonmarket values (see Hausman 1993). Hence, the main objective of the concept is to portray the WTP to improve the river water quality in the study area based on empirical aspects of the CV method.

The survey was conducted using the CVM to ascertain the household's actual WTP to improve solid waste management by Tirunelveli Corporation because environmental services do not have explicit markets like other commodities and services that can be expressly traded in the market. In order to understand the WTP ranges, the researcher has used welfare loss based on the CVM models through various econometric regression models like the Logit and Tobit estimations to arrive at a result. The main reason for using the WTP approach is to see whether there is a strong enough demand among the people within the city for improved solid waste management services. When there is a strong implicit demand for such services, it is then possible to generate considerable additional revenues to support the improved solid waste management services. This additional revenue can also supplement the amount currently spent by the municipal authorities for solid waste management. But, it is important to note that both the probability and the level of WTP, as well as the extent of the additional revenue, depend on the people's perception of the delivery of assured and qualitatively improved solid waste management services.

Despite its wide use in practical policy purposes, CVM's ability to reliably estimate WTP is not universally accepted. While some economists have expressed scepticism over the use of direct questioning to estimate the WTP, one of the early verdicts on the soundness of CVM came from a group of world-renowned economists: Kenneth Arrow, Robert Solow, Roy Radner, Edward Leamer and Howard Schumann (Arrow et al. 1993).

CVM has improved significantly during the past 50 years. One of the pioneers in the field of CV surveys, V. Kerry Smith (2006), argues that CV research has witnessed robust progress, enabling better understanding of consumer preferences. More specifically, the progress of econometric analysis, survey research methods, sampling and experimental design and policy applications in the past 50 years has been remarkable. In Smith's assessment, concerns relating to measurement bias in estimating nonuse values can be excessive. However, in our case, a similar measurement bias is a lesser concern because of the estimation of direct use values. As Smith further elaborates, hypothetical bias can also be large because of the nature of CV surveys. Careful development of survey instruments (through initial preparatory work, focus groups, cognitive interviews and pretests); conscientious implementation of fieldwork and rigorous econometric analysis that link the data to underlying theoretical models (e.g. utility functions) can help reduce hypothetical bias in a CV study. In this context, the pragmatic approach is to use CVM meticulously, applying the improved methodology to generate a reliable estimate of the WTP to improve solid waste management within the Tirunelveli Corporation limit.

Contingent Valuation Method

In this study, we will use regression models in which the dependent or response variable itself can be dichotomous in nature. Basically, it is a 'Yes'- or 'No'-type answer received from the respondents with regard to improvement of solid waste management in Tirunelveli Corporation. We use the values of 1 or 0 to measure this. With respect to this question, some of the respondents are willing to pay and the others are not. To estimate and infer the WTPs, we will use the Logit model. We have to classify all categories according to their actual contribution in terms of rupees to improve solid waste management. To measure the actual contribution to the respondent's solid waste disposal improvement, we will use the Tobit model.

The specification of the Logit equation is as follows:

$$WTP = \alpha + \beta_{1\text{AGE}} + \beta_{2\text{SEX}} + \beta_{3\text{MS}} + \beta_{4\text{INCOME}} + \beta_{5\text{DIS}} + \beta_{6\text{RUPWTP}} + \beta_{7\text{HCOST}} + \beta_{8\text{WLOSS}} + \beta_{9\text{PRIEDU}} + \beta_{10\text{HEDU}} + \beta_{11\text{DEDU}} + \beta_{12\text{PRI}} + \beta_{13\text{GOVT}} + \beta_{14\text{BUSI}} + \beta_{15\text{PQUAL}}, + \beta_{16\text{MQUAL}} + \beta_{17\text{FAIRLY}} + \beta_{18\text{HIGHLY}} + \text{Ui}$$

where

dependent variable $WTP = 1$ if the respondent is willing to pay for solid waste management improvement = yes and = 0 otherwise.

Dummy independent variables (description) are as follows:

β_1 = Age of the respondent (years)
β_2 = 1 if sex = male, 0 = otherwise
β_3 = 1 if married, 0 = otherwise
β_4 = 1 if income earner, 0 = otherwise
β_5 = 1 if distance is closer to dustbin, 0 = otherwise
β_6 = 1 if willing to pay in rupees, 0 = otherwise
β_7 = 1 if health cost is high, 0 = otherwise
β_8 = 1 if wage loss, 0 = otherwise
β_9 = 1 if primary educated, 0 = otherwise
β_{10} = 1 if high school educated, 0 = otherwise
β_{11} = 1 if the respondent is a graduate, 0 = otherwise

*Base category—illiterates (for education)

β_{12} = 1 if private employee, 0 = otherwise
β_{13} = 1 if government employee, 0 = otherwise
β_{14} = 1 if business, 0 = otherwise

**Base category—unemployed

β_{15} = 1 if SWM is poor quality, 0 = otherwise
β_{16} = 1 if SWM is middle quality, 0 = otherwise

***Base category—very poor quality

β_{17} = 1 if the person is fairly agreed to improve solid waste management, 0 = otherwise

Table 11.2 Logit estimates of WTP for improvement of solid waste management. Dependent variable: WTP (willingness to pay to improve solid waste management). Source: Computed from primary data

Independent variable	Coefficient	Marginal effects
Constant	0.39776 (2.51)	0.0119
Age	−0.00109 (−0.83)***	0.4067
Sex	0.03530 (0.89)**	0.3734
Marital status (MS)	−0.00453 (−0.08)***	0.9361
Income	−9.71238 (−3.59)*	0.0003
Distance	7.20779 (0.73)**	0.4642
Rupee Willingness to Pay (RUPWTP)	0.00557 (19.51)*	2.8865
Health cost (Hcost)	1.42612 (0.12)***	0.9033
Wage loss	1.02141 (1.36)**	0.1721
Primary	0.12401 (1.93)**	0.0524
High	0.09747 (1.55)**	0.1193
Degree	0.18956 (3.08)*	0.0020
Private	−0.20014 (−1.75)***	0.0784
Government	−0.15817 (−1.44)***	0.1471
Business	−0.16333 (−1.43)***	0.1511
Poor	−0.00644 (−0.15)***	0.8793
Middle	0.04714 (1.04)**	0.2980
Fairly	0.05496 (1.04)**	0.2945
Greatly	0.11306 (2.32)*	0.0199
Log likelihood	113.0455	
Restricted log likelihood	129.8231	
Chi-square	46.10672	
Pseudo R^2	0.37	

Figures in parentheses show the *t* values
*Statistically significant at the 1% level; **statistically significant at the 5% level; ***statistically significant at the 10% level

β_{18} = 1 if the person is highly agreeable to improved solid waste management, 0 = otherwise

****Base category—not at all interested to pay WTP for SWM

The actual estimation in the Logit model will capture a simple Yes/No answer on whether a respondent would pay to improve MSWM in Tirunelveli city. The data from all the sample households were used at this stage in order to understand a broad perspective of the factors underlying a respondent's decision. The results are reported in Table 11.2. This survey report of the WTP for the improvement of solid waste management has been included; the data from various stretches were pooled to get a WTP group. Out of 510 respondents who were questioned on their WTP to improve solid waste management, 322 (that is, 63.14%) gave positive answers and the rest gave negative answers. These results have several noteworthy features. Mainly, the model has a good fit. The chi-square value is 46.10, which is highly significant at 1%. Pseudo R^2 value is 0.37, which means that about 37% of the variations in the WTP are explained by the included independent variables. Almost all the independent variables have a positive influence on the WTP except the variables of occupational classifications. The age variable is positively related to the WTP. As the age goes up, the probability of getting a positive response also increases.

The variables—sex, income, education and distance—have a higher probability of influencing WTP for improving MSWM in Tirunelveli city. In the case of sex variable, there was a higher probability of positive response from female respondents towards improving solid waste management as compared with male respondents. Awareness and income level was also higher among the female respondents compared with the males. When the respondent's income rises by 1%, the probability WTP for better MSW quality also rises by 0.0219%. Distance has a positive significance. Respondents residing closer to street dustbins showed higher probability for WTP for improving solid waste management. WTP dropped when the street dustbins are a little away from the dwellings. Those dwellings near the landfills or disposal areas are important factors to decide positive influence on the WTP because the coefficients of the variable are positive; they imply that a respondent, who has a higher education, knows about the importance of improving solid waste management in an urban city and who has a higher probability of paying for it. Age and income have a positive significance at 1 and 5% and sex has a 5% level of significance.

The variable health cost also plays a major role in determining WTP. If the health costs were high, the probability of WTP for improving the solid waste management increased at 10% level of significance. Wage loss was a lesser deciding criterion for WTP among the respondents. It directly influenced WTP and indicated a positive sign and significance at 5%. The deterioration in health was due to an improper management of solid waste disposal and something must be done to conserve and improve the environment.

Education at the primary and high school level had a negative sign and significance at 5%. But education at the degree level had a positive sign at 1% level of significance. Thus, education may also be interpreted as a proxy for the knowledge about the poor quality of solid waste management practices taking place in Tirunelveli city and it clearly highlighted the importance of education at the graduation level. As the level of education goes up, the probability of WTP for improving solid waste management also goes up. This was evident with respondents who had degree-level education, whereas those who had primary and high school-level education do not have much awareness about MSWM. It had a positive sign and significance at 5%, confirming the earlier results.

Occupation with private, government and business groups had a negative impact on WTP. The respondents working in the private sector get lower wages, thereby causing a poor response towards the WTP for improving MSWM.

Under this Tobit model, the actual magnitude of the monetary value of the WTP is directly linked with the respondent's WTP for improving MSWM. If the coefficient sign was positive, one unit increase in age when other things remain constant would increase the WTP amount by about 0.14%. Sigma value (0.478) is highly significant. Because of this, the ordinary least square (OLS) is an unbiased estimate, which is highly significant, and it shows that leaving the sample would lead to selection bias. It is the same case as with that of the variable sex. It would increase the probability of WTP by about 0.3332% for 5% level of significance. If the distance decreases, the probability of WTP increases by 0.4957%. Health cost and wage loss have a negative influence on WTP and, to some extent, variable health has got a

Table 11.3 Tobit estimates of WTP for solid waste management improvement. Dependent variable: WTP. (Source: Computed primary data)

Independent variables	Coefficient	Marginal effects
Constant	0.18581 (0.79)	0.4266
Age	−0.00168 (−0.86)***	0.3865
Sex	0.05621 (0.96)**	0.3332
Marital status (MS)	−0.00250 (−0.02)***	0.9763
Income	−1.4628 (−3.65)*	0.0002
Distance	9.93958 (0.68)**	0.4957
Rupee Willingness to Pay (RUPWTP)	0.00764 (17.09)*	2.8865
Health cost (Hcost)	1.07757 (0.06)***	0.9515
Wage loss	1.41199 (1.29)**	0.1947
Primary	0.19387 (1.97)**	0.0483
High school	0.14875 (1.54)**	0.1227
Degree	0.2856 (3.05)*	0.0022
Private	−0.29345 (−1.75)***	0.0786
Government	−0.22826 (−1.42)**	0.1528
Business	−0.23514 (−1.40)***	0.1592
Poor	−0.00925 (−0.14)***	0.8834
Middle	0.07359 (1.09)**	0.2720
Fairly	0.08049 (1.02)**	0.3056
Greatly	0.16324 (2.23)*	0.0251
Thatchanallur	0.00904 (0.13)***	0.8932
Palayamkottai	−0.06933 (−0.92)***	0.3570
Melapalayam	−0.02614 (−0.35)***	0.7257
Sigma	0.478	
Likelihood function	2,029.1032	
N	338	

Figures in parentheses show the t values
*Statistically significant at the 1% level; **statistically significant at the 5% level; ***statistically significant at the 10% level

positive influence at the 5% level of significance. It would increase the probability of health cost and wage loss by 0.9515 and 0.1947% respectively. Education has a much stronger influence. As expected, it improved the WTP amount at each level of education, namely, primary, high school and degree level, by about 0.0483%, 0.1227% and 0.0022%, respectively. Occupation does not have any influence on the WTP amount for improving solid waste management. Therefore, as predicted in theory, there are many factors that influence the WTP amount, leading it to deviate. It has a negative sign and is also insignificant. However, the variables government employees and business group have a positive effect on WTP. In contrast, one unit increase in the business group variable will influence WTP by 0.1592% as against the government employee, which is just 0.1528%. The respondents have responded well to the personal health loss because solid waste as a subjective variable influences an increase in the WTP amount by 0.3056 and 0.0251% for fairly affected and highly affected variables, respectively. Thus, the estimated Tobit model is realistic in explaining the role of different socioeconomic factors in the levels of WTP by the respondents (Table 11.3).

Table 11.4 Morbidity statistics of Tirunelveli Corporation from 2004 to 2010. (Source: Municipal Corporation, Tirunelveli-1)

Sr. No	Type of disease	2004	2005	2006	2007	2008	2009	2010
1	Vector-borne	*241*	*62*	*592*	*246*	*35*	*222*	*524*
		(6.01)	*(1.53)*	*(26.40)*	*(6.27)*	*(0.72)*	*(4.56)*	*(10.15)*
2	Air-borne	169	278	87	124	183	619	637
		(4.22)	(6.87)	(3.88)	(3.16)	(3.75)	(12.73)	(12.34)
3	Water-borne	26	51	10	149	45	191	70
		(0.65)	(1.26)	(0.45)	(3.80)	(0.92)	(3.93)	(1.36)
4	Others	3,572	3,654	1,553	3,404	4,618	3,832	3930
		(89.12)	(90.34)	(69.27)	(86.77)	(94.61)	(78.78)	(76.15)
Total		*4,008*	*4,045*	*2,242*	*3,923*	*4,881*	*4,864*	*5161*
		(100.0)	*(100.0)*	*(100.0)*	*(100.0)*	*(100.0)*	*(100)*	*(100)*

Location, as captured by the variable representing different zones, also influences WTP for improving MSWM. The variations in the level of WTP for the three zones Thatchanallur, Palayamkottai and Melapalayam are 0.8932, 0.3570 and 0.7257% respectively. The Melapalayam zone has a higher level of WTP because this zone generated more solid waste as the New Bus Stand is located here and it also has a huge Muslim population who have more mutton and chicken stalls, which generate high volumes of solid waste in this region. Another significant factor that needs to be noted is that the lifestyle of the people in this zone is also one of the influencing factors which generate more solid waste. The percentage of respondents who said 'yes' for the WTP question here is less as compared with other zones, whereas the actual mean value of WTP is relatively higher for Palayamkottai and Thachanallur zones showing their high-income status. However, the magnitude of the amount of WTP for improving solid waste management is not as much as we expected in all the zones. It has a negative sign with a statistically insignificant value.

It is important to note that it might be possible and correct to directly formulate a linear regression model based on the OLS method using maximum WTP figures as the dependent variable. Similar to the WTP, the data employed also exclude the protest bids. In addition, outliers are also identified and excluded from the estimation process. The outcome of the OLS model is given in Table 11.4 and the outcomes of both linear models are mostly on expected lines, not only in terms of variables that affect the fees but also their signs and levels of significance. For WTP, coefficients associated with the variables—referendum fee, level of education, income, need for the study, the severity of existing solid waste management practices and whether a respondent is living near street dustbins—are all observed to be significant. Their positive relationships are also consistent with what we have predicted. It should be noted that sex seems to play a significant role in determining WTP in this equation. However, a relatively low R^2 is a bit of a concern. The explanation might lie in the fact that the actual fee (value of WTP) that respondents are willing to sacrifice has a very wide dispersion and their increments are very small, making it difficult for a model to precisely determine each individual figure. However, the results indicate a significant positive relationship between the referendum fee and the stated fee.

Regression results indicate that 46.10% of the variation in WTP was explained by the hypothesized household characteristics. Only age and marital status were not significant in explaining household WTP. This may perhaps be due to multicollinearity. All coefficients for the income and education variables were highly significant and negative as expected, suggesting that respondents who were degree holders (17.25%) with a household income in the range of ₹ 15,001–20,000 or more were willing to pay significantly more than those in other income and education categories. Hypothesis testing indicates that respondents who were degree holders with household incomes between ₹ 15,001 and ₹ 20,000 were also willing to pay significantly more than most respondents with less education and equal or less income. This finding, in conjunction with the lack of significance of most other differences in the above table, suggests that income and education may not significantly influence WTP unless the respondent is a degree holder. The significance of the coefficients for income and education suggests that degree holders who were in the highest income class were willing to pay about ₹ 300 more than degree holders with household incomes between ₹ 20,001 and ₹ 25,000. Hence, for degree holders, the level of income appears to be important.

The coefficients for sex (0.96) had their hypothesized signs and were highly significant. Female respondents (sex) were willing to pay about ₹ 175 more than male respondents, whereas respondents who depended on piped water or bottled water for drinking were willing to pay about ₹ 60 less than those who relied on bore well or river water. Those who said they were very concerned about health risks from the proposed landfill were willing to pay ₹ 300 more than those who said they were unconcerned. Another major finding of the results shows that household size significantly reduced WTP only for households with more than four members. It seems possible that the lack of difference in WTP between the one-to-three person households with the previous group may be due to the likely presence of children in the latter, offsetting the effect of the lower per capita income on the ability to pay. The year of residence in Tirunelveli is also significant in determining WTP. However, certain anomalies existed in its parameter estimates. Because of residence loyalty, one might expect that the respondents who had lived in Tirunelveli city longer would be willing to pay more than those who had moved in more recently. Another interesting point to be noted in the field survey is that the household characteristic that exhibited an unusual pattern in its coefficients was the distance of the household from the dustbins. Respondents who lived closer to the dustbin were expected to be willing to pay more than those who lived farther away. This pattern holds for a distance of up to 500 m, whereas those households who lived within 100–200 m were willing to pay between ₹ 150 and 200, more than those who lived within 300–500 m. However, those who lived more than 300 m from the dustbin were not willing to pay significantly less than those who were living within 200 m. They were, in fact, willing to pay significantly more than those households located within 300–500 m.

These findings reported above are valuable to policymakers for several reasons. First, since Tirunelveli Corporation is about to develop comprehensive waste management plans, it could use the approach adopted here for evaluating the external

costs or benefits of all waste disposal alternatives, including the use of street dustbins, landfill disposal, incineration and recycling. If such expenditures are to be made in a cost-effective manner, a more complete analysis is needed to compare the total costs of all solid waste disposal alternatives. Second, if minimizing the overall costs was the only objective and if similar results were found to hold for other areas, one might conclude that landfills could be situated in areas with fewer degree holders in higher income classes. However, equity considerations would likely limit an explicit statement of such a strategy publically.

The increasing threat posed to human health as a consequence of the improper way of solid waste dumping in Tirunelveli Corporation has become a burning issue in recent years. This study has attempted to introduce environmental tax by the way of WTP in order to improve the solid waste collection. The results of the WTP indicate that unhygienic conditions and the mosquito menace are due to an unplanned dumping of MSW. The survey results show that the respondents in the area are well aware of the present situation of the MSW collection and management by the corporation and the necessity of their participation to maintain the city clean and tidy. The study results also give a positive scope for introducing environmental tax (user fee). Most of the WTP studies carried out in developing countries in the past have been mainly limited to the estimation of the user's mean WTP. This research has attempted to extend the use of WTP survey results indicating that charging for improving the solid waste management in Tirunelveli Corporation may not have a negative impact among city dwellers. In this case of the observed behaviour method, the assumptions made about the use of WTP for improving the MSW services may be far from true in developing countries. Also, there could be difficulties in charging excessive amounts as WTP because of low levels of education and faulty perception about environmental values due to lack of awareness. The paucity of adequate data on the extent of solid wastes and their effects on people's health cannot be stated as the reason for inaction. Generally, the community and nature in general can only be speculated and the fast deteriorating trend of the urban civic environment can never be denied. The spread of vector-borne diseases has been increasing at an alarming rate in recent days because of unhygienic maintenance of urban civic environment. If the present quantum of MSW generation continues in future and preventive steps are not taken by Tirunelveli Corporation, the society's foregone health expenditure would accrue, causing a huge burden for the people.

The Tirunelveli city's annual solid waste collection is 3,94,01,000 kg (as per 2010). Solid waste collection coverage is very low, which means that solid waste is thrown everywhere in the city, such as open spaces, green areas, rivers, canals, ditches, etc. Because of this, the waste gets spread to all houses in the form of dust, which is distributed by the high wind in the city and causes disease. River stretches and other water bodies are found to be replete with waste, thus causing flooding on the streets. In addition, none of the modern solid waste management practices are implemented and still there are no recycling activities by the municipality in an organized manner. Solid waste is not separated or sorted out at the source and after collection—it is simply dumped all together. But, more importantly, cost recovery is a serious problem of solid waste management in the city. The revenue generated

covers only 9.5% and the rest 90.5% has to be recovered from other sources. Since the waste management does not have enough source of revenue, it cannot be sustained even in the present condition. This study aims to analyze households' WTP to improve the solid waste management service in Tirunelveli city by using the data obtained from a sample of 510 household heads.

The CVM was employed with the single-bounded elicitation format followed by open-ended follow-up questions in a face-to-face interview. The study used both descriptive and econometric techniques of analysis and developed a model, where 18 explanatory variables were used within a regression framework. The Probit and Tobit models were used to identify the determinants of the households' WTP for an improved solid waste management system and to analyze the mean WTP of households.

In the estimated results of the Probit model, the variables that are significantly related to providing positive WTP values are only household education and the income of the respondents. Age has a negative but significant relation with the likelihood that the respondent will provide a positive WTP value. All the signs for the coefficients of these three variables make intuitive sense. The rest of the variables have no significant impact on the likelihood that the respondent will provide a positive WTP value.

In the Tobit model regression results, on the other hand, 4 variables out of 18 explanatory variables have a statistically significant impact on the amount of WTP for improved solid waste management system. The amount of solid waste generated by the household, educational level of respondents, income and age of respondents and house ownership of the household heads have a positive relationship with the amount of WTP and are significant even at 1% level. The type of solid waste service demanded by the households and the income of respondents (income) have a positive relationship and are significant at 5% level and the sex of respondents has positive and significant relationship at 5% significance level, whereas the perception of respondents for the current solid waste management has a negative relation and is significant at 5% level with the amount of WTP for improved solid waste management system.

When the single-bounded method is used, the mean WTP for improved solid waste management per month per household is found to be ₹ 100. But, when the open-ended approach is used, the maximum WTP is found be in the range of ₹ 150–200 per month per household. The total monthly WTP for the city as a whole using the aggregation method is estimated to be ₹ 1,28,94,700. When the dichotomous single-bounded method is used, the monthly WTP is estimated to be ₹ 50–100. This means that the actual WTP of the households in the Tirunelveli city may fall between these two figures. Comparing with the revenue collected based on the service fee regulation and current expenditure on the existing solid waste management, this WTP is much larger and SWM of the city can be improved with the payment and participation of the residents.

The use of OLS models also concludes that the amount of fee the respondents are willing to pay depends a great deal on the referendum fee, income, education and the frequency of solid waste collection in the city. Finally, the significance of

the referendum fee in determining the stated fee in the OLS application also leads to the discovery of a starting point bias as the referendum and the means of the corresponding stated fees tend to go in the same direction. A majority of those unwilling to pay for the service have been found to be either protesting the bid or too poor to pay. The implication of this finding is that if they are more aware of the status of MSW and understand its importance, they might be more willing to support and even to pay the necessary fee to maintain solid waste. Institutional arrangements are essential for improving the condition of solid waste and the most controversial issue which needs to be addressed is which organization should be responsible for collecting an environmental tax for maintaining solid waste management. Based on the results of the household survey, it is likely that while initial charges will be constrained somewhat low by WTP, they could be set at levels which would support the system that could encourage building a feasible way to finalize the surcharges effectively. To improve MSWM in the city, the residents should be aware of the prevalence of vector-borne diseases and based on which the government should appropriately respond to this issue and keep the city clean, which is mandatory in this era of urbanization without any further delay.

Valuation of Municipal Solid Waste Management Activities

In this study, each activity of the MSW management has been formulated into a multivariate functional model based on theoretical considerations with due consideration given to all the implicit costs and benefits. The researcher has valued each component and the MSW management as a whole, and this is done by collecting data for various parameters from Tirunelveli Municipal Corporation. The following section presents multivariate functional models for each activity of the MSW management, followed by a valuation of those components of the MSWM in Tirunelveli. The unit cost of waste disposal is used to measure the efficiency of the system. The unit cost of waste disposal is defined as follows:

Unit cost of waste disposal (₹/t), $C_{\mathrm{OD}} = \frac{\sum_{i=1}^{3} e_i - b_i}{W_{\mathrm{a}}}$

where

MSW generation per year (million tonnes)	W_{a}
Cost of collection (₹)	e_1
Cost of transportation (₹)	e_2
Cost of disposal (₹)	e_3
Benefits	b_i
Cost of collection (e_1)	
Waste generated per day (metric tonnes) (161.44 t)	W_{d}
Waste that can be collected by each worker per day (tonnes)	W_{w}
Number of workers per tonne of waste per day	$1/W_{\mathrm{w}}$

Salary of each worker per day (₹)	W
Collection cost per day (₹)	$(1/W_w w)W_d$
Waste generated per year	$W_d 365 = W_a$
Number of bins used for collection	N_b
Cost of each bin	C_{bin}
Total cost of bins	$N_b C_{bin}$
Annual cost of collection (e_1) (₹)	$\left(\frac{1}{W_w} w\right) W_a + N_b C_{bin} + misc$
(Miscellaneous includes cost of minor equipment, trolleys, etc.)	
Cost of transportation (e_2)	
Length of travel per truck per year	$L\,an-km$
Cost of travel per truck per tonne in a year	$Ctr/t/yr$
Number of trucks required	T_n
Travel cost per tonne (Ctr)	$Ctr/t/yr T_n$
Total cost of transport (e_2) (₹)	$C_b W_a C_{coll}$
Collection efficiency	C_{coll}
Cost of disposal (e_3)	
Cost of maintenance of disposal sites (₹ Nil)	m (not spent for 2009–2010)
Tirunelveli Corporation ignores the cost of land, hence the total cost of disposal (₹ Nil) (e_3)	m
Valuation of Tirunelveli MSW management	
W_d (tonnes)	5,89,25,600 kg (converted into kilograms)
W_w (kg)	294.72
$1/W_w$ (kg)	0.294
w (₹)	298.46
Waste generated per year (tonnes)	58,925.6
Number of containers	442
Price per container (₹)	9,206.74
Total cost of containers (in ₹)	40,69,379.08
Miscellaneous expenses (stores, uniforms) (in ₹)	15,46,000
Total cost of collection (in ₹)	10,03,19,000
Owing to lack of data, the cost of transportation is taken from Tirunelveli Corporation estimates. The total cost of solid waste management, without considering implicit costs, is as follows:	
e_1 (₹)	5,61,15,387.31
e_2 (₹)	42,06,000
e_3 (₹)	40,97,000
Total cost of MSW (₹)	6,44,18,387.31
Unit cost of disposal	1,032.46
Total solid waste generation per day (tonnes)	161.44
Total solid waste collection per day (tonnes)	108
Uncollected waste (shortfall) (tonnes)	53.44

The unit cost of disposal calculated by Tirunelveli Corporation is not available. However, if there is any difference in the estimates of the unit cost of disposal as assessed by the researcher and by the corporation, it could be due to errors in the estimation. Keeping in view the importance of solid waste management, the money which has been spent for collection and disposal is not sufficient for an existing expansion of urbanization in Tirunelveli Corporation as the population size has been increasing manifolds in recent years. Out of 161.44 t of solid waste generated, only 108 t of solid waste was collected and the remaining 53.44 t of solid waste has been neglected or uncollected due to nonavailability of sufficient funds and other infra-

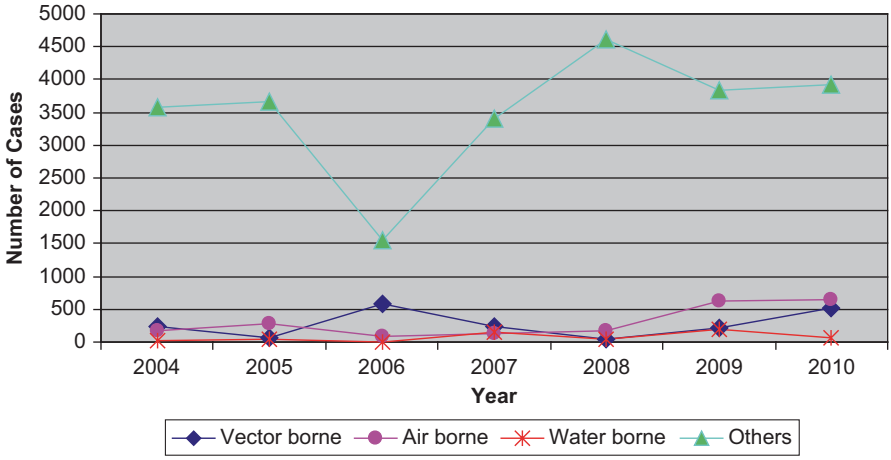

Fig. 11.1 Morbidity trends in Tirunelveli Corporation

Table 11.5 Linear regression model of health impact of solid waste. Dependent variable—distance. (Source: computed data)

R	Standard error of the estimate	Degrees of freedom	Significance	R^2	Adjusted R^2
0.074	159.6575	2	0.253	0.005	0.001

Independent variable—health greatly affected

structural limitations. Even the money spent for solid waste collection per tonne is not enough for efficient collection when we compare the same with other metropolitan cities in India. Therefore, this study would recommend to the municipal authorities to enhance the fund allocation for solid waste management, at least to the tune of the people's WTP so that the solid waste in the city can be efficiently managed (Fig. 11.1).

Table 11.5 shows a positive value for the variable *R*, which indicates that there is a positive relationship between the distances where dustbins are kept (i.e. whether it is placed near a residence) and the impact on health. The model result shows that the data are good fit revealing an R^2 value of 0.005, which indicates that there is a positive significance between health impact and the distance between the garbage dustbins and the residence. It is a well-established fact that dumping of waste into areas close to residences or on roadside will cause mosquito menace that often goes uncontrolled in Tirunelveli in almost all the wards. Therefore, many complaints have been filed by the residents of Tirunelveli city to the corporation officials but nothing has been done to reduce the increasing vector-borne diseases. However, in recent years, with some strict instructions from officials and councillors, the mosquito control operation is being carried out, but this is only in selected areas and other areas still remain neglected.

Conclusions

Most of the MSW in Indian cities is dumped in open space or near roadside in an uncontrolled manner. Such inadequate disposal practices lead to problems that will impair human and animal health and result in economic, environmental and biological losses. An open dump or an uncontrolled waste disposal area should be rehabilitated. It is advisable to move from open dumping to sanitary land filling in a phased manner. The current regulations (MSWM rules, 2000) are very stringent. Norms have been developed to ensure a proper MSWM system. Unfortunately, clearly there is a huge gap between policymaking and its implementation. The producer responsibility is to avoid having products on the market that cannot be handled effectively and cannot be safely disposed of environmentally when they become waste products. The study concluded that the lack of resources, such as financing, infrastructure, suitable planning and data and leadership, are the main barriers in MSWM. Therefore, this study would recommend to Tirunelveli Corporation to adopt minimum user fee—based on the results obtained—from city dwellers by the way of WTP analysis towards MSW. Finally, this methodology and results reported here are not without limitations. The model is not complete as many relevant variables could not be included. For instance, the variable capturing the perception of the public as to the assurance of quality service has not been included. As a result, the WTP estimates may be biased downwards. Similarly, since the MSW is heterogeneous in nature, a large number of samples have to be collected and analyzed to obtain statistically reliable results. Some of these issues will be explicitly addressed in future empirical research on the subject.

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