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Abstract

Cities in developing countries experiencing rapid urbanization and population growth too often lack the financial resources and institutional capacity to provide needed municipal infrastructure for adequate solid waste management, despite citizens' demand for it. This paper uses a cross-sectional survey of 226 randomly selected households in Mekelle City, Ethiopia, to assess the current municipal sanitation fees and the willingness to pay (WTP) of residents for improved urban waste management, and suggests mechanisms for cost recovery. We used Tobit and probit models in the empirical analysis to determine the factors that influence households' WTP for improved solid waste management. Results reveal that residents' WTP for improved solid waste management is significantly related to income and awareness of environmental quality, among other factors. Study results reveal that the current city fee for sanitation is far below the WTP of the residents. The mean WTP we found can be a guide for municipal officials in setting a more appropriate fee that can finance improvements in city SWM, where all households receive collection services, waste is disposed of properly, and recycling and composting features are added.

Key Words: urban waste management, willingness to pay, cost recovery, developing countries, cities

JEL Classification: D13, Q51, Q53

Contents

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Introduction

Due to lack of appropriate planning, inadequate governance, resource constraint, and ineffective management, solid waste—especially insufficient collection and improper disposal of it—is a major concern for many rapidly growing cities in developing countries (Chuen-Khee and Othman 2010; Medina 2010). According to the United Nations Environment Programme (UNEP 2004), solid waste generation is an increasing global environmental and public health problem. The swift expansion of urban agricultural and industrial activities, stimulated by population growth, has produced vast amounts of solid and liquid wastes that pollute the environment and destroy resources. Changing economic trends and rapid urbanization also complicate solid waste management (SWM) in developing countries. Consequently, solid waste is not only rising in quantity but also changing in composition (from less organic matter to more paper, packing materials, plastics, glass, metal, and other substances), which is exacerbated by low collection rates (Bartone and Bernstein 1993; Medina 2002).

Establishing effective municipal solid waste management should be a priority for emerging cities, given their crucial role in protecting public health and the environment. However, in the past, most attempts by cities to improve solid waste management focused on the different technical means of collection and disposal (World Bank 1992; Altaf and Deshazo 1996; Medina 2002). More recently, cities have begun paying more attention to enhancing municipal systems and sustainable solid-waste service delivery, with special emphasis on involving the private sector.

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Ethiopia has experienced rapid urbanization and increasing urban population in the last few years due to more rural-urban migration and rising per capita incomes (FDRE PCC 2008). Presumably, increased demand for infrastructure and public services (Chakrabarti and Sarkhel 2003) accompanies this growth, but this has not been the case. Many towns in Ethiopia lack the financial resources and institutional capacity to provide the most basic municipal infrastructures and services, including solid waste management.

Commercial clients and especially households—which are the primary producers of solid waste and suffer the effects of uncollected solid waste more directly—should be able to participate in municipal discussions on improving SWM and structuring effective public-private partnerships to deliver such services. The service provider (whether city or private vendor) needs to better understand households' demands and motivation. Therefore, the key question here is how much citizens are willing to pay for efficient and cost-effective delivery of solid waste services to residential areas.

Solid waste management in the city has always been gauged and evaluated by the performance of the service provider (the supply side), while the demand side has been ignored. With the increasing volume of solid waste, the Mekelle City administration has not been able to collect and dispose of the waste satisfactorily, plus cost recovery poses a critical problem. Solid waste collection services only about 50 percent of households most of the time (Mekelle Municipality 2008). According to Promise Consulting (2005), the city's annual solid waste generation is over 28 million kilograms (kg) of solid waste. Overall collection coverage, however, is only about 34 percent, which exposes city residents to serious public health problems and diseases, including often fatal water-borne diseases, such as cholera and dysentery (Venkateshwaran 1994; McMichael 2000). In addition, the city improperly disposes its municipal solid waste on open land near farms and cultivated fields (G-Michael 2002). Plastic bags and other debris from the waste disposal site are carried away by the wind, which trashes surrounding farms and homesteads. These problems will only become more pronounced as urbanization continues to expand.

The aim of this paper is to assess the current sanitary service fees and the willingness to pay (WTP) of residents for improved urban waste management, and to suggest mechanisms for cost recovery. The paper uses a cross-sectional survey of 226 randomly selected households in Mekelle City, Ethiopia. The remainder of the paper is organized as follows. Section 1 presents a brief review of studies on households' demand for improved environmental quality. In section 2, we provide the analytical framework and a brief review of the empirical literature on valuation focusing on municipal solid waste management. Section 3 provides the empirical strategy of the

study. Section 4 describes the study area, survey, and data collected. Section 5 discusses the results and section 6 concludes with some policy implications.

1. Households' Demand for Improved Environmental Quality: A Brief Review

Economic studies on solid waste management in Ethiopia, especially those involving contingent valuation, are extremely scanty or non-existent. Therefore, in this section, we review the broader literature, particularly studies in other developing countries that look at the demand for improved environmental quality or services using contingent valuation technique.

Altaf and Deshazo (1996), in a study of households in Gujranwala city, in the Punjab, Pakistan, surveyed the existing solid-waste disposal system, WTP for improvements, and the priority that households attach to improvements in solid waste management, relative to improvements in water supply and sanitation. They use a stratified random sample of about 1,000 households. Their study explores the demand-side information and verifies whether using such demand-side information helps improve solid waste management in developing countries. Put differently, they want to test the beliefs that integrating demand-side information can improve the planning for provision of municipal services.

They collected both demand-side and supply-side information. They analyzed the municipal budget and conducted field observations and interviews with municipal officials to solicit information on the supply of solid waste services. Their study calls for a different approach that is based on integrating demand-side information into the planning process. Their analysis also challenges the conventional presumptions that households accord low priority to solid waste management, compared to other urban services and are unwilling to pay for it. They argue that, despite the fact that solid waste management in most cities of the developing world is unsatisfactory and yet consumes a relatively high proportion of municipal budgets, most attempts to improve performance have focused on supply-side issues, such as collection and disposal capacity, but have failed to yield significant results. They also argue that simple and inexpensive household surveys can provide valuable inputs into the planning process.

Using data from a survey of 1,500 randomly sampled households in Kathmandu, Nepal, Whittington et al. (2005) investigate households' demand for improved water services. Specifically, they look into coping costs and WTP, and assess how coping costs and WTP vary across types of water users and income. They find that households in Kathmandu Valley engage in various types of behaviors to cope with unreliable water supply. These activities impose average coping costs of US$ 3 per month per household, or about 1% of current incomes,

representing hidden but real costs of poor infrastructure service. Their finding shows that these coping costs are almost twice as much as the current monthly bills paid to water utility, but are significantly lower than estimates of WTP for improved services. They also find that coping costs are statistically correlated with WTP and certain characteristics of households.

In light of the fact that use of wastewater for irrigation, which is common in many developing countries, can cause considerable harm to public health and the environment, Weldesilassie et al. (2009) estimate the economic value of safe use of wastewater for crop production on farms within and around Addis Ababa, Ethiopia, using contingent valuation. They find a surprisingly large welfare gain from policies for safe use of wastewater for irrigation. Their study also highlights the potentials and possible pitfalls of using nonmarket valuation techniques as an input into public decisionmaking, where traditional resource use interacts with public health and environmental concerns in complex ways.

Chuen-Khee and Othman (2010) estimate the economic values of household preference for enhanced solid-waste disposal services in Malaysia, employing contingent valuation. They estimate and compare the mean WTP for two alternative disposal methods, representing improved options with better levels of service characteristics, versus the current disposal method, both in the generic and labeled format. The generic options are "existing facility" vis-à-vis "proposed alternatives" and the labeled options are "control tipping"[1] vis-à-vis "sanitary landfill" and "incineration." In their case, the WTP is interpreted as the additional or incremental monthly SWM payment that the public pays for improved quality of services.

The authors also assess the factors influencing the probability of households' WTP, finding an average of €0.77–€0.80 (estimated) of additional monthly WTP for solid waste management charges with improved waste disposal services. They find a slightly higher WTP from the generic contingent valuation question, compared to the label-specific question.

Chuen-Khee and Othman's study also further reveals a higher WTP, €0.90, for sanitary landfill, compared to €0.63 for incineration, suggesting that sanitary landfill is a preferred alternative. Their logistic regression estimation of a household's concern about where their rubbish is disposed also shows that age, ownership of house, household income, and format of the contingent valuation question are important factors that significantly influence WTP.

[1] Controlled tipping is method of controlled disposal of municipal solid waste (refuse) on land. Britannica Online Encyclopedia (http://www.britannica.com/EBchecked/topic/522463/sanitary-landfill). Accessed March 2012.

Wang et al. (2011) conducted economic analysis of municipal solid waste management in Eryuan, a poor county located in Yunnan Province, China. They estimate the WTP of residents for an improved solid waste collection and treatment service and compare it with the project cost. Their study finds that the mean WTP is about 1 percent of household income, and the total WTP can basically cover the total cost of the project.

Their analysis also shows that the poorest households in Eryuan, in general, are not only willing to pay more than the rich households, in percentage of income terms, but also are willing to pay not less than the rich, in absolute terms, particularly where no solid waste services are available. They argue that the poorest households have stronger demand for public solid-waste management services, while the rich have the capability to substitute private measures when public services are not available. Wang et al. emphasize that municipal SWM continues to be a major challenge for local governments in both urban and rural areas across the developing world, and that one of the key issues is their financial constraints.

Per our review, the contingent valuation has been applied in both developed and developing countries (Carson et al. 1998; Carson 2002; Carson et al. 2001; Tait et al. 2005) for valuation of a number of environmental and natural resources. However, despite the fact that SWM in most cities of the developing world is unsatisfactory, and consumes a relatively high proportion of their municipal budgets, applications of contingent valuation to SWM in developing countries, particularly Ethiopia, are limited and rare. To our knowledge, the few studies focus on the capital city, Addis Ababa (Terfasa 2007; Fantu 2007) or other aspects of improvement in environmental quality (Weldesilassie et al. 2009). We do not know of any study of SWM for Mekelle City. Also, our review of contingent valuation in developing countries shows that simple and inexpensive household surveys can provide valuable inputs into cities' planning processes and, in our case, can inform policymakers on how to improve SWM service delivery.

2. Analytical Framework of Municipal Solid Waste Management

A considerable part of empirical environmental economics concerns the economic benefit of changes in the level of environmental quality. Such benefits are typically not marketed and are usually measured using such concepts as individuals' willingness to pay. A typical measure of such benefits is referred to as Hicksian compensating surplus (see, e.g., Freeman 2003).

Suppose, as in our case, Mekelle City is considering an improvement in SWM (environmental quality) and desires a measure of WTP—in other words, a Hicksian compensated

surplus, where a participant is asked to respond by giving the difference of two expenditure functions:

$$e(p, q_0\, U_0, Q, T) - e(p, q_i\, U_0, Q, T)\ , \qquad (1)$$

where p is vector of prices for the marketed goods; q_i is the environmental quality being changed; U_0 is the initial level or status quo of the utility to which the respondent is assumed to be entitled; Q is the vector of other public goods that are assumed not to change; and T is a vector of the participant's taste parameters.

Suppose that Y_0 is the value of the first expenditure function (i.e., the participant's current income); and Y_i is the level of income that solves for U_0, given p, q_i, Q, and T, the value of the second expenditure function. Now, we can define WTP as the difference between Y_0 and Y_i. The Willig condition states that equation (1) can equivalently be expressed as an income compensation function. If WTP is the desired benefit measure, then the WTP function is given by:

$$WTP(q_i) = f(p,\ q_0, Q, Y_0, T)\ , \qquad (2)$$

where q_o is now the baseline level of the public good of interest. This equation forms the basis for estimating a valuation function that depicts the monetary value of a change in economic welfare that occurs for any change in q_i (Freeman 2003).

In this study, contingent valuation is widely used to estimate the benefits of improved solid waste management. Compared with other valuation techniques (e.g., the travel-cost method), it is more flexible and better adapted to valuation tasks, such as improvement in waste management. In addition, its results are relatively easy to understand and interpret, which makes it valuable to policymakers.

3. Empirical Strategy

One of the purposes of the study is to assess the residents' WTP for improved urban waste management and to suggest mechanisms for cost recovery. In this regard, the main objectives of the WTP survey are to calculate mean WTP and estimate a parametric model that includes respondents' socioeconomic factors in the WTP function.

We asked yes and no questions, and elicited a specific monetary value for yes responses. Because we do not know the random preferences and can only make probability statements about the yes and no responses, we used a probit model to estimate the probability of WTP. Also,

because the dependent variable, or WTP, is not fully observed (it is censored at zero), we also included a Tobit model. Both models are detailed below.

3.1 The Probit Model

The probit model specifies an indirect utility function for each respondent. Assume that the representative household gains utility from improvement in SWM and the two possible levels of environmental quality involved are the status quo q^0 and a specific level of improvement, q^1. Hence, each household's utility function at status quo (no improvement) is:

$$u_{oi} = u(y_i, z_i, q^0, \varepsilon_0) \quad (3)$$

and each household's utility function with improvement is:

$$u_{1i} = u(y_i, z_i, q^1, \varepsilon_1). \quad (4)$$

We can rewrite equations (3) and (4) into one equation as:

$$u_{ji} = u_j(y_i, z_i, q^j, \varepsilon_j), \quad (5)$$

where $j = 0; 1$ refers to the two different states of the environment; $i = 1,2,\ldots, n$ refers to household i; U_{0i} and U_{1i} represent, respectively, indirect utilities at the status quo and the hypothetical improved scenario; y_i is the ith utility maximizer's (individual household consumer i) discretionary income; z_i represents a vector of household socioeconomic, demographic, environmental, and design variables (initial fee levels, etc.); q^j refers to the quality of the good being valued (improved solid waste management); and ε_j represents other variables known to the utility maximizer, but not observed by the researcher (the error term).

Note that when the quality of environmental good q changes from q^0 to q^1 (as the result of a change in policy), the household's utility also changes from $u(y_i, z_i, q^0, \varepsilon_{0i})$ to $u(y_i, z_i, q^1, \varepsilon_{1i})$. Therefore, the condition that utility maximizer i answers yes to the offered price (bid) b_i is given by:

$$u_1(y_i - b_i, z_i,, q^1, \varepsilon_{1i}) > u_0(y_i, z_i, q^0, \varepsilon_{0i}) \quad (6)$$

Equation (6) states that household i will answer yes to the question about the offered price (bid) b_i if the household's utility at the improved level, net of the required payment, exceeds its utility at the status quo. However, because we typically do not know the random preferences and can only make probability statements about yes or no responses, the probability of a utility maximizer answering yes to the valuation question is consequent upon $U_1 > U_0$ (i.e.,

the utility maximizer is better at q^1 even with the required payment b_i). Hence, the probability yes for utility maximizer i is given by:

$$Pr(yes) = pr[u_1(y_i - b_i, z_i, q^1, \varepsilon_{1i}) > u_1(y_i, z_i, q^0, \varepsilon_{0i})] . \quad (7)$$

For parametric estimation of the above model, we need to choose a functional form for $U(y_i, z_i, q^1, \varepsilon_{1i})$ and specify the distribution of the error term ε_{ji}. Generally, most applied empirical research, whether it employs a random WTP model (Cameron and James 1987) or a utility differential model (Hanemann 1984), begins specification by assuming a utility function that is additively separable in systematic and stochastic components of preferences:

$$u_j(y_i, z_i, \varepsilon_{ji}) = v_j(y_i, z_i,) + \varepsilon_{ji} . \quad (8)$$

Given the specification in equation (8), the probability of utility maximizer i giving a positive response to the valuation question becomes:

$$Pr(yes) = pr[v_1(y_i - b_i, z_i, q^1) + \varepsilon_{1i} > v_0(y_i, z_i, q^0) + \varepsilon_{0i}] \quad (9)$$

$$= pr[v_1(y_1 - b_i, z_i\, q^1) - v_0(y_i, z_i, q^0) > \varepsilon_{0i} - \varepsilon_{1i} .$$

Note that the probability of the utility maximizer i giving a negative response (i.e., rejects the improvement) is given by:

$$Pr(no) = 1 - pr(yes) . \quad (10)$$

This equation is still too general for parametric estimation. However, when the systematic component of the preference function is assumed to be linear in income and other covariates, the model can be simplified as:

$$v_{ij}(y_i) = \alpha z_i + \beta(y_i) , \quad (11)$$

where y_i represents the individual consumer's (utility maximizer i) discretionary income; z_i represents an m-vector of household socioeconomic, demographic, environmental, and design variables; and α_i is an m-dimensional vector of parameters. For the new scenario, in which the dichotomous choice question will require a yes or no response to some offered price b_i, the probability that respondent i will answer yes to the valuation question is given by:

$$pr(yes) = pr[\alpha z_i + \beta b_i + \varepsilon_i > 0] . \quad (12)$$

To estimate equation (12), we assume that the error term is normally, independently, and identically distributed with mean zero and variance 1.

If we assume that $\eta = \varepsilon_{0i} - \varepsilon_{1i}$ and that $F_\eta(\,)$ is the cumulative distribution function of η, then the probability that the household is willing to pay for the improvement is:

$$pr(yes) = F_\eta(\Delta V) \quad (13)$$

$$pr(no) = 1 - F_\eta(\Delta V),$$

where $\Delta V = V_1(y_i - b_i, z_i, q^1) - V_0(y_i, z_i, q^0)$.

Note the main purpose of the analysis is to estimate WTP and drive a WTP function from the assumed utility function. Assuming that p_i is the household's unobservable actual WTP for improved SWM service, then:

$$p_i = \alpha z_i + \beta(y_i)$$

$$\alpha_0 z_i + \beta y_i + \varepsilon_{0i} = \alpha_1 z_i + \beta(y_i - b_i,) + \varepsilon_{1i} \quad (14)$$

$$= \alpha_1 z_i + \beta(y_i - WTP_i,) + \eta_i,$$

where p_i is the unobservable individual household's actual WTP for improved SWM service. By solving equation (14), household i's WTP can be expressed as:

$$WTP_\text{i} = (\alpha z_i + \eta_i)/\beta. \quad (15)$$

In the probit model, F_η (…) is the normal cumulative distribution function. As we define it above, the unobservable individual household's actual WTP for improved SWM service is $p_{i,}$ with linear relation to the initial bid b_i and the covariates, and the actual WTP for an individual can be presented as:

$$WTP_i = 1 \text{ if } p_i \geq b_i \quad (16)$$

$$WTP_i = 0 \text{ if } p_i < b_i.$$

With dichotomous choice contingent valuation, the i^{th} household (utility maximizer) is asked if it would be willing to pay the initial bid (b_i) to get a given improvement in solid waste management (both quality and quantity). This is a random variable. The probability of yes or no response can be presented as:

$$pr(\text{"yes" to } b_i) = pr(p_i \geq b_i) \quad (17)$$

$$pr(\text{"no" to } b_i) = pr(p_i < b_i).$$

The log likelihood function of this single bounded survey response is:

$$\ln L(\theta) = \sum_{i=1}^{N} \{d_i^Y \ln \Pi^Y(b_i) + d_i^n \ln \Pi^A(b_i)\}$$

$$= \sum_{i=1}^{N} \{ d_i^Y \ln G(b_i,\theta) + d_i^N \ln[1 - G(b_i,\theta)]\}, \quad (18)$$

where $d_i^Y = 1$ if the i^{th} response is yes and 0, otherwise; $d_i^N = 1$ if the i^{th} response is no and 0, otherwise. $G(b_i\ \theta)$ and $1\text{-}G(b_i,\theta)$ are the cumulative distribution function for the probability of yes and no responses; and θ represents the vector of parameters that index the distribution of WTP.

3.2 The Tobit Model

It is important to note that the dependent variable, or the WTP, is not fully observed and the dependent variable assumes zero values for a substantial part of the sample. Because an OLS (ordinary least squares) estimator cannot be applied, we use a Tobit model for the observed maximum willingness to pay (MWTP):

$$\begin{aligned} MWTP_i^* &= \alpha+\beta_{X'i}+\varepsilon_i \\ MWTP_i &= MWTP_i^* \text{ if } MWTP_i^* > 0 \\ &= 0 \text{ if } MWTP_i^* \leq 0 \ , \end{aligned} \qquad (19)$$

where $MWTP_i^*$ is a household's unobserved maximum willingness to pay for improved solid waste management; $MWTP_i$ is a household's actual maximum willingness to pay for improved solid waste management; X' is vector of independent variables; β is vector of coefficients; α is the intercept; and ε_i is disturbance term, which is assumed to be normally independently distributed, i other words, NID $(0, \sigma^2)$ and independent of x_i. Assuming that censoring point is zero, then:

$$\begin{aligned} MWTP = {}& \alpha + \beta_1 ASWG + \beta_2 Income + \beta_3 Bid + \beta_4 SER + \beta_5 AGR + \beta_6 EDLR + \\ & \beta_7 EAR + \beta_8 Fam\_Sz + \beta_9 Marriage + \beta_{10} PERCEPT + \beta_{11} House \\ & + \beta_{12} TSWSD + \varepsilon_i \text{ if } MWTP_i^* > 0 \\ = {}& 0 \text{ otherwise } (\text{if } MWTP_i^* \leq 0). \end{aligned} \qquad (20)$$

4. Study Area, Survey and Data Description

The study assesses current sanitary service fees and the WTP of residents for improved urban waste management, using contingent valuation method. It uses a cross-sectional survey data of randomly drawn households in Mekelle City, Ethiopia. This section describes the study area, survey design, elicitation format, and data collected.

4.1 Study Area

Mekelle City is the capital of Tigrai National Regional State, with a population of about 257, 290, an annual growth rate of 5.4 percent, and an average family size of 5 people (FDRE PCC 2008). The city generates about 0.3 kg of solid waste per capita per day (Tesfay 2004). This is low compared to other developing countries, such as Nepal, Bangladesh, and Cambodia, which generate 0.5–1.0 kg per capita per day (Zurbrügg 2002). The city is the main collector of solid waste, employing 14 waste collection cooperatives[2] (mainly micro and small enterprises). Of these, 11 cooperatives handle house-to-house collection, 2 are street sweepers (only asphalt streets), and 1 gathers waste dumped in open spaces and near the communal containers. All waste collection cooperatives bring waste to the city's communal refuse containers. Mekelle City pays the cooperatives ETB 33.30[3] per cubic meter (m^3) of waste collected.

Solid waste is primarily collected with hand carts (cooperatives and private firms), horse-drawn carts (private firms), and wheel barrows (street sweepers and adult laborers).[4] There are 64 communal refuse containers located throughout Mekelle City, one container per 54 hectares on average. The city transports the collected solid waste from the communal containers to the landfill site, using three skip loaders, each with an 8 m^3 capacity (Tesfay 2004; MCA 2007a).

Mekelle City has a number of problems with collection and disposal of solid waste (G-Michael 2002; MCA 2003). First, collection coverage is hugely inadequate: less than 50 percent of solid waste is collected. Second, lack of cost recovery and the unsustainable fee structure for current waste collection and disposal are serious issues. For example, during the first half of fiscal year 2007/2008, waste collection fees only brought in ETB 90, 283, while expenditures for the same six-month period were ETB 953,422[5] (MCA 2007b). Basically, revenue from solid waste collection and disposal covers only 9.5 percent of the cost and the remaining 90.5 percent has to come from other sources. As a result, there are insufficient numbers of refuse containers

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[2] Private firms may be subcontracted by the waste collection cooperatives, which are collectively owned and operated by members. (For example, the waste collection cooperatives may hire privately-owned and -driven horse-drawn carts.) There is a difference in size and scale between the two, and they both collect the same type of waste. The city encourages cooperatives because it sees them as employment generation. The municipality pays the cooperatives and the cooperatives pay the private firms. There are also instances where households and neighborhoods contract the cooperatives directly.

[3] ETB = Ethiopian birr. US$ 1 = ETB 9.7898 at the time of the study.

[4] The adult laborers are largely self-employed. Because waste collection coverage is not sufficient, the municipality also hires adult laborers for street sweeping.

[5] ETB 90, 283 = US$ 9,222; ETB 953,422 = US$ 97,387.

and the long distances between these containers increases the likelihood that citizens will dump waste in open spaces and along the roadsides (Tadesse, Ruijs, and Hagos 2008).

Mekelle City needs to find a sustainable source of funding to improve solid waste management and broaden collection. One solution is to involve the community in determining how to finance this service, hence the need to estimate the households' willingness to pay as a starting point.

4.2 Sampling and Design of Survey Questionnaire

Sample households for the study were drawn from a list of household heads residing in six local administrations[6] in Mekelle City, who had been in residence for one year or longer. With proportionate random sampling, 240 households were selected and 226 questionnaires completed.

The design of the survey followed recommendations from the NOAA Panel on Contingent Valuation (Arrow et al. 1993) and Mitchell and Carson (1989), and consisted of four sections. Questions in the survey's first section asked about respondents' awareness of the current situation with solid waste in Mekelle City. Survey section 2 covered general environmental problems and the proposed SWM improvement scheme. The third section questioned respondents about their WTP, and the survey's fourth section asked about socioeconomic conditions in the households. The improved SWM scenarios detailed the services to be provided, reliability of services, the current waste management problems in the city, the hypothetical improved condition, and how each consumer would pay for the improvement (payment vehicle).

Our contingent valuation employed a single-bounded dichotomous choice format, followed by open-ended questions in the WTP section. The survey was conducted March–May 2008 and was translated into Tigrigna, the local language, to ensure that respondents would understand the questions. Six data collectors (one from each local administration) with college diplomas or more, were given one day's training to ensure they understood each question and learned how best to approach and interview respondents to get valid information. In the training session, we emphasized that they had to obtain the consent of each respondent. We also

[6] Kedamay Woyane, Adi Haki, Hadnet, Hawelti, Semen, and Ayder are the local administrations.

conducted a trial survey of 12 household heads to determine the initial fee value and work out any problems.

The survey was given to 226 randomly selected households in Mekelle City. Data covered socioeconomic and demographic characteristics of the household, including gender and age of household head, marital status, family size, income, and house ownership; environmental attributes, such as level of environmental awareness, amount of solid waste generated by the household, etc.; and design variables, such as initial fee size and maximum WTP for environmental improvement and better SWM. Table 1 describes the variables. Table 2 presents the four initial fee points used in the study, which were based on responses in the trial survey and assessment of the sanitation fees that existed in Mekelle City at the time of the survey. Only 24 individuals (10.6 percent of all respondents) said no to the initial fee size. The frequency of the no response for WTP increased as the amount of the initial fee rose. (The mean of the initial fee points suggested in the survey was ETB 7.25 per month.)

Table 1. Description of Variables

Variable	Description	Mean	Std. dev.
WTP*	1 = WTP > 0; and 0 otherwise (i.e., 1 = yes to the stated starting bid; 0 otherwise)	0.920354	0.271345
Maximum WTP	Monthly maximum WTP of respondent in ETB**	7.878319	5.21255
Initial fee (bi)	Initial monthly fees offered to the respondents: ETB 2.50, ETB 5, ETB 10, ETB 15	7.47549	4.161797
Age (AGR)	Age of respondent in years	39.5354	10.8538
Sex (SER)	Gender of respondent (1 = female; 0 otherwise)	0.5132743	0.5009332
Perception	Perception of the respondent on the current solid waste management (1 = respondent perceives current solid waste management as fair; and 0 otherwise)	0.4867257	0.500933
Household waste (ASWG)	Household's weekly generation of solid waste measured in sacks	0.436946	0.25420
Educational level (EDLR)	Educational level of respondents (0 = illiterate or informal education; 1 =for elementary school; 2 = secondary school; 3 = university)	1.743363	1.02223
Family size (Fam_Sz)	Number of members of household	4.756637	1.94777
Marriage	Marital status of respondent (1 =	0.7212389	0.449385

	married; 0 otherwise)		
Income	Monthly income of the head of the household in ETB	1495.854	1325.04
Awareness (EAR)	Environmental awareness of the respondent (0 = not aware; 1 = fairly aware; 2 = much aware)	1.287611	0.680866
House ownership	Respondent owns house (1= owns; 0 otherwise)	0.5353982	0.499852
Type of solid waste service (TSWSD)	Type of solid waste service demanded by the household (1 = collection, recycling, and disposal; 0 otherwise)	1.41592	0.493975

Table 2. Willingness-to-Pay Responses for Initial Fee Points

Response	Initial fee points (in ETB)			
	2.50	***5.00***	***10.00***	***15.00***
No. of “yes” responses	16	99	64	23
No. of “no” responses	24	40	139	203
Percentage of “no” responses	10.62%	17.70%	61.50%	89.82%

4.3 Data Description

Table 3 provides WTP responses in relation to the socioeconomic characteristic of the sample households. About 92 percent had positive WTP values for the improvement in SWM. Considering the entire sample, 51.33 percent of household heads are women,[7] and a higher proportion of female respondents, (95.69 percent) had a positive WTP for improved SWM, compared to male respondents (88.18 percent). This may be due to the fact that women traditionally are more responsible for solid waste management in the household. The average monthly income of the sample households was ETB 1,495.85, with a minimum monthly income of ETB 200 and a maximum of ETB 12,776. As the level of income and education increased, so did the percentage of yes responses for the improved SWM system. The average age of respondents was 39.5 years and average family size 4.76. In addition, 53.54 percent of respondents currently own their home, and the others rent rented houses, either from public or private owners.

[7] Not all of the females were heads of households. Some were wives and others were elders interviewed when the head of the household was not available for the interview.

Table 3. Willingness-to-Pay Responses and Socioeconomic Characteristics of Sample Households

Socioeconomic variables		WTP (yes/no) for improved solid waste management		
		Yes	*No*	*Percentage of "yes" responses*
Gender	Male	97	13	88.18
	Female	111	5	95.69
Age of household head (in years)	20–40	122	-	100
	41–60	81	15	84.38
	Above 60	5	3	62.50
Educational level	Illiterate	20	11	64.52
	Elementary	55	6	90.16
	Secondary	68	1	98.55
	University	65	-	100.00
Income	< ETB 600	34	11	75.56
	ETB 600–1,200	75	5	93.75
	ETB 1,201–1,000	42	2	95.45
	Above ETB 2,000	57	-	100.00
Family size	≤ 2 people	31	-	100.00
	3–6 people	145	15	90.63
	> 6 people	32	3	91.43
Marital status	Married	154	9	94.49
	Single	25	1	96.15
	Widow/widower	7	6	53. 85
	Divorced	22	2	91.67
Employment	Civil servant and company employed	77	2	97.47
	Traders	84	5	94.38
	Self employed and daily laborers	24	3	88.89
	Unemployed	12	4	75.00
	Other*	11	4	73.33

Source: Study survey

* Other includes retired individuals.

Regarding environmental attributes, 53.33 percent sample households considered the current SWM to be inadequate, and 48.67 percent perceived the current SWM system as fair. Furthermore, 58.4 percent demanded only collection and disposal services of solid waste, while 41.6 percent demanded recycling in addition to collection and disposal. On average, sample households generated 0.44 sacks[8] of solid waste per week, with the minimum and maximum being 0.25 and 2 sacks per week, respectively.

About 40 percent of respondents reported that they disposed of their solid waste in nearby community containers, 12 percent dumped it in an open space, and 2.6 percent on the river banks near their home. Only 45.6 percent of respondents had their waste collected from home by the waste collection cooperatives contracted by the municipality. Almost all respondents reported that they did not separate their solid waste (organic, plastic, or glass) before disposing of it. In addition, 90.26 percent agreed that women were responsible for dealing with household waste, 5.6 percent said children were responsible, and the remaining 4 percent responded that both were responsible.

Respondents were also asked who was responsible for SWM at the city level. Around 44 percent said the city should take care of it, about 28.3 percent thought the community should deal with it, and 27.8 percent wanted government, community, and polluters to share responsibility. On the question of who should provide the improved services for SWM, 34 percent preferred that the municipal government take charge, 24 percent said private contractors should manage it, and 42 percent wanted it organized by the community.

5. Results and Discussion

In this section, we present and discuss the results of the multivariate empirical analysis to help determine which factors are significant for WTP for improved solid waste management service, as well as the amount respondents are willing to pay.

[8] As is common in such studies in developing countries, we used sacks as a measurement unit, which is the most common unit in this case. It should be noted, however, that it is not an accurate measure since sack sizes differ. However, in this particular study, we weighed sacks randomly and in most cases they ranged between 15 and 20 kilograms.

Of the 226 completed interviews, 24 respondents (10.6 percent) had invalid responses[9] to the valuation question. We also checked whether excluding invalid responses would insert a sample selection bias by comparing the means of household covariates of the two groups (i.e., valid and invalid responses). For some variables, such as gender, income, perception of existing SWM system, educational level, and household generation of wastes, the differences between the two groups (i.e., valid and invalid responses) was quite significant. If these variables influence the respondent's WTP value for the scheme, then the final estimates obtained from the sub-sample of valid responses may be affected by selectivity bias. Thus, we included all the respondents in the analysis.

We computed correlation coefficient matrix in order to test for multicollinearity and omitted the expenditure variable due to its high correlation with income. On the whole, we found that multicollinearity was not a serious problem in our dataset. Testing for heteroskedasticity also revealed no problem.

Table 4 presents the probit results for the variables that are significantly related to the probability of providing positive WTP values. While household income and awareness of environmental quality are positive, age of head is negative for WTP. The signs of these three variable coefficients make intuitive sense. A consumer with higher income has a greater demand for waste management and is more willing to pay for it. Households with greater awareness of environmental quality also have positive WTP values. On the other hand, age of household head is negative for WTP, suggesting that older people who have freely disposed their solid waste for many years are less willing to pay for improved solid waste management.

In table 5, the Tobit results, 8 of the 12 explanatory variables are statistically significant: educational level, environmental awareness, household income, marital status, perception of the current SWM system, house ownership, amount of solid waste generated by the household per week, and type of solid waste service demanded by the households. Except for the perception

[9] By invalid, we mean WTP responses that were excluded from the censored regression, actual (6) and protest (12) zeros, as well as outliers (4). We identified actual or protest zeros to the valuation question by asking respondents to give reasons for not wanting to pay for SWM. In this respect, 6 had insufficient income, 2 had no faith in the scheme, and 10 preferred to wait until the city government acted. Outliers were those whose maximum WTP bids are more than 5% of their estimated income and those who wanted the improvement at a significantly lower amount than the initial stated fee.

Table 4. Probit Results for Willingness to Pay Determinants

Variable	Coefficient	z-statistic
Age of head	-0.064**	-2.39
Sex of head	0.428	0.96
Education	0.108	0.29
Awareness	1.581***	2.54
Family size	-0.026	-0.21
Income	0.004***	6.98
Marriage	0.556	1.07
Perception	0.457	0.82
House ownership	0.618	1.12
Household waste	0.039	0.03
Type of solid waste service	0.025	0.04
Starting price	-1.972	-1.30
Pseudo R^2	0.6398	
McFadden	0.608461	

** represents significance at 5% level and *** represents significance at 1% level.

Table 5. Tobit Results for Amount of Willingness to Pay Determinants

Variable	Coefficient	t-statistic
Age of head	-0.035	-1.32
Sex of head	-0.168	-0.38
Education	1.120***	3.96
Awareness	2.287***	5.02
Family size	-0.106	-0.83
Income	0.001***	3.21
Marriage	0.905*	1.74
Perception	-1.239***	-2.47
House ownership	1.310***	2.82
Household waste	4.795***	5.18
Type of solid waste service	1.217**	2.38
Starting price	-0.751	-0.48

* represents significance at 10% level; ** represents significance at 5% level and *** represents significance at 1% level.

variable, they have a positive effect on the amount of WTP, as expected. Households that generated more solid waste have a higher demand for improved SWM.

The type of SWM service demanded by the households positively correlates with the amount of WTP and is significant at 5 percent. Note that this also captures whether or not respondents choose collection, recycling, and separation of waste as a bundle and that these households have a higher WTP for improved SWM. Educational level and environmental awareness of respondents are strongly positive for amount of WTP and are significant at 1 percent.

Income of respondents is also positive for amount of WTP (significant at 1 percent), indicating that improved solid waste management is a normal good since its demand increases with income. Respondents' perception of current SWM was negative for WTP for improved solid waste management and significant at 5 percent, indicating that households who perceive the current SWM system as good are less willing to pay than households who perceive the current solid waste management system as bad. Marital status is positive and significant at 10 percent with amount of WTP.

House ownership has significant impact at 1 percent and is positive for WTP, perhaps because households that rent consider their residences to be temporary or because, under the current SEM system, only house owners pay for waste collection.

The other four variables considered (initial fee, sex of respondents, family size of the household, and age of the respondent) have no significant effect on the amount of WTP for improved solid waste management.

In order to assess the implications for cost recovery and sustainability of the service, we use the probit model for the single-bounded dichotomous format and calculate the mean WTP (μ) as $\mu = -\alpha/\beta$, where α is the intercept and β is coefficient of the bid. The mean WTP for improved solid waste management per household per month is ETB 11.89 (table 6). We can also compute the mean WTP using the open-ended format, the maximum WTP of the respondents.

Table 6. Probit Results for Initial Fee Point

Variable	Coefficient	Z
Starting price	-0.056**	-2.08
Constant	-0.666***	-3.51

** represents significance at 5% level and *** represents significance at 1% level.

As seen in table 1, the mean WTP is ETB 7.88 per household per month, which is less than but closer to the WTP obtained using the close-ended format. Therefore, households' mean WTP for improved solid waste management is in the range of ETB 7.80–ETB 11.89 per month. Hence, we can calculate the monthly WTP for the city by multiplying this mean by the total number of households to get about ETB 532,536.05 per month. We can also estimate by aggregating WTP. Given the current population of Mekelle of 257,290, with an average family size of 4.76 (in the sample), the number of households is about 54,090.

The total monthly WTP of the city, using the mid WTP, is estimated at ETB 430,566 (table 7). Using the dichotomous single bounded question, the monthly WTP is estimated at ETB 532,536.05. The actual WTP of the households in Mekelle City falls between these two figures.

Table 7. Total Monthly Willingness-to-Pay Estimates for Improved Solid Waste Management

WTP interval (in ETB*/month)	Frequency of sample distribution		Mid WTP	Total no. of households	Total WTP (in ETB)
	Number	***Percent***			
0–3	36	15.93%	2	8616.106195	17,232.21
4–6	83	36.73%	5	19864.9115	99,324.56
7–9	19	8.41%	8	4547.389381	36,379.12
10–12	59	26.11%	11	14120.84071	155,329.2
13–15	12	5.31%	14	2872.035398	40,208.5
16–18	2	0.88%	17	478.6725664	8,137.434
19–21	14	6.19%	20	3350.707965	67,014.16
22–24	0	0	23	0	0
25–27	0	0	26	0	0
28–30	1	0.44%	29	239.3362832	6,940.752
Total	*226*	*100*		*54,090*	*430,566*

* ETB = Ethiopian birr.
Source: Authors' calculations.

6. Conclusions and Policy Implications

In rapidly growing cities in developing countries, solid waste is a major source of concern due to lack of appropriate planning, inadequate governance, resource constraint, and ineffective solid waste management. According to UNEP (2004), the generation of solid waste has become an increasing environmental and public health problem everywhere in the world, particularly in developing countries cities. The aim of this paper is to assess the current sanitary fees in Mekelle City, Ethiopia, and the WTP of residents for improved urban waste management, and suggest mechanisms for cost recovery.

We used contingent valuation with a single-bounded format followed by open-ended follow-up questions. We administered our survey via in-person interviews. We randomly selected a sample of 226 household heads, and used twelve explanatory variables in the regression models based on the degree of theoretical importance and their impact on WTP. Probit and Tobit models were used to identify the determinants of households' WTP for improved solid waste management system and to analyze the mean WTP of households.

In Mekelle City, solid waste management is mainly provided by the municipality. Traditionally, SWM has been measured and evaluated based on the performance of the service supplier, while the demand of the residents has been ignored. Resident households, who are the primary producers and generators of uncollected solid waste and perhaps the main victims of its deleterious effects, should be allowed to determine their SWM providers and participate in deciding effective solutions for SWM. Among other benefits, this would help providers understand households' willingness to participate and pay.

Solid waste collection in Mekelle is poor, its SWM system is not modern, and there is no organized recycling. Solid waste is primarily dumped haphazardly by the citizens in open spaces and the too-few community refuse containers are dumped in an improperly sited landfill. More important, cost recovery of SWM is a serious problem for the city. The revenue generated covers only 9.5 percent and the remaining 90.5 percent has to be covered from other sources. Because waste management has no adequate source of revenue, it cannot be improved nor even sustain present level of service.

In the probit model, only the variables for household income and respondents' awareness of environmental quality are positive for WTP (which make intuitive sense), while respondents' age is negative. The other nine variables have no significant impact on the likelihood that the respondent will provide a positive WTP value.

In the Tobit regression, on the other hand, 8 of 12 explanatory variables are statistically significant for households' WTP for improved solid waste management system and amount of WTP. The level of solid waste generated by the household per week, education of household head, environmental awareness, and house ownership are positive for WTP. Type of solid waste service demanded by the households, income of households, and marital status of household head are also positive, while perception of households of current SWM is negative.

The mean WTP for improved solid waste management per month per household is ETB 11.89, while the open-ended (maximum WTP) is ETB 7.88 per month per household. The total monthly aggregated WTP of the city is estimated as ETB 430,566. Using the dichotomous single-bounded question, the monthly city WTP is estimated at ETB 532,536. The actual WTP of the households in Mekelle City may fall between these two figures. Compared to the current sanitary fees, this WTP is much higher. The citizens are eager for improved SWM, so there is plenty of room to increase the fee and acquire sufficient funds to substantially improve and modernize SWM in Mekelle City. Comparing the mean WTP to what a private solid waste collector currently charges a household for its service (ETB 10 per month) offers a starting point for municipal officials in determining a more appropriate sanitation fee.

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