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Household waste disposal in Mekelle city, Northern Ethiopia

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Abstract

In many cities of developing countries, such as Mekelle (Ethiopia), waste management is poor and solid wastes are dumped along roadsides and into open areas, endangering health and attracting vermin. The effects of demographic factors, economic and social status, waste and environmental attributes on household solid waste disposal are investigated using data from household survey. Household level data are then analyzed using multinomial logit estimation to determine the factors that affect household waste disposal decision making. Results show that demographic features such as age, education and household size have an insignificant impact over the choice of alternative waste disposal means, whereas the supply of waste facilities significantly affects waste disposal choice. Inadequate supply of waste containers and longer distance to these containers increase the probability of waste dumping in open areas and roadsides relative to the use of communal containers. Higher household income decreases the probability of using open areas and roadsides as waste destinations relative to communal containers. Measures to make the process of waste disposal less costly and ensuring well functioning institutional waste management would improve proper waste disposal.

1. Introduction

In many fast growing cities of developing countries, dealing with household waste has become a vital policy problem. Policies and regulations aimed at good management of wastes, ranging from specifically controlling wastes at the household level to integrated municipal and economy-wide waste reduction efforts have been implemented with mixed outcomes (Choe and Fraser, 1999). Good solid waste management involves the sequential hierarchy of source reduction, reuse, recycling and safe disposal. In the modern world, there has been a contextual shift in how wastes are treated by humans. This shift in conception is the transfer from '*the disregard of waste to the recognition of its health implications, to the acceptance of the need to collect and process waste*' (Bisson, 2002). It would be impossible to successfully understand and manage waste if management does not consider waste generation. So as to maintain good waste management, we need not only accurate data on waste generation but also information on the behavior and attitude of people with regard to waste. This is because waste is the product of human behavior (Bisson, 2002). For example, household waste attitudes like NIMBY-'*not in my back yard*', will affect success and acceptability in such waste management practices as the siting of solid waste containers and landfill sites in quarters of the city (Goddard, 1995; Schubeler, 1996).

Household waste reduction efforts both at source and by means of various techniques like recycling, reuse and composting (Choe and Fraser, 1999) determine the optimal waste management scheme. It is pointed out that environmental damage not only results from the amount of waste generated (from consumption and production) but also from the way wastes are disposed of (Choe and Fraser, 1999). Unlike in the developed world, dumping in open areas, roadsides, and valleys has been widely used in many cities of developing countries. Many studies (Anwar et al.,

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2002; Ebreo and Vining, 2001; Li, 2003; Scott, 1999) have investigated the determinants of various behaviors and attributes on the recycling practices for household waste. However, there exists a gap in the literature on the factors responsible for household solid waste disposal, particularly in cities of developing countries. Discrete choice regression models in waste management are applied by some researchers (Chung and Poon, 1996; Li, 2003; Wright, 1991) where they try to determine the determinants of waste recycling behavior at the household level. While all of these studies focused on recycling behavior, this study emphasizes the behavior of households on the choice of alternative waste disposal practices.

While understanding the economic and social behavior of households is vital in improving household solid waste management, such studies in developing countries are hardly available. Empirical studies investigating the impact of household economic and social status, and waste and environmental concern attributes on solid waste disposal practices are required in order to improve solid waste management at the household level. In this regard, this paper aims at analyzing household waste disposal decisions in the city of Mekelle in Northern Ethiopia. The analysis is based on a survey of households and investigates the impact of household socioeconomic and demographic characteristics, environmental features and waste facility attributes on disposal behavior. For this purpose, a multinomial logit model, which allows for investigating the choice from a number of alternative disposal options, has been used.

The paper is presented as follows. Section 2 provides a concise description of household and municipal waste collection and disposal practices in Mekelle. In Section 3, the Random Utility Model which underlies the theoretical base for analytical econometric approach is briefly discussed. Section 4 introduces the data, study area and survey methodology. The model results are presented in Section 5. Section 6 summarizes and discusses the main results and formulates some implications.

2. Waste collection and disposal practices

Since the turn of the new millennium, solid waste generation in the city of Mekelle has been increasing. However, on average only one-third has been collected and disposed (Tesfay, 2004). Per capita waste generation in Mekelle is estimated to vary between 0.30 kg/day (Tadesse, 2006) and 0.33 kg/day (Tesfay, 2004). While wide varieties of household solid wastes are generated in the city, the major ones include dust/ashes, plastics and textile products, glass and metals, and organic residues. Tesfay (2004) holds that dust/ash and organic matter constitute the major components of household wastes as a result of the day-to-day lifestyle and consumption behavior of residents.

Household solid waste collection and disposal in the city of Mekelle is largely the responsibility of the municipality. There are a few contractors and informal waste collectors whose participation in the collection and disposal of wastes remains very limited. Although the city's population boom has witnessed an increasing generation of solid waste, the system of managing these wastes remained largely traditional and with an acute shortage of human and material capital. Having assumed the lion's share of managing not only household wastes but commercial and institutional wastes as well, the municipality collects and transports solid wastes to open dumping sites.

Solid waste collection service at household level by the municipality of Mekelle is primarily carried out using two major methods: door-to-door collection services by tractor-trailers and collection service using fixed-point communal containers (skips). The primary waste collection and disposal practice used is the communal containers service. The containers have a holding capacity of 8 m^3 each. They are placed in a position where they could be as accessible and proportional as possible to the households. In fact, factors involved in the siting of these containers include population density, location, road accessibility to loaders, and health impact. Mekelle has 58 containers, allotting a container for an average of 810 households (Tadesse, 2006), which is highly inadequate. Households are required to dispose their wastes into the nearby containers as needed, but it can be constantly witnessed that a full container can remain uncollected for days. As a result, households have no choice but to dump their waste on the ground, on roadsides around the container and in open areas. Barring technical failure and under capacity performance of the skip-loaders, containers are picked up once or twice a week depending on the amount of waste and location (Tesfay, 2004). The regulation by the municipality over the use of containers is not strong, which does not help in the proper disposal of household waste. Many residents have to travel a long distance to reach the containers and they resort at times to dumping their waste on the nearby roadsides and in open areas (Tadesse, 2006).

The second largest method of waste collection and disposal used by the municipality is the tractor-trailer system. In the process of solid waste collection using tractor-trailers, the co-driver gains the attention of households by using a manual alarm (or an alarm on the tractor) to bring their wastes out for collection. The crew members of the tractor-trailer unload the wastes from the bins and household containers into the trailers and return the containers to the households. Some containers, such as plastic bags and sacks, are taken with the wastes. The collection of wastes at household level and delivery of these wastes is largely carried out by women and children (Tadesse and Hadgu, 2007). When the trailer is filled to its capacity, it is carried by a tractor for disposal into communal containers.

Generally speaking, the supply of waste facilities is inadequate. Solid waste collection services are irregular. Institutional arrangements for collection and disposal services by the municipality are poor (Tadesse, 2006). There is acute shortage of human and material capital for solid waste management (Tesfay, 2004). The city has currently only

58 containers (excluding Quiha and Aynalem[1]), 3 skip-loaders and 4 tractor-trailers. The three available skip-loaders pick up the containers and transport them to the dumping sites. In such cases, recycling is not expected, and the municipality does not currently apply recycling to household wastes. These waste collection and disposal facilities are inadequate, such that there are only 0.0003 containers per capita (0.001 containers per household), 1 skip-loader for 15,667 households and 1 tractor-trailer for 11,750 households (Tadesse, 2006). While there are some other entities involved in the collection of household wastes in the city, final disposal is solely carried out by the municipality. Solid wastes are finally disposed at two uncontrolled open dumping sites outside of the city, which are located roughly 10 km away from the city in Quiha and Messobo (open areas).

3. The theoretical model and econometric specification

Household solid waste disposal practices are influenced by the supply of waste disposal services and other infrastructures; and where solid waste facilities are readily available, households tend to use them in a better way (Cointreau, 1982). Household wastes in cities of developing countries have different alternative destinations. These waste destinations include all sorts of containers provided by the municipality, tractor-trailers, open areas and roadsides, waste collection and disposal contractors, and informal waste pickers. The practice of solid waste disposal by households at these destinations is influenced by factors such as socioeconomic status of the household, urbanity, supply of waste disposal infrastructure, regulation by the municipality and environmental and health concerns (Cointreau, 1982; Bisson, 2002).

In microeconomic theory, consumers consume goods or services so as to optimize the utility they derive from it. Household utility maximization depends on various household features, as well as on other attributes related to the consumption of the good or service from which utility is derived. In this study, households are assumed to choose the disposal alternative that maximizes the unobserved (indirect) utility. It is also assumed that there is no natural ordering in the waste disposal alternatives. That is, we may not say that alternative 1 is better than alternative 2 in absolute terms. For such situations, the Random Utility Model (RUM) can be applied, in which the utility obtained from each alternative is a linear function of the observed characteristics plus an error term (Verbeek, 2004). Although the Random Utility Model is so far rarely used to derive the link between waste disposal and utility maximization, it could be useful to derive and model a household's choice of solid waste disposal activity.

[1] Quiha and Aynalem are two administrative neighborhoods of the city, which are not part of the study. The study area is limited to the mainland city.

This study uses a discrete Random Utility Model to explain how an individual household chooses a specific waste disposal alternative from a discrete set of alternatives. In the model, the actual choice reflects the choice yielding the maximum perceived utility (Cramer, 1991; Greene, 1997), which is a random attribute of the alternative waste disposal options in this case. As a result, households choose probabilistically between alternatives according to their random utilities (Pazgal et al., 2005). The utility derived from the choice of a waste disposal alternative is measured as a function of, for example, the supply of waste disposal facilities, demographic features (such as income), attributes of waste infrastructure (such as distance to dumping facilities) and environmental and waste values plus a random component (Devkota et al., 2004).

Assuming that an individual household i has j exhaustive and mutually exclusive waste disposal alternatives $j \in m$, the derived utility for choosing category $j \in m$ can be represented as

$$U_{ij} = \theta x'_{ij} + \varepsilon_{ij}, \tag{1}$$

where U_{ij} is the utility derived by household i from the adoption of waste disposal alternative j, x'_{ij} is the matrix of household factors and characteristics of the alternatives that affect disposal, ε_{ij} is the unobserved component, and θ is the vector of parameters of the model. Household i therefore chooses waste disposal destination j so that U_{ij} is maximized. In this study, there are four waste disposal alternative destinations available to households. The first waste disposal alternative is communal waste containers provided by the municipality (*alternative 1*). The second alternative is dumping in open areas and roadsides (*alternative 2*). The third alternative is disposal into tractor-trailers provided by the municipality (*alternative 3*). The last alternative is labeled as 'Others', which includes waste disposal using informal pickers and contracted private waste collectors (*alternative 4*). These alternatives are grouped in the set j, which is the dependent variable.

The utility that household i receives from waste destination j is U_{ij}, which is not observed. Only the waste destination choice is observed. Household i chooses alternative j if it provides the household the maximum utility, $U_{ij} = \mathrm{Max}(u_{i1}; u_{i2}; u_{i3}; u_{i4})$. For a certain disposal option chosen (y_i) by household i, it follows that:

$$\begin{aligned} P(y_i = j) &= P(U_{ij} = \mathrm{Max}(u_{i1}, u_{i2}, u_{i3}, u_{i4})) \\ &= P(\theta x'_{ij} + \varepsilon_{ij} = \mathrm{Max}(\theta x'_{i1} + \varepsilon_{i1}; \theta x'_{i2} + \varepsilon_{i2}; \theta x'_{i3} \\ &\quad + \varepsilon_{i3}; \theta x'_{i4} + \varepsilon_{i4})) \end{aligned} \tag{2}$$

with

$$\sum\nolimits_{j=1}^{4} P(y_i = j) = 1 \quad \text{and} \quad P(y_i = j) \geqslant 0$$

Notice that U_{i1} is the utility obtained from alternative 1, U_{i2} is the utility obtained from alternative 2, U_{i3} the utility obtained from alternative 3, U_{i4} the utility obtained from alternative 4. The optimal waste disposal choice is then estimated using a multinomial logit model on each alternative waste disposal attributes and demographic features. The results of this model show the probability of choosing a specific waste disposal activity. To formalize this, there is a choice from an unordered set of four waste disposal alternatives, indexed by set $j = 1, 2, 3, 4$. Assuming the disturbances between choices are independent, the multinomial logit model can be derived as (see Verbeek, 2004)

$$P(y_i = j) = \frac{\exp\left(\theta x'_{ij}\right)}{\sum_{j=1}^{4} \exp\left(\theta x'_{ij}\right)} \iff y_i = \begin{cases} 1 = \text{if disposal choice is communal containers} \\ 2 = \text{if disposal choice is open areas and roadsides} \\ 3 = \text{if disposal choice is tractor trailers} \\ 4 = \text{Others} \end{cases} \tag{3}$$

To solve this, the utility level of one of the choices is normalized to zero (say $\theta x_{ij_{\text{base}}} = 0$) (see Greene, 1997; Verbeek, 2004). Given the generic formula in Eq. (3), from normalization it follows that:

$$P(y_i = j) = \frac{\exp\left(\theta x'_{ij}\right)}{1 + \sum_{j=1, j \neq j_{\text{base}}}^{4} \exp(\theta x'_{ij})}, \quad j = 1, 2, 3, 4 \quad (j \neq j_{\text{base}}) \tag{4}$$

$$P(y_i = j_{\text{base}}) = \frac{\exp\left(\theta x'_{ij}\right)}{1 + \sum_{j=1, j \neq j_{\text{base}}}^{4} \exp(\theta x'_{ij})} \tag{5}$$

The essence behind the multinomial logit model is that the probability of an individual household choosing a solid waste disposal alternative is a simple expression of the different solid waste options and other household variables (x_{ij}) and the coefficients (θ's) which are estimated by using maximum likelihood estimation.

Discrete choice models such as multinomial logit and bivariate probit models share the property that their parameter estimates cannot be interpreted in a straightforward manner. Instead, additional computations are required. As a result, marginal effects and elasticities are estimated to express the probability of change in waste disposal as a function of each explanatory variable. These effects are evaluated at the mean of each variable. The marginal effects (the effect of an additional use of a specific waste disposal alternative) and the elasticities (percentage change in the use of an alternative waste disposal choice) of alternative waste disposal categories are respectively given by (see Greene, 1997)

$$\frac{\partial y_i}{\partial x_{ij}} = \left(\theta - \sum y_i \theta\right) y_i, \quad \frac{\partial y_i}{\partial x_{ij}} \cdot \frac{x_{ij}}{y_i} = \left(\theta - \sum y_i \theta\right) x_{ij} \tag{6}$$

Marginal effects refer to the change over the use of waste disposal alternatives when one of the explanatory variables change, keeping others constant. The elasticity shows the percentage change in the use of a waste disposal destination when one of the explanatory variable changes by 1%, keeping others constant.

4. Data study area and survey methodology

The study was conducted in the city of Mekelle located in Northern Ethiopia. Mekelle is situated at 783 km North of the national capital, Addis Ababa. Founded by emperor Yohannes IV 150 years back as the political center of Ethiopia, it is one of the fastest growing urban areas in the country. In 1984, the city of Mekelle had a size of 16 km^2, whereas in 2004, its area was already more than 100 km^2. Waste size increased with population growth and the city's spatial dimension.

Overall, households in the city use various methods to manage their waste. The use of communal containers, dumping in open areas and roadsides, burning, and use of tractor-trailer are among the ways households use to get rid of their wastes. In line with the expansion of the city, there is growing pressure on municipal services like waste collection and disposal.

To understand the choice of residents in solid waste disposal destinations, a household survey was conducted in an attempt to extract both qualitative and quantitative data about the practice of solid waste disposal by households. A structured questionnaire was set up and conducted (through interviews) among 200 households. The sample size was limited to 200 households for two reasons. On the one hand, given that the number of households in the city is around 47,000 (Tadesse, 2006), it is believed that 200 households would represent the population sufficiently. Besides, when households of the city are categorized in clusters and income groups, the sampling frame becomes much smaller and ensure better representation of the population. On the other hand, however, there was financial limitation not to extend the sample size. The sample of households covered 8 administrative *tabias*[2] of the city.

The questionnaire included aspects of solid waste management, environmental and solid waste attitude, municipal waste management practices, and household socioeconomic and demographic attributes. Since socioeconomic level of the population affects not only the practice of solid waste management but also the amount and nature of waste generated (Qdais, 1997), a combination of clustered and stratified random sampling procedures were applied to select the sample. The criteria used to select households were the household's economic status, i.e., high-, medium- and low-income levels, neighborhood household number, solid waste facilities and geographic

[2] *Tabias* are the lowest administrative units in the city. A group of *tabias* make up a *Wereda* (District).

Table 1
Specification of variables

Variable name	Measurement description	Mean	SD
Household head gender	1 if female, 0 otherwise	0.39	0.49
Age of household head	Age of the head of the household	43.8	12.5
Household head education	Number of years of schooling	7.91	6.07
Number of female household members	Number of female household members whose age is 15 and elementary school graduate as well	1.39	1.06
Family size	Number of household members	4.48	2.13
Years of stay	Number of years the household lived in the city	23.78	15.98
Home ownership	1 if the household owns the house it lives in, 0 otherwise	0.65	0.48
Household income	Household income per year (birr) (1US$ = 9.078 birr)	12739	12155
Household source separation of wastes	1 if yes, 0 otherwise	0.16	0.37
Access to waste disposal containers by households	0 if none at all, 1 if not enough, 2 if enough access	1.08	0.36
Municipal regulation if households are using the disposal containers properly	0 if none at all, 1 if regulation is weak, 2 if strong regulation	0.89	0.54
Waste quantity generated per year	1 if total generation is between 0 and 200 kg 2 if total generation is between 201 and 500 kg 3 if total generation is larger than 500 kg	1.83	0.81
View of people with the placement of waste containers near their houses (NIMBY[a])	1 if agree, 0 otherwise	0.32	0.47
Distance to waste containers	Total distance in m (meters)	293	457
Participation in recycling practice	1 if yes, 0 otherwise	0.18	0.39
View of people with the placement of waste containers anywhere in the city (NIABY[b])	1 if agree, 0 otherwise	0.46	0.50
Primary waste disposal alternative that households use (dependent variable)	1 if a household uses municipal waste containers 2 if a household uses open areas and roadsides 3 if a household uses tractor-trailers to dispose of the waste 4 other alternatives (formal and informal waste pickers)	1.32	0.72

[a] NIMBY represents for *Not In My Back Yard.*
[b] NIABY stands for *Not In Anyone's Back Yard.*

settlement of households. The households were then randomly selected, given these criteria, in such a way that a representative sample is obtained from the sampling frame. In stratifying the sample based on income, households were chosen roughly proportionally based on traditional measurement of affluence (such as housing and community knowledge whether a specific household is rich, middle income or poor). Neighborhood population also varies in the 8 administrative *tabias*. Proportional household samples were therefore selected accordingly. The supply of waste collection and disposal services also is different in the administrative *tabias*. Therefore, in the sample selection process, it was attempted to take into account this variation by selecting households with different levels of access to waste collection services. Only a single household was chosen from a *kanshelo* or *mekabebiya*[3] (house yard in approximate English translation). A respondent older than the age of 18 and who is the household-head within each household was interviewed. Four interviewers were sufficiently trained for the data collection. The fieldwork was carried out in the period between January 10 and 31, 2006.

In Table 1, the various explanatory variables and the dependent choice variable are specified. The dependent variable in this case is the primary waste disposal alternative that the household uses. These alternatives include a choice of four waste destination areas: communal containers (municipal waste containers), tractor-trailers, open areas and roadsides, and others (such as informal waste pickers and private formal waste collection services). The choice of these waste disposal destinations is governed by utility (indirect) maximization. A lot of variables affect this random utility maximizing choice directly and indirectly. These explanatory variables include household attributes, features of the waste disposal alternatives, municipal characteristics, city features, waste and environmental attributes.

4.1. Household waste generation and perceptions

Households use different alternatives to treat their wastes. These management alternatives include disposal (by making use of municipal waste facilities such as communal containers and tractor-trailers), burning, open dumping and to some extent recycling. Households may for example reuse or recycle glass materials and dispose or burn their cover if they are not useful anymore. The point is that households use one or a combination of these waste management methods whereby communal containers are the primary waste destination (Table 2). Around 82.5% of the households use municipal containers. Household

[3] *A kanshelo* or *mekabebiya* is an enclosure in which more than a single household lives. It is a common dwelling system especially in the poor and middle income neighborhoods of the city of Mekelle. It sometimes houses more than five households.

Table 2
Primary household solid waste management mechanisms

Waste management types[a]	Percent (%)
Burning	5
Use of municipal containers	82.5
Dumping in open areas and roadsides	3.5
Recycling and reuse	3
Use of tractor-trailers	6

[a] The choices of waste management are not exclusive. There are other management ways such as informal waste pickers who serve (collect wastes from) the very rich households. However, this is very insignificant and it was decided to ignore it.

burning and open dumping supplement the use of containers in disposing solid wastes by households in the city.

The type of solid waste generated affects the subsequent treatment mechanism adopted by households. Moreover, social and economic status, neighborhood, accessibility of waste facilities, municipal regulation, and other household attributes such as environmental concern, education and family size can determine solid waste management practices. In particular, the availability of municipal waste infrastructure is believed to affect the choice of waste treatment mechanisms. Table 3 shows the various waste, waste facilities and environmental perception of households in the city. A component of good solid waste management is source separation of solid wastes based on their type, which paves the way for recycling and reuse. Asked if they engage in source separation of wastes, 83.5% of the household respondents revealed that they do not separate wastes at source while only 16.5% of the respondents separate wastes at some stage.

Recycling and reuse not only improve the process of waste management, but they bring economic benefit to those involved as well. However, from the results of the survey, it follows that there is no clear relationship between household income and recycling practice. Only 18.5% of the respondents recycle wastes or use recycling as waste management method. Although reuse is common among the poorer households, it also is to a small extent used by some households in all income groups. Different types of bottles, plastic containers for liquids, plastic shoes, clothing, shopping paper, and forage for cattle are among the most practically reused and recycled solid wastes by households in the city. The fact is that the practice of recycling and reuse is limited among households in the city. It is also limited to some waste types (components).

In addition, household attitude on solid wastes and the environment can have an impact on solid waste management. About 58% of the respondents believe that solid wastes are useless, i.e., no economic benefit, whereas 30.5% of the respondents have the opinion that wastes can be partly useful and 11.5% of the respondents insist that solid wastes are very useful. However, cross tabulation results show no significant (chi-square test with p-value of 0.231) relationship between waste attitude and recycling.

The attitude on solid wastes again influences the siting of solid waste facilities such as containers or skips. Basically, decisions on the siting of these solid waste collection and disposal containers are made based on factors such as population density, road accessibility to loaders, health impacts and the extent of resistance by households against the placement of the facility in their neighborhoods. Related to this, when households are asked whether or not they would agree with the placement of waste containers nearer to their houses, 69% responded 'no' and 31% said 'yes' (see Table 3). This reveals that there is strong resistance against waste facilities such as containers to be placed within a short distance of dwelling areas (houses). At some points, the resistance is so strong that it forces

Table 3
Household solid waste and environmental perceptions

Waste or environmental attribute	Response by households	Count and percentage rates
Do you agree with the placement of waste containers near your houses?	Yes	62 (31.0%)
	No	138 (69.0%)
Do you agree with the siting of waste containers not only nearer to your houses but in any part of the city as well?	Yes	93 (46.5%)
	No	107 (53.5%)
Source separation of wastes by the household	Yes	33 (16.5%)
	No	167 (83.5%)
Extent of household access to solid waste containers	No access at all	5 (2.5%)
	Inadequate access	173 (86.5%)
	Adequate access	22 (11.0%)
Regulation by the municipality if households are using appropriate waste disposal	No regulation at all	40 (20.0%)
	Weak regulation	141 (70.5%)
	Strong regulation	19 (9.5%)
Recycling and reuse practice by the household	Yes	37 (18.5%)
	No	163 (81.5%)
Household head attitude to solid wastes	Wastes are useless	116 (58.0%)
	Wastes are partly useful	61 (30.5%)
	Wastes are useful	23 (11.5%)

the municipality to replace (reposition) the waste containers. Households oppose the siting of waste facilities in their housing proximity for reasons of negative externalities such as health hazards, disamenities and bad odor. Most households who live in compacted neighborhoods are less inclined to have the containers around. Since the undesirable outcome is the concentration of waste in containers for days, these households would prefer disposing their waste mainly in open areas away from their dwelling places. Health hazards resulting from the waste in containers are the major concern of these households. Wastes dumped in roadsides are mainly plastic and organic in nature. While the organic wastes decompose quickly, thus eliminating the health hazard, plastic wastes are usually washed away by winds. Households want their surrounding to be as clean and unproblematic as possible. A lot of these households as a result may go to open areas away from their neighborhood to dispose wastes. On the other hand, other households who hardly enjoy the services are in favor of siting of the containers near their dwellings because of access reasons. All of these perception choices depend on access to such containers, availability of open areas and distance to the containers. In spite of the fact that the majority of households (86.5%) believe that waste containers are inadequate, if more containers are supplied by the municipality, they want the containers to be located somewhere not very close to their dwelling places (see Table 3).

Finally, perception about the supply side of waste facilities and institutional regulation of appropriate waste management by the municipality is also presented in Table 3. Asked if they have sufficient access to waste collection and disposal containers, 2.5% of the respondents turn out to have no access to the containers. A large proportion of the respondents (86.5%) revealed that the supply of containers is inadequate, i.e., they do not have enough access to the containers; and 11% responded that they have sufficient access to the limited number of containers.

Weak municipal regulation does not help the poor solid waste management practices by households. Enforcement of appropriate solid waste disposal by the municipality lacks strength. About 70.5% of the household respondents witnessed weak municipal regulation on household waste disposal. A mere 9.5% of the respondents said that there is strong municipal regulation, while 20% of the respondents witnessed the absence of any regulation by the municipality. This institutional factor may have its own impact on the way households behave while disposing of wastes.

5. Analytical results

In Section 4, the various waste management mechanisms that households use were explored. It is revealed that disposal is the major waste treatment method by households. Household choice regarding waste disposal practices (alternatives) is analyzed and the results are presented below. To estimate the parameter coefficients, predicted marginal values and elasticities of the multinomial logit model, the econometrics software STATA was used. As explained earlier, the direct interpretation of the coefficient estimates from a multinomial logit model is misleading. Therefore, the marginal effect and elasticities are used to describe the impact of variables on solid waste disposal choice. Since the interpretation of the parameter estimates of a multinomial logit model are explained with respect to the baseline alternative specified, the output of four different waste destination categories can be outlined. In other words, each of the solid waste disposal categories can act a base case and allow interpretation of the coefficients in terms of the base case. Despite this, only one scenario (where 'communal container' is the base case) is provided. The three major disposal destinations (communal containers, open areas and roadsides, and tractor-trailers) and the fourth group (including informal waste pickers and formal private waste collectors) are separately grouped. The dependent variable, waste disposal destination therefore is grouped into four classes: 1 = communal containers, 2 = open areas and roadsides, 3 = tractor-trailers and 4 = others. The variables considered in this study are described in Table 1 and results are presented in Table 4.

The supply of waste facilities[4] such as communal waste containers does have a significant impact on waste disposal by households. The coefficient of access to waste containers (see Table 4) for the open areas and roadsides waste disposal category is negative. This demonstrates that the probability of disposing wastes in those unauthorized destinations decreases relative to the use of communal waste containers when more waste containers are available. When container access decreases, household waste disposal in unauthorized areas such as open areas, roadsides and agricultural fields significantly increases relative to the use of communal waste containers. This relationship signifies that the limited supply of waste containers compels households to dump their wastes in open areas and roadsides. Attitudes on the siting of waste containers also affects the choice of waste disposal destination. Less concern by households to the placement of waste containers anywhere in the city (as depicted by NIABY in the model) results in an increased probability of disposing wastes in open areas and roadsides relative to the use of containers. The position of waste containers also affects the choice of disposal alternatives. The larger is the distance of waste containers from the houses, the larger is the probability of households

[4] The inference that choice over waste disposal methods depends on access to waste facilities designed specifically for that purpose may be an endogenous response. To investigate this, the sample households were divided into two groups, controlling for access to waste containers. Having run the regression (for the full model and for the two groups), the log-likelihood ratio test was performed (this is analogous to the Chow test in Categorical outcome regressions). With chi-square value of 7.34 (where the critical value is 8.67), $\chi^2 \approx -2[L(\text{full}) - L(G_1) - L(G_2)]_{(17,0.95)}$, the null hypothesis that the coefficients are the same in both groups cannot be rejected. Thus, we work with the full model.

Table 4
Multinomial logit estimation for waste disposal (base case = communal containers)

Variables	Open areas and roadsides			Use of tractor-trailer		
	Coefficient ($\hat{\theta}$)	Marginal effects (dy/dx)	Elasticity (ey/ex)	Coefficient ($\hat{\theta}$)	Marginal effects (dy/dx)	Elasticity (ey/ex)
Constant	−0.34 (0.873)	–	–	−3.84* (0.08)	–	–
Household socioeconomic features						
Household head gender	−0.86 (0.302)	−0.02 (0.283)	−0.33 (0.301)	−0.92 (0.292)	0.002 (0.905)	0.05 (0.903)
Household head education	0.09 (0.248)	0.002 (0.296)	0.69 (0.260)	0.13 (0.213)	0.002 (0.286)	0.95 (0.225)
Household head age	0.02 (0.529)	0.0005 (0.561)	0.75 (0.530)	0.01 (0.888)	0.0001 (0.898)	0.22 (0.897)
Numerical income	−0.0001** (0.015)	−2.9e−06** (0.025)	−1.35** (0.019)	−0.00003 (0.305)	0.00 (0.202)	−1.45 (0.114)
Number of females	−0.59 (0.140)	−0.02 (0.200)	−0.80 (0.147)	−0.11 (0.809)	−0.002 (0.838)	−0.13 (0.837)
Household size	0.17 (0.378)	0.01 (0.385)	0.77 (0.368)	−0.24 (0.380)	−0.005 (0.421)	−1.20 (0.417)
Years of stay	−0.01 (0.743)	−0.0002 (0.739)	−0.18 (0.731)	0.02 (0.562)	0.0003 (0.559)	0.40 (0.556)
Household waste and environmental attributes						
NIMBY	−0.10 (0.893)	−0.002 (0.919)	−0.02 (0.925)	−0.97 (0.100)	−0.02 (0.143)	−0.26 (0.208)
NIABY	1.6** (0.042)	0.05* (0.059)	0.74** (0.042)	−1.35 (0.177)	−0.02 (0.239)	−0.64 (0.167)
Waste size	0.21 (0.644)	0.01 (0.667)	0.34 (0.673)	1.00 (0.115)	0.02 (0.161)	1.81 (0.121)
Waste separation	0.55 (0.533)	0.02 (0.599)	0.09 (0.525)	−0.58 (0.639)	−0.01 (0.542)	−0.10 (0.631)
Access to containers	−4.87*** (0.006)	−0.14** (0.016)	−5.17*** (0.007)	0.62 (0.511)	0.03 (0.224)	1.86 (0.166)
Institutional regulation	−0.36 (0.647)	−0.01 (0.660)	−0.31 (0.651)	0.002 (0.998)	−0.004 (0.776)	−0.21 (0.773)
Home ownership	0.81 (0.322)	0.02 (0.295)	0.52 (0.317)	−0.51 (0.603)	−0.01 (0.626)	−0.34 (0.587)
Recycling	−0.15 (0.862)	−0.004 (0.841)	−0.03 (0.852)	−0.18 (0.85)	0.01 (0.651)	0.11 (0.576)
Distance in meters	0.002*** (0.005)	0.00005* (0.077)	0.48*** (0.007)	0.002*** (0.004)	0.0001** (0.034)	0.46*** (0.006)

Notes: figures in parentheses are p-values. $R^2 = 0.4$, Log likelihood = −82.981478, LR $\chi^2(51) = 103.11$, Prob > $\chi^2 = 0.000$.
* 10% significance level.
** 5% significance level.
*** 1% significance level.

opting to use open areas and roadsides to dispose their wastes relative to disposing in communal waste containers.

A 1% increase in distance results in an 0.48% increase in the probability of disposing waste in unauthorized areas (open areas and roadsides) relative to municipal containers. Distance of containers also increases the use of alternative waste disposal practices like tractor-trailer services. The results in Table 4 also show that a 1% increase in the distance of waste containers increases the probability of using tractor-trailer service by 0.46% relative to communal containers.

Household income, as expected, has a negative impact on the use of unauthorized waste destinations as compared to communal waste containers. An increase in household income by 1% reduces the probability of disposing waste in open areas and roadsides by 1.35 % (see Table 4). This implies that higher income levels allow households to use alternative options such as private waste pickers or waste containers.

Outcomes of the study show that demographic features are largely insignificant in their influence of choice among disposal options. Household size, number of female household members, household head age and educational status are found to have a statistically insignificant impact on the choice of waste disposal alternative. A possible explanation could be that some sort of awareness change rather than the number of years of education or age may affect waste disposal. Limited variability of the education variable can also be another explanation. Since the effect of this awareness change could not be investigated with our data, future study is warranted in this regard.

Results show that the amount of waste generated and institutional regulation do have an insignificant impact on the destination choice of waste disposal. It can be argued that households are bound by limited proper waste disposal facilities and they may have no option but dispose anywhere. As well, it may be awareness change by households rather than regulation or waste size that determines waste disposal choice, apart from the supply of waste facilities that determine proper disposal.

6. Conclusions and discussion

Results of the study provide interesting implications about the impact of socioeconomic variables, waste facilities and environmental concerns on the choice of waste disposal alternatives. The supply of waste disposal facilities has a large impact on the alternatives that households choose to dispose of their waste. The empirical evidence only partly supports the concept in the literature that demographic features affect solid waste management. In fact, most of the literature is focused on recycling practice and its relationship with various demographic features. Analytical results reveal that demographic variables such as age, education, household size and gender have an insignificant impact on the choice of waste disposal practices.

More importantly, results show that the supply of waste facilities significantly affects the choice of a disposal option by households. Longer distance and inadequate access to communal containers partly encourage households to dump their wastes in unauthorized areas or use alternative methods, such as the use of tractor-trailers. This is emphasized by the fact that most of the households (86.5%) have inadequate access to waste disposal containers.

On the other hand, household income significantly counts against the use of open areas and roadsides relative to the use of communal containers. The implication is that increased income means households will have the willingness and ability to pay informal waste pickers and private workers for waste disposal.

Household attitude against the placement of waste containers nearer to their houses or anywhere in the city (NIABY) results in the choice of disposal in open areas and valleys rather than waste containers. This is reflected by the observation that 69% of the households resist the siting of containers in the proximity of their dwelling areas (53% resist siting anywhere in the city). Households would not want to have waste containers in close proximity of their houses because of health hazards, bad odors and disamenities. Many of them can go to open areas located in a reasonably distant location for disposal. The positive coefficient of NIABY for the disposal alternative 'open areas and roadsides' implies that households are not really concerned about environmental safety. They might rather be more sensitive to the health hazards and bad smell inflicted by waste accumulated in containers for days. A further study may benefit cities in developing countries to really understand household behavior with regard to waste disposal and environmental sensitiveness. The consequence of this NIABY mentality is an appalling condition from an environmental safety perspective.

A win–win strategy in this regard can be the increase in the number of tractor-trailers and the frequency of collection. This door-to-door collection of waste helps to ensure safe disposal of household wastes. The institutional regulation on the proper use of communal waste containers has an insignificant impact on the choice of containers. A reason can be that households, confronted with an inadequate supply of containers, do not have alternative options but to dispose in unauthorized areas. It can also be attributed to the inadequate waste collection services (example by tractor-trailers) they get from the municipality or other parties. The results also may point to the poor enforcement of regulations by the municipality. The appalling reality in connection to this is the poor management of these waste facilities by the municipality. One can witness that a full container can remain uncollected for as long as two weeks. The result is that wastes are scattered all over the place in a neighborhood inflicting all sorts of negative externalities (health problems, attracting vermin, bad smell and disamenities). This may fuel the NIMBY mentality of households and perhaps encourage dumping in open areas in other neighborhoods.

A major implication is therefore that measures to increase the number of communal containers do improve proper waste disposal. It is not however only the number that matters but siting these containers in such a way to be accessible to all households (within a reasonable distance) is an important issue. Many households live far away from the containers and they usually opt to dispose wastes in open areas or along roadsides rather than going that far to the containers. Proper regulation (over their use) and regular pick up of these waste containers would also help proper waste disposal practices by households. This relationship is not examined in this study. Thus, further research over the impact of overall regulation and regular pick up of containers is warranted. A better functioning system of waste facilities (for example cleaner and regular pick up of containers) may also ease the strong NIMBY and NIABY attitudes of households.

It is also shown that higher income promotes proper waste disposal. It increases the probability of using communal containers rather than open areas. Given the effect of income on the choice of disposal destinations raises the question of how to make disposal methods less costly, an area which could be further investigated. Many developing countries encounter similar waste disposal problems, ranging from poor facilities to poor management.

Although institutional variables (regulation for example) in this study appear to have no significant impact on waste disposal behavior, they could be vital in shaping the overall municipal and household waste management system. The institutional aspect can be further investigated as such. Because income is one determining factor of waste disposal choice, cities in developing countries may profit from establishing mechanisms that would make disposal less costly as well. It pays also for cities to reduce the cost of disposal by decreasing the distance to waste facilities, which reduces time and labor cost. A relentless effort is also required to increase the capacity of the waste disposal infrastructure in order to successfully manage wastes in developing countries. This improves regular and timely waste collection and disposal, which could ease NIMBY or NIABY attitudes and result in a better environment.

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