ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

HOUSEHOLDS' PREFERENCES FOR IMPROVED SOLID WASTE MANAGEMENT OPTIONS IN AKSUM TOWN: AN APPLICATION OF CHOICE MODELING

BY
METKEL AREGAY

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ABBREVIATIONS AND ACRONYMS

ASC……………………………………….. Alternative Specific Constant
BAU……………………………………… Business as Usual
CE……………………………………….. Choice Experiment
CM…………………………………….. Choice Modelling
CS……………………………………….. Compensating Surplus
CV……………………………………….. Contingent Valuation
CVM…………………………………….. Contingent Valuation Method
EPA…………………………………….. Environmental Protection Agency
HHs…………………………………….. Households
HPM…………………………………….. Hedonic Pricing Method
IIA…………………………………….... Independence of Irrelevant Alternatives
MAS…………………………………….. Multistage Area Sampling
MNL…………………………………….. Multinomial Logit
MSW…………………………………….. Municipal Solid Waste
MSWM………………………………….. Municipal Solid Waste Management
MWTP………………………………….. Marginal Willingness To Pay
n.d. ……………………………………… No Date
OLS…………………………………….. Ordinary Least Squares
RPL……………………………………. .Random Parameter Logit
RUT……………………………………. .Random Utility Theory
SW……………………………………. .Solid Waste
SWM…………………………………. ..Solid Waste Management
TCM……………………………………Travel Cost Method
US EPA……………………………......United States Environmental Protection Agency
WTP……………………………………Willingness to Pay

ABSTRACT

This thesis is aimed at estimating the non-market welfare gain from different improved solid waste management options for households in Aksum town using choice modeling. The proposed improvements in solid waste management were presented by three service attributes (i.e. frequency of waste collection, waste disposal mechanism and mode of transport used to transport waste) along with a monetary attribute (monthly charges of households for the service rendered). For the purpose of the survey 150 dwellers of the town were randomly selected. Two multinomial logit models and a random parameter logit model were used for the estimations. In both the basic and the extended multinomial logit models the coefficients of the attributes are significant and with the priori expected signs. Except for gender of the respondent, family size and monthly income of the households, all included socioeconomic variables in the extended multinomial logit model significantly affect utilities of the respondents. Since the IIA test (standard Hausman test) cannot be completed, random parameter logit model is also estimated. As in the multinomial models, the coefficients of the attributes are significant and have expected signs. Implicit prices were calculated and found 4.7, 1.7 and 2.7 birr for frequency of waste collection, waste disposal mechanism and mode of transportation respectively for the RPL. The equilibrium values or trade offs between the non-monetary attributes were also calculated. Analogous results were found for the three models and frequency of waste collection ranked top in terms of relative importance to households. Finally various hypothetical scenarios were set up and their values estimated using the results of the RPL. Among the included hypothetical alternative programs, Scenario Nine with three times irregular frequency of collection, incinerator as waste disposal mechanism and covered trucks as mode of transport incorporates the maximum levels of the attributes. For a change from status quo to scenario nine, households are willing to pay 37.3 birr per month. Generally dwellers of the town are willing to pay for improvements in the existing solid waste managementactivities.

CHAPTER ONE

Introduction

1.1. Background of the Study

Urbanization and increase in population come with immense increase in the amount and composition of solid wastes around the world (Ku et al., 2009; Beede & Bloom, 1995; Mehra et al**.,** 1996**;** Bartone and Bernstein, 1993; Eugenia et al., 2002). Being the mixture of many things including hazardous materials, an increase in quantity and content of solid waste poses serious environmental problems and hence needs to be managed properly so as to reduce its negative impacts. Proper management of solid waste involves many hierarchical steps which include reducing waste, reusing, recycling, energy recovery and finally landfilling (Hajkowicz et al., 2005; Gray**,** 1997). Each stage must be taken carefully, the major aim being minimizing the environmental impact of the unmanaged solid wastes. Land filling should also be the final step. Before simply being disposed to land fills, it is wise to reuse reusables, recycle recyclables and recover possible energy.

If not managed properly, solid waste has social, economic and environmental implications. These implications make solid waste management one of the critical concerns facing the world and the problem is more pronounced for less developed countries. The central aim of managing waste is to reduce its volume, composition and its adverse effects. However, cities in developing countries have great challenges to deal with the solid waste management activities. Budget and infrastructural constraints, rudimentary organization and planning of solid waste collection and disposal, poor or no segregation at source and corrupt public sector

(Buenrostro and Bocco, 2003; Das et al., 2008), are among the main problems of developing countries in properly managing solid waste. Beeds and Bloom (1995) argue in their paper that developing countries have poor waste management; only 30 - 50 % of the waste of developing countries is collected and managed properly. The rest is either burned or left to decompose in open space or dumped in unregulated landfills, which is environmentally damaging.

Most municipalities in developing countries spend a large proportion of their budgets on the collection, transport, and disposal of solid wastes. According to Cointreau (1987), in most cities of developing countries, municipalities spend some 20-50% of their revenues in municipal solid waste management , however, only 50-70% of residents receive the service, most disposals being precarious. Poor solid waste management is a threat to public health and reduces the quality of life for urban residents. Moreover, the situation is likely to worsen due to continuing population growth and urbanization in developing countries.To improve things, it is wise to look at possibilities that households might share the possible costs of solid waste management. The study in this aspect tries to asses if households are willing to contribute to an improved solid waste management by presenting them with different policy options.

1.2. Statement of the Problem

Increasing globalization and changing lifestyles have resulted in increased consumption of packaged and processed goods in recent years including food and other items which in turn increases the volume and composition of solid wastes and there by the cost of managing it. In most countries of the world and especially in developing countries solid waste management has been considered to be the responsibility of the government, financed by general revenues of nations. Consequently, many municipalities in developing countries spend a large proportion of their budgets on the collection, transport and disposal of solid waste. Their solid waste management is a costly service that consumes between 20 and 50 percent of available operational budgets for municipal services, yet serves no more than 70 percent of the urban inhabitants (Longe et al., 2009; Bartone and Bernstein, 1993; Schubeler, 1996). This indicates that the management of solid waste in many developing countries absorbs large share of their respective budgets but still is in its unsatisfactory stage.

Aksum, as an emerging town in a developing country, has series problems of solid waste management. The management of solid waste is undertaken by the municipality of the town. The service rendered by the municipality is not adequate owing to many factors, the main being financial constraint. All the same, households are the main sources of solid waste as well as the main victims of the negative effects of unmanaged solid waste; therefore, it will be reasonable to include these stakeholders in designing related policies. If households participate in solid waste management activities starting from policy design unto cost sharing, municipalities can render reliable services. Willingness to pay or not to pay by households for improved management plans can affect concerned policies. Preferences of citizens must be assessed for the success of proposed mechanisms. The study attempts to asses the preferences of the dwellers of Aksum town by presenting them with different waste management options.

To find solutions for the mismatch between demand and supply in the solid waste management services, many researches had been undertaken in many parts of the world by employing different approaches mostly contingent valuation method. In recent times, however, choice modeling is becoming more appealing due to the variety of options it offers. The Ethiopian case is not different, almost all studies in this respect employed contingent valuation method (for e.g. Tesfahun, 2007; seleshi, 2007; Tolina, 2006; Alebel and Dawit, n.d.). Very few studies employed choice modeling (for e.g. Solomon, 2007) concerning solid waste management. This study employed choice modeling which will be a valuable addition to the unexploited approach.

1.3. Objectives of the Study

The general objective of the study is to estimate the non-market welfare gain from different improved solid waste management options for households in Aksum town using choice modeling.

The specific objectives include:

- To estimate the implicit prices.
- To approximate the equilibrium values of the non-monetary attributes.
- To draw out WTPs of different service options.

1.4. Significance of the study

With increase in population and continuous urbanization, solid waste generated increases in quantity and composition. To cope up with the undesirable effects of this waste such as public health problems proper management is crucial. The thesis attempts to asses the stakeholders‟ demand side preferences for various policy options to improve the current solid waste management system. The outcome of the thesis can serve as an input for sound policy formulations to fill and reconcile the gap between the demand and the supply for better solid waste management services. The willingness of households to participate in different management options could give policy makers insights for future courses of action in this respect.

1.5. Scope and Limitations

The study is limited to the analysis of households‟ preferences to management options for residential solid waste only. It does not include other types of solid waste such as industrial, commercial and agricultural. The sample size is comprised of 150 households. It is obvious that larger sample helps for statistical accuracy, however time and especially financial constraints are the impediments for not choosing a relatively larger sample.

1.6 Organization of the Study

The thesis is organized as follows. The first chapter is devoted for the introductory parts. Chapter Two deals with the theoretical and empirical literatures. Various literatures regarding solid waste management and choice modelling are reviewed. Issues related to survey methods, model specification, questionnaire design and methods of data analysis are discussed in Chapter Three. Chapter four presents a detailed discussion of the overall findings of the study. Results of the various included models are estimated and interpreted in this chapter. The last Chapter i.e. Chapter Five comes up with the conclusions and some policy implications.

CHAPTER TWO

Review of Related Literatures

2.1. Theoretical Literature Review

2.1.1. Conceptual Framework of Solid Waste

US EPA defines solid waste as any garbage or refuse, sludge from a waste water treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities. For Schübeler (1996) municipal solid waste is defined to include refuse from households, non-hazardous solid waste from industrial, commercial and institutional establishments (including hospitals), market waste, yard waste and street sweepings. Beede and Bloom (1995) consider municipal solid waste to include all solid wastes generated in a community except for industrial and agricultural wastes.

Generally solid waste includes discarded durable and nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic debris, including household hazardous wastes and often construction and demolition debris and sludges and ashes generated by sewage treatment plants and MSW incinerators. Sources of MSW include households, commercial enterprises such as food markets and offices, and institutions such as schools, transportation terminals, and hospitals. Summing all up municipal solid waste, also called urban solid waste, is a type of waste that includes predominantly household waste (domestic waste) with, sometimes, the addition of commercial wastes collected by a municipality within a given area. They are in either solid or semisolid (substances with less than 85% humidity according to Penido et al. (2009)) form and generally exclude industrial hazardous wastes.

Classifications of Solid Wastes

There are numerous classifications of solid waste which presuppose many different criteria. The more usual classifications take into account the waste‟s potential risk for environmental contamination or its nature and origin. Penido et al. (2009) employed these two criteria to classify solid waste as follows; taking the potential environmental contamination risks solid waste can be classified into three as: class I hazardous solid waste, class II non- inert solid waste and class III inert solid waste.

Hazardous solid waste (class I) is solid waste that is intrinsically inflammable, corrosive, reactive, toxic or pathogenic and therefore represents a risk to public health in the form of increased mortality or morbidity, or produces adverse environmental impacts when inappropriately handled or disposed of. On the other hand non-inert solid waste (class II) is Combustible, biodegradable or soluble waste that can represent health or environmental risks but does not fall within Class I, hazardous waste, or Class III, inert waste. Inert (class III) solid waste is solid waste with intrinsic characteristics that do not represent a risk to health or the environment and that when sampled in a representative way in accordance with the relevant norms and subjected to static or dynamic contact with distillate or deionized water at room temperature (dissolution tests), does not have any of its dissolved components in concentrations higher than those in drinking water patterns, except in regard to aspect, colour, turbidity and taste.

Origin is also a principal element in categorizing solid waste. By considering the nature of the waste and the origin where it comes, solid wastes can be grouped in to five categories (Penido et al., 2009). These are residential or domestic waste, commercial waste, street waste, special domestic waste :(rubble, batteries, fluorescent tubes, tyres) and special origin waste :(industrial waste, radioactive waste, port, airport, railway station and bus terminal waste, agricultural waste, medical waste).

Residential or domestic waste is waste generated by daily activities in houses, apartments, condominiums and other types of residential building. On the other hand waste generated by commercial establishments, the characteristics of which depend on the particular activities pursued by such establishments is said to be commercial waste. Other members of this classification are street waste and special domestic waste. Waste that is found in the streets produced by nature, such as leaves and waste discarded by people in a disorganized and improper way, such as paper, packaging and food remains is all about street waste whereas special domestic wastes consists of construction rubble, batteries, fluorescent tubes and tyres. It is important to emphasize that construction rubble, also known as civil construction waste, only comes under this category due to the large amounts in which it is generated and the importance that its recovery and recycling is acquiring globally. The final category here is special origin wastes. It is waste that due to its particular characteristics requires special handling, preparation, storage, transport and final disposal. The main types of special origin waste include industrial waste, radioactive waste, agricultural waste, medical waste and port, airport, railway station and bus terminal waste.

Industrial waste is type of waste generated by industrial activity. Its composition varies greatly according to the type of product that is being made. Waste that emits radiation in excess of limits stipulated by environmental law are said to be radioactive waste. Due to its specific nature and dangerous characteristics its handling, storage and final disposal are the responsibility of national public bodies and are subject to very rigorous controls. Another category under special origin wastes is port, airport, railway station and bus terminal waste. This comprises waste generated in terminals as well as in boats, airplanes, trains and buses. These types of wastes result from consumption by passengers and loads which might come up with already eradicated diseases from infected areas. Agricultural and medical wastes are also categorized under special origin wastes. Agricultural wastes mostly comprise the remains of containers and packaging impregnated with dangerous pesticides and chemical fertilizers used in agriculture whereas medical waste consists of all the waste generated by healthcare institutions like hospitals, pharmacies, clinics and the like.

In another attempt, Othman (2002) has classified solid wastes in to six employing various criteria as follows: Physical characteristics (solid, liquid, gas), original use (e.g. packing waste), material (glass, paper, plastics), physical properties (combustible, biodegradable), origin (domestic, commercial, industrial, agricultural), and safety parameters (hazardous, radioactive).

2.1.2. Solid Waste Management

Solid waste management has evolved from primitive origins through the development of open dumps in ancient civilizations of the world to the sophisticated collection and disposal systems that are in use today. Othman (2002) defined solid waste management (SWM) as the control of waste generation, storage, collection, transfer and transport, processing and disposal of solid wastes (SW) consistent with the best practices of public health, economics, financial, engineering, administrative, legal and environmental considerations.

For Ogwueleka (2009) municipal solid waste management (MSWM) refers to the collection, transfer, treatment, recycling, resources recovery and disposal of solid waste in urban areas. The goals of municipal solid waste management are to promote the quality of the urban environment, generate employment and income, and protect environmental health and support the efficiency and productivity of the economy. Generally solid waste management is a cyclical process where objectives are set and the different activities regarding waste ranging from collection to disposal are coordinated to reduce the possible negative impacts solid wastes.

The changing economic trends and rapid urbanization complicated solid waste management (SWM) in developing countries. Consequently, solid waste is increasing in quantity as well as changing in composition to more of paper, packing waste, plastics, glass, metal wastes among other waste, a fact leading to the low collection rates. This makes it one of the critical concerns of developing countries (Bartone and Bernstein, 1993; Alebel and Dawit, n.d.). Since the aim of any waste management system is to reduce the volume and impact of the generated wastes on the society, it is clear that the increased composition and volume of waste poses immense problems for the municipalities of developing nations. This inturn requires integrated efforts of the society and the government.

The solid waste management system comprises four activities: waste generation, collection, transportation, and disposal (Sharholy et al., 2007). Therefore, any solid waste management option must place these four in its concern and try to coordinate activities accordingly. Let‟s briefly look at them individually;

Solid Waste Generation

Waste generation is an activity which encompasses the identification of materials which are no longer being of value, in the contemporary form, and are either thrown away or gathered together for disposal. It is all about the emanation of different forms of solid waste from their origin.

Solid Waste Collection

Solid waste collection, as one element of SWM, includes the gathering of solid wastes and recyclable materials from their temporary destinations. For example solid waste might be collected door to door if households kept them in their sacks at their respective houses.

Transportation of Solid Waste

The subsequent transport of the wastes, usually over long distances, to a processing or disposal site. This is the movement of the collected waste to a tranfer station or to its final destination usually by vehicles.

Solid Waste Disposal

Pek and Jamal (2009) put solid waste disposal as an integral and final part of the solid waste management process on which solid wastes which are by-products of human and animal activities are discarded. Nowadays disposal of wastes by landfilling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities, residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities.

Solid Waste Management Hierarchy

Dealing with solid waste and its effects is done under the guidance of a certain hierarchy commonly known as solid waste management hierarchy throughout the world. There are slight differences in the hierarchies adopted by various nations. In line with this the following hierarchical arrangement can be built. (Gray, 1997; US EPA, 2001; Hajkowicz et al., 2005; Cilinskis and Zaloksnis, 1996) a) Avoidance b) Minimization or reduction of waste c)Reusing d) Recycling e) Energy recovery (Composting) f) Disposal.

A) **Avoidance**

This entails possible avoidance of a product from production activities or from entering one‟s territory if that respective product results in large volume of waste or dangerous content. Though the most desirable technique of dealing with solid wastes, it is not widely applied in many countries.

B) Minimization or Reduction of Waste

Waste prevention; also known as "source reduction," is the practice of designing, manufacturing, purchasing, or using materials (such as products and packaging) in ways that reduce the amount or toxicity of trash created. (US EPA, 2001) Waste minimisation or reduction at source is the most desirable activity next to avoidance, because the community does not incur expenditure for waste handling, recycling and disposal of waste that is never created and delivered to the waste management system. Therefore, the costs associated with handling and environmental impacts of solid waste are at ease relatively.

C) Reusing

Reusing involves launching products acquired from the solid waste for further uses. The classic example here is milk bottle which is used many times in its life (Gray, 1997). Other examples like second hand clothing and furniture can be cited here. In most parts of Africa, materials recovery takes place only in the informal sector. Scavengers play big role here (UNEP, 2005). Since waste is nothing than a useful thing in a wrong place, things from that can be further used.

D) Recycling

Recycling is the act of gathering and refining the by-products of production or consumption activities for use as inputs for production activities.(Beede and Bloom, 1995). It entails sorting, collecting, and processing materials to manufacture and sell them as new products. Since it brings dead products to life, many nations are adopting many new technologies of recycling

E) Energy Recovery or Composting

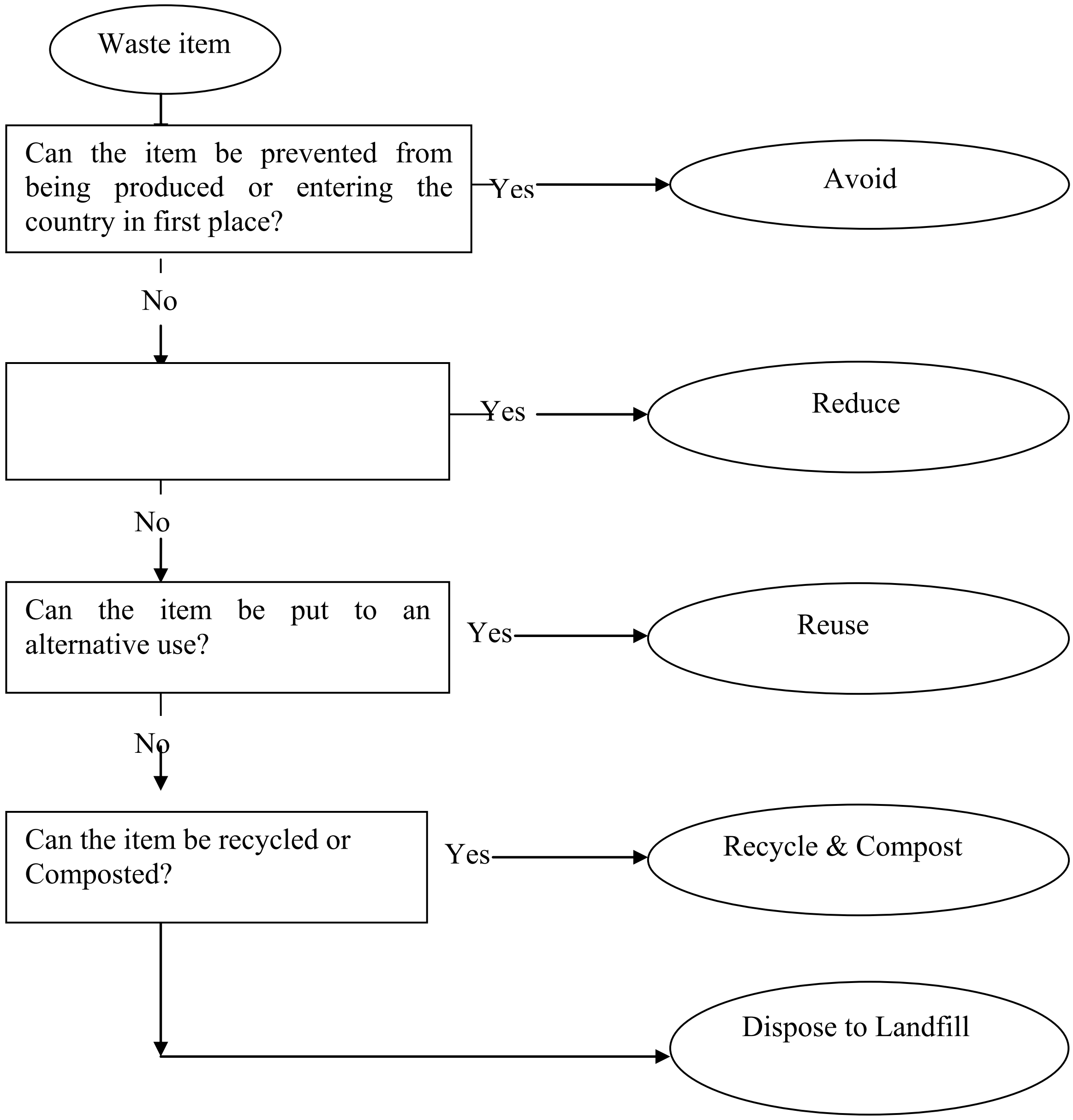
This is a process which involves biological treatment which uses micro-organisms to decompose the biodegradable components of waste. Two types of processes are used, namely: Aerobic processes and anaerobic processes (Beede and Bloom, 1995; Penido et al., 2009). In the aerobic process the utilisable product is compost which serves as a fertilizer (for soil amendment) whereas in the anaerobic process the utilisable product is methane gas which is a source of energy.

F) Disposal

The final stage in the waste management hierarchy is disposal. It is segregation and containment of the residual waste left after processing . Disposal takes the last stage of the solid waste management hierarchy because it is the least desirable option of dealing with waste by any society. The most common way of solid waste dosposal is landfilling which entails disposing waste by burrying it. Landfills require land and must be carefully built. UNEP (2005) states that in many developing countries open dumping, which is totally unsafe method, is still widely applied.

The discussed solid waste management hierarchy can be summarized by the following figure.

Fig. 2.1: solid waste management hierarchy



Source: Adopted from Hajkowicz et al. (2005)

2.1.3. Impacts of Solid Waste

When not managed in the proper way, solid wastes come up with undesirable effects. The general environment is polluted and after all citizens will be vulnerable to different diseases hence public health is endangered (Penido et al., 2009; UNEP, 2005; Gray, 1997; Das et al., 2008; World Bank, 1992). The environmental and public health concerns of unmanaged solid waste can be summarized in table 2.1.

Table 2.1: Types of environmental and health hazards due to unmanaged solid waste

Environmental and health hazards	Examples
Environmental pollution	Air pollution, water contamination, land acidity, noise pollution
Communicable diseases	Diarrhoea, Gastro-intestinal diseases, respiratory infection, skin diseases, jaundice
Non-communicable diseases	Poisoning, hearing defects/loss, dust
Injury	Occupational injury by sharps, needles, glasses, metals, wood etc.
Aesthetics	Bad odour, unpleasant scene of open dumps, dust etc.

Source: Adopted from Das et al (2008) with slight modification

Looking at the above bad effects of unmanaged solid waste, one can simply argue that proper management is crucial. It is obvious that proper managements require great and non-stop efforts together with large sum of money to deal with. Whatever the case, however, concerned bodies should strive towards keeping the health of the general public and the aesthic value of the environment by introducing modern and proper solid waste management options.

2.1.4. Environmental Valuation Methods

Proper solid waste management improves environmental quality and public health. As a result of this people have different preferences on various solid waste management schemes. Valuing these different options of the people is very difficult since there is no direct price on the market. Microeconomic consumer theory is the pillar of mathematical theories of individual preferences (Ramos, 2010).

Various actions of the consumers are expressed in terms of demand functions under this theory. The consumer demand is measured by the amount of environmental quality consumed and it is built as a function of the faced prices, real income of the consumer and the tastes and preferences of the consumer as approximated by various characteristics. The consumer therefore, is in a place to trade off his limited budget with the different consumption possibilities his sole aim being to maximize his utility subject to the budget constraint.

In this respect a certain individual is highly challenged in determining his optimal allocation. The problem enlarges when talking about environmental goods because those goods contain large elements of public goods by their nature and there exists high possibility of free riding. When we attempt to value certain changes in these environmental commodities it is assumed that going for the non market value of the change, one is valuing human preference and not the environment (Aadland and Caplan, 2003; Suh and Harrison, 2005). This tells us that huge care is required when trying to value changes in environmental goods. Since the value of most of these goods cannot be reflected in the market, cautious analysis of human behavior is needed. We need environmental valuation techniques to obtain the values of environmental resources and thereby to approximte a socially optimal decision and to demonstrate the importance of environmental policy.

Environmental valuation methods can generally be divided in to two namely: Revealed Preference Methods and Stated Preference Methods. (Alpízar et al., 2001; Kolstad, 2000)

Revealed Preference Methods: Sometimes known as behavioural methods are indirect valuation techniques where the market value of an environmental good or service is inferred from the buying and selling of a related market good. This can allow an estimate of the unit price of an environmental good. Under revealed preference methods there are many techniques which include Travel Cost Methods (TCM), Hedonic Pricing Method (HPM), Defensive or Averting Behavior, Cost of Illness and others.

Stated (Expressed) Preference Methods: Are direct valuation methods which assume that individuals can be induced to reveal their true preferences for environmental goods through their behaviour in hypothetical markets (Hanley et al., 1998). These techniques rely on surveys of the general population about their willingness to pay for environmental services or their willingness to accept compensation for the loss of those services. The market is typically treated as hypothetical as payments do not occur in reality. As of Adamowicz et al. (1999) Stated Preference Methods include Contingent

Valuation Method (CVM), Choice Experiment (CE), Contingent Ranking and Contingent Rating. For the purpose of this study Choice Experiment (CE), which is one of the stated preference methods, is employed.

Theoretical Foundation of Choice Modelling as a Valuation Method

I) What is Choice Modelling?

Bennett (2005) defined choice modeling (CM) as a „stated preference" technique that can be used to estimate non-market environmental benefits and costs. It involves a sample of people, who are expected to experience the benefits/costs, being asked a series of questions about their preferences for alternative future resource management options. In this study case people are expected to choose various solid waste management options. Each question, called a „choice set", presents to respondents the outcome of usually three or four options.

The alternatives are described in terms of a common set of attributes. Presenting more number of choice sets contribute positively to the level accuracy of a certain research. However, as choice sets increase in number analyses become more complex. In a survey setting respondents choose their preferred alternative from a choice set. There are repeated questions where the respondent is subject to answer more than one question. Monetary attribute is always included as one of the attributes which simplifies the calculation of welfare measures.

The alternatives are differentiated one from the other by the attributes taking on different levels. One of the alternatives – that relating to the „business as usual" (BAU) option which is always called status quo – is held constant and is included in all the choice sets. While presenting the choice sets to respondents, using pictures might help in creating clear images of the hypothetical market created.

Choice Models evolved from Conjoint Analysis in the marketing and transport literature. Recently it has been developed and applied in the environmental economics context. The theoretical basis of CM is random utility theory (RUT). Under RUT, it is assumed that the utility function of a good can be broken down into two parts, one deterministic and one stochastic (Othman, 2002; Das et al., 2008; Timothy et al., 2002).

It is impossible to specify and estimate a discrete choice model that will always succeed in predicting the chosen alternatives by all households. Random utility, therefore, is real solution in this case. The true utilities of the alternatives are considered random variables, so the probability that the alternative is chosen is defined as the probability that it has the greatest utility among the available alternatives. Though an individual is assumed to select the alternative with the highest utility, the analyst of random variables does not know the utilities (Sansa and Kaseka, 2004). A researcher can deduce four important findings from choice experiment study: (a) which attributes significantly influence choice; (b) the implied ranking of these attributes; (c) the marginal WTP for an increase or decrease in any significant attribute and (d) implied WTP for a programme which changes more than one attribute simultaneously (Hanley et al., 1998) which of course must first pass the experimental design stage.

II) Its Uses

CM is versatile in its application. Because the alternatives presented to respondents in the choice sets are hypothetical, the CM analyst can design an application to estimate a wide range of values including use and non-use values of the environment. Studies have also estimated non-market, social values associated with environmental management strategies including the impacts of unemployment.

Where the outcomes of alternative environmental management strategies are sufficiently complex to require their description using more than five attributes, the ability of respondents to cope with the choice sets is likely to be compromised (Bennett, 2005). CVM is the most widely applied environmental valuation method to measure the non-market values of natural resources. Despite its wide application CVM is criticized for its weaknesses which include strategic bias (respondents deliberately misrepresent their preferences in order to influence the decision making process) and yea- saying (respondents agree to pay not because of the strength of their preferences for the environmental impact but because of a desire to make themselves good) problems among others (Bennett and Blamey, 2001). In this regard choice experiment is taken as a substitute approach to make non- market valuation. As compared to CVM choice experiment has the following advantages;

- CE avoids the part-whole bias problem[1] of CVM. Since different levels of the good can be easily built into the experimental design. (Ramos, 2010; Hanley et al., 1998)

[1] This occurs when respondents bid for a more inclusive category of the good being valued, rather than the good it self.

- CE is a natural generalization of a binary choice CVM and it has rich data set. (Alpizar et al., 2001) it is capable of capturing more information from each respondent.
- CE may avoid some of the response difficulties of CV such as yea- saying. (Adamowicz et al., 1999)
- CE do better job than CV in measuring the marginal value of changes in the characteristics of environmental goods because it is easier to disaggregate values for environmental resources into the values of the characteristics that describe the resource.(Hanley et al., 1998)
- CE designs can reduce the extreme multicollinearity problems in models based on variations in actual attribute values across sites which troubles revealed preference analysis.

In a non- market valuation exercise, one can measure the total value of a resource, rank the attributes, determine to which attributes do people place significant values and measure the values of changing more than one of the attributes at once using choice modeling. All the above merits are then making choice modeling preferable to CVM and other techniques (Catalina and Font, 2009) and to be widely applied in recent times throughout the globe.

III) Analytical Steps in CM

In conducting choice modeling study with its complexities, one should follow certain analytical steps. There are minor differences in the steps adopted by various authors. Here is a brief discussion of the commonly adopted ones (Bennett, 2005; Adamowicz et al., 1999; Adamowicz and Boxall, 2001; Ramos, 2010).

1. Define the issue: Before commencing any study in choice modeling, the issue to be studied must be identified. The statement of the problem needs to be clarified and known well.

2. Define the Attributes: The attributes which serve as an input to the choice sets must be decided. Recognizing the attributes simplifies the design stage.

3. Define the Levels: Only knowing how many attributes you employ is not enough the levels that they will take must also be defined.

4. Conduct an Experimental Design: The CE data generation process relies on experimental design. An experimental design is a combination of attributes and their levels used to construct the alternatives included in the choice sets. The generation of the experimental design represents a main and complex component of stated choice studies (Ramos, 2010). Experimental design is key and complex aspect of studies which apply choice modeling.

5. Questionnaire Development: Once the experimental design is undertaken, the next task is to develop questionnaire. The questionnaire to be developed must pay special attention to the conceptualization of the choice process and the existence of status quo option (Ramos, 2010). The other thing to be focused in this sense is the pre-testing of the questionnaire. (Adamowicz and Boxall, 2001)

6. Survey Implementation and Sampling: The next analytical step is deciding on the optimal sample size of the study conducting the actual surveying. As of Alpízar et al. (2001) choice modeling is advantageous in the sense that the amount of information extracted from a given sample size is much larger than, for example, using referendum based methods and, hence, the efficiency of the estimates is improved.

7. Data Analysis: The collected data should be properly processed to deduct useful policy implications. The most commonly used approach of estimation is Multinomial Logit

(MNL) model, the estimation method being maximum likely hood method (Adamowicz and Boxall, 2001).

8. Report compilation and Policy Analysis: finally the results of the collected and processed data should be reported. Since the aim of researches is to suggest possible solutions to the problem at hand, at last elements of policy relevance must be drawn accordingly.

2.2. Empirical Literature Review

Ku et al. (2009) attempted to apply choice experiments with regard to the residential waste disposal system in Korea by considering various attributes that are related to residential waste disposal systems. The attributes selected were cleanness (shows food waste collection facility), collection of small items and frequency which actually indicates number of times in a week recycling vehicles pick up along with the respected prices for the rendered options. Using data from a survey conducted on 492 households, the empirical analysis yields estimates of the willingness to pay for a clean food-waste collection facility, the collection of small items (such as obsolete mobile phones and add-ons for personal computers), and a more convenient large waste disposal system.

The results reveal that residents have preferences for the cleanliness of facilities and the collection of small items. In Korea, residents are required to purchase and attach stickers for the disposal of large items; they want to be able to obtain stickers at not only village offices but also supermarkets. On the other hand, the frequency of waste collection is not a significant factor in the choice of the improved waste management program which is comparable to Jin et al. (2006). Although socioeconomic factors such as age, income and education were included in the multinomial logit model analysis, none of them are significant.

Choice experiment method was employed by Das et al (2008) to estimate residents‟ willingness to pay (WTP) for improvements in the solid waste management (SWM) services provided in Chandernagore and South Dum Dum municipalities of Greater Kolkata in West Bengal, India. The study applied three attributes along with an expected increment in the municipality taxes for the planned improved solid waste management options. The attributes are frequency of vat collection (number of times in a day waste is collected from vats), covered vats (whether or not vats are covered), and covered collection trucks (whether the trucks that collect the waste are covered or not).

A total of 101 randomly selected residents took part in a choice experiment survey. Data are analysed with conditional logit, random parameter logit and random parameter logit with interactions models. The results reveal that on average residents of these municipalities have significant WTP amounts, in terms of higher monthly municipality taxes, to increase the frequency of waste collection, and to ensure that the waste is collected by covered trucks. In the analysis of the random parameter logit model with interactions taxes were interacted with various socio-demographic variables. Among the interacted variables education of household head, total expenditure and domestic help in waste management are found to be significant whereas the interacted variable which shows that households are contended with existing solid waste management service is insignificant. In contrary to Ku et al. (2009) and Jin et al. (2006), the findings of Das et al. argue that residents have significant willingness to pay amounts for frequency of waste collection.

Employing both Choice Modeling and Contingent Valuation techniques to elicit consumers‟ willingness to pay for different service options and to estimate the implicit price for each service attribute (collection frequency, mode of transportation, the provision of facilities and containers to facilitate separation of waste at source) in Malaysia, Othman (2002) found that households highly value improvements in SW management plan. However, results on curbside recycling attribute was rather inconclusive. The CM reveals that households derive positive utility from the provisions of recycling facilities and compulsory curbside recycling. The CV, on the other hand, indicates that respondents were not willing to pay any additional waste charges for non-voluntarily compliance of curbside recycling, despite the provision of free recycling facilities by service providers.

Othman had included various socioeconomic and attitudinal variables in his study. However, among these only age of the respondents, their gender, total income of households, dummy which represents whether the respondent is concerned about the general solid waste management activities, the number of working people in household, dummy which represents awareness of the respondent about waste minimization, number of large bags of waste generated from the household per week, dummy variable that represent if the respondent has ever heard the importance of recycling from media and dummy which stands for whether the household practices waste separation or not are found to significantly affect the possible management options of households.

In a certain study in Macao, China Jin et al. (2006) applied choice experiment method to understand the public‟s preferences for solid waste management programmes. The attributes included in the study are the need for waste segregation and recycling at source, the waste collection frequency, whether the government takes measures to reduce noise in the waste collection and transportation process and accompanied by the cost to be incurred by the respondents for the different management options presented. A random sample survey of 260 respondents was used in the study. The survey data was analysed using conditional multinomial logit models. According to the study residents of Macao prefer: (1) waste segregation and recycling at source (this is analogous to Othman (2002)); (2) noise reduction during waste collection and transportation and (3) lower garbage fees. The socioeconomic variables included in the study, which are composed of total household income, education level of respondents, number of household members earning income, dummy variable denoting the concern about solid waste management, age of respondents, dummy variable denoting whether a household supports waste segregation or not, dummy variable denoting participation in environmental conservation activities and number of children (below 15 years old) living in the household, are all significant and with the expected signs.

Pek and Jamal (2009) employed choice experiment methodology in a study conducted in Malaysia. The results show that all the services attributes are tested significant. Using the implicit prices and equilibrium values, river water quality is found to be the most important attribute followed by psychological fear, air pollution, and land use, the least important. Among the socioeconomic and attitudinal variables included in the study only distance ratio of proposed site to existing site of solid waste disposal facility from respondents" residence, age of respondents, gender of respondents, dummy variable which represent whether respondents care where the SW they generate would be disposed, dummy variable that represents whether respondents are members of any environmental related organizations, household income, dummy variable which stands for whether respondents are engaged as professionals and management related personnel and dummy variable which represent whether respondents would support peaceful street demonstrations to stop construction of harmful solid waste disposal facility or not significantly affect respondents choice.

Coming to the Ethiopian context handful environmental studies have been undertaken to value various environmental goods. Most of these studies employ contingent valuation method. Solid waste management studies are not different. Most studies that attempted to elicit households" willingness to pay for improved solid waste management make use of the CVM technique. Alebel and Dawit (n.d.) employed CVM to elicit households" willingness to pay for the possibility of integrating solid waste management services in Addis Ababa. They used bidding game question format followed by follow up questions and conducted a face to face interview with 494 households. The acquired data was analyzed using censored quantile regression and found that the average willingness to pay of the included households is 9.46 Birr. Among the included socio-economic and demographic factors income, status of respondents, interest in environmental issues, occupation, servant, area and types of service provider are significant determinants of WTP of households.

Employing CVM Tesfahun (2007) has conducted a study to elicit households" willingness to pay for improved solid waste management options in Yeka Sub-City, Addis Ababa. In this study a single bounded questionnaire format with a follow up questions was used. He interviewed 230 households and analyzed the collected data using Probit and Tobit models. The monthly willingness to pay of households for solid waste management improvement was found to be 9.49. Family size, household income, quantity of solid waste, number of children and experience and knowledge of households in solid waste management significantly affect willingness to pay of households for improved solid waste management services among the included socio-demographic and socioeconomic variables.

Another study that surveyed households‟ willingness to pay for improved solid waste management was conducted in Adama by Tolina (2006). He employed CVM and made interview with 250 households and applied an open ended question to do this. The empirical analysis was made using Probit and Tobit models. The results from the Probit analysis show that age, sex and waste receptacle have all significant negative effect on the willingness to pay of the respondents whereas household income, status of the respondent and quantity of solid waste generated affect willingness to pay positively and significantly. Coming to the Tobit model the positive and significant effect on willingness to pay came from household income, level of education, marital status, quantity of waste generated, time spent in the area and house ownership.

Many CVM studies to elicit households‟ willingness to pay for improved solid waste management were undertaken in Mekelle city. These include Hagos (2003) and Dagnew (2009) among others. Hagos (2003) made use of open ended iterative bidding game questions format to collect the needed data. 164 households were selected by systematic random sampling and conducted a face to face interview. The acquired data was analyzed by Ordinary Least Squares (OLS) method. Total household income, age, household‟s awareness about SWM problems and family size significantly affect willingness to pay of respondents. Dagnew (2009) on the other hand employed single bounded dichotomous choice elicitation format to make face to face interview with the random sample of 226 respondents. The Probit model shows income, age and awareness of environmental quality significantly affect households‟ WTP among the included socioeconomic and demographic variables.

Choice modelling was attempted to value households‟ preferences for improved solid waste management options in Yeka Sub-City, Addis Ababa by Solomon (2007). The attributes included in the study are separation of waste at source, collection frequency and monetary charge. Multinomial model was estimated twice. First for the basic and then the basic model together with socioeconomic and demographic variables which include age, sex, income, education level, family size and number of working household members. All attributes are significant in the basic model. However, in the extended model even if the attributes are significant, only age and income significantly affect the choice of the randomly selected 242 respondents. Yonas (2010) has also employed choice modelling to value households‟ preferences for improved solid waste management options in Adama town. He gathered data from 200 households and estimated the multinomial model. However due to the IIA assumption, random parameter logit model was estimated. The study concluded that dwellers of Adama are willing to pay for improved solid waste collection and disposal services.

Seleshi (2007) had tried to estimate WTP of common building residents for improved solid waste management services by employing CVM. Using single bounded dichotomous choice elicitation format questions followed by open ended follow up questions, he gathered data from 130 randomly selected households. Income, residence of condominium and current solid waste management service are significant in the Tobit model. The Probit model on the other hand shows the significant variables are income, life expectancy, type of solid waste service, current solid waste management service and location.

From the above reviewed related literatures one can understand three important points: the first essential point is the importance of rigorous research in the area of solid waste management. The amount of solid waste which grows in quantity and composition parallel to economic growth and urbanization poses serious problems to a certain society. The problems include endangering public health and altering the aesthetic value of the living environment. To maintain the public health and our environment introduction of proper solid waste management options is crucial. These management options, however, are to be identified by detailed studies on the area. The other important point from the literatures is that CM as a research methodology is recently preferred technique than CVM and has merits upon other methods. The final point is concerning researches on solid waste management in Ethiopia. Most studies employed CVM and are concentrated in few areas, mostly Addis Ababa. Unlike these previous Ethiopian studies in this respect, this study attempted to search for different angle. The method which allows for greater flexibility and which has many uses over CVM as discussed above i.e. CM is employed and the study was undertaken outside the traditional concentration areas. Therefore the study combines the three main points that we have discussed concerning the reviewed literatures.

Policy Experiences on What Should be Done

Damage to the environment owing to poor solid waste management can be avoided by implementing environmentally insightful solid waste management techniques involving the solid waste hierarchies that we have discussed above. The easiest way to deal with solid waste at hand is open dumping which is totally unsafe for overall environment in general and the health of the society in particular. The next option to this is landfilling which of course is better than open dumping but still not safe as such. Therefore it is beyond doubt that sound environmental policies regarding this are crucial.

In line with this one can learn more from the European Union Waste Framework Directive in general and particular principles from UK and Italy which centres on principles such as developing national programmes for waste management research and practice, raising public awareness, ensuring that waste is properly packaged, labelled, and handled during the phases of collection, transport, temporary storage, treatment, and definitive disposal and ensuring suitable infrastructures for efficient treatment of the various types of solid waste among others (Read et al., 1998; Mastellone et al., 2009).

Policies regarding solid wastes are also indicated in the environmental policy of Ethiopia under „human settlement, urban environment and environmental health". The policies under discussion include:

- To ensure that improved environmental sanitation be placed highest on the federal and regional agendas for achieving sustainable urban development;
- To recognise the importance of and help bring about behavioural change through education and public awareness of environmental sanitation problems in trying to achieve demand driven community led programs of improved urban environment as well as the sustainable use and maintenance of sanitation facilities;
- To bring about at sound partnership between government and communities in the development of an integrated sanitation delivery system and to foster the supplementary role of NGOs;

- To give priority to waste collection services and to its safe disposal;
- To undertake studies which identify suitable sanitary landfill sites in the major cities and towns of Ethiopia; and
- To the extent possible to recycle liquid and solid wastes from homesteads and establishments for the production of energy, fertilizer and for other uses (EPA, 1997).

In addition to these, regional regulations pertinent to solid waste were formulated by Tigray National Regional State under hygiene and environmental sanitation proclamation number 4/1997. Among other things, the regulation prohibits the disposal of solid wastes along roads, rivers, gullies, and other unauthorized sites. The same regulation indicates that solid wastes within a distance of 10 meters in any direction of residential houses or other activities are considered as disposed from the nearby residential houses and other activities within the stated range of distance. While attempting to create clean environment, the municipality of Aksum town must take into consideration and implement these policy directives.

CHAPTER THREE

Methodology

3.1. Data Source and Survey Methodology

The study was conducted in Aksum town. The town of Aksum, in the northern highlands of Ethiopia is today an administrative centre of the central zone of Tigray regional state and of great importance to the Ethiopian Orthodox Church. The town is one of the major tourist attraction sites in the country. Aksum was the administrative capital of the legendary Aksumite kingdom and is found at 14^0 N $38^0 30$" E 1024kms north of Addis Ababa. The town gets 763mm annual rainfall on average and falls at temperate type of weather condition (AIDP, 2001). According to the figures from the 2007 national population census report the population of the town is estimated to be 44,629.

The population and there by the solid waste generation of the dwellers of the town has been increasing. A certain individual dweller was estimated to generate 0.15kgs of solid waste per day in 2001 and for 2008 it was projected that residential households can generate 5466.9kgs of solid waste per day (AIDP, 2001).

The researcher has used some useful information about how waste is collected in the town, controlling mechanisms of open dumping and others from the municipality of the town. Field observation was also good source of information in this study. However, the main source of information was face to face interview with the selected households. Enumerators were carefully selected depending on their experience and educational background. The researcher has offered detailed training regarding the methodology and general guidelines of data collection in choice modeling to the selected enumerators.

3.2. Sampling Technique

Aksum town is divided into four “Tabias” and these “Tabias” are in turn are divided into “Ketenas”. Because of this administrative division the researcher used Multistage Area Sampling (MAS) technique. MAS is a cluster sampling technique, hence a probability sampling technique, with several stages. Accordingly, First all the “Tabias” were taken for the sake of reperesentativeness and then respected “Ketenas” were randomly selected from the selected “Tabias” (actually two “Ketenas” from each “Tabia”). Finally 150 households were selected from the “Ketenas” using systematic radom sampling technique. The sampling frame is the total number of households in the town.

3.3. Questionnaire Design

In order for the whole work in choice modeling to be successful, careful and detailed design and preparation of questionnaire is indispensable. By its nature choice modeling offers different options and let the respondents to choose their favoured one. The alternatives that were presented in the choice sets are integral parts of the questionnaire which demand a cautious identification and experimental design during the course of the questionnaire prepartion.

The questionaires designed generally include questions that elicit households‟ perception of the current solid waste management status of their environment, their socio-economic and demographic characterstics and their choice of different solid waste management alternatives (which were reflected by the choice sets). In the first part questions regarding the general perception of the current status of their environment and specifically in connection with solid waste management were presented to the respondents. Here the intention is to know the perception of respondents with regard to the current solid waste management situation of their vicinity. The second and the main part of the questionnaire has to do with the presentation of the choice sets. A series of five choice sets with several solid waste management options were part of the questionnaire. Similar service attributes taking on different levels make up the choice sets in such a way that the attributes varied independent of one another. The choice sets were constructed using the optex procedure in SAS statistical software and fractional factorial design was employed to reduce the number of alternatives to a managable size.

Table 3.1 presents an example of a certain choice set presented to the respondents during the actual survey.

Table 3.1 A reperesentative Actual Choice Set

Attributes	Status Quo	Alternative 1	Alternative 2
Frequency of waste collection	Once Irregular	Three times irregular	Once regular
Waste disposal mechanism	Open Dump	Incinerator	Sanitary landfill
Waste transportation mode	Carts and Open truck	Open trucks only	Covered trucks only
Charge	2	10	15
	☐	☐	☐

Five choice sets were presented to each respondent together with other questions in the questionnaire. Each choice set has three options. The first option, the „status quo", which is similar across all the choice sets, advocates no changes in the current solid waste management situation. The status quo allows the current solid waste management situation to continue as it is. The two additional options (alternative 1 and alternative 2) vary across choice sets according to the experimental design and were presented to the respondents with proposed improved solid waste management options. The respondents were first asked to keep in mind their level of income and their total spending behavior before attempting to choose among the presented options. The final part of the questionnaire has to do with different socio-economic and demographic characteristics of the respondent such as age, sex, marital status, employment, income and others. The questionnaires were translated into Tigrigna language to facilitate the data collection process.

3.4. Defining Attributes and their levels

The need for improved solid waste management and thereby enhanced quality of environment is beyond doubt. This study focuses on the improvement of solid waste management options. Since the methodology used is choice modelling, the overall improvement in solid waste management was attempted to be represented by some attributes with their respective levels. Preliminary attributes and their levels were developed in consultation with members of a union who works on solid waste management in Aksum town and municipality officials of the town who specialize on solid waste management.

Five attributes with their respective levels including monthly charge were proposed at first. These were: frequency of waste collection per week (once, twice, three times and four times), waste disposal mechanisms (open dump, sanitary landfill and incinerator), mode of transportation used to transport the collected waste (carts and open truck, open trucks only and covered trucks), separation of waste at source (No and Yes) and monthly charges to be paid by households for the services rendered in birr (2, 5, 10 and 15). Focus Group Discussion was organised to discuss on the proposed attributes and their levels. After exhaustive discussions with the participants of the Focus Group Discussion, separation of waste at source was omitted and the levels for frequency of waste collection per week were revised. Table 3.2 presents the final attributes and their levels used in the study.

Table 3.2 Attributes and Levels Used in the Study

Attribute	**Description**	**Levels taken**
FREQ	Frequency of waste collection per week	Once irregular*, once regular, twice regular, three times irregular
DISPO	Waste disposal mechanisms	Open Dump*, Sanitary landfill, incinerator
TRANS	Mode of transportation used to transport the collected waste	Carts and open truck*, open trucks only, covered trucks
COST	Monthly charges to be paid by HHs for the services rendered	2*, 5,10, 15

* indicates the status quo or the existing situation that currently prevails in the study area.

The first attribute is frequency of waste collection and it is all about how many times in a week waste is collected. It takes four levels; currently waste is collected once irregular (the collection day is not fixed and known) and it is proposed that waste be collected once regular, twice regular and three times irregular. The second attribute is waste disposal mechanism and it is about how solid waste is finally disposed. This attribute takes three levels; at present waste is disposed in open dumps and the proposed levels are sanitary landfill and incinerator[2]. The next attribute is mode of transportation used to transport waste. It takes three levels; carts and open truck (current situation), open trucks only and covered trucks. The final attribute is cost. It represents the monthly charges to be paid by households for the service rendered. This attribute has four levels; 2(current situation), 5, 10 and 15.

3.5. Econometric Model Specification

The theoretical foundation of choice modelling rests upon random utility theory. The central idea behind this theory is that consumers derive satisfaction not from goods themselves but from the attributes they provide. Let us illustrate this by considering solid waste management options of an individual. Suppose utility of an individual depends on the choices he/she made from a given choice set C, which includes all possible solid waste management options. The utility function takes the form (Adamowicz et al., 1999):

$$\mathbf{U_{im} = V_{im} + \varepsilon_{im}.}$$

This utility function is composed of an objective component (V_{im}) and an error component (ε_{im}). Selection of one solid waste management option over another implies that the utility

[2] Sanitary landfill is an engineered area where waste is placed to the land whereas incinerator is a place to burn waste (US EPA, 2001)

(U_{im}) of that option is greater than the utility of another, say U_{jm}. Since overall utility is random one can only analyse the probability of choice of one package over another, or

$$\mathbf{Pr\ \{i\ chosen\} = Pr\ \{V_{im} + \varepsilon_{im} > V_{jm} + \varepsilon_{jm},\ all\ j \in C,\ i \neq j\}}$$

Where C is the choice set. Specific choices of error distributions lead to methods for the estimation of the parameters of this utility function and to quantitative representations of trade-offs between attributes. Assuming that the error terms are identically and independently distributed, the probability that an individual m chooses alternative i over j is given by (Timothy et al., 2002; Adamowicz et al., 1999);

$$\mathbf{Pr_{im} = e^{V_{im}\lambda} / \sum e^{V_{jm}\lambda}}$$

This represents the multinomial logit model. It gives the probability that individual m chooses alternative i over alternative j as a function of individual characteristics and unknown parameters. λ is a scale parameter which always is normalized to 1 (Othman, 2002).Coming to the empirical model the most basic form of the utility function takes an additive structure, which includes the attributes from the choice sets only (Louviere et al., 2000):

$$V_{im} = ASC_i + \Sigma \beta_{iK} X_{iK}$$

whereV_{im} is the utility function from choosing different management options, ASC_i stands for an alternative specific constant which captures any systematic variations in choice observations that are not explained by the attribute variations, β is a coefficient and X represents a vector of attributes from the sets.

The effect of attributes in the choice sets are captured by the X variables while ASC represents the effect of systematic but unobserved factors that explains the respondents‟ choices. Technically ASC reflects the differences in the error terms.

It is possible to include socio-economic and environmental attitudinal variables into the utility functions by estimating the variables interactively, either with the ASC or with any of the attributes from a choice set. (Pek and Jamal, 2009; Morrison et al., 1999). An added advantage of CM is its flexibility to incorporate simultaneously the importance of economic, social and environmental factors in a valuation exercise. In this case the model can be represented as;

$$\mathbf{V_{im}} = ASC_i + \sum \gamma_{im}(\mathbf{ASC_i * S_m}) + \sum \beta_{iK} \mathbf{X_{iK}}$$

where **Sm** indicates the socio-economic or environmental attitudinal variables for the mth individual and γ_{im} is a vector of coefficients associated to the individuals‟ socio-economic characterstics interacted with the **ASC**. Inclusion of socioeconomic and demographic variables is important part of a certain model as it may help to overcome problems associated with violations of important assumptions in MNL models such as Independence of Irrelevant Alternatives (IIA). The IIA states that for any individual, the ratio of probabilities of choosing two alternatives is independent of the presence of attributes of any other alternative.

IIA allows additions or removals of an alternative from the choice set without affecting the structure or parameters of the model. In case the IIA assumption is violated results of MNL are biased and, therefore Random Parameter Logit (RPL) which has the following advantages over MNL, should be employed: First RPL is not subject to IIA assumption.

Second, it accomodates correlations among panel observations. Third, RPL explicitly incorporates and accounts for heterogeneity in tastes across respondents by allowing the model parameters to vary randomly over individuals (Adamowicz and Boxall, 2001). McFadden and Train (1998) have shown that any random utility can be approximated by some RPL specification.

The following functional form represents the random parameter logit model:

$U_{im} = V_{im} + \varepsilon_{im} = X_i (\boldsymbol{\beta} + \eta_m) + \varepsilon_{im}$

Where U_{im} stands for the total utility of the respondent from choosing different alternatives in a choice set. This total utility is assumed to include both systematic component (V_{im}) and stochastic component (ε_{im}). The indirect utility function is a function of the attribute vector and socioeconomic variables if included. Contrary to the MNL model, the stochastic component of the utility function can now be correlated among alternatives and across choices by the common influence of η_m. The model estimates a mean and a standard deviation for each distribution. Most applications of this model utilize the normal distribution assumption for the model parameters (Bennett and Blamey, 2001). The probability that a certain individual picks alternative i from each choice set can be presented as:

$P_{im} = e^{Xim(\beta + \eta m)} / \sum e^{Xjm(\beta + \eta m)}$

Incase of RPL, the following is the general form of the indirect utility function:

$V_{im} = ASC + \sum\beta_K X_K + \sum\gamma_n S_n$

Where ASC is alternative specific constant as usual, X_K are the included attributes and S_n are the included socioeconomic factors K and n being the number of attributes and number of socioeconomic variables respectively.

3.6. Method of Data Analysis

3.6.1. Implicit Prices

The coefficients of included attributes in MNL model can be used to measure the rate at which respondents are willing to trade off one attribute for another. When the attribute sacrificed is a monetary attribute, the trade off estimated is called „implicit price‟ or „part-worth‟. It demonstrate the amount of money that respondents are willing to pay in order to receive more of the non-marketed environmental attribute:

Implicit Price = $-(\beta_{\text{non-marketed attribute}}/\beta_{\text{monetary attribute}})$

β is the coefficient of the attributes after estimation of the MNL model. Estimates of part-worths are made on a „ceteris paribus‟ basis, that is , they are estimates of the willingness to pay of respondents for an increase in the attribute of concern, given that every thing else is held constant. The principles applying to the determination of part-worths can also be applied to derive the willingness to trade off between any pairs of attributes. Hence maginal rate of substitution across all the attributes can be estimated.

The implicit prices are important in that they demonstrate the trade off between individual attributes. They allow an analysis of the composition of potential alternative allocations of resources. A comparison of the implicit prices of attributes gives some understanding of the relative importance that respondents hold for them. On the basis of such comparisons, policy makers are better placed to design resource use alternatives so as to favour those attributes which have higher implicit prices. Comparision of implicit prices across attributes should be undertaken in full recognition of the differing units used to define the attributes (Bennett and Blamey, 2001).

3.6.2. Welfare Measures in Choice Modeling

Assesment of economic welfare involves an investigation of the difference between the utility achieved under the status quo alternative and some other alternative. It is therefore a matter of considering the marginal value of a change away from the status quo.

First, the values of the attributes that are associated with status quo are substituted into the equation that estimates the indirect utility associated with that option. If socioeconomic and demographic variables are included in that equation, the values to be substituted are the sample means. (or individual specific welfare measures can be computed). Note that the monetary attribute is assigned a value of zero for this stage. Next, the values of the attributes that are associated with the alternative allocation of resources are substituted into the equation that relates to the relevant change alternative. The value of the relevant ASC should be included in this calculation. Socioeconomic and demographic variables are treated as in the status quo option and again the monetary attribute is set to zero. The value associated with the change alternative is then subtracted from the value associated with the status quo option. If the model is linear (in the monetary attribute) this „indirect utility difference" is then divided by the negative of the coefficient associated with the monetary attribute:

Economic Surplus = $-(1/\boldsymbol{\beta})(V_0-V_1)$

Where V_0 stands for the status quo and V_1 indicates the improved situation. A negative value for this surplus estimate would mean respondents are willing to pay the amount of the surplus in order to experience an improvement in their well-being caused by a re-allocation of resources from the status quo to the change alternative. Having access to this potential to estimate any combination of attribute levels (within the ranges intially established in the choice set design process) provides the decision maker with the flexibility to consider numerous options without the need to commission separate valuation exercises (Bennett and Blamey, 2001).

3.7. Specific Equations for the Models

A basic model which includes only the attributes in the study and an extended model which includes socioeconomic variables were estimated using the survey data from Aksum town. The basic model tries to reveal the importance of the included service attributes in explaining respondents perception for different solid waste management options in the town and is specified as follows:

$$\mathbf{V_i = ASC_i + \beta_1{*}FREQ + \beta_2{*}DISPO + \beta_3{*}TRANS + \beta_4{*}COST}$$

Where ($i = 1,2,3$; $ASC_i = 0$ for $i = 1$)

Definition of Variables

Dependent Variable

$\mathbf{V_i}$ = Utility of option i (1 = choice option, 0 = non choice-option)

Explanatory Variables

ASC: This stands for Alternative Specific Constant and takes values 1 for options 2 and 3 in the choice sets and 0 for the status quo option.

Frequency of Waste Collection (FREQ): This attribute takes the values 0,1,2 and 3 for the four levels once irregular, once regular, twice regular and three times irregular and refers to the number of times solid waste is collected per week. If frequency of waste collection is increased, environmental quality also increases thereby increasing the overall utility of respondents. Due to this the expected sign of this attribute is positive.

Waste Disposal Mechanisms (DISPO): is an attribute that stands for the existing and proposed solid waste disposal mechanisms. It takes the values 0,1 and 2 for open dumping, sanitary landfill and incinerator respectievely. Introducing improved waste disposal mechanisms enhances the quality of environment and hence expected to have positive sign.

Waste Transportation Mechanism (TRANS): This attribute refers to the mechanisms of of transportation that are used to trasport solid waste in the town and takes the values 0,1 and 2 for carts and open truck, open trucks and covered trucks respectievely. Improvement in the waste transportatrion mechanisms affects the utility of the respondents positievly hence the expected sign for this attribute is positive.

Monthly Charges to be Paid by Households (COST): households are expected to pay monthly charge for the service rendered. It takes the values 2,5,10 and 15 and is expected to have negative sign since increase in cost affects utility negatievly.

The second model includes socioeconomic and demographic variables. Since these characterstics do not vary across alternatives, they must be introduced as an interactions with either the attributes or the alternative specific constant (Bennett and Blamey, 2001). Age, sex, marital status, education, family size, availability of children under 10 years, house ownership, length of living in the area where they are now, employment and level of monthly income of the household are included as interaction with the alternative specific constant. The specification is as follows:

$$V_i = ASC_i + \beta_1*FREQ + \beta_2*DISPO + \beta_3*TRANS + \beta_4*COST + \gamma_1*ASC_i*AGE + \gamma_2*ASC_i*SEX + \gamma_3*ASC_i*MARSTAT + \gamma_4*ASC_i*EDU + \gamma_5*ASC_i*FAMSIZ + \gamma_6*ASC_i*UND10 + \gamma_7*ASC_i*HOWOW + \gamma_8*ASC_i*LENLIV + \gamma_9*ASC_i*EMPL + \gamma_{10}*ASC_i*INC$$

Definition of Variables

As for the attributes the definitions and the expectations are the same with the basic model. Here are definitions and expected results for the rest of the variables in the model:

Age of the Respondent in years (AGE): older people are expected to be less willing to pay for improved environmental quality therefore negative sign is expected for this variable.

Gender of the Respondent (SEX): is a dummy variable that takes one for females and zero for males. Since females are more concerned for improved solid waste managemnt, positive sign is expected for this variable.

Marital Status (MARSTAT): married people are bound to have children and large family than singles and hence are expected to be more concerned for improved solid waste managent. Positive sign is expected for the coefficient of this variable.

Education Level of Respondents in Years (EDU): Respondents with higher level of education will have good knowledge about environmental quality in general and about solid waste management in particular therefore positive sign is expected for this variable.

Respondent's Family Size (FAMSIZ): Households with large family members choose improved solid waste management than households with small family members.

Availability of Children Under 10 Years (UND10): is a dummy variable that takes one if there are children under ten years and zero otherwise. Households with children under ten years are expected to choose cleaner environment than others.

House Ownership (HOWOW): is a dummy variable that takes one if the respondent lives in his/her own house and zero otherwise. Respondents that own a house are expected to care more for their homes than those who live in house rent.

Length of Living (LENLIV): Respondents who lived longer in a certain vicinity are expected to have more inclination for improved solid waste management.

Employment (EMPL): Is dummy variable taking 1 for employed and 0 otherwise. Employed people are expected to earn income and to be willing for improvement in solid waste management.

Household's Monthly Income in Thousands of Birr (INC): As income increases the capacity to pay for improved solid waste management also increases therefore positive sign is expected for the coefficient of income.

Having all these necessary inputs, the models can be estimated using maximum likelihood method in the econometric software package LIMDEP NLOGIT 4.0. After getting the coefficients from the estimated models, one can calculate marginal willingness to pay (MWTP) and compensating surplus (CS) of respondents. MWTP is the marginal value of a change with in a single attribute and it can be calculated as follows:

$$\mathbf{MWTP = -(1/\beta_{ma})(\beta_{nma})}$$

Where MWTP is marginal willingness to pay, β_{nma} is the coefficient of the non-monetary attribute and β_{ma} is the coefficient of the monetary attribute also called the marginal utility of income. This calculation gives us the marginal rate of substitution between the attribute of interest and the monetary attribute. The other possible welfare measure of respondents is the compensating surplus. We can measure CS for different solid waste management scenarios relative to the status quo. CS can be obtained by the following formula:

$$\mathbf{CS = -(1/\beta_{ma})(V_0 - V_1)}$$

Where β_{ma} is the coefficient of the monetary attribute and V_0 and V_1 represent the level of indirect utility before and after the change under cosideration.

CHAPTER FOUR

ANALYSES AND DISCUSSION

4.1. DESCRIPTIVE STATISTICS

Out of the total 150 questionnaires used at the survey in Aksum town, five were found to be unusable. The rest 145 complete questionnaires are analysed and discussed here. Since the experimental design produces five choice sets, these 145 usable questionnaires give us 725 completed choice sets.

Looking for the socioeconomic composition of the respondents: 52.4% of the respondents were females while the rest are males; coming to marital status 76.6% of the respondents are married, 17.9% are singles and the rest are in the others group (like widows and widowers); in terms of their employment structure civil servants and self-employed people comprises 29.3% and 65.4% of the surveyed households respectively. Workers of non-governmental organizations consists 3.3% and the rest lie in the others group which includes segments of the society like pensioners. Out of the total surveyed households 64.1% live in their own houses and the rest lives in rented houses. A larger percentage of the households (i.e. 57.2%) have members with the age of under ten years. Table 4.1 presents descriptive statistics of some selected variables.

Table 4.1 Descriptive statistics of some selected variables.

Variable	Mean	Std.Dev.	Minimum	Maximum
AGE	37.409	14.314	18	84
EDUCATION	6.584	4.994	0	19
FAMILY SIZE	4.295	1.982	1	9
LENGTH OF LIVING	11.829	8.528	0.5	40
INCOME	954.409	1243.33	100	12,000

One can see from Table 4.1 that the mean age of the respondents (AGE) is 37.4 years with the minimum of 18 years and the maximum being 84 years. As for the education level of the respondents (EDU), the maximum education level achieved by the respondents is 19 years of formal education and the minimum is zero years of education with the average being 6.6 years of education. On average households included in the survey have 4.3 family members (FAMSIZ). The largest family in the survey consists of 9 members and the smallest family has one member only. Coming to the length of living at the respective environment (LENLIV), it ranges from six months to forty years the average being 11.8 years. The last variable included in Table 4.1 is average level of household income (INCOME) per month. This variable has a maximum value of 12,000 birr and a minimum value of 100 birr. The mean income level is 954.4 birr per household per month.

Households included in the survey were also asked if they are concerned about solid waste management issues in their vicinity and 95.6% of the households said they are concerned. For the question to rate the current solid waste management in their area, 36.2% rated it as average and 15.9% rated it poor which actually calls for immense work of improvement.

Solid waste is collected door to door and there is one union with thirty members in this regard engaged in this though far from covering the whole town. The municipality of the town monitors every movement of the union and offers help when needed. Households in some segments of the town dispose solid waste on mobile waste collectors (carts and truck) by themselves. Others are completely uncovered by like services and simply dispose waste on open space.

Plastic bags, by their nature, stay for so long in the environment and cannot simply decay. Therefore, special focus is needed for their treatment. Households were asked on how they dispose plastic bags; only 8.2% of the respondents separate and burn plastic bags. The rest did not practice separate treatment for plastic bags and they dispose it together with other solid wastes. The solid waste disposal behavior of very few households, especially households on the edge of intermittent rivers through the town, is found to be affected by the location of the households. This is because rather than waiting for the collectors, some households carelessly dispose wastes on the rivers which of course poses negative externality for the nearby dwellers.

Although it is not that much practical, there is a rule called "20 meter radius" to protect dumping in open areas. The rule holds every household responsible for wastes disposed up to 20 meters in every direction of its house. The municipality works in cooperation with the respective „Tabias" in this regard but with much unsatisfactory results yet.

4.2. ECONOMETRIC RESULTS

The econometric findings are estimated using two multinomial logit models: The basic model (the model which includes the attributes only) and the model which included the socioeconomic and demographic variables (hereafter called the extended model) together with one random parameter logit model. Table 4.2 presents the empirical findings of the basic model. The basic model is a multinomial model estimated by maximum likelihood estimation method.

Table 4.2 Results of the Basic MNL Model

Discrete choice (multinomial logit) model

Variable	Coefficient	Standard Error	P[|Z|>z]
COST	-0.0741***	0.0164	0.0000
Frequency of Waste Collection	0.3500**	0.1478	0.0179
Waste Disposal Mechanism	0.1228*	0.0709	0.0835
Waste Transportation Mode	0.2000**	0.0835	0.0165
ASC	1.0765***	0.2808	0.0001

Summary Statistics

Number of observations	725
Log likelihood function	-753.5105
R-sqrd	.11649

*** Significant at 1%
** Significant at 5%
* Significant at 10%

All the coefficients of the attributes in Table 4.2 are significant and with the priori expected signs. A positive sign and significance for the coefficients of the three attributes frequency of waste collection (FREQ), waste disposal mechanism (DISPO) and mode of transportation used to transport waste (TRANS) indicates respondents are willing to pay for improvement of these attributes since improvement in these attributes increase their utility. The coefficient for monthly charges to be paid by households for the service rendered (COST) is negative and significant indicating the decrease in utility for respondents as the monthly charges increases. This indicates that people become less willing to pay for changes as the charges keep increasing.

The second multinomial logit model (the extended model) is a multinomial logit model estimated by including various socioeconomic and demographic variables together with the attributes in the basic model. Age of the respondent (AGE), gender of the respondent (SEX), marital status of the respondent (MARSTAT), level of education of the respondent (EDU), family size (FAMSIZ), availability of children under 10 years in the household (UND10), house ownership (HOWOW), length of living in the area (LENLIV), employment status (EMPL) and average income level of the household (INCOME) are the included socioeconomic variables. These variables are interacted with the alternative specific constant (ASC) to account for heterogeneity of preferences. Here are the results of the extended model.

Table 4.3 Results of the Extended MNL Model

Discrete choice (multinomial logit) model

Variable	Coefficient	Standard Error	P [|Z|>z]
COST	-0.0775***	0.0169	0.0000
Frequency of Waste Collection	0.3574**	0.1503	0.0174
Waste Disposal Mechanism	0.1320*	0.0737	0.0733
Waste Transportation Mode	0.1970**	0.0849	0.0203
ASC	-2.6375***	0.6852	0.0001
ASC*AGE	-0.0199*	0.0116	0.0856
ASC*SEX	0.1195	0.2555	0.6400
ASC*Marital Status	0.7083**	0.2726	0.0094
ASC*Education	0.1470***	0.0286	0.0000
ASC*Family Size	0.0934	0.0682	0.1708
ASC*Children Under10	0.5052*	0.2652	0.0568
ASC*House Ownership	1.0755***	0.2888	0.0002
ASC*Length of Living	0.0334**	0.0169	0.0483
ASC*Employment	0.4717**	0.2225	0.0340
ASC*Income	0.0006	0.992509D-04	0.1212

Summary Statistics	
Number of observations	725
Log likelihood function	-688.8980
R-sqrd	.12083

*** Significant at 1%
** Significant at 5%
* Significant at 10%

The inclusion of the socioeconomic variables in the basic model has improved the overall fit of the model in Table 4.3 as can be seen by the decreased log likelihood function and the increased R-squared. The coefficients of the ten included socioeconomic variables are with the priori expected signs but three of them are insignificant. The coefficient of age of the respondent (AGE) is negative and significant signifying elder people are reluctant to changes from the environment they are accustomed with and hence are likely to be less willing to pay for improvements in solid waste management services.

Married people are more willing to pay for improvements in solid waste management services than singles as can be seen from the positive sign and significance of the coefficient of marital status (MARSTAT). The coefficient of the variable level of education of the respondent (EDU) is positive and significant at 1% and tells us that people with more years of education favour the improvements in solid waste management services. Since educated people have rich awareness as compared to people with less years of education, this result is intuitive.

As compared to households with out little children, households with children under 10 years opt for improvement in solid waste management services as reflected by the positive and significant coefficient of the variable availability of children under 10 years old (UND10). House ownership (HOWOW) has positive and significant (at 1%) coefficient implying that households who live on their own houses favour improvements in solid waste management services than those households who live in rented houses. The coefficients for length of living in the area (LENLIV) and employment status (EMPL) of the respondent are also positive and significant which indicates that households who lived longer in that area and employed households opt for the improved plans.

Multinomial logit models impose IIA assumption strongly i.e. the IIA assumption must hold so as the multinomial logit model to be valid. IIA is an assumption which states that each alternative must be independent of each other (Hensher et al., 2005). The most common approach to look at whether the IIA assumption holds or not is the standard Hausman test. However, for our case the test cannot be completed since the difference matrix is not positive definite. Results of Multinomial Logit models are biased if the IIA assumption doesn‟t hold. Since the Hausman test cannot be completed, using Random Parameter Logit Model does better. This is because Random Parameter Model is independent of the IIA assumption and has many other advantages over Multinomial Logit Model as discussed in subsection 3.4. To account for this the Random Parameter Logit Model is estimated as follows.

Table 4.4 Results of the Random Parameter Logit Model

Random Parameters Logit Model

Variable	Coefficient	Standard Error	P [|Z|>z]
COST	-0.0742***	0.0165	0.0000
Frequency of Waste Collection	0.3499**	0.1479	0.0180
Waste Disposal Mechanism	0.1227*	0.0710	0.0837
Waste Transportation Mode	0.2000**	0.0835	0.0165
ASC	1.0758***	0.2812	0.0001

Summary Statistics

Number of observations	725
Log likelihood function	-733.5058
R-sqrd	.1526650

*** Significant at 1%
** Significant at 5%
* Significant at 10%

The log likelihood function and the pseudo R- Squared values in Table 4.4 show how the Random Parameter Logit Model improved the overall fit of the model. As in the Basic Multinomial Model, all the coefficients of the attributes are significant and with the priori expected signs. Improvements in frequency of waste collection per week, waste disposal mechanisms and mode of transportation used to transport waste affect the utility of respondents positively. The coefficient of monthly charges for the service rendered

(COST) has significant and negative sign. This indicates increase in monthly charges has inverse relationship with the utility those households acquire from improvement of different attributes.

4.3 Calculating Implicit Prices

Implicit price or part worth is the amounts of money respondents are willing to pay in order to receive more of a non-marketed environmental attribute. Implicit prices are marginal rate of substitution between the monetary attribute and the non-monetary attribute under consideration. It can be calculated by dividing the negative of the coefficient of the non-monetary attribute by the coefficient of the monetary attribute. Table 4.5 presents the implicit prices of the included attributes.

Table 4.5 Implicit Prices of the Attributes

Attributes	MWTP in Birr		
	Basic MNL	Extended MNL	RPL
Frequency of Waste Collection	4.72	4.61	4.715
Waste Disposal Mechanism	1.657	1.70	1.653
Waste Transportation Mode	2.699	2.541	2.695

The results of the three estimated models are comparable. These values measure individual‟s willingness to pay for the introduction of improved non market attribute, other things remain constant. Taking the RPL for example respondents are willing to pay 4.7 birr per month for an additional improvement in frequency of solid waste collection, ceteris paribus.

4.4 Calculating Equilibrium Values of the Non-monetary Attributes

Following Othman (2002) equilibrium values for the non-monetary attributes can be estimated. These equilibrium values are trade offs between the non-monetary attributes that will leave the respondents in the same utility level. Calculation of these values involves the identification of the reference implicit price and the implicit price of interest. We follow the formula below for the calculations.

Equilibrium values = $WTP_{REFERRED\ ATTRIBUTE} / WTP_{SEARCHED\ ATTRIBUTE}$

The values in Table 4.6 are calculated based on DISPO.

Table 4.6 Equilibrium Values of the Non-Monetary Attributes.

Attributes	Equilibrium Values			
	Basic MNL	Extended MNL	RPL	Ranking
Frequency of Waste Collection	2.71	2.85	2.848	1
Waste Disposal Mechanism	1.000	1.000	1.000	3
Waste Transportation Mode	1.495	1.63	1.629	2

All non-monetary attributes are not divisible therefore these values indicate relative importance of the attributes to households. In terms of importance to households frequency of waste collection takes the lead followed by mode of transportation used to transport waste and waste disposal mechanisms ranked last.

4.5 Estimating Compensating Surplus of Alternative Programs

Choice modelling approach allows for the estimation of compensating surplus from the coefficients of the attributes. The compensating surplus is estimated as a result of changes from the status quo (current solid waste management) to various proposed improved scenarios. The compensating surplus in this essence measures the change in income that would leave a certain individual indifferent between the current solid waste management and the proposed improved solid waste management system assuming that the individual has a right to the status quo level of utility. The following nine scenarios together with the status quo are considered.

Status Quo (Current Situation): Frequency of waste collection is once per week and irregular, waste disposal mechanism is open dump and waste transportation mechanism is carts and open truck.

Scenario One: Frequency of waste collection is once per week and irregular, waste disposal mechanism is open dump and mode of transport is open trucks.

Scenario Two: Frequency of waste collection is once per week and regular, waste disposal mechanism is open dump and mode of transport is open trucks.

Scenario Three: Frequency of waste collection is once a week but regular, waste disposal mechanism is sanitary landfill and mode of transport is open trucks.

Scenario Four: Frequency of waste collection is twice per week and regular, waste disposal mechanism is sanitary landfill and mode of transport is open trucks.

Scenario Five: Frequency of waste collection is twice per week and regular, waste disposal mechanism is open dump and mode pf transport is open trucks.

Scenario Six: Frequency of waste collection is once per week and irregular, waste disposal mechanism is sanitary landfill and mode of transport is covered trucks.

Scenario Seven: Frequency of waste collection is three times a week and irregular, waste disposal mechanism is incinerator and mode of transport is open trucks.

Scenario Eight: Frequency of waste collection is twice regular, waste disposal mechanism is incinerator and mode of transport is carts and open truck.

Scenario Nine: Frequency of waste collection is three times per week but irregular, waste disposal mechanism is incinerator and mode of transport is covered trucks.

Since the compensating surplus measures the change in income that would leave a certain individual indifferent between the current solid waste management and the proposed improved solid waste management system, the utilities attached to the status quo and the improved plan should be measured. Utility attached with the current solid waste management is calculated by substituting the model coefficients together with the current ones and the coefficient of the alternative specific constant for alternatives 2 and 3 is included.

Compensating surplus estimates for the nine scenarios are presented in the Table 4.7. The coefficients of the attributes from the random parameter logit model are used in the calculations since the random parameter logit model represents better fit.

Table 4.7 Compensating Surplus of Various Scenarios

Scenarios	**Compensating Surplus Or WTP per month (Birr)**
Status Quo	0
Scenario One	17.194
Scenario Two	21.909
Scenario Three	23.563
Scenario Four	28.279
Scenario Five	26.625
Scenario Six	21.543
Scenario Seven	31.341
Scenario Eight	27.237
Scenario Nine	37.344

What consumers are willing to pay for a change from the status quo to various scenarios per month is presented in Table 4.7. For instance for a change from the status quo (Frequency of waste collection is once per week and irregular, waste disposal mechanism is open dump and waste transportation mechanism is carts and open truck) to scenario four (Frequency of waste collection is twice per week and regular, waste disposal mechanism is sanitary landfill and mode of transport is open trucks) consumers are willing to pay 28.3 birr per month.

Scenario nine presents the combinations of the maximum included levels of the attributes, where frequency of waste collection is three times per week but irregular, waste disposal mechanism is incinerator and mode of transportation is covered trucks, has the highest compensating surplus value of 37.3 birr. One can see the strength of choice modelling here. Hypothetical scenarios are created and then their value can be inferred from the findings of the model where policy makers can come up with important deductions to match peoples" willingness and ability.

Generally households in Aksum town favour improvements in frequency of waste collection, waste disposal mechanisms and mode of transport used to transport waste. Das et al. (2008) found that households are willing to pay for the provision of covered trucks for waste collection. Households in this study are also willing to pay for improvements in mode of transportations used to transport waste which includes covered trucks. In this study households are willing to pay more for additional frequency of waste collection than other attributes which is comparable to Yonas (2010) who found similar results. Looking at the relative ranking of the attributes in terms of their equilibrium values, Othman (2002) found that separation of waste is more important to households. However, the equilibrium values of this study show that frequency of waste collection is relatively more important than other included attributes.

CHAPTER FIVE

CONCLUSION AND POLICY IMPLICATIONS

5.1 Conclusion

The main aim of the study was to estimate the non-market welfare gain from different improved solid waste management options for households in Aksum town using choice modeling. Survey data from 150 randomly selected households was employed for the analysis. Believing that proper solid waste management makes huge contribution to clean and healthy environment, its improvement was represented by various service attributes and presented to households to account for their options. The included attributes were frequency of waste collection per week, waste disposal mechanisms and mode of transport used to transport waste along with monthly charges by households for the service rendered.

Two multinomial logit models were estimated at first: the basic model and the extended model. Coefficients of all included attributes were significant and with the expected sign in the basic model. As for the extended model the case of the attributes is the same to that of the basic model but out of the included ten socioeconomic and demographic variables gender of the respondent, family size and household monthly income was insignificant though with the priory expected signs.

To verify the validity of the multinomial logit models, standard Hausman test was attempted. It cannot be verified whether IIA assumption holds or not because the standard Hausman test cannot be completed. Random Parameter Logit Model whose results are not biased whether the so called IIA assumption holds or not is then estimated. The model has better fit as can be seen by the improvement of the R-squared and the log likelihood function. Coefficients of the three attributes (frequency of waste collection, waste disposal mechanism and mode of transport) are positive and significant implying that the improvement in these attributes increases utility of households. However, the coefficient of household‟s monthly charge is negative and significant. As monthly charges keep on increasing, utility of respondents decreases.

Implicit prices or marginal willingness to pay of the attributes for the three models are also calculated. For the random parameter logit model households are willing to pay 4.7 birr, 1.7 birr and 2.7 birr per month for additional improvements in frequency of waste collection, waste disposal mechanism and mode of transport respectively. The equilibrium values of the attributes were also estimated and the attributes were ranked in terms of their relative importance to households. Frequency of waste collection per week was relatively more important than the other attributes to the households.

The final analysis deals with the estimation of compensating surplus or values of different programs. Hypothetical programs are setup and their values estimated based on the model coefficients. Accordingly nine different scenarios were created and considered along with the status quo. Scenario nine presents the combinations of the maximum included levels of the attributes, where frequency of waste collection is three times per week but irregular, waste disposal mechanism is incinerator and mode of transportation is covered trucks. A change from the status quo to scenario nine has the highest compensating surplus value of 37.3 birr per month. In general improvements in the service attributes enhances utility of respondents.

5.2 Policy Implications

Having the above results, we recommend the following;

- Since households are the main sources of solid waste as well as primary victims of the negative effects of unmanaged waste, their perception should be included in the making and implementation of policies regarding solid waste management. In other words, demand side information should be exploited in this respect.
- The calculated implicit prices and values of the hypothetical scenarios are useful tools to match demand and supply of solid waste management services. Different combinations of the attributes and their levels can be used to understand willingness to pay of households and then reconcile it with the service to be rendered.
- Other results that policy makers should be keen are the equilibrium values of the attributes. These equilibrium values indicate trade offs between the non-monetary attributes and thereby relative importance of the attributes to the society. Therefore, they can be used to set priorities.

- Only 8.2% of the households were found to separate and burn plastic bags. Therefore, concerned bodies should work in creating awareness regarding this. If not treated properly, plastic bags stay long in the environment by their nature.

REFERENCES

Aadland, D. and Caplan, A.J. (2003) Willingness to Pay for Curb side Recycling with Detection and Mitigation of Hypothetical Bias. American Journal of Agricultural and Resource Economics 85(2), pp 492-502.

Adamowicz, V. and Boxall, P. (2001) Future Directions of Stated Choice Models for Environmental Valuation, Paper for Choice Experiments, London, England.

Adamowicz, W. L., Boxall, P. C., Louvier, J. J. and Swait, J. (1999) Stated-Preference Methods for Valuing Environmental Amenities, Oxford University Press Inc., New York, USA

Alebel Bayrau & Dawit Walelegne (n.d.) Integrated Solid Waste Management in Addis Ababa, Paper presented on „Local Economic Development and Globalization" conference organized by Addis Ababa University and Institute of Social Study (ISS) at Ghion Hotel, Addis Ababa (Ethiopia).

Alpizar, F., Carlsson, F., and Martinsson, P., (2001), "Using choice experiments for non-market valuation", Working Papers in Economics No. 52, Department of Economics, Göteborg University.

Aksum Integrated Development Plan (AIDP) (2001)

Bartone, C. L. & Bernstein, J. D. (1993) "Improving Municipal Solid Waste Management in Third World Countries", Resources, Conservation and Recycling; 8; 43-45.

Beede, D. N. and Bloom, D. E. (1995) The Economics of Municipal solid waste, The World Bank, Research Observer 10(2): 113 -151.

Bennett, J. (2005) Choice modelling: A step-by-step guide, Economics Techniques Series: Fact sheet No.1

Bennett, J. and Blamey, R. (2001) The Choice Modelling Approach to Environmental Valuation, Edward Elgar Publishing Inc., Cheltenham, UK.

Buenrostro, O. and Bocco, G. (2003): Solid waste management in municipalities in Mexico: goals and perspectives Resources, Conservation and Recycling 39(3), pp 251-263.

Catalina, M. T. and Font, A. R. (2009) Defining environmental attributes as external costs in choice experiments: A discussion

Cilinskis, E. and Zaloksnis, J. (1996) Solid-Waste Management in the City of Riga, Latvia: Ambio, Vol. 25, No. 2, Allen Press on behalf of Royal Swedish Academy of Sciences

Cointreau, S. J. (1987) Environmental Management of Urban Solid Wastes in Developing Countries, Urban Development Technical Paper, no.5., The World Bank, Washington, D.C.

CSA (2007) Ethiopian National Census Report

Dagnew Hagos (2009) Households‟ Willingness To Pay for Improved Solis Waste Management; The Case of Mekelle City, Master‟s Thesis, Addis Ababa University, Department of Economics, Addis Ababa.

Das, S., Birol, E. and Bhattacharya, R .N. (2008) Informing Efficient and Effective Solid Waste Management to Improve Local Environmental Quality and Public Health: Application of the Choice Experiment Method in West Bengal, India, Department of Land Economy, University of Cambridge, UK

Environmental Protection Agency of Ethiopia (EPA) (1997) Human Settlement, Urban Environment and Environmental Health

Eugenia, C. B., Georgina, N. and Ramil, C. (2002) "Solid Waste Segregation and Recycling in Metro Manila: Household Attitudes and Behavior", The Economy and Environment Program for Southeast Asia (EEPSEA) publications, Philippines.

Gray, J. M. (1997) Environment, Policy and Municipal Waste Management in the UK, Transactions of the Institute of British Geographers, New Series, Vol. 22, No. 1, pp. 69-90

Hagos Baraki (2003) Contingent Valuation Survey on Households‟ Willingness To Pay for Improved Solid Waste Collection and Disposal; The Case of Mekelle Town, The Working Paper Series of Faculty of Business and Economics, Civil Service College, Addis Ababa

Hajkowicz, A., Tellames, K., Aitaro, J. (2005) The Costs of Solid Waste Pollution in Palau, A Consultancy Report to the Office of Environmental Response and Coordination of the Republic of Palau, CSIRO Sustainable Ecosystems, Brisbane, Australia.

Hanley, N., Wright, R. and Adamowicz, W. (1998) Using Choice Experiments to Value the: Environment. Environmental and Resource Economics 11(3-4): 413-428.

Hensher, D. A., Rose, J. M. and Greene, W. H. (2005) Applied Choice Analysis: Cambridge University Press, Cambridge, UK.

Jin, J., Wang, Z. and Ran, S. (2006) Estimating the Public Preference for Solid Waste Management Using Choice Experiment in Macao, International Solid Waste Association, SAGE Publications.

Kolstad , C. D. (2000) Environmental Economics, New York, Oxford University Press.

Longe, E. O., Longe, O. O. and Ukpebor, E. F.(2009) People‟s Perception on Household Solid Waste Management in Ojo Local Government Area in Nigeria, Iran. Environ. Health. Sci. Eng., Vol. 6, No. 3, pp. 209-216

Louviere, J. J., Hensher, D. A. and Swait, J. D. (2000) Stated Choice Models: Analysis and Application. Cambridge University Press, Massachusetts, USA.

Mastellone, M. L., Brunner, P. H. and Arena, U. (2009) Scenarios of Waste Management for a Waste Emergency Area: A Substance Flow Analysis, Journal of Industrial Ecology, Vol. 13, No. 5

McFadden, D. and Train, K. (1997) Mixed MNL Models for Discrete Responses; Working paper, Department of Economics, University of California, Berkeley: In Bennett, J. and Blamey,

R. (2001) The Choice Modelling Approach to Environmental Valuation, Edward Elgar Publishing Inc., Cheltenham, UK.

Mehra, R., Ngoc Du, T. T., Nghia, N. X., Lam, N. N., Chuyen, T. K., Tuan, B. A., Tran, P. G. and Nhan, N. T. (1996) Women in Waste Collection and Recycling in Hochiminh City, Population and Environment, Vol. 18, No. 2, Women and Sustainable Development, pp. 187-199

Morrison, M., Bennett, J. and Blamey, R. (1999) Valuing Improved Wetland Quality Using Choice Modelling. Water Resource Research, 35(9), 2805-2814.

Ogwueleka, T. C. (2009) Municipal Solid Waste Characteristics and Management in Nigeria, Iran. J. Environ. Health. Sci. Eng., Vol. 6, No. 3, pp. 173-180

Othman, J. (2002), "Household preference for solid waste management", the economy and environment program for South East Asia (EEPSEA) publication, Malaysia

Pek, C. K. and Jamal, B. O. (2009) Solid Waste Disposal: A Choice Experiment Experience in Malaysia, Singapore Economic Review Conference (SERC).

Penido, J. H., Mansur, G. L. and Segala, K. (2009) Manual on Municipal Solid Waste Integrated Management in Latin American and Caribbean Cities: International Development and Research Centre, Canada

Ramos, D. H. (2010) Using Discrete Choice Experiments for Environmental

Valuation: Environmental Economics Unit, Institute for Public Economics, University of the Basque Country, Bilbao, Spain

Read, A. D., Phillips, P. and Robinson, G. (1998) Landfill as a Future Waste Management Option in England: The View of Landfill Operators. The Geographical Journal, Vol. 164, No. 1, pp. 55-66

Sansa, A. and Kaseka, N. (2004) Welfare Gains Due To Improved Solid Waste Management: A Case Study of Bogoloobi Flats, Kampala, Uganda.

Schubeler, P. (1996) Conceptual Framework for Municipal Solid Waste Management in Low-income Countries, Working Paper No. 9, SKAT, Switzerland

Se-Ju Ku, Seung-Hoon Yoo and Seung-Jun Kwak (2009) Willingness to Pay for Improving the Residential Waste Disposal System in Korea: A Choice Experiment Study, Environmental Management 44:278–287

Seleshi Fantu (2007) Household Heads‟ Willingness to Pay for Improved Solid Waste Management: The case of Common Building Residence in Addis Ababa, Masters Thesis, Addis Ababa University, Departement of Economics, Addis Ababa.

Sharholy, M., Ahmad, K., Vaishya, R.C., and Gupta, R.D. (2007): Municipal Solid Waste Characteristics and Management in Allahabad, India, Waste Management 27 (4), pp 490–496.

Solomon Tarfassa (2007) Households Willingness to Pay for Solid Waste Options: The Case of Yeka Sub-city, Addis Ababa, Masters Thesis, Addis Ababa University, Department of Economics, Addis Ababa.

Suh, J. and Harrison, S. (2005) A Test for the Presence of a Purely Altruistic Motive in Non-Market Valuation: Discussion Paper No. 338, School of Economics, The University of Queensland.

Tesfahun Bekele (2007) Valuing Households‟ Willingness to Pay for the Provision of Improved Solid Waste Management Program: The Case of Yeka Sub-city Centre of Addis Ababa, Masters Thesis, Addis Ababa University, Department of Economics, Addis Ababa.

Timothy, C. H. and McConnell, K. E. (2002) Valuing Environmental and Natural Resources: The econometrics of non-market valuation, New horizons in Environmental Economics, USA

Tolina Tiruneh (2006) Households‟ Willingness to Pay for Improved Solid waste Management: The Case of Adama, Masters Thesis, Addis Ababa University, Department of Economics, Addis Ababa.

UNEP (2005) Solid Waste Management (Volume II: Regional Overviews and Information Sources): UNEP International Environmental Technology Centre (IETC), Osaka, Japan.

United States Environmental Protection Agency (US EPA) (2001) Solid Wastes: http://www.epa.gov/waste (accessed on Dec. 24, 2010)

World Bank (1992) World Development Report: Development and Environment, New York.

Yonas Berihun (2010) Analysis of Households‟ Preferences for Improved Solid Waste Management in Adama Town: Application of Choice Modelling, Master‟s Thesis, Addis Ababa University, Department of Economics, Addis Ababa.

APPENDIX

Appendix one: Questionnaire Used in the survey

A CHOICE EXPERIMENT QUESTIONNAIRE FOR VALUING IMPROVED SOLID WASTE MANAGEMENT SERVICE IN AXUM TOWN

Date of interview______________________________________

Interviewer's code______________________________________

Starting time__________________ End time_________________

Hello! How are you? Thank you for giving me your precious time. Mr. Metkel Aregay is undertaking a research entitled "Households' Preferences for Improved Solid Waste Management Options in Axum Town: An Application of Choice Modelling" as a partial fulfilment for the reward of MSc degree in Economics and this interview is part of his research. You are randomly selected from the dwellers of the city and the information from this interview will be used to help policy makers to make informed decisions. This interview is completely confidential; your name will never be associated with your answers. Most of the questions have to do with your attitudes and opinions and there are no right or wrong answers. The questionnaire has three sections. Try to give answers to the best of your knowledge.

Section One: Questions about households' perception about the existing solid waste management system

1. Are you concerned about solid waste management issues in your vicinity?
   a) Yes b) No
2. How do you rate the current solid waste management system in your area?
   a) Very good c) Average
   b) Good d) Poor
3. How does your household dispose solid waste?
   a) Dispose on mobile waste collector (truck or cart)
   b) Dispose on container around
   c) Dispose on open space around
   d) Collected door to door

   3.1. If your answer to question (3) above is (d) who provides you the service?

   ____

4. Who takes care of solid waste in your household?
____

5. How does your household dispose plastic bags?____
____
____

6. Does the location of your household affect your solid waste disposal behaviour?
a) Yes b) No if yes how?____
____
____

7. What happens to solid waste that is disposed in open spaces (like streets,…) around your vicinity?____

____

____

____

8. What are the environmental impacts of inappropriately disposed solid waste in your surrounding?

____

____

____

____

Section Two: Statement of the Issue

This study tries to identify the desirable future solid waste management system in Axum town based on the values that households attach for different service attributes which take various levels. The research mainly attempts to estimate households‟ willingness to pay for the improved solid waste management options. In order to come up with better management options implemented, some fund must come from households. The payment vehicle is such that service receivers pay a monthly charge to the service provider. The information obtained is confidential and may be used to design future waste management policy. You are invited to participate in this survey by providing answers to the best of your knowledge.

2.1. Introducing the Choice Sets

We are assessing households‟ preferences for various improved solid waste management options. These options are defined in terms of the service attributes of frequency of collection per week, waste disposal mechanisms and waste transportation mechanisms. Improvement in these service attributes will cost your household. The options provided in this questionnaire are not exhaustive solutions to the problem at hand there are many variants to the solutions outlined in this questionnaire. There are no right or wrong answers

it is only to have your say in what future policy options regarding solid waste management should look like. The given service attributes take on different levels and these levels are independent of each other. Before answering the choice sets, we do request you to keep in mind your available income and other things on which you may need to spend money.
Here it is supposed that there are only three alternatives. The status quo refers to the current solid waste management service and in this case the quality of the environment continues the way it is at present and no more payment is required from you. Alternative 1 and alternative 2 represent two different proposed situations that would involve households paying an extra amount of money to achieve an environmental outcome better than the current solid waste management situations in your area. Therefore you are expected to carefully look at your income and choose among the proposed options accordingly. There are five choice sets to be dealt with.

Choice set 1

Consider carefully each of the following three alternatives. Suppose these options were the only ones available, which one would you choose? (Please tick in the box given below your preferred option).

Attributes	Status Quo	Alternative 1	Alternative 2
Frequency of waste collection	Once Irregular	Three times irregular	Once regular
Waste disposal mechanism	Open Landfill	Incinerator	Sanitary landfill
Waste transportation mode	Carts and Open trucks	Open trucks only	Covered trucks only
Charge	2	10	15
	☐	☐	☐

Choice set 2

Consider carefully each of the following three alternatives. Suppose these options were the only ones available, which one would you choose? (Please tick in the box given below your preferred option).

Attributes	Status Quo	Alternative 1	Alternative 2
Frequency of waste collection	Once Irregular	Once regular	Once regular
Waste disposal mechanism	Open Landfill	Incinerator	Sanitary landfill
Waste transportation mode	Carts and Open trucks	Covered trucks only	Open trucks only
Charge	2	15	10
	☐	☐	☐

Choice set 3

Consider carefully each of the following three alternatives. Suppose these options were the only ones available, which one would you choose? (Please tick in the box given below your preferred option).

Attributes	Status Quo	Alternative 1	Alternative 2
Frequency of waste collection	Once Irregular	Once regular	Once regular
Waste disposal mechanism	Open Landfill	Sanitary landfill	Incinerator
Waste transportation mode	Carts and Open trucks	Covered trucks only	Open trucks only
Charge	2	5	5
	☐	☐	☐

Choice set 4

Consider carefully each of the following three alternatives. Suppose these options were the only ones available, which one would you choose? (Please tick in the box given below your preferred option).

Attributes	Status Quo	Alternative 1	Alternative 2
Frequency of waste collection	Once Irregular	Twice regular	Three times irregular
Waste disposal mechanism	Open Landfill	Sanitary landfill	Incinerator
Waste transportation mode	Carts and Open trucks	Open trucks only	Covered trucks only
Charge	2	15	5
	☐	☐	☐

Choice set 5

Consider carefully each of the following three alternatives. Suppose these options were the only ones available, which one would you choose? (Please tick in the box given below your preferred option).

Attributes	Status Quo	Alternative 1	Alternative 2
Frequency of waste collection	Once Irregular	Twice regular	Three times irregular
Waste disposal mechanism	Open Landfill	Incinerator	Sanitary landfill
Waste transportation mode	Carts and Open trucks	Open trucks only	Covered trucks only
Charge	2	5	10
	☐	☐	☐

Section Three: Socio-economic and Demographic Aspects

1. How old are you? ____________________

2. Gender: a)Male b) Female

3. Marital Status a) Single b) Married c) Other __________________

4. What is the maximum formal education level you have attained in years? __________

5. How many family members dwell in your household? __________________

6. Are there children below 10 years in your household? a) Yes b) No

7. Is the house where you live yours? a) Yes b) No

8. How long have you lived here?_________________

9. Are you employed? a) Yes b) No

10. If your answer to (9) is (a) what is your job? a) Civil Servant b) NGOs Worker

    c) Self-employed d) Other__________________________

11. How much is your households" approximate monthly income in ETB? _________________________