AN ECONOMIC ASSESSMENT OF HOUSEHOLD SOLID WASTE

MANAGEMENT OPTIONS: THE CASE OF KIBERA SLUM, NAIROBI
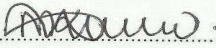
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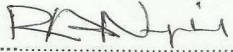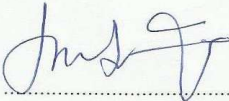
UNIVERSITY OF NAIROBI

JUNE 2013

DECLARATION

DECLARATION

This thesis is my original work and has not been submitted for a degree course in any other academic institution.

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DEDICATION

With love and sincere appreciation I dedicate this thesis to my dear family and friends for their support.

ACKNOWLEDGMENT

ABSTRACT

In Kenya every person has a duty to cooperate with state organs and other persons to protect and conserve the environment and ensure ecologically sustainable development and prudent use of natural resources. The rights and responsibilities to environment are however, apparently neglected with respect to waste management. This study characterized the different types of household solid waste in Kibera slum and assessed the determinants of households' choice of solid waste management options. The study used both primary and secondary data. A sample of 250 households was drawn using a multi-stage random sampling technique. This study sought to answer four research questions; first on the major types of solid waste produced by households,second on the waste management options known to households, third on the possibilities for effective recycling and/or reuse and finally on how household attributes, institutional and agricultural factors influence the choice of solid waste management options by households in the slum. Management options hyphothesized in this study included solid waste reuse, burning, recycling and disposal.Descriptive statistics was used to answer the questions on the types of waste, the management options known to households and the possibility for potential recycling and/or reuse. Multinomial logit regression model was applied in assessing the effect of household, institutional and agricultural attributes on the choice of solid waste management options. Findings were that ownership of slum/sack gardens, livestock keeping, contractual arrangements, income, years of schooling, family size, disposal returns and waste segregation had significant effects on household solid waste management. The implication of these findings is that enforcing contractual arrangements will provide a solution to unauthorised household solid waste disposal.

Organic solid waste manure presents an alternative for fertilizers in soil fertility improvement and hence policy and practice promoting solid waste decomposition should be encouraged to provide a sustainable solution to the current manure shortage farmers are facing in Kenya. The municipal council should promote pro-environment behaviour among households on solid waste recycling, reuse and proper disposal through continuous campaigns and community based programs.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADB: African Development Bank (Banque Africaine De Developpement)

CBO: Community Based Organisation

DC: District Commissioner

EMCA: Environmental Management and Coordination Act

GoK: Government of Kenya

GPRB: Government of the People's Republic of Bangladesh

IIA: Independence of irrelevant alternatives.

MDGs   Millenium Development Goals

MNL: Multinomial logit model

MNP: Multinomial probit model

NEMA: National Environment Management Authority

OECD: Organisation for Economic Co-operation and Development.

RUM: Random Utility Model.

UNEP: United National Environment Programme

UNFCCC: United Nations Framework Convention on Climate Change

SDPRU: Sustainable Development and Poverty Reduction Unit.

CHAPTER 1 INTRODUCTION

1.1 Background

Waste management is a process that involves handling, packaging, treatment, recycling, reusing, storage and disposal of waste in a way that is environmentally sound for human health and environmental protection (Government of Kenya(GoK), 2006). Good solid waste management is a step by step process that involves source reduction, reuse, recycling and safe waste disposal in designated licensed waste receptacles. Household solid waste generation is an unavoidable consequence of economic activities that involve production and consumption of goods and services and has a positive relationship with income and urbanization levels.

In other words solid waste is an externality resulting from unintended actions of producers and consumers to others and is said to bear both positive and negative impacts.Positive externalities accrue from the increased income obtained from waste recycling and reuse practices while negative externalities result from the health hazards that occur from poor waste management. Waste management policies are hence, designed to reduce the negative externalities of poor solid waste management. Furthermore, households with higher incomes and in more urbanized economies generate higher levels of solid waste due to their higher purchasing power leading to higher consumption levels.In developing countries' cities, waste is often dumped in open areas, roadsides and even valleys unlike in cities in developed countries (Niringiye and Douglason 2010; Tadesse *et al.,* 2007).This naturally damages the environment.

Kenya is one of the developing countries in which residents in informally constructed structures, in particular slum areas, have presented challenges to waste collection by the municipalities and

private waste companies. Physical constraints such as inadequate infrastructure including roads, drains, and sanitary facilities have worsened the situation. Nairobi Kenya is a typical case of a developing country city, where rapid population growth has contributed to the challenges of household waste management.Slum areas expand to accommodate rural-urban migration, yet the designated waste receptacles and dumpsites probably do not expand as fast.The household waste phenomenon has attracted a lot of interest, both locally and abroad.The concerns are about the immediate environments controlled by individual households, and the designated dumpsites determined by the municipality authorities.Kibera slum is the largest of its kind in sub-Saharan Africa, with approximately one million people (Lawrence *et., al* 2009; Zhuang *et., al* 2007;Peter, 1996).

Over a decade ago, the Sustainable Development and Poverty Reduction Unit (SDPRU) of the African Development Bank (ADB) commissioned a study on solid waste management options, examining waste management practices in cities in Africa such as Cairo, Nairobi, Accra, and Cape Town.The main aims of the study were to address environmental concerns such as capacity building for environmental management, effective management of the environment portifolio and to endorse appropriate waste management strategies among others. In Nairobi solid waste recovery and recycling was found to be undertaken by poor households who picked waste as an income generating activity.The scavengers were found to jump in garbage trucks to sort and secure recoverable materials before the fresh garbage was offloaded. Households were also found to use organic waste in urban agricultural sector for feeding livestock and cropping purposes . The study found out that urban agriculture existed throughout the city both on private and public land. Bascially urban agriculture is a key survival strategy for the urban poor since it

reduces the amount of money spent on food. Urban agriculture also generates a demand for fertilizer produced at small scale waste compositing facilities (Palczynski 2002).

Waste contains macronutrients such as potassium, nitrogen and phosphorus which are key for both plant and crop growth hence the reason for use of biodegradable solid waste as an input in fertilizer production .The mixture of decomposed household solid waste and ashes from burned urban solid waste has also been used to ameriolate soils to improve soil fertility for agricultural practises (Babayemi *et al.,* 2009).In Kibera slum households who practice urban agriculture have an opportunity to use decomposed solid waste and ash in Kales and maize production, among other agricultural crops. Kales production is mainly done in sack gardens because of the scarcity of land.

The sack garden project was introduced by a French relief NGO in 2009 after the Kenya post-election violence of 2007 that hit Kibera slum the most. It was funded by the French government to increase income from sales of vegetables and also increase food access using the garden in a sack concept. The target groups of the project were low-income populations and those affected by HIV/AIDs. Kibera inhabitants have adequate experience in vegatable growing because majority of the people living there are direct migrants from the rural areas who were farmers before. The only problem that prevented them from practising agriculture was lack of land and cash to buy agricultural inputs. The French government provided money for the seedlings and sacks while households provided soil and manure to plant the vegetables. Sack gardens were recommended because they were found to be cost-effective in terms of space, safety of produce,cost of establishment and their yield given the slum conditions.In the sack garden

preparation, soil is mixed with manure and seedling of vegetables are planted on top and sides of the earth filled sack (Pascal *et al.,* 2009).

Households obtain manure which has decomposed over time from household solid waste dumping areas and/or ash from combustible solid waste after sorting it to remove the unburnt materials. Below are photographs of an open dumpsite along railway line and a sack garden of kales. The sack garden is established on an area previously used as a dumpsite in Soweto village, Kibera slum.

Source: Railway line along Gatweikera Village, 2012   **Source:Sack gardens in Soweto Village Kibera slum, 2012**

1.2 Problem Statement

Kenya's waste management regulations of 2006 define the responsibility of waste generator that no persons should dispose any waste in public highways, streets, roads, recreational areas or in any public place except in designated waste receptacles (GoK, 2006).Despite the regulation, it is not uncommon to find household waste dumped in places that the law prohibits.The phenomenon

is worse in more densely populated areas of urban centres. Kibera slum is one such area, where household solid waste is openely dumped along roads,rivers, railway line and public places.

Owing to poverty, food insecurity and the low income levels, some households in the slum have adopted minimal waste recycling and reuse at an individual or community level as a means to earn a livelihood. For instance, *Taka ni Pato plastic recycling plant and scrap metal business dealer* in Kibera is one of the main community based household solid waste dealers, who promote good solid waste disposal through recycling.The use of household solid waste manure from dumping areas for agricultural purposes especially in kales production in sack/slum gardens is also an option.Furthermore, the City Council of Nairobi provides large bins at strategic places, and has also licenced several private companies to collect and dispose off garbage from households and business units.

Despite the law, and the various opportunities to recycle, reuse or safely dump solid waste at specified places, the practice was different. Household solid waste reuse and recycling were minimal, and solid waste mountains along streets, roads, pathways and in public places in the congested Kibera slum were common due to the overwhelming amounts that remain uncollected by the city council because of infrastructural constraints.It was not clear how households chose their patterns of waste handling, which ranged from prudent management to careless dumping.

This was supported by the fact that household solid waste management in developing countries is characterised by a myriad of technical, financial, institutional, economic and social constraints (Zhuang *et al.,* 2007). Kenya has waste management regulations, and Nairobi has respective institutions that handle waste, yet there is an apparent failure at least at the household level in

waste management especially in the slums.The types of solid waste households produced and the various waste management options they used to handle their waste in the slum were unknown. It was also not known whether the apparent failure of waste management in the slum areas were as a result of institutional and or were due to household socioeconomic factors.

1.3 Purpose, objectives and research questions

The purpose of this study was to evaluate household solid waste management options in Kibera slum,Nairobi city, Kenya.

The specific objectives of the study were;

a) To characterize the different types of household solid waste in Kibera slum.

b) To assess key determinants of households' choices of different solid waste management options in Kibera slum.

The research questions addressed in this study were;

a) What are the major types of recyclable and non-recyclable solid waste produced by the households in Kibera?

b) What waste management options(reuse, recycle, burning, disposal) are actually used by the residents of Kibera?

c) What are the possibilities for effective recycling and /or reuse?

d) What are the factors that influence the households' choices of solid waste management options in Kibera? (The factors which included education level, household size, awarenesss of waste management regulations of 2006, distance to the

main road, years of stay, home ownership, view on placement of municipal garbage receptacles, access to municipal receptacles, livestock keeping, household's income, ownership of sack/slum garden , returns to disposal, contractual arrangements, waste segregation and community based waste recycling practise were investigated).

1.4 Justification of the study

According to Article 69 of the Kenyan constitution every person has a duty to cooperate with the state organs and other persons to protect and conserve the environment and ensure ecologically sustainable development and use of natural resources for a clean and healthy environment. This means that the people of Kenya cannot leave the management of the environment and natural resources to government agencies only, it is rather the duty of every citizen to participate actively in carrying out such tasks (GoK, 2010).

In this light, the basic reason for assessment of solid waste management options in this study was necessitated by the need to incorporate the possibility of an optimal solid waste management policy reduction effort at the household level.Also by assessing the determinants of household solid waste management options, this study was expected to provide useful information for different stakeholders.For decision making it was believed that the information from this study would be useful in deciding whether for sure reuse, recycle, burning and disposal are sustainable solutions to the persisting problem of the growing garbage in cities in developing countries such as Kenya and whether or not proper solid waste in the slum improves the welfare of households.If it were indeed beneficial then policies in support of reuse, recycle, and disposal of

household solid waste would be formulated. In addition, this study also sought to contribute to literature on household solid waste management in Kenya.

1.5 Organization of the thesis

Chapter 1 of this thesis is a general overview of waste management in Kenya. This section also states the problem under investigation, objectives of the study and research questions. The rest of the thesis is organized as follows: Chapter 2, is a review of relevant literature generally on solid waste management in Kenya, models used and empirical studies on solid waste management. Chapter 3 is a description of the methodology used, emphasizing on the sampling procedure and data collection methods, theoretical, and conceptual framework used.Chapter 4 presents the results of the study and discussions, while a summary, conclusions and policy recommendations are presented in Chapter 5.

CHAPTER 2 LITERATURE REVIEW

2.1 Theoretical considerations of waste generation and management

2.1.1 Meaning of Household Solid Waste

Solid waste is the non-liquid and non-gaseous products of consumption and production activities of humanbeings.It takes the form of refuse, garbage and sludge (Babayemi *et al.,* 2009). The scope of this study was limited to solid waste which constists of organic solid waste, plastics, metal, wood, glass/ceramics among others generated in the household .

2.1.2 Solid Waste Mangement Options

Reuse involves the recovery of items by using them again.It helps save energy and water, reduces pollution and lessens society's consumption of natural resources when compared with single-use products and materials. Households reuse plastic bags, containers, newspaper and glass bottles among others.Reuse not only saves money but also is a source of revenue for those who implement it (Government of the People's Republic of Bangladesh (GPRB), 2010)

Recycling simply constists of finding new ways of using previously discarded materials. Soli waste recycling is therefore recognized as a tenable solution for cleaning up the cluttered environment. The materials that can be recycled include plastics, wood, metals, glass, textiles, paper, cardboard, rubber, ceramics and leather. Organic solid waste can also be recycled into fertilizer for agricultural purposes. Recycling reduces the amount of household solid waste to be collected, transported and disposed off promoting cleaner environment and economic competitiveness (Al-Salem and Baeyens, 2009; Zikmund and Stanton, 1971).

Compositing is a process of biological decomposition of materials under temperature, humidity and pH and is used in landscaping and horticultural agriculture projects (Al-Salem and Baeyens, 2009)

2.1.3 Solid Waste disposal

In Kenya solid waste management is an essential factor that contributes to the social welfare, productivity and the health of people. Solid waste composition differs from household to household depending on their income levels(Palczynski 2002; Ojeda-Benitez *et al* 2002). Common solid wastes from households are as classfied in table 2.1 below:

Table 2.1 Composition of Household Solid Waste

Composition	Types of waste	Characteristics of waste
Organic	Foodstuff, Garden wastes, wood and textiles,newspaper,magazines,office paper, cardboard	Recyclable organics
Organic	Human excrement,cellophane,waxed paper, plasticized paper	Non-recyclable organics
Inorganic waste(plastics and Metal)	Plastic, tin, glass,aluminium, other metals	Recyclable inorganics
Inorganic	Plastic bags, miscelleneous plastics, miscelleneous glass, sanitation wastes,disposable diapers.	non-recyclable inorganics

Source: Palczynski (2002); Ojeda-Benitez (2002)

2.1.4 Existing regulations and standards for solid waste management in Kenya.

A wide range of policies are available at international, national and local levels governing solid waste management. In Kenya several by-laws, regulations and Acts of Parliament as well as policy documents exist governing the management of solid waste at different stages.The Environmental Management and Coordination Act (EMCA) of 1999 addresses issues on solid waste segregation and reduction at production and consumption levels, primary storage, collection, transportation and transfer stations, treatment and landfills, incineration and recycling of solid waste among others (Kuria *et al.,* 2010; GoK 1999).

The City Council of Nairobi (Solid waste management) By-laws of 2007 exist. They govern the primary role of the city council on regulating and managing solid waste generated within its jurisdiction. They also govern primary storage, collection and transportation of solid waste by the city council. The Factories Act (Cap 514 of the Laws of Kenya) deals with the sectors that generate waste; compliance is mandatory for factory owners (GoK, 1977). Above all the Environmental Management and Coordination (Waste management) regulations, 2006 prescribe the procedure for and criteria for handling waste. The Public Health Act, Cap 242 section 118 is responsible for nuisances which include accumulation of hazarous waste.This Act further specifies that appropriate handling, treatment and disposal of waste by type can help reduce costs and hence protect public health(GoK, 1986).

Vienna convention for protection of ozone layer, United Nations Framework Convention on Climate Change and basal convention are some of the international treaties that Kenya is signatory to as they form part of the international environmental law (UNEP, 2001;UNFCCC 1997).These aforementioned treaties and regulations are key in waste management. Vision 2030

and the Millenium Development Goal (MDG7) on environmental sustainability do not clearly reflect waste management at the household level; they look at the general environmental concerns (GoK, 2008; MDG Report, 2013).This study therefore was an attempt to assess the waste management options at household level in order to come up with policy reccommendations encouraging sustainable solid waste management.

2.2 Empirical studied on solid waste management

Concern for solid waste management is not in any way just a local phenomenon. Ojeda-Benitez *et al.,*(2002) carried out a study in the community of Mexicali city in Mexico on characterisation and quantification of household solid waste. The authors used descriptive statistics method, specifically median, standard deviation and percentages to describe the different household solid waste generated by the community in order to determine the potential for recycling of the waste. The authors used the results obtained to evaluate the recycling potential for similar communities to the one studied but located close to the Mexican city.The findings of the study were that there was a grave environmental risk associated with household solid waste disposal and programs designed to promote pro-environmental behavior by residents such as reduction in consumption, reuse and recycling needed to be introduced accompanied by constant municipal campaigns on collection and sale of recyclable wastes.However, these study had two gaps; first the study focused on characterisation and quantification of household solid waste in a mid-level income country's city, Mexico City and secondly it focused on recycling potential which was only a single waste management option out of the several existing options for sustainable household solid waste management.Therefore, a study in a slum in a developing country needed to be carried out, combining the characterisation of household solid waste with the determinants of

household's choice of waste management options. The resulting policy prescriptions in Kibera were found to be relevant particularly after characterization of the waste and recommendation of adoptable management options.

Johnstone *et al.,* (2004) studied generation of household solid waste in countries that are part of the Organisation for Economic Co-operation and Development (OECD). Countries that are part of OECD promote policies designed to achieve the highest sustainable growth and employment raising the standards of living of member countries while at the same time maintaining stability for development of the world economy. These member countries are 34 in number and they are mostly the European countries with a developed economy. The authors of this study used macroeconomic data in which a model based on household utility maximization proposed by Kinnaman and Fullerton (1997) was used to analyze data. In this model household waste collection services by municipal council were considered to be dependent upon a vector of demographic characteristics such as average household size, number of working age in the household and the proportion of population living in urban areas. Household size was important because of the diseconomies of scale in waste generation. The findings were that economic and demographic charactericstics are key determinants of generation rates of both total and household municipal solid waste and that generation rates are relatively inelastic with respect to household final consumption expenditures. The said study focused on waste collection by municipal council disregarding other waste management options and the socioeconomic and institutional factors influencing them. It therefore, presented a scenario of an effective city council, which in reality does not exist and especially not in the case of a developing country. This far, it was not known how household characteristics and institutional factors influenced the

choice of waste management options in a slum. The current study came in to fill in the gap by assessing the household socioeconomic and institutional factors influencing the choice of waste management options.

Pasquini *et al.,* (2005) carried out a study on efficient use of urban waste ash to improve soil fertility on the Jos Plateau, Nigeria. Data collected from the study was analyzed using descriptive statistics. The study was motivated by the acute problem of waste disposal in numerous African cities and the possibility of a solution in recycling of the nutrient-rich waste in urban and peri-urban agriculture. The authors found out that farmers involved in vegetable production around Jos, Nigeria developed a sophisticated soil fertility management strategy that combined inorganic fertilizers, manure and urban waste ash. The authors investigated the socio-economic constraints linked to obtaining scarce organic inputs, in particular urban waste ash and the health hazards caused by using the ash, and suggested ways to improve its use.The ash was produced either from wood or from open burning of urban waste which involved sorting the ash after combustion for leftover materials such as plastic bags and containers, glass and other non-combustible debris. Reccomendations from this study were that farmers should use urban ash and wood ash to improve soil fertility .It also encouraged diposal of degradable and non-degradable waste separately in order to address safety in using this waste for agricultural purposes. The study focused on burning of combustible household solid waste to produce ash to improve soil fertility but did not provide a mechanism for handling inorganic non-combustible household solid waste.The current study therefore, came in and characterized household solid waste and then addressed holistically various waste management options for all waste types identified.

Xavier *et al.,* (2006) assesed instruments to reduce waste for mixed household solid waste collection services in the Flemish region of Belgium. Waste management instruments include policies and plans used by public authorities to encourage recycling and reduction of solid waste. The authors used multivariate regression analysis in order to determine the relevant factors influencing the amount of waste generated. The quantity of collected mixed household solid waste was used as the dependent variable influenced by a variety of factors in the multivariate regression analysis. Instruments to reduce waste were divided into three groups; pecuniary incentives, service level and measurements stimulating prevention and waste reduction.They found out that service level had significant impact, pecuniary incentives are effective in reducing waste and that direct cost attributable to waste service helped reduce waste. The study reccomended the implementation of polluter-pays principle. However, the authors overlooked the role of households in managing waste by treating waste management as single sector practice involving only public authorities while on the other hand disregarding the fact that effective waste management is a trisector model involving government,private sector and households.This was why it reccomended polluter-pays principle ignoring the income levels of households among other household characteristics.The current study therefore, came in to address these issues. Ideally in Kibera slum, many households have low incomes and therefore recycling or reuse may be the better alternatives to polluter-pays principle.The proposed study also sought to assess the factors that influenced the reuse and recycling waste management options and characterised the various waste types into recyclable and non-recyclable waste types for a sustainable solution.

Tadesse *et al.,*(2007) carried out a study on household waste disposal in Mekelle city in Ethiopia. The authors collected data on effects of demographic factors, social status, waste and environmental attributes on household solid waste disposal options. The authors used multinomial logit model to estimate the optimal waste disposal choice on each alternative disposal attributes and demographic features.The results of the model were used to show the probability of a specific disposal activity. The findings were that disposal in open areas and in roadsides was increased by inadequate disposal containers and longer distances to these few containers.Higher household incomes decreased the probability of waste disposal along the roads and open areas.Finally the authors concluded that well functioning policies would improve waste disposal.However, the study focused on disposal alternatives such as communal containers, open areas and roadsides and tractor trailers among others. Therefore, this author left a number of gaps.First the study focused on waste disposal as the only waste management option by assuming that recycling and reuse were neglible in Mekelle city. A scenario that called for a lot of concern in a developing country like Ethiopia, where poverty and high unemployment rates coexist.Second, waste disposal activities ranging from the municipal containers, disposal along roads and open places,communal containers and private waste collectors were the only waste handling practises assessed; it did not focus on the alternative solid waste management options besides disposal.The current study therefore came in to fill in these gaps by assessing various waste management options in Kibera slum which included disposal, burning, recycle and reuse options reccommending policy implications for adoption at household level.

Kaundal *et al.,* (2007) carried out a research on the problems of household waste management in Himachal Pradesh.Multi-stage stratified random sampling was used to draw the sample of

respondents.Probit model was used to analyze possibility of recycling waste or not between two communities; teaching community as compared to non-teaching community.The authors found out that garbage disposal outside the house was a major problem and that waste recycling was higher in teaching community than in non-teaching community.This study was however, found to have a gap due to its narrow focus on a specific group of people; teaching and non-teaching community.This meant it treated waste management as a practice influenced by only one socioeconomic factor; education, which was not true since other household and institutional characteristics exist and collectively would eventually influence waste management options preferred by households.The current study therefore came in to focus on Kibera slum which is inhabited by people of several different occupations, the analysis of which was of interest and on the various determinants of the household's choice of waste management options in an area where illiteracy is high.

Pandyaswardgo (2009) carried out a study aiming at integrated Life Cycle Assessment (LCA) on the available European Municipal Waste (MSWM) technologies.The author reflected on Japan European Union (EU) Knowledge and technologies for a sustainable Municipal Waste management for developing countries.The assessment was an attempt to find the potential of technology adaptation in developing countries as well as providing general discussion on social and economic aspects.Data was analyzed using Modified Life cycle Assessment methodology known as Environmental Load Point (ELP) formulated at Waseda University, Nagata Laboratory.Findings from this study were that technologies promoting strict emission limit, pollution reduction, those encouraging recycling, and waste reduction needed to be adapted in African and Asian countries.Such technologies involved incineration plants equipped with heat

recovery facility, Mechanical-Biological Treatment plant (where metals and inert materials are separated),Refuse Derived Fuel(RDF), aerobic digesters for biogas and compositing plants. However, there was a gap in this study resulting from the high cost involved in adapting these technologies in Kenya and in particular, Kibera slum.Therefore, due to the current upgrading program being undertaken in the slum, the current study was found relevant because it would provide short run solutions to the existing problem, information on the waste types and management options and eventually on the socioeconomic and institutional factors influencing the choice of waste management options by households in the slum.This information is important for planning and adoption of the Japanese waste management technologies in Kenya.

Niringiye *et al*., (2010) assessed determinants of willingness to pay for improved household solid waste management in Kampala City.The model used to elicit willingness to pay for improved household solid waste management was a dichotomous choice contingent valuation technique.The authors used logistic model to establish the determinants of willingness to pay for solid waste management.The study found out that the age of the household head was negatively associated with the willingness to pay for solid waste management and that there was little chance of success if household solid waste collection service charges were introduced.The gap of this study was the cost issue introduced in solid waste management in Kampala City. It made waste management to appear as a practice for the high income earners targeting private waste collectors as their only single option of waste management. Further, it overlooked waste recycling and reuse and the benefits and costs involved in managing waste by households using these options.It also did not characterize the various waste types households produced in Kampala city.The current study therefore came in to address these gaps.

Xavier *et al.,* (2010) identified the key factors in increasing recycling and reducing residual household waste in Flemish region of Belgium.The authors used binary logistic regression model which covered a number of variables such as household characteristics, provision of recycling services, frequency of waste collection and charging for waste services.Analysis of these variables produced results that were meant to reduce and maintain the amount of residual household waste to the reccomended amount per capita. The authors found out that income per capita, cost of residual waste collection, collection frequency and separate curbside collection of organic waste contributed significantly to waste recycling and residual reduction.Curbside recycling is a tool that communities use to reduce the need for landfill space. The gap of this study was presented by the authors' focus on the recycling and residual levels as the only main waste issues in a developed country scenario, where moderate waste management practices were emphasized leaving a gap for a similar case in a developing country.Therefore to fill in this gap, a similar study in a developing country in an informal settlement setting required to be carried out. Such a study was done in Kibera slum, and indeed in the whole country it was found to be relevant since there was no recommended ceiling on per capita waste generation. However, households who engaged in private garbage collection firms were restricted within their agreements with such firms. Any additional waste above what was in the agreement was charged separately. It was of interest therefore to float a ceiling on per capita waste generation in Kenya.

2.3 Summary

The studies reviewed in this chapter showed that waste management is a key environmental issue in developing countries that required to be addressed. Proper solid waste management requires a trisector model involving the household, municipal authorities and private waste

collectors and therefore with the incorporation of households in waste management a household waste reduction policy will be of great help to counter negative effects related to poor waste management.Different studies reviewed above used different models to analyze the data collected.The model used to analyze waste management diposal alternatives include the multinomial logit model. This study built on the reviewed literature by using the multinomial logit (MNL) model to assess the household waste management options in Kibera slum. This model is widely used because it permits the analysis of decisions across more than two choices hence allowing the determination of choice probabilities for different categories in choice or decision making involving multiple choices due to its simplicity in computation.

CHAPTER 3 METHODOLOGY

3.1 Conceptual Framework

This study was conceptualized as an adoption study, where the waste management options taken by a household were determined by the institutions involved, household characteristics and the economic characteristics.Factors such as household income, education, size of the family and institutional factors were perceived to relate to the choice of waste management options undertaken by residents in Kibera slum to manage their solid waste.Households chose to manage their solid waste either through burning, recycling, reuse and disposal (to waste receptacle, open areas, roads, rivers and railway line).

The conceptual framework is presented in Figure 3.1 below.

Figure 3.1 Conceptual framework for household solid waste management options in Kibera slum in Nairobi.
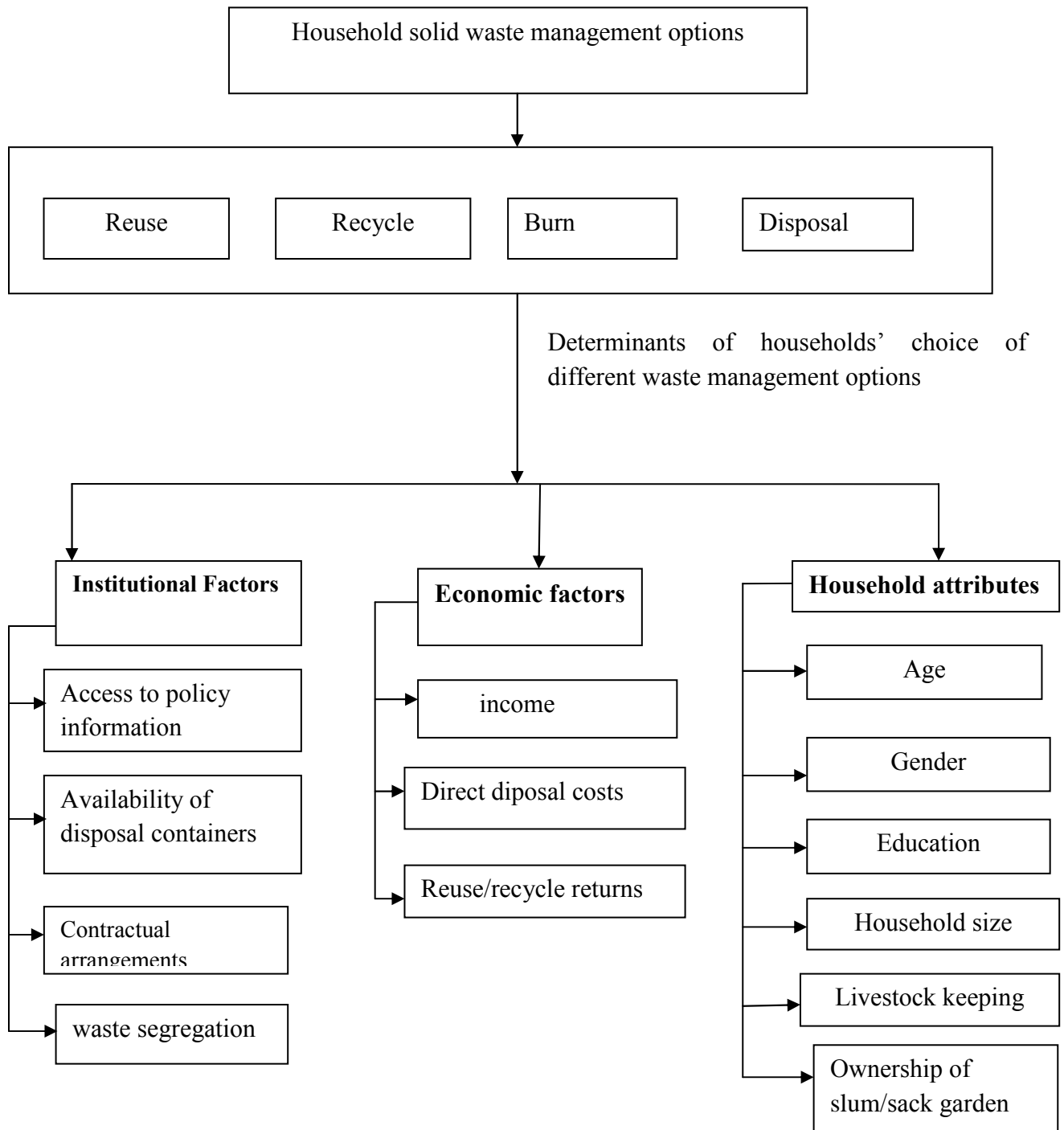
Source: Author conceptualization 2012

3.2 Theoretical framework

This study was based on the Random Utility Model (RUM). According to Thurston(1972) a household is assumed to maximize a welfare-enhancing factor which is the utility in this case.Household utility maximization is a function of household characteristics,as well as on other attributes related to the consumption of goods and services. In this study households were assumed to choose the waste management option that maximized their unobserved utility.The Random Utility Model (RUM) was used for each option to form a linear function of the observed factors plus an error term.The Random utility model was used to link waste management and utility maximization hence making it useful in deriving and modelling the households' choices of waste management options.

Given two waste management options K_1 and K_2 with their associated utilities U_1 and U_2 respectively and where U_2 is greater than U_1.Based on RUM, a household would adopt K_2 instead of K_1 because K_2 has a higher utility than K_1.The household would choose the waste management option that yields the highest utility. The utility derived from the use of a given waste management option was expressed as a linear sum of two components; a deterministic part, V_{ij} that captures the observable components of the utility function and ε_{ij}, a random error term, that captures unobservable components of the function including measurement errors.The random utility model was represented as follows;

$$U_{ij} = V_{ij} + \varepsilon_{ij} \tag{3.1}$$

where U_{ij} is the utility derived by an individual household i from the waste management option j, V_{ij} is the observable component which contains the vector of household, economic and

institutional factors as well as the vector of parameters or the coefficients to be estimated while ε_{ij} is the unobserved component or the error term (McFadden, 1984).

In the second objective of this study,there were four waste management options available to households. Household i therefore chose waste management option j so that the U_{ij} was maximized. The first option is burning, second option is disposal in (open areas, roads, railway lines), third option is reuse (for urban agriculture) and fourth option is recycle (sale scrap metals and plastics).These options were grouped in the set j which was the dependent variable.

The utility that household i received from waste management option j was U_{ij} which was unobserved. Household i chose option j if it provided the household the maximum utility, $U_{ij}=Max(\mu_{i1}, \mu_{i2}, \mu_{i3},\mu_{i4})$. Note that μ_{i1} was the utility obtained from option 1, μ_{i2} was the utility obtained from option 2, μ_{i3} was the utility obtained from option 3 while μ_{i4} was the utility obtained from option 4. For each management option chosen by household i it followed that:

$P(y_i=j)=P(U_{ij}=Max(\mu_{i1}, \mu_{i2}, \mu_{i3},\mu_{i4})$...(3.2)

The model used in this study was the multinomial logit model.

3.2.1 Empirical model

Figure 3.2 below was used to show a step by step procedure of how objectives one and two were analyzed.Objective two had 4 choices which included reuse, recycle,burning and disposal.The management options were analyzed using a multinomial logit model while characterisation of solid waste produced by households was analyzed using descriptive statistics as indicated below

Figure 3.2 Step by step analysis of objective one and two.
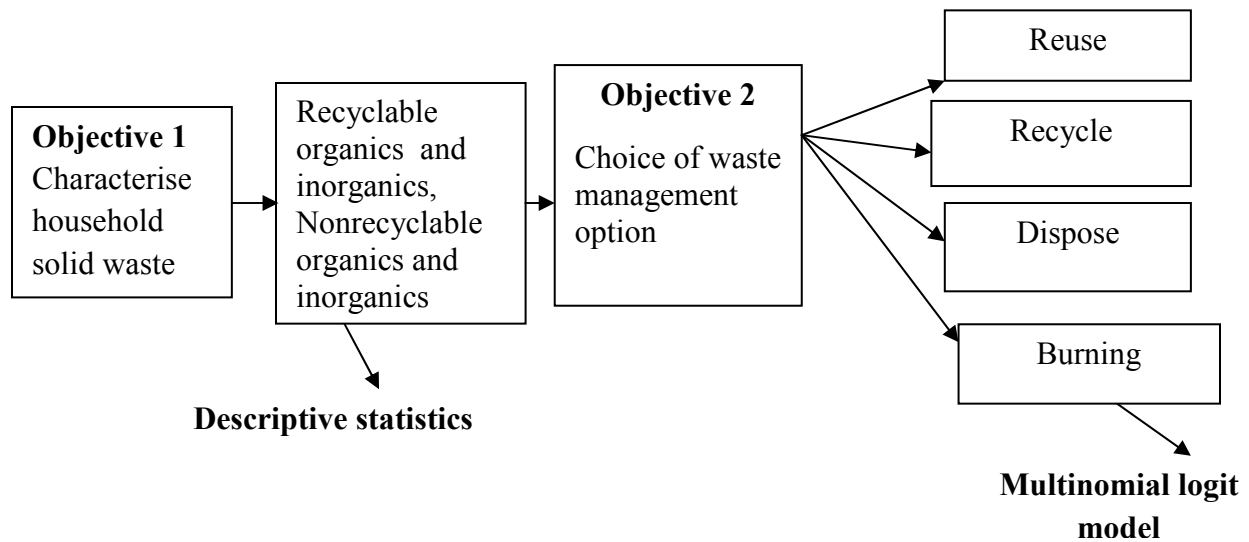
3.2.2 To characterize the different types of household solid waste in Kibera slum

This objective had three main research questions as indicated below.

3.2.3 What are the major types of solid waste in Kibera slum?

To answer this question a total of 250 households were asked to rank their solid waste from the one they produce in the largest to the lowest quantity in their own opinion in descending order. For the purpose of accuracy, in this study, the first three ranks were presented for each type of waste and a mean calculated in order to obtain an accurate overall rank of each waste type. Percentages were calculated based on the mean of the three ranks.

3.2.4 What waste management options are known to be used by residents of Kibera?

To determine the primary choice of solid waste management option, households were given a chance to choose the most preferred option to manage their solid waste among alternatives (Burning, Disposal, Reuse and Recycling). The total number of times a particular waste management option appeared across the 250 households sampled for the 12 different types of

waste were counted and percentages calculated using EXCEL. The waste types investigated were 12 (see APPENDIX IV).

3.2.5 What are the possibilities for effective and/ or reuse?

Solid waste produced by households was grouped into three categories; recyclable organics, nonrecyclable inorganics and recyclable inorganics.The total counts under each category was estimated using EXCEL and percentages were calculated. The results were presented in a pie chart.

3.2.6 An Evaluation of Key Determinants of Household's Choice of Solid Waste Management Options.

The determinants of household's choice of solid waste management options were evaluated using the multinomial logit model as described below.

3.2.6.1 Multinomial Logit model

The empirical model used in this study is the multinomial logit model. According to Ku S *et al.,* (2009), developed countries consider integrated waste management (reduce,reuse and recycle) as one way of mitigating increased waste disposal costs hence minimizing environmental damage. Korean government introduced a volume waste fee system to reduce waste generation and maximize waste recycling. Many other developed countries have based their waste management practices on such a system. These countries also have a set of recycling standards, streamlined existing laws that have been tightened up to enhance waste management. Models such as Choice set models, multinomial logit models have been used in studies in Korea. Other models include probit models and logit models among others that have been succesfully used in empirical work

in developed countries. Developing countries studies have modelled their empirical work as far as waste management is concerned on the basis of successful studies in the developed countries. The Kibera slum study involved several choices. Mainly two approaches are appropriate in analyzing multiple choices for households solid waste management options; the multinomial logit (MNL) and multinomial probit (MNP) models. Both the multinomial logit and Multinomial probit model are used in analyzing solid waste management options decisions that are made jointly. The two appraoches are also very important for evaluating alternative combination of management options.This study however used multinomial logit model to analyze the determinants of household's choice of management options because of its wide use in multiple choice studies and its also easier to compute than its alternative, the Multinomial probit model (Hassan *et al* 2008).

MNL has a computational simplicity in calculating the choices that are expressible in analytical form. In addition it provides a convinient closed form for underlying choice probabilities, with no need of multivariate integration hence making it simple to compute choice situations characterised by many alternatives (Hausman and M**c**Fadden, 1984). The main disadvantage of this model is the independence from irrelevant alternatives (IIA) assumption which states that for any individual, the ratio of any probabilities of any two alternatives is entirely unaffected by the systematic utilities of any other options (Hassan *et al.,* 2008).

On the other hand, the Multinomial Probit model specifification for discrete choice models do not require the independence from irrelevant alternatives(IIA) assumption and a test from this specification is provided by a test of the covariance versus the independent probit specification which is similar to logit specification.The main limititaion of the MNP is the requirement that

multivariate normal integrals must be evaluated to estimate the unknown parameters making the MNP complex and inconvinient sepecification test than the MNL(Hausman and McFadden, 1984). This reasons made the MNL the most preffered model in this study.

Taking the most preffered waste management option the Multinomial Logit Model (MNL) did not imply that households are supposed to exclusively use only sinlge choice of waste management option. Of course they would choose a variety of waste management options to maximize their utility. In this study the interest was on the factors that motivated households to have a higher preference for one management option over another. Therefore the multinomial logit model used was written as follows:

Equation (1)

$$Pr(Y_i = j) = \frac{e^{\beta_j' X_i}}{\sum_{k=0}^{J} e^{\beta_j' X_i}} , j = 0, 1, 2 \ldots J \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

where β_j is a vector of coefficients on each of the independent variables X. The above equation was normalized to remove indeterminancy in the model by assuming that the $\beta_o = 0$ and the probabilities were estimated as (Hausman and McFadden, 1984):

$$Pr(Y_i = j \mid X_i) = \frac{e^{\beta' X_i}}{1 + \sum_{k=0}^{J} e^{\beta' X_i}} , j = 0, 2 \ldots J; \beta = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(1.1)$$

Equation(2)

This equation resulted to the J log-odd ratios;

$$Ln \left(\frac{P_{ij}}{P_{ik}}\right) = X_i(\beta_i - \beta_k) = X_i' \beta_j, \text{if } K = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 2$$

The dependent variable is presented as the log of one to the base alternative. The MNL coefficient estimates are difficult to interpret, and also associating the β_j with the jth outcome is

tempting and misleading.This means that, the coefficients are not directly interpreted to draw policy implications rather, to interpret the effects of explanatory variables on the probabilities, marginal effects are derived (Hassan and Nhemachena, 2008; Greene, 2003).

Equation (3)

To be able to obtain equation 3 a step-by-step procedure was used to obtain the first order condition and second order conditions of the multinomial logit model as follows (Hausman and McFadden, 1984)

First order conditions;

$$\frac{\partial P_j}{\partial x_i} = \sum_i^k [y_{ik} - p_{ik}]x_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 1$$

$$\frac{\partial p_{ij}}{\partial \beta_j} = p_{ij}x_i - p_{ij}p_{ij}\,x_i \dots\dots\dots\dots\dots\dots\dots\dots\dots 1.1 \text{ For } j \neq k$$

The second order equations was expressed using the two equations below; equation 2 and 3 (Hausman and Mcfadden, 1984).

$$\frac{\partial p_{ij}}{\partial \beta_k \, \partial \beta_k} = -\sum_{i=1}^N \sum_{j=1}^J p_{ij}(\partial_{ij} - \rho_{ij})x_i x'_i \dots\dots\dots\dots\dots\dots\dots 2$$

Therefore, the marginal effects are finally expressed as shown below. This then gave us equation 3 below.

$$\delta_i = \left(\frac{\delta P_j}{\delta x_i}\right) = P_j\left(\beta_j - \sum_{k=0}^j P_k\, \beta_k\right) = P_j\left(\beta_j - \bar{\beta}\right) \dots\dots\dots\dots\dots\dots 3$$

Equation 3 is important in deriving the marginal effects of the coefficient estimates.Marginal effects measure the expected change in probability of a particular choice being made with respect to a unit change in an explanatory variable.

Equation (4)

The empirical model derived for the analysis of the determinants of household's choice of solid waste management options was as shown below. Socioeconomic and institutional factors were regressed on the waste management options for each of the four waste management options; reuse, recycle disposal and burning.The model fitted consisted of the following socioeconomic and institutional variables;

$$
\begin{aligned}
\text{Option}_i \quad = \quad & \beta_0 + \beta_1\,Educ + \beta_2 Income + \beta_3 Yrsc + \beta_4 HHSize + \beta_5 Sack\ or\ slum\ garden + \\
& \beta_6 returnstodispo + \beta_7 Livestock + \beta_8 Contractarrang + \beta_9\,wastesegre + \\
& \beta_{10}\,Communityrecyclingpractise + \beta_{11}\,Distmn + \beta_{12}\,homeownershipt
\end{aligned}
$$

The dependent variable, OPTION, took four descrete values (1=Burning 2=Disposal 3=Reuse, 4=Recycling).Disposal was taken as the reference in the regression.The β's are coefficient estimates for each of the independent variables.

3.2.6.2 Estimation of variables

Table 3 below shows the household and institutional factors estimated in this study.The factors included education level, household size, awarenesss of waste management regulations of 2006, distance to the main road, years of stay in residence, home ownership, view on placement of municipal receptacles, access to municipal receptacles, livestock keeping, household's income, ownership of sack/slum garden , returns to disposal, contractual arrangements, waste segregation and community based waste recycling practise.

Table 3.1 Hypothesized variables determining Households' choice of solid waste management options.

Dependent variable		
MGTOPT	1 if households burn solid waste, 2 if househods Dipose solid waste, 3 if households Reuse solid waste , 4 if solid waste Recycle solid waste.	
Independent variables	**Definition of variables**	**Expected sign**
Household specific variables		
YRSCH	Household Years of formal schooling	+ve/-ve
INCOME	Household income per month in Kshs.	+ve/-ve
YRSTAY	Number of years a household lived in Kibera slum	+ve/-ve
HSOWN	Dummy; 1 if household owns the house he lives in , 0 otherwise	+ve/-ve
DISMN	Distance in kilometers to the main road	+ve/-ve
HHSIZE	Number of household members	+ve
Institutional factors		
WASTREG	Dummy; 1 if households know waste management regulations of 2006, 0 otherwise	-ve
CNTRAR	Dummy;1 if sign contractual arrangements with private waste collectors and, 0 Otherwise	+ve/-ve
WSTSEG	Dummy; 1 households separate waste, 0 otherwise	+ve
MNCT	0 if none at all, 1 if not enough, 2 if enough access	+ve
PLCONT	Dummy;View of households with the placement of containers, 1 if agree, 0 otherwise	+ve

COMBSE	Participation in recycling practise, 1 if Yes, 0 otherwise	+ve/-ve
DISRTNS	Income generated from solid waste recycling per month in Kshs.	+ve
Agricultural variables		
SLU MS AK	Dummy; 1 if household owns a slum/sack garden, 0 otherwise	+ve/-ve
LVS K	Dummy; 1 if household keeps livestock, 0 otherwsie	+ve/-ve

Source: Hypothesized for use in Survey data, 2012.

Below is a brief discussion on the independent variables used in the multinomial logit regression model and their apriori expectation about the direction of effect to solid waste management options.

Years of schooling of the household head

It was hypothesized that education had a negative effect on household solid waste disposal in open areas, along the roads/railway line but a positive effect on solid waste recycling and reuse. Households with high education levels were expected to reduce unauthorised waste diposal and increase waste reuse and recycling. Studies such as Niringiye *et al., (*2010) and Ekere *et al.,* (2009) also found out that education of households has a positive effect to willlingness to pay for improved solid waste management and waste separation and utilization among households respectively.

Household head income

According to Amfo-otu *et al*., (2012) Income is the amount a household earns on monthly basis and the higher the income the more willing individual are to manage their waste through the payment fee system. Studies such as Nirigiye *et al.,* (2010) found out that there is a general agreement in enviromental economics literature on the positive relationship between income and demand for the improvement of environmental quality and hence hypothesized income had a positive and significant effect to willingness to pay for solid waste disposal. Afroz *et al.,* (2008) found out that high income among households enhance their ability to pay for solid waste diposal charges. It was hypothesized in this study that income had a positive effect to unauthorised solid waste disposal and reuse and a negative effect to solid waste recycling.It was assumed that household solid waste recycling was not an undertaking for the poor households only.

Household size

Family size was expected to have positive effect to solid waste management options.Household size coefficient had a positive sign and if not significant should be inferred that the larger the family size of the household, the better the chance of either reusing and or recycling household solid waste. Studies such as Deressa *et al.,* (2009), household size had insignificant and positive effect to climate adaptation startegies and the larger the family the higher the chances of adapting to climate change strategies.

Contractual arrangements.

Contractual arrangements were expected to have a positive effects on solid waste burning, reuse and recycling.Paying private waste collectors to dispose off solid waste in designated waste receptacles such as Dandora dumpsite was expected to increase waste burning, recycling and reusing.Paying for solid waste disposal is a cost and households were expected to opt for burning, reusing and recycling to reduce the volume of the waste they pay for on weekly basis.

Home ownership

Land tenure gives households full rights and security for longterm investment. House ownership acts as an incentive to a clean environment because households will keep their home and sorroundings clean. It was therefore, hypothesized that home ownership has a postive effect on solid waste reuse, burning, recycle and disposal.

Distance to the main road.

Taddese *et al.,* (2008) found out that distance to waste containers has a positive effect to open areas/roadsides and use of tractor-trailer disposal.Distance to the main road is used in this study

because it was expected that due to the nature of settlement patterns in Kibera slum, there were minimal municipal waste containers and dumpsites, and roads could be the possible destinations for solid waste disposal.Therefore, there was no definite direction hypothesized apriori on the effect of distance to the main road.

Awareness of waste management regulations of 2006

Waste regulations of 2006 forbids waste generators from disposing waste in open areas along the roads and in public places. Therefore, waste regulations of 2006 were expected to have negative effect to solid waste burning and a positive effect to solid waste reuse and recycling. The reason for positive effect to solid waste reuse and recycling was because the regulations reccommend reuse and recycling as cleaner production principles.

Waste segregation

The regulations further authorises persons involved in activities generating waste to segregate and safely dispose off the waste in designated waste receptacles as licensed by NEMA. Waste segregation was expected to have a positive effect to solid waste reuse, recycling and burning. This is because its very important component as households would probably separate organic waste from inorganic waste accordingly.

View on placement of containers

Taddese *et al.,* (2008) also found out that 53.5 percent of the households disagreed with the placement of containers not only near the households but also in any other area of Mekelle city in Ethiopia due the environmental and health hazards that would result from the waste disposed into the containers.Only 46.5 percent agreed to the placement of such containers near their

houses. It was however, hypothesized that households in Kibera slum agree to the placement of such containers near their houses due to the current devastating situation. Therefore, view on placement of containers was expected to have a positive effect to solid waste management options.

Livestock Keeping

It was hypothesized that livestock keeping should have a positive effect on solid waste reuse and disposal and a negative effect on solid waste recycling. Studies such as Deressa *et al.,* (2009) showed that livestock ownership was positively related to adaptation options.

Ownership of slum/sack gardens

Ownership of slum/sack garden was hypothesized to have a negative effect to unauthorised waste disposal and a positive effect to solid waste reuse and recyling.Pasquini *et al.,* (2005) found out that farmers involved in vegetable production around Jos, Nigeria, developed a sophisticated soil fertility management strategy that combined inorganic fertilizers, manure and urban waste ash and reccommended use of urban ash in soil fertility improvement in the city . Ownership of sack gardens was therefore expected to have a positive effect to solid waste reuse and recyling because organic waste can be recycled to manure and/or used directly to enrich soil with nutrients.

Participation in waste recycling practise

Participation in solid waste recycling practise was expected to have a positive effect on solid waste reuse, recycling and burning. This is because community members are expected to work together and manage waste by recycling the recyclable and obtain income which they share

among themselves to enhance their livelihoods and reuse the rest of the waste in slum/sack to improve soil fertility. They were also expected to come together to burn solid waste and keep the environment clean.Ojeda-Benitez *et al.,* (2002) found out that the utilization of domestic waste requires community participation which includes an integrated plan of Citizens committed to practicable environmental management based on the conservation and protection of the environmental natural resources. Tadesse *et al.,* (2008) also found out that 18.5 percent of households participated in a recycling and reuse practise while 81.5 percent did not. It is hypothesized in this study that households involved in recycling practise would have a positive effect to solid waste reuse and recycling and a negative effect to solid waste disposal in unauthorised areas and burning.

Disposal returns.

Disposal returns were expected to have a positive effect to solid waste reuse and recycling and a negative effect to solid waste burning. Disposal returns are expected to be direct from recycling and indirect from reuse especially in slum/sack gardens.

3.2.6.3 Model diagnostics

Multicollinearity, heteroskedasticity; assumption of normality test, the problem of Irrelevance of Independent Alternatives (IIA) and Hausman test for the goodness-of-fit using the likelihood ratio test. were the main data problems identified.

Testing for multicollinearity

Multicollinearity is a statistical phenomenon in which two or more predictor variables in a multiple regression model are highly correlated.It is nomally caused by perfect linear

relationship among independent variables.The variance inflation factor (VIF) and pairwise correlation were used to check for multicollinearity. The rule of thumb is that independent variables with a VIF of more than 10 present evidence of presence of multicollienearity and therefore such variables should be dropped (Greene, 2000; Gujarati,2004).

Test for heteroscedasticity

Heteroscedasticity means a situation in which the variance of the dependent variable varies across the data. It complicates analysis because many methods in regression analysis are based on an assumption of equal variance (Gujarati, 2004).The white test was used.

Test for normality

Kurtosis is the ratio of average of the power of the deviations from the mean, to the square of the variance (Chissom 1970). A normal distribution has skewness and excess kurtosis of 0, so if distribution has excess kurtosis (0's) or values close to zero, then it is probably normal (Greene 2000).

Assessing Goodness of fit of the multinomial logit model

The likelihood ratio reported below indicate a very low p value=0.000 which implies that the model fits the data well. The LRI (also called McFadden R^2 or pseudo R^2) is analogous to the R^2 in an Ordinary Least Squares (OLS) regression (McFadden, 1984). Empirical evidence suggests that LRI (computed as $LRI = 1 - L_o/L$) usually lies between 0.2 and 0.4 (Jarvis, 1990 quoted by Mbata, 1997).

Tests independence from irrelevant alternatives (IIA)

The logic behind the Hausman and McFadden (1984) test is that if Independence from Irrelevant Alternatives property is valid, the parameters of restricted set model should be approximately the same as those of the choice set model (Fader *et al*, 1996).Hausman test was done.

3.3 Area of study and Data Management

3.3.1 Study area

Kibera is the largest slum in sub-Saharan Africa. It is in Langata Constituency 7 kilometres southwest of the city of Nairobi, with an approximately 124,533 people (KNBS, 2009). It stands on an area of 2.5 square kilometres. Kibera slum has 2 locations; Kibera and Sarangobe locations. Kibera location has three sub-locations; Kibera, Makina and Lindi while Sarangobe Location has Gatwikeira and Olympic/Kianda sub-locations. There are several small scale waste recycling dealers who mainly sell plastics and scrap metals. Kibera slum residents practise agriculture on small scale and crops grown include maize,bananas and kales.Kales are commonly grown in slum/sack gardens. There is also a cows' bone recycling youth group project that recycles bone into jewelery in Soweto village near the railway line. Kibera slum inhabitants have a diverse culture and living standards in each of the five sublocations differ.

3.3.2 Data sources and Management
   a) **Secondary Data sources**

Secondary data were collected from National Environment Management Authority on the number of licensed waste transporters, designated waste receptacles in Kibera, awareness of waste management regulations of 2006 and the waste management options that it recommends for use by households.

b) Collection of Primary Data

Primary data were obtained from a survey in which households in Kibera slum were interviewed on solid waste characteristics and the determinants of household's choice of waste management option.

Research design

Quantitative research design was used where cross-sectional household data were collected from residents in Kibera slum. Such data were on households' and institutional characteristics, which were perceived to influence choice of waste management options.

Data collection procedure

A semi-structured questionnaire was used to collect the primary data. This was administered directly to the households in the study area. Data captured included education level, household size, awarenesss of waste management regulations of 2006, distance to the main road, years of stay, home ownership, view on placement of municipal waste receptacles, access to municipal receptacles, livestock keeping, household's income, ownership of sack/slum garden , returns to disposal, contractual arrangements, waste segregation and community based waste recycling practise.

Data and survey

To evaluate the household solid waste management options in Kibera slum, households were selected using the multi-stage sampling technique.In the first stage the two locations in Kibera slum were selected.These two locations are the ones that cover the slum areas in Kibera division.

However, due to time and money constraints, the sample size was estimated as follows.For the purpose of representation, 50 households were randomly selected from each sublocation to make a sample size of 250.This sampling method was chosen because it ensures that the sample size has a high degree of representativeness of the population by providing all the respodents in slum with an equal chance of being selected as part of the sample. Information collected included data on household and environmental management.

Data analysis procedure

Data coding, entry and cleaning was done with Statistical Package for Social Sciences (SPSS) software version (16) and analysed using EXCEL for the first objective and STATA statistical packages for the second objective.The analysis used both descriptive and quantitative techniques and results were presented in tables, graph and a pie chart.

CHAPTER 4 RESULTS AND DISCUSSION

This section presents both the descriptive and econometrics results of the study. The first subsection presents the descriptive statistics of the research questions on; the major types of solid waste produced by household in Kibera, waste management options known to residents and the possibilities for effective recycling and or reuse of household solid waste. The second subsection discusses the results of the Multinomial Logit regression on the key determinants of households' choice of solid waste management options in Kibera slum.

4.1 Characterisation of household solid waste in Kibera slum

Table 4 below presents the ranks and percentages of the different solid waste produced by households in Kibera slum.

Table 4.1 Types of solid waste produced in Kibera slum: rank, percentage and market potential

Type of waste							
Recyclable organics	1st Rank	2nd Rank	3rd Rank	Mean	Percent (%)	Rank	Recyclable with market potential (percent)
Vegetable remains	107	105	29	81	32.13	1	
Wood	18	11	9	13	5.07	12	
Ash	73	49	35	53	20.93	4	
Newspaper	72	41	40	51	20.4	5	28.8
Recyclable Inorganics							
Plastic containers	71	63	57	64	25.47	3	36.2
Broken Glass	28	15	14	19	7.6	10	
Soda and Beer Bottles	34	31	24	30	11.78	9	17
Scrap Metal	16	13	10	13	5.2	11	7.3
Rubber	54	43	20	39	15.6	6	10.7
Non-recyclable Inorganics							
Sanitation wastes	41	40	28	37	14.53	7	
Old Clothes	40	40	26	36	14.13	8	
Plastic paper bags	129	87	18	78	31.2	2	
Key: The values presented under 1st, 2nd and 3rd Ranks are the total number of counts each of the 12 waste type appears across the 250 households sampled in Kibera slum. The column labelled **"mean"** is the average count of the three ranks calculated to give an accurate position of each waste type out of the 12 types identified.The column labelled **"recyclable with market potential"** shows the percentage (%) of the specified waste type that households are able to sell directly to the market for money.							

Source:Survey Data 2012.

Based on the analysis of the different types of solid waste,it can be seen that vegetable remains (32.13 percent) is the waste representing the largest percentage of the total by volume, followed closely by plastic paper bags(31.2 percent).Therefore, by volume vegetable remains take the lead followed by plastic paper bags.

Wood and scrap metals are produced in the lowest quantities. That is, wood waste (5.07 percent) is the least while scrap metal (5.2 percent) is the second last.A comparison of the different types of waste produced by households in Kibera slum is illustrated in Figure 4.1 below.
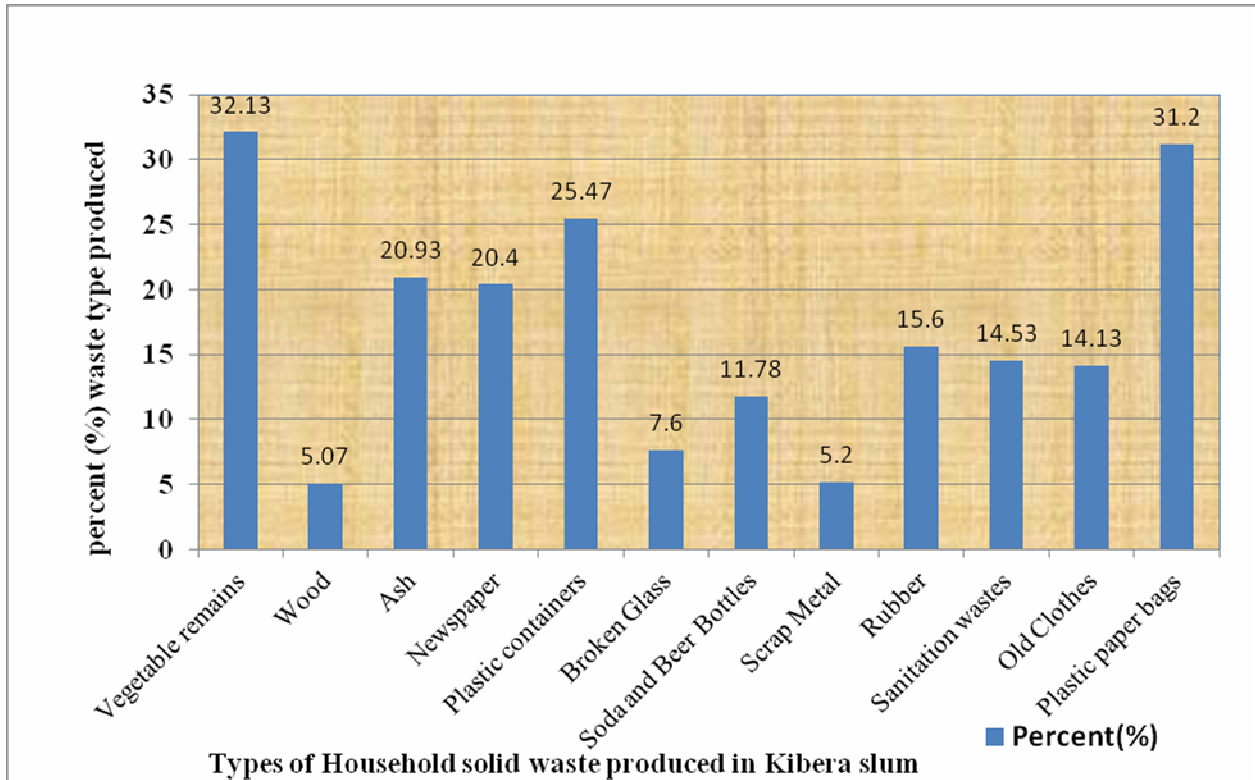
Figure 4.1 A comparison of different types of waste produced by households in Kibera Slum

4.1.1. Potential for effective solid waste reuse and/or recycling

The results presented in table 4.1 above show that a high percentage of household solid waste produced in Kibera slum can be recycled or has a potential for recycling.Of the total recyclable inorganics only broken glass does not have a market potential at the moment due to lack of a glass recycling company in Kenya.In this study household solid waste is further categorized into three main groups as shown in Figure 4.2 below, namely non recyclable inorganics (29.38

percent), recyclable organics (38.52 percent) and recyclable inorganics (32.10 percent).Recyclable organics forms the highest percentage followed by recyclable inorganics.
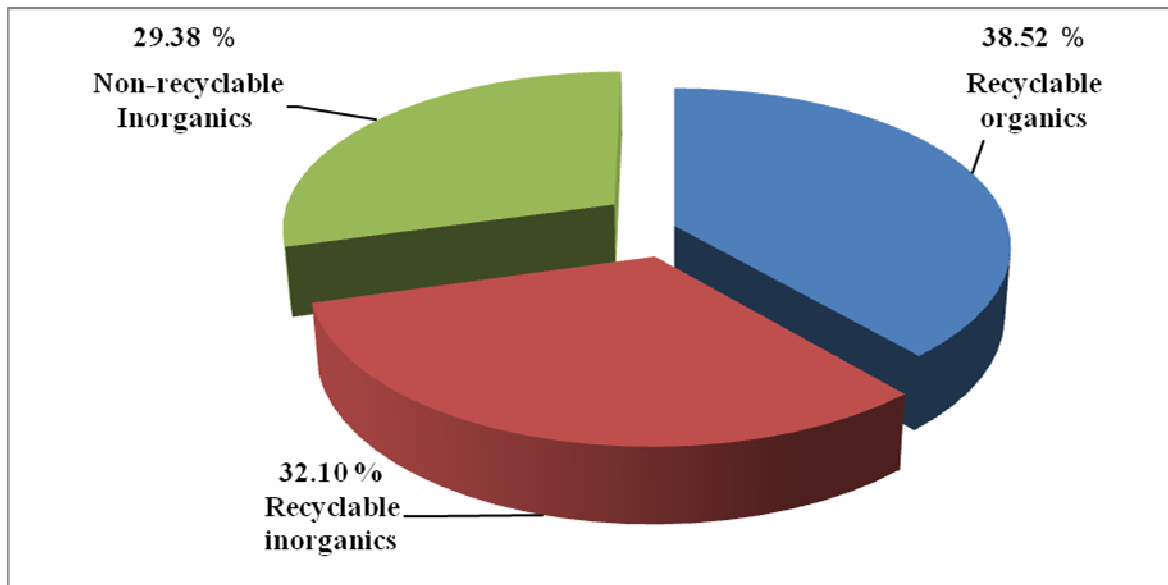
Figure 4.2 Percentage waste categories;recyclable and non-recyclable solid waste

Of the total from Kibera Slum only plastic containers (28.8 percent) is recycled locally in Kibera slum by *Taka ni Pato* community based waste recycling group as shown in table 4 above.The rest have a potential for recycling although no recycling industries exist in Kibera slum or its sorroundings.

4.1.2 Household Solid Waste Management Options

Table 4.2 below represents a summary of household waste management options in Kibera.

Table 4.2 Primary household solid waste management options in Kibera slum

	Waste management option type	Counts	Percent (%)
1	Burning	140	8.55
2	Disposal in open areas and roads	832	50.8
3	Reuse: ✓ Paper (lighting fires) ✓ Cloth (mopping and cleaning) ✓ Ash (in sack garden as manure)	373	22.79
4	Recycling (plastics, rubber and Scrap metal)	186	11.36
5	Compost	26	1.59
6	Private waste collectors	80	4.89
	Total Counts	**1637**	**100.00**

Source: Survey Data, 2012.

The descriptive statistics showed that 8.55 percent, 50.8 percent, 22.79 percent 11.36 percent, 1.59 percent and 4.89 percent of households opted for burning, disposal in open areas and roadsides, reuse, compost and recycling respectively.Disposal in open areas and along the roads, railway line and river/sewerage took the lead; these are the waste mountains in Kibera slum.During the rainy season good proportions of the garbage mountains find their way into the Nairobi water dam.

The choice of the waste management options above are not exclusive. There are other management options such as municipal council containers and a golf club dumpsite in DC area, which serves an insignificant number of households living near the DC Office ; the study ignored this option. Most households dump within their neighbourhoods.

Kibera slum has poor roads and drainage systems due to the informal settlements, which exhibits as an apparent neglect by the municipal council on social services. National Environment and Management Authority(NEMA) records revealed that there are only about 50 licensed waste transporters in number in Kibera mainly serving the upgraded area of Kibera, famously known as "Raila Village" located next to Langata estates. The are two temporary holding stations for household solid waste particularly in DC area and Lindi.NEMA recommends that households decompose biodegradable waste, separate waste into categories and participate in community owned waste management groups (GoK, 2012).

However, the NEMA records showed that households in Kibera slum did not know the contents of the Waste Management Regulations of 2006 and NEMA was creating public awareness measures through adverts in the local daily newspaper (The Standard newspaper and the Daily Nation) and radio. The environmental regulator records further confirmed that there was no separate policy directly addressing household solid waste in Kenya. NEMA prohibits disposal along the roads, railway line and in public places and being a pro-environment conservation, it encourages the public to report such dumping through its priority telephone lines. NEMA does not do any monitoring for anauthorised household solid waste disposal but on the other hand it encourages households to reuse organic solid waste in urban agricultural farming for sustainable waste management. Therefore, to elaborate on the waste management options a number of environmental concerns were addressed in order to provide information to NEMA and the Municipal council as follows.

4.1.3 Environmental concerns

Table 4.3 below shows the findings on environmental concerns responses from households in Kibera slum.This concerns are meant to act as guidelines to NEMA and the Municipal Council to solve most of the problems.

Table 4.3 Responses by households on Environmental concerns

Waste or Environment Attribute	Response by households	Counts	Percentages (%)
Knowledge of the waste management Regulations of 2006	Yes	159	63.6
	No	91	36.4
Contractual arrangements with private waste collectors	Yes	77	30.8
	No	173	69.2
Segregation of solid waste before disposal	Yes	78	31.2
	No	172	68.8
Household view on the placement of municipal containers near house	Yes	184	73.6
	No	66	26.4
Extent of access to municipal waste containers in Kibera	Not Enough	5	2
	Enough Access	3	1.2
	None at all	242	96.8
Participation in any community based waste recycling practice	Yes	31	12.4
	No	229	87.6

Source: Survey data, 2010.

Over 70 percent of the repondent households agreed with placement of garbage receptacels nearer to the houses . However, they did so due to abscence of such containers in the past and the long distances to open areas. Households who opposed did that due to proximity reasons of negative externalities such as health hazards and bad odour. They however said they would only support if the municipal council agreed to empty the containers as soon as they were full because health hazards resulting from the containers was their major concern.

Over 60 percent of the respondent households knew about the waste management regulations of 2006. While majority know its an offence to dump in open areas and along the roads, this does not help the poor solid waste management practices of residents in Kibera slum. The designated waste receptacles are scarce, and even where they exist the municipal council does not empty them on time.

On perception of access to municipal containers for solid waste disposal by households, over 90 percent said they had no access at all (this explains the waste mountains in open areas in Kibera slum).Only 2 percent did not have adequate access while only 1.2 percent responded that they had sufficient access.

Only about 30 percent of the respondent households had contractual arrangements with private garbage collectors.The larger proportion that did not have any contractual arrangements said that it was not because they were not willing to pay but because the existing practititoners (*Kazi kwa Vijana)* did not offer good service. On the other hand the *Kazi kwa Vijana* groups indicated they were willing to collect the solid waste regardless of the distance but one of the main problem was that there were no temporary holding stations for household solid waste in Kibera slum and all the temporary holding places were already pathetic

Households were not willing to participate in waste recycling due lack of local recycling industries, a dumpsite and adequate information to the communities on safe handling of household solid waste. Only about 12 percent participated in some form of recycling while the rest did not. A large proportion of households, about 69 percent,   did not segregate household

solid waste, and they indicated they found no need to do so. This means that such households did not know the value of segregating the solid waste before disposing it.

4.1.4 Regression results and Discussion

The estimation of the multinomial logit model was preceded by diagnonistic tests for multicollinearity, heteroscedasticity, normality assumption, goodness of fit and independence from irrelevant alternatives (IIA).The results for these tests were described as follows.

Testing for multicollinearity

Results obtained for a VIF test showed that there was no multicollinearity because all the variance inflation factors were less than 10 (See APPENDIX I).

Test for heteroscedasticity

The Bruesch-Pagan/Cook-weisberg test for heteroscedasticity (H_0)gave a χ^2 (chi^2) of 14.22 and a p value of 0.0002. Heteroscedasticity was therefore not evident in the data.

Test for normality

Out of fifteen independent variables only two seemed important here; YRSCH has a kurtosis of 0.088, HHSIZE has a kurtosis of 0.024 the rest has a kurtosis of 0 (see APPENDIX II).The data in this study is therefore close to normal.

Assessing Goodness of fit of the multinomial logit model

This study gives a McFadden's R^2: of 0.347 and a maximum likelihood R^2 of 0.587 which is a indication that the model fits well. The results are shown in APPENDIX III.

Tests independence from irrelevant alternatives (IIA)

In this study, Hausman test was carried out to test the H_0 that the study did not meet the IIA assumptions. Test results indicated that there was not evidence to fail to reject H_0. This therefore meant that the study met the IIA assumptions (see APPENDIX IV).

Overall, the multinomail logit was highly significant in explaining determinants' of households choice of different waste management options. The Pseudo-R^2 was equal to 0.35. The predictive power of the model was estimated correctly with 29.25 percent for burning, 37.41 percent for reuse and 33.82 percent for recycling. The overall prediction was 33.49 percent. The predictive power of this model is not as high in this study as that in other studies for example Wale *et al.,* (2005), because waste management in Kibera slum and in Kenya generally is an issue that has not been given adequate attention. It is characterised mainly by dumping in open areas than in reuse and recycling as indicated in this study.The model shown below was estimated to give the results tabulated below;

$$
\begin{aligned}
\text{Option}_i ={}& \beta_0 + \beta_1\,Educ + \beta_2\,Income + \beta_3\,Yrsc + \beta_4\,HHSize \\
& + \beta_5\,Sack\ or\ slum\ garden + \beta_6\,returnstodispo + \beta_7\,Livestock \\
& + \beta_8\,Contractarrang + \beta_9\,wastesegre \\
& + \beta_{10}\,Communityrecyclingpractise + \beta_{11}\,Distmn + \beta_{12}\,homeownershipt
\end{aligned}
$$

The dependent variable, OPTION, took four descrete values (one=Burning 2=Disposal 3=Reuse, 4=Recycling). Disposal was taken as the reference in the regression.β's are coefficient estimates for each of the independent variables. The regression results presented in Table 4.4 below report the coefficient estimates and p values of the determinants of household choice of waste management options estimated using the above model.

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Table 4.4 Regression results of Multinomial Logit Model to explain determinants of choice of Waste Management Options

Independent variables	Estimated coefficients for different waste management options					
	Burning		**Reuse**		**Recycle**	
Household Socioeconomic features						
Years schooling	0.160	(0.096**)	0.114	(0.175)	0.197	(0.013***)
Income	0.250	(0.633)	0.394	(0.385)	0.069	(0.866)
Years of stay	-0.057	(0.507)	-0.012	(0.857)	-0.100	(0.118)
Home ownership	0.681	(0.254)	-0.698	(0.224)	-0.122	(0.806)
Family Size	0.308	(0.019***)	0.048	(0.725)	-0.048	(0.714)
Institutional factors						
Waste reg. of 2006	-0.189	(0.738)	1.194	(0.023***)	0.588	(0.193)
Contractual Arrang.	4.312	(0.000***)	5.286	(0.000***)	2.688	(0.000***)
Municipal containers	-0.311	(0.725)	-0.452	(0.532)	0.022	(0.970)
Waste segregation	2.295	(0.000***)	1.095	(0.064*)	2.222	(0.000***)
Place. of containers	0.138	(0.834)	-0.301	(0.584)	0.191	(0.695)
Membership to CBO	0.145	(0.804)	0.650	(0.204)	0.299	(0.521)
Recycling practise	-1.097	(0.136)	-0.346	(0.570)	1.083	(0.057*)
Disposal Returns	-0.015	(0.003***)	-0.007	(0.038***)	0.011	(0.004***)
Distance to main roads	-0.311	(0.160)	-0.460	(0.028***)	-0.298	(0.123)
Slum/sack gardens	1.968	(0.004***)	1.49	(0.013***)	0.475	(0.432)
Livestock keeping	-0.488	(0.492)	1.028	(0.019***)	1.088	(0.022***)
Cons	-6.362	(0.186)	-6.55	(0.127)	-2.726	(0.478)

Notes: Figures in parenthesis are p-values. R^2 =0.35, Log likelihood = -209.67   LR χ^2 (48)= 225.91,   Prob > χ^2 =0.000   * 10 percent   ** 5 percent   *** 1 percent significance level, Disposal in open areas and roadsides is the option left as reference (base case outcome),   Number of observations 250, natural log of income.

Source: Survey data, 2012

In this analysis, the multinomial logit model regression sets by defualt the option with the highest

frequency of occurence as the base outcome. Therefore in this study, solid waste disposal (in

open areas, along the roads and rivers) is used as the base category for no choice and the other

choices are evaluated as the alternatives to this option. The marginal effects for three other

choices are shown as in table 4.5below.

Table 4.5 Marginal effects Dy/Dx of the MNL regression model

Independent variables	(Dy/Dx) : Burning		(Dy/Dx): Reuse		(Dy/Dx) : Recycle	
Household Socioeconomic features						
Years schooling	0.006	(0.401)	0.004	(0.753)	0.025	(0.048**)
Income	0.010	(0.806)	0.066	(0.381)	-0.021	(0.755)
Years of stay	-0.002	(0.746)	0.006	(0.580)	-0.017	(0.119)
Home ownership	0.200	(0.123)	-0.139	(0.276)	-0.002	(0.976)
Family Size	0.028	(0.010***)	0.004	(0.853)	-0.021	(0.336)
Institutional factors						
Waste reg. of 2006	-0.067	(0.188)	0.189	(0.012***)	0.039	(0.583)
Contractual Arrang.	0.102	(0.019***)	0.623	(0.000***)	-0.057	(0.285)
Municipal containers	-0.017	(0.798)	-0.078	(0.477)	0.043	(0.691)
Waste segregation	0.121	(0.058*)	-0.052	(0.513)	0.277	(0.002***)
Place. of containers	0.016	(0.740)	-0.080	(0.429)	0.054	(0.490)
Membership to CBO	-0.014	(0.758)	0.107	(0.237)	0.004	(0.953)
Recycling practise	-0.056	(0.192)	0.022	(0.843)	0.140	(0.060*)
Disposal Returns	-0.001	(0.024***)	-0.003	(0.057*)	0.001	(0.072*)
Distance to main roads	-0.008	(0.634)	-0.062	(0.066*)	-0.016	(0.597)
Slum/sack gardens	0.154	(0.079*)	0.187	(0.092*)	-0.094	(0.089*)
Livestock keeping	-0.091	(0.336)	0.132	(0.145)	0.142	(0.271)
Notes: Figures in parenthesis are p-values. * 10 percent ** 5 percent *** 1 percent significance level, Number of observations 250 , Note: (*) Dy/Dx is for discrete change of dummy variable from 0 to 1, natural log of income.						

Source: Survey Data 2012

Results show that the key factors determining the choice of burning as a solid waste management

option are education, family size, contractual arrangements with private waste collectors, diposal

returns, waste segregation and ownership of slum/sack garden.Factors influencing reuse include; waste regulations of 2006, contractual arrangements, waste segregation, disposal returns, distance to the main road, ownership of slum/sack garden and livestock keeping.On the other hand recycling is influenced by factors such as; years of schooling, contractual arrangements, waste segregation, recycling practise, disposal returns and livestock keeping. Detailed explanation of each of this factors per waste management option follow below.

4.1.5 Discussion on Waste Management Options

4.1.5.1 Burning

Factors influencing burning as a household waste management option are explained below.

Education

Education is an important factor influencing household solid waste management option decisions. Results indicate that the estimated coefficients for years of schooling is positive and statistically significant at 5 percent for burning.Marginal effects show that, as years of schooling increase, the opportunity for solid waste management by burning increases by a substantial 9.6 percent.This means that households with higher education level preferred burning and recycling most of their solid waste than disposing off openly, implying that better educated households make reasonable waste management decisions as compared to their less educated counterparts.

Family size

Family size has a positive estimated coefficient and is significant at 1 percent for burning. Households with large number of members were likely to burn their waste than those with few members.This was because they produced large amounts of inorganic waste such as plastic paper bags and sanitary towels that could easily be burnt.Burning was therefore more preferred to such

households.A number of individuals have various myths about exposing used sanitary pads, hence the preference to burning.Burning was also done to produce ash that was used to improve soil fertility for the slum/sack gardens for vegetable production.

Contractual arrangements

Contractual arrangements had a positive coefficient and was significant at 1 percent for burning. The marginal effect of contractual arrangements to solid waste burning in Kibera slum was found to show an increased likelihood of proper waste management by a substantial 1.9 percent.These results implied that households involved in contractual arrangements were more likely to manage their waste by burning in order to save on costs.

Waste segregation

Unlike disposal in opens areas and roadsides where households threw all waste together without separating it, waste segregation was found to have a positive coefficient to burning and was statistically significant at 1 percent.The marginal effects showed that a 1 percent increase in solid waste segregation led to a 5.8 percent increase in solid waste burning.This implies that waste segregation enables households separate waste into categories encouraging households to manage their waste using various management options among which some households choose to burn their waste.

Disposal returns

Coefficient for disposal returns are negative for solid waste burning.Marginal effects indicate that as burning increases by 9.2 percent, solid waste disposal returns decreases.Waste burning is

cost free and some households may end up burning waste that could have otherwise been recycled to increase income hence the negative effect.

Ownership of slum/sack gardens

Ownership of slum/sack gardens coefficient was positive and statistically significant at 1 percent for burning in reference to disposal.This implied that those households who burnt their solid waste, produced ash which increased the probability of being reused as manure in the slum/sack gardens to improve soil fertility.

4.1.6.2 Reuse

The choice of solid waste reuse by households of Kibera slum was influenced by a number of factors as described below.

Knowledge of waste management regulations of 2006

The coefficient for knowledge of waste management regulations of 2006 to solid waste reuse was positive and significant at 1 percent.Also as the awareness of the waste management regulations of 2006 increases, solid waste reuse increases by 1.2 percent as indicated by the marginal effects. This therefore implies that increasing educational campaigns will create the awareness of the contents of the waste management regulations leading to increased solid waste reuse and hence sustainable solid waste management.

Contractual arrangements

Relative to disposal in open areas and roadsides, contractual arrangements had a positive coefficient and was significant at 1 percent for reuse.The marginal effect of contractual arrangements to solid waste reuse indicated that payment to private waste collectors to manage

household solid waste in Kibera slum increased the likelihood of proper waste management by a substantial 1 percent for solid waste reuse.These results implied that households involved in contractual arrangements were more likely to increase solid waste reuse. Contracts limit the amount handled in a given period due to the cost issue, hence households control what the contractors take through reuse and recycling.

Waste segregation

Coefficient estimate for solid waste segregation was found to be positive and significant at 5 percent in reuse.Waste segregation is a key component in intergrated solid waste management hence enhancing proper household solid waste management . Waste segregation encourages solid waste reuse hence sustainable solid waste management.

Disposal returns

Coefficient estimate of disposal returns to solid waste reuse is positive and statistically significant at 1 percent.Marginal effects also show that as waste reuse increases, disposal returns increase by a substantial 7.9 percent. This implies that households can reuse solid waste ash in slum/sack gardens and/or vegetable remains to feed livestock. Indirect returns are obtained from sale of the vegetables from the slum/sack gardens and or livestock to get extra income giving them an incentive to increased solid waste reuse.

Distance to the main roads

The results further showed that distance to the main road had a negative coefficient that was statistically significant at 1 percent to reuse as compared in reference to disposal. The marginal effects indicate that as distance to the main road decreases by 6.6 percent solid waste reuse

declines. Close to the main road, commercial activities increase attracting high population density hence making land for slum/sack garden establishment and livestock keeping scarce.

Ownership of slum/sack garden

Ownership of slum/sack garden coefficient estimate was positive and significant at 1 percent for solid waste reuse.Marginal effects show that waste reuse increases as ownership of slum/sack increases by 1 percent.This implies that solid waste ash is important for reuse in slum/sack garden to improve soil fertility.

4.1.7.3 Recycling

The following factors influence solid waste recycling in kibera slum.

Education

Coefficient estimate for education was found to be positive and statistically significant at 1 percent for recycling.The marginal effects show that as the number of years of schooling increase, the opportunity for solid waste recycling also increases by a substantial 4.8 percent. Education ehnances the ability of households to perceive and conceptualize waste management options by influencing the depths and richness of social networks that produce skills relating to effective contribution to a clean, safe and sustainable environment.This means that households who have more years of schooling have a higher probability of recycling solid waste because they are better placed in perceiving and conceptualizing the benefits that accrue from reducing waste build up through recycling.

Contractual arrangements

Contractual arrangements had a positive coefficient and was significant at 1 percent for recycling.This implies that households engaged in waste disposal with private collectors (*Kazi kwa Vijana groups*) were likely to pay for the other waste disposal and recycle the rest to generate additional income to cater for the disposal charges among other needs.

Waste segregation

Unlike disposal in opens areas and roadsides where households throw all waste together without separating it, waste segregation as expected was found to have a positive coefficient estimate and was significant at 1 percent for recycling.Marginal effects show that a 1 percent increase in solid waste segregation leads to 0.2 percent increase in solid waste recycling.Waste segregation is a key component in intergrated solid waste management hence enhancing proper household solid waste management .Waste segregation allows households to separate solid waste into categories; recyclable with direct market potential, recyclable with non direct market potential and non-recyclable.These findings imply that those households who are willing to segregate solid waste are able to value the waste accordingly and are more likely to engage in recycling and burning more than those who stuff solid waste together and dispose off. Segregation of solid waste also enhances its recycling and burning to produce ash which is converted into manure for soil ehancement.

Community based recycling practise

The marginal effect of participation in community based recycling practise increased the probability for solid waste recycling by 6 percent. This is because households come together and form community based organisations that get involved in solid waste recycling business. They

buy and sell scrap metal and plastics. Such an example is the *Solidarity* group (that was formed during the French sack garden Project in 2007,) and *Taka ni Pato* among other small dealers that also recycles and reuses household solid waste.

Disposal returns

In reference to disposal, coefficient for disposal returns are positive and statistically significant at 1 percent for solid waste recycling. Marginal effects show that as waste recycling increases by 1 percent disposal returns increase by about 7.2 percent.This implies that households who recycle waste and get returns out of it begin to value waste and hence increase recycling. Practically, selling recyclables such as newspapers, plastic containers and scrap metal also generates income. This means that recycling presents an opportunity to increase household income hence making solid waste a valuable asset while at the same time enhancing livelihoods of residents in the slum.

Ownership of slum/sack gardens

Ownership of slum/sack gardens coefficient estimate was positive and significant at 1 percent for recycling.Marginal effects indicate that an increase in ownership of slum/sack garden increased waste recycling by about 8.9 percent. This implied a possibility of recycling waste into organic manure in Kibera slum for local and country wide organic manure supply.

4.1.6 Cost effective waste management option

The three waste management options require to be used together by any individual household in order to be able to manage household solid waste effectively. Among the three options assessed, waste burning is cost free in the short run and households burn the combustible waste at no

charge.However, households burn plastics and wooden waste which produces smoke mainly consisting carbon dioxide which in the long run will cause ozone layer depletion leading to climate change.However, waste recycling has direct benefits on income through the disposal returns realized from the sale of recyclables such as scrap metal, newspapers, and plastic containers. Households involved in contractual arrangements with households in Kibera slum pay a fee on weekly basis for their waste to be disposed off. Besides, households realize extra income termed as disposal returns from waste recycling and reuse. For this reason, disposal returns have a positive influence on the choice of reuse and/or recycling as waste management options in the slum. Therefore, recycling and reuse are important in improving the livelihoods of households in the slum while at the same time ensuring sustainable waste management.

Years of stay, home ownership, access to municipal containers, placement of containers near household houses and income, however did not significantly influence any of the solid waste management options

CHAPTER 5 SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Summary and Conclusions

This study focused on the determinants of household solid waste management options in Kibera slum.It identified both positive and negative influence on socioeconomic, agricultural and institutional attributes. The specific objective of the study was to assess the determinants of households'choice of waste management options by residents in Kibera slum with a view to derive policy reccommendations for sustainable solid waste management. The study utilized primary data collected from households in Kibera slum and multinomial logit econometric model was used to analyze the data .

Empirical analysis has revealed that years of schooling, family size, contractual arrangements, knowledge of waste management regulations of 2006, waste segregation and ownership of slum/sack gardens positively influence waste management options. Distance to the main road negatively influences solid waste management options while the influence of disposal returns to waste management options is indeterminate (negative influence on burning and reuse and positive influence on recycling).

This study found out that education level is key in waste reuse and recycling decisions. Reuse and recycling reduces waste disposal both in public places and also in landfills. The government should encourage education especially on proenvironment behaviour with specific emphasis on waste handling practices and waste management regulations of 2006. It should also encourage public health education to households on the effect of adopting poor waste management practises both to the environment and human wellbeing.

Results also show that, it is not the household socioeconomic factors that influence the household's choice of waste management options in Kibera slum, rather they are the institutional factors that influence the choice of waste management options that households decide to use to manage their waste.Therefore, the government in particular, NEMA, should promote and advocate for effective policy implementation, infrastructure development and public education to solve the problem of waste management in Kibera slum.

Further, findings on the study show that contractual arrangements encourage recycling and reuse and is expected to discourage disposal in open areas and roadsides.This implies that government, private sector and community based recycling groups should encourage households to take responsibility in proper waste management.Households should therefore be encouraged to willingly pay for waste collection and disposal by private collectors or community based groups such as the *Kazi kwa Vijana* groups in order to enjoy the right to a clean and healthy environment as per the supreme law of Kenya.

Programs of separation of recyclable waste from non-recyclable household solid waste and environmental education must be created to foster a deeper meangiful individual understanding of the separation, reuse and recycling activities of solid waste.Waste segregation at the household level needs to become a new waste management policy reduction effort or by-law to enhance solid reuse.The municipal council should provide containers at the household level to promote the separation of solid waste into the different categories for easier management.

Participation in community based recycling practise also encourages solid waste recycling. The government, NGOs and proenvironment organisations such as Greenbelt Movement should

encourage households to take part in recycling practices by forming community based groups engaging in recycling activities.These stakeholders should therefore increase awareness and financial support in order to ensure that households adopt sustainable waste mangement practises.

Disposal returns realised encourages waste reuse and recycling and discourages solid waste burning.This is to imply that the government should promote entreprenuership in waste reuse and recycling business as a solution to the current unemployment levels among the youth. This can be reinforced by giving loans from *Youth Fund* to Kibera residents to start business in waste recycling and livestock feed reuse.The government should also promote waste reuse and recycling since these two options increase the income of households through direct and indirect returns and hence are important in improving household's welfare.

Distance to the main roads discourages reuse of household solid waste and encourages waste disposal.Advocacy and education on waste management regulations of 2006 should be emphasized by the city council in colaboration with NEMA.The penalties on disposal of waste in open areas and roadsides as cited in the waste management regulations of 2006 and the Environmental Management and Coordination Act should be made public through campaigns.
Ownership of slum/sack gardens encourages burning and waste reuse.The government should encourage the ownership of slum/sack gardens as part of the strategy to increased food security to meet Vision 2030 and millenium development goal on poverty reduction.Waste reuse and burning should be encouraged since burning is not only a method of disposing inorganic non-recyclable combustible waste, but also produces ash which has macronutrients for increasing soil fertility.

5.2 Reccomendations

In Kibera slum there is a grave environmental risk associated with unauthorised household solid waste disposal along the roads/railway line and in the river.The management of any environment has a high proportion of public good, and needs to be treated so. It may be necessary to empower the *Kazi Kwa Vijana* programs in Kibera slum who are currently managing household solid waste to facilitate a short term solution to solid waste management.

The government may consider integrating a community based residents programs designed specifically to promote pro-environmental behaviour such as waste reduction and increased practice of waste reuse and recycling as per waste management regulations cleaner production principle. However, such efforts need to be supported by the municipal authority and NEMA through campaigns on waste collection, sale of recyclables, reuse and the licensing of designated waste receptacle which is currently a key contributor to the waste mountains along the roads and in public places in the slum.

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APPENDIX I Variance inflation factor results for multicollinearity test

Variable	VIF
Plcont	1.16
Mnct	1.15
Yrstay	1.13
Dismn	1.12
Mrship	1.12
Hhsze	1.12
Cntrar	1.09
Yrsch	1.09
Combse	1.09
Lvsk	1.09
Lnincome	1.09
Munrg	1.09
Hsown	1.09
Slumsak	1.07
Disrtns	1.06
Wstseg	1.05
Wstreg	1.05
Mean VIF	**1.1**

There was no multicollinearity problem because VIF is less than 10 for the explanatory variables

APPENDIX II Assumption of Normality test

Skewness/kurtosis tests for Normality				
			Joint	
Variable	Pr(Skewness)	Pr(Kurtosis)	adj chi^2(χ^2)	Prob>chi^2 (χ^2)
Yrsch	0.756	0.088	3.02	0.2208
Cntrar	0.001	0		0
Income	0	0		0
Yrstay	0	0		0
Hsown	0	0	73.47	0
Dismn	0	0		0
Hhsze	0	0.024	20.76	0
Wstreg	0	0		0
Wstseg	0	0		0
Mnct	0	0		0
Plcont	0	0	44.44	0
Lvsk	0	0		0
Slumsak	0	0		0
Combse	0	0		0
Disrtns	0	0		0

Assumption of normality not violated

APPENDIX III Assessment of goodness of fit

Measures of Fit for multinomial logit model

Log-Lik Intercept Only:	-318.16	**Log-Lik Full Model:**	-207.65
D(196):	415.292	**LR(51):**	221.028
		Prob > LR:	0
McFadden's R^2:	0.347	**McFadden's Adj R^2:**	0.178
Maximum Likelihood R^2:	0.587	**Cragg & Uhler's R^2:**	0.637
Count R2:	0.504	**Adj Count R^2:**	0.133
AIC:	2.093	**AIC*n:**	523.292

The model fitted well with a McFadden's R2 of 0.347 and a Maximum Likelihood R2 of 0.587 as explained in the study.

APPENDIX IV Hausman test results for IIA

Omitted	chi^2(χ^2)	Df	P>chi^2(χ^2) evidence
1	30.792	37	1 for Ho
2	13.002	36	1 for Ho
3	25.646	38	1 for Ho
4	22.94	37	1 for Ho

There is evidence that the model did not violate the Irrelevant Independent assumptions.

APPENDIX V Questionnaire for Household Solid Waste Management in Kibera Slum, Nairobi

GENERAL INFORMATION

Date of interview (**dd/mm/yyyy**)...

Name of Enumerator...

Approved by... Date of approval....................................

HOUSEHOLD AND SITE IDENTIFICATION

Name of Respondent...

Sublocation...

HOUSEHOLD DETAILS

Variable	Variable values *(Circle appropriately)*
1. **Family Position of the Respondent**	
2. **What is your Age in years?**	
3. **Gender**	*1=Female 0=Male*
4. **How many years have you been in school?**	
5. **What is your marital status?**	1. *Married* 2. *Single* 3. *widow/widower* 4. *Separated*
6. **What is your KEY employment status?**	1. *Full-time employee* 2. *Self-employed* 3. *Casual* 4. *Unemployed* 5. *Other*

	(specify.. ....)
7. **How much income on average in (kshs) do you earn per month from:**	*-Agricultural production..................................* **-***Selling* *plastics,bottles,newspaper.........................* *-Other (specify...)*
8. **How many years have you stayed in this house?**	
9. **Do you own this house you stay in?**	*1=Own 0=Rented*
10. **How far is your house in Kilometers (Km) from the main road?**	

HOUSEHOLD FAMILY MEMBERS

Name of family member Start with the Respondent	Gender Codes: 1.female 0 Male	Relation to HH Codes 1. Related 0. not related	Age (Years)	Years of schooling	Employment status 1.Employed 2. Student 3. Casual 4.unemployed 5.Other specify...................	Salary/Wages received per month
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

CHARATERISATION OF HOUSEHOLD SOLID WASTE

1) What type of household solid waste do you produce?

Types of wastes	Rank in terms of quantities produced from the highest to the lowest	Characteristics of waste(use codes below)
1. Vegetable remains (*sukumawiki sticks, potato peelings,cabbage remains, food remains*)		
2. Plastic containers		
3. Torn Plastic paper bags		
4. Ash		
5. Diapers and sanitary towels		
6. Metal		
7. Glass(soda bottles, beer bottles)		
8. Broken glass		
9. Paper (*old newspaper*)		
10. Wood waste		
11. Rubber		
12. Others		

Codes   1. Recyclable   2. non-recyclable

2. Please describe how your household MOSTLY gets rid of the following types of garbage from your house (*Tick one appropriately*).

	Dump								
	Burn	**River /gulley**	**Along the road**	**Feed livestock**	**Sale for Recycle**	**Reuse**	**Compost**	**Beside the house**	**Slum/ Sack garden**
Type of garbage	1	2	3	4	5	6	7	8	9
1. Vegetable remains (*sukuma wiki sticks, potato peelings, cabbage remains, food remains*)									
2. Plastic containers									
3. Torn Plastic paper bags									
4. Ash									
5. Diapers and sanitary towels									
6. Metal									
7. Glass(soda bottles, beer bottles)									
8. Broken glass									

9. *Paper (old newspaper)*								
10. *Wood waste*								
11. *Rubber*								
12. *Others*								

INSTITUTIONAL FACTORS

1. Do you know about the waste management regulations of 2006? *1= Yes   0= No*

2. How much do you know about the following?

Solid waste management option	Codes
Compositing (for agricultural use)	
Disposal (in dumpsites, along the road **etc**)	
Reuse (use again for other purposes)	
Recycle(Reprocess to new products)	

Codes 1=well   2=Fair   3=Just heard   4=None

2. Which one among the following waste management companies **MOSTLY** disposes your

household solid waste? *(Choose one)*

Company Name	Name	Service frequency	Type of containers Provided	Waste Collection service received	Amount Paid (Kshs)
Private waste companies					
Community based organization					
Municipal council					

Codes
1. Service frequency *1= Daily   2= Weekly   3 = Never*
2. Waste collection service received *1= Door-to-door 2=Collection trucks   3= Others*

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Type of containers 1 =Plastic Buckets 2 =Plastic paper bags 3 = Others

(If Household's waste is disposed by either private waste company or a community based organisation please fill in either private waste collection services or community based sections below accordingly)

PRIVATE WASTE COLLECTION SERVICES

1. Do you have any contractual arrangements with private waste collectors for your solid

   waste disposal?   *1= Yes   0=No*

   (If yes go to Q2)

2. What type of contract do you have with them? *1= verbal agreement   0=signed*

   agreement

3. Do you segregate solid waste before giving it out to the private waste collector for

   disposal*? 1=Yes   0= No*

4. Do you know what they do to the solid waste after they collect it from

   you?**..**

MUNICIPAL SERVICES

1. Do you have access to municipal waste disposal containers? *1= Not enough 2=Enough*

   Access 0=None at all

2. What is the distance of the waste containers from your house?**....................................**.

3. What is your view on the placement of the containers near your houses? **1=agree   0=**

   Disagree.

4. Are you aware of any municipal council regulation in place to make sure households are

   using the containers properly or not? *0=None   1=Regulation is weak   2=Strong*

   Regulation

COMMUNITY BASED ORGANISATION

1. Do you have any contractual arrangements with any community based organisation for your solid waste disposal? *1= Yes   0=No*

    (If yes go to Q2)

2. What type of contract do you have with them? *1= verbal agreement   0=signed agreement*

3. Are you a member of this community based organisation? *1=Yes   0=No*

    (If yes Go to Q4, If No Go to Q5)

4. What benefits do you get as a member from the community based organisation?**...**

5. Do you do any farming as a group? *1= Yes   0=No*

    If yes, what Kind of farming do you do?**..**

6. Do you segregate solid waste before giving it out to the community based organisation for disposal*? 1=Yes   0= No*

7. Do you know where they dispose off the waste after they collect it?**..**

AGRICULTURE

1. Do you have slum/sack gardens? *1=Yes   2= No*

    (If yes go to Q2, If No go t*o* Q4)

2. What type of crops do you grow in the slum/sack gardens? *1=Kales   2= Maize*

3= Others specify..

3. Do you use organic manure to improve soil fertility before planting your crops in the sack/slum garden*? 1=Yes   0=No*

If yes, where do you obtain your manure from,

 1 =*Waste disposal space* 2=*Households* 3= *Other specify...........................*

3. Do you keep any type of livestock? *1=Yes 0=No*

If yes, what type of livestock do you keep? *1=Rabbit 2=Goat 3=Sheep*

4=Pigs 5. Poultry 6. Other…............................………………..

WASTE RECYCLING

1. Do you participate in any community based waste recycling practice? *1= Yes 0=No*
        If yes
3. What is the name of the community based recycling organization?**..**

4. To whom do you sell the following types of waste?

Types of solid waste	Company/dealer/community based group name	Amount	Frequency
1. Plastic containers			
2. Metal			
3. Glass(soda bottles, beer bottles)			
4. Broken glass			
5. Paper(old newspaper)			