KNOWLEDGE, ATTITUDE, PRACTICES, AND WILLINGNESS OF INSECT-BASED ORGANIC WASTE MANAGEMENT IN NAIROBI COUNTY, KENYA

WAMWONDWE TERESIA GATHONI

A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for the Degree of Master of Science in Agricultural Economics of Egerton University

EGERTON UNIVERSITY

FEBRUARY, 2025

DECLARATION AND RECOMMENDATION

Declaration:

This Thesis is my original work and has not been presented for an award of a degree, diploma,or certificate in Egerton University or any other University.

Signature……   Date…19/11/2024……….

Wamwondwe Teresia Gathoni

KM15/13011/21

Recommendation:

This Thesis has been submitted with our approval as Egerton University and ICIPE supervisors

Signature ..   Date …26/11/2024…………..

Prof. Hillary Bett

Department of Agricultural Economics and Agribusiness Management,Egerton University, Njoro

Signature……………………..   Date …19/11/2024………….

Dr. Beatrice Muriithi, PhD

Social Science and Impact Assessment Unit,ICIPE

Signature……   Date …19/11/2024………….

Dr. Chrysantus M. Tanga, PhD

Head of Insects for Food, Feed and Uses (INSEFF) Programme,ICIPE

COPYRIGHT

DEDICATION

This thesis is dedicated to my parents Mr. Simon Wamwondwe and Mrs. Idah Karimi who have invested their time and resources in support of my academic pursuit; my brothers Fr. Stephen Githaiga, Michael Njeru and my sister Sylvia Mukami for being a great source of inspiration and motivation. To my late grandma, Silveria Ciambaka, who ensured that through it all, she educated her children and enlightened everyone she met on the importance of education.

ACKNOWLEDGEMENTS

My sincere gratitude to God for life and good health throughout my academic journey. I would like to acknowledge International Centre of Insect Physiology and Ecology (ICIPE) for funding this research, my Master of Science degree, and Egerton University for the conducive learning environment. Special appreciation to my supervisors Prof. Hillary Bett, Dr. Beatrice Muriithi and Dr. Chrysantus Tanga for their guidance, keen interest and relentless support. I am equally indebted to the entire staff of the Department of Agricultural Economics and Agribusiness Management and Faculty of Agriculture of Egerton University for their invaluable insights and constructive criticism during my pursuit of Master degree period. Finally, I appreciate my colleagues, friends and family for their useful insights. The enumerators, organic waste producers and collectors from Nairobi County are acknowledged for their collaboration during the entire field work.

ABSTRACT

Organic waste management remains a great challenge, particularly in the rapidly growing urban areas. However, despite insects being a possible solution to the organic waste problem, its adoption rate is low. This study surveyed 485 organic waste producers and collectors in Nairobi County, that were selected using a multi-stage technique, to map and characterize the respondents, assess factors influencing their knowledge, attitudes, and practices (KAPs) and the extent of willingness to use insect-based technologies to recycle organic waste into value-added products. Logistic regression, multinomial logit, and Tobit model were used for analysis. Each household produces approximately 1.53 kgs of organic waste daily, with most waste being kitchen waste while other organic waste producers produce higher kgs. A waste collector collected approximately 21.67 tonnes of waste daily. Most respondents (98.6%) knew about insect-based waste management, with 80% showing positive attitudes and 57.4% practicing it. About 71 % of the respondents segregated organic waste. Black soldier flies (33.8%), crickets (10.2%), mealworms (5.3%), and cockroaches (3.9%) were the most known insect species. Pig and poultry farmers were the most willing to add value (89%), while 75% of respondents were willing to sell the waste if not in a position to add value. The amount of waste the respondents were willing to recycle was highly influenced by market availability and cost-effectiveness. Despite most respondents possessing good knowledge, positive attitudes, and willingness to add value using insects, only a few of them recycled organic waste using this approach, with the majority citing ineffectiveness of trainings on organic waste management using insects which is crucial for the enhanced adoption of this innovation. It is recommended that there be collaboration with legislators for incentives and policies that foster market acceptance, and enhance cost-effectiveness through partnerships and subsidies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA: Analysis of Variance

C1DP: County Integrated Development Plan

ICIPE: International Centre of Insect Physiology and Ecology

KAPs: Knowledge, Attitude, and Practices

MSW: Municipal Solid Waste

NEMA: National Environment Management Authority

UNEP: United Nations Environment Programme

UNSD: United Nations Statistics Division

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Waste refers to "materials that are not prime products for which the generator has no further use for his own purpose of production, transformation or consumption, and which he discards, or intends or is required to discard." However, upon recovery, re-use or recycling at the source of generation, these materials cease to be wasted (UNSD & UNEP, 2010). The management of municipal solid waste (MSWM) comprises resource recovery, collection, transfer, recycling, and treatment (Henry *et al*., 2006). The main goals of MSWM are to protect public health, advance environmental quality, foster sustainability, and boost economic output. Poor organic waste management is a global concern (Silpa *et al*., 2018). It is exacerbated by rapid urbanization leading to significant population growth in urban areas (Gumbo & Simelane, 2015). Also, among other wastes, organic waste management is more difficult to manage because of its bulky form and quick degradation (Surendra *et al.*, 2016). Urbanization without economic and employment growth has led to wide practice of urban agriculture as a way to supplement household income, contribute to food security, and poverty alleviation. To boost urban agriculture, key aspects of waste hierarchy; reduction, reusing, recycling, and recovering need to be incorporated in waste management policy formulation (Drechsel & Kunze, 2001).

According to the World Bank (2012) urban areas worldwide had a population of about 3 billion in 2012 with everyone producing a daily average of solid waste weighing approximately 1.2 kg. The expected urban resident production of waste daily is 1.42 kgs by 2025. Approximately 3 to 4 billion tons of solid waste and up to 300 million tons of hazardous waste are generated worldwide (Nabegu, 2010). This substantial amount of solid waste poses serious environmental risks such as disease outbreaks, ecosystem degradation, soil and water pollution, global warming, and climate extremes (United Nations Environmental Programme, 2011).

In many developing countries, including Kenya, solid waste management in urban areas poses a significant challenge due to inefficient and haphazard disposal systems (Henry *et al*., 2006). According to the World Bank (2020) 2400 tonnes of solid waste are generated daily in Nairobi County by households, industry and commercial sectors. The percentage of waste collected ranges from 35 to 68, a range that aligns with waste collection rates observed in other urban councils in developing nations (Palczynski, 2002; Scheinberg, 2011; Supriyadi *et al.*, 2000; Vidanaarachchi *et al*., 2006). Most of the waste collected, exceeding 50%, consists of organic solid waste. The potential reusability of Nairobi's waste reaches 93%, yet only 10% is recycled and composted despite the establishment of Nationally Appropriate Mitigation Action (NAMA), 2016) (Henry *et al.*, 2006). Roughly 60% of the collected waste ultimately ends up in partially controlled dumpsites and landfills. According to a report by Kimani *et al*. (2007), in the Dandora dumping site, to accommodate additional waste, an earth mover is employed to spread the waste, leading to a portion of it being unintentionally pushed into the Nairobi River. This increases the risk for downstream communities that rely on the river for domestic and agricultural activities. The study also noted that from 2003 to May 2006, an average of 9,121 individuals annually sought treatment at the center for respiratory tract issues.

Agricultural waste, including field and process residues, is a valuable resource that is often not fully utilized (Sadh *et al*., 2018). Field waste has been employed for soil moisture and erosion control purposes. In developing countries, agricultural waste has also been converted into charcoal briquettes (Sabiiti, 2011). However, the primary uses of agricultural waste are fertilizer and animal feed (Dou *et al*., 2018; Menyuka *et al*., 2018; Saravanan *et al*., 2013; Wadhwa & Bakshi, 2013). Truong *et al*. (2019) pointed out that as more corn is diverted from animal feed to biofuel production, there will be an increased demand for alternative animal feeds, which could be met by utilizing the abundant agro-food waste. This integration of waste into animal feeds is expected to reduce greenhouse gas emissions by 3.7 million metric tonnes of carbon dioxide.

The source and accessibility of agro-food waste are crucial factors in estimating its demand. Agro-food waste is mainly obtained from residential, industrial, commercial (hotels, stores, restaurants, markets, and offices), institutional (schools, hospitals, prisons, government centers), municipal services, and agricultural sources (farming households) (UN, 2000; World Bank, 1999). This implies that transaction costs are expected to be a significant consideration in acquiring agro-food waste, which could potentially hinder its utilization (Asian Development Bank, 2011).

To boost urban agriculture and reduce environmental impacts, key aspects of waste management hierarchy; reduction, reusing, recycling, and recovering need to be incorporated in waste management policy formulation (Drechsel & Kunze, 2001). Despite several obstacles, MSW created in developing countries offers immense opportunities for resource recovery, recycling, reuse, and job creation (Alwaeli 2015; Vaish *et al*., 2019). For example, the organic portion of urban waste can be used to produce biogas, compost, and energy, which will help society economically and sustainably in the long run (Srivastava *et al*., 2023). The practices of composting and utilizing raw materials such as poultry waste, cow dung as manure, and food waste from hotels, markets, and other institutions as animal feeds play a crucial role in diminishing the amount of organic waste that needs to be disposed of in Nairobi (Baud *et al*., 2006). Yet, in addition to being expensive, the current methods of managing organic wastes—land filling and treating/stabilizing waste through anaerobic digestion and composting—have negative effects on the environment, including contaminating ground and surface waters and emitting greenhouse gases (Surendra *et al.*, 2016).

However, the rapid degradation of waste by insects such as black soldier fly (BSF) larvae, ranging from 40% to 80% efficiency according to studies by Diener *et al.*(2011), allows them to convert organic wastes into organic fertilizers within a shorter timeframe (less than or equal to 5 weeks) compared to traditional composting methods that typically take 8 to 24 weeks. This innovation has the potential to significantly benefit a large population of farmers in a short period by providing them with high-quality and cost-effective organic fertilizers. (Beesigamukama *et al*., 2023). The commercialization of insect-based bioconversion is therefore an emerging and promising approach to address poor organic waste management globally (Nyakeri *et al*., 2017; Wang & Shelomi, 2017).

Through BSF farming, the US could substitute over 60 million tons of insect-based animal feed production annually, leading to 200 million tons of recycled organic waste, 60 million tons of organic fertilizer production, and 15 million jobs while saving 86 million tons of carbon dioxide emissions (Abro *et al*., 2020). Considering the global estimates of food waste reaching 1.3 billion tonnes and continuing to increase, along with the growing demands for protein, biofuels, and fertilizers, businesses adopting insect-based bioconversion present economically viable options (Barry, 2004; FAO, 2017; Parfitt *et al.*, 2010; Timmermans *et al*., 2014).

In addition to the economic benefits, insect-based bioconversion of food waste that would otherwise be discarded provides a valuable means of recirculating nutrients and resources back into agricultural production. This aspect resonates with environmentally conscious consumers who are increasingly concerned about sustainability (D'Souza *et al*., 2007). Therefore, the utilization of insect-based bioconversion becomes an attractive and marketable asset for businesses catering to sustainability-minded customers. As insects are a natural component of the diets of many animals and are used to feed farmed animals such as fish, poultry, and pigs (Sogari *et al*., 2019).

For the successful implementation of insect-based waste management practices, assessing the knowledge, attitude and practices of waste producers and collectors and their willingness to embrace these approaches and actively participate in the value addition process is crucial. Insects play a crucial role in cultural diets by serving as supplementary food sources, offering substantial nutritional and economic advantages to rural communities (Van Huis *et al*., 2013). They also offer a solution to the increasing demand for animal-based protein while avoiding deforestation as by traditional livestock grazing, or competition for foods such as soya beans that could be otherwise used for human consumption (Poma *et al.,* 2017). In East Africa, the practice of insect farming for food and feed is a recent development, but more than 75% of farmers and feed millers have indicated a readiness to embrace these technologies (Tanga *et al*., 2021).Unfortunately, indigenous knowledge and practices related to insects are in danger of disappearing before they are adequately documented.

Traditionally, insects have been overlooked, especially in terms of understanding how to sustainably manage them as a food source to enhance food security (Van Huis, 2003). Also, despite the benefits, the widespread adoption of insects as a protein source faces significant challenges including low acceptance of insects as food among consumers (Mlcek *et al*., 2014). Attitudes towards insect-based food are often rooted in psychological rather than rational reasons (Poma *et al.,* 2017). Also, the absence of clear regulations governing the production and sale of insect-based products is a challenge. It may discourage companies from entering the market, with some stakeholders perceiving the regulatory process as both expensive and time-consuming (Belluco *et al.*, 2017).

Limited studies have been carried out regarding factors influencing knowledge, attitude, and practices of organic waste producers and collectors regarding insect-based organic waste management and their willingness to enhance the value of insect-derived products. This study intends to fill that gap. The findings are critical in identifying gaps, barriers, and opportunities for organic waste management using insects. This information will inform policy makers and other stakeholders along the waste management value chain to make informed decisions, initiate targeted awareness and behavioural change campaigns and create policy and regulatory framework aimed at sustainable management of organic wastes using insect-based recycling technologies.

1.2 Statement of the Problem

According to the World Bank (2020), Nairobi produces approximately 2400 tons of solid waste daily and out of it, more than 50% is organic. Of the waste generated, only 45% is recycled. This is majorly attributed to the increased population in the region and poor waste management over the years. With the massive amount of organic waste, concurrently, food security remains a major threat in the country. Most policies established in line with organic waste management have not been successful, making extraction of recyclable materials from unsorted wastes impractical. Few studies in Kenya have been done in line with knowledge, attitude and practices of organic waste management and environmental economics. Also, despite insects being a possible solution to the organic waste problem, their adoption rate is low. Additionally, studies examining stakeholders' willingness to improve the value of the insect-derived products are scarce to fully comprehend the extent to which the efficiency of waste recycling could be improved.

Another challenge is that there is little information regarding the identification and categorisation of the different organic waste streams within Nairobi. Knowledge of the distribution and characteristics of waste across the country is vital in designing and putting into practice efficient insect-based waste management systems. This study aimed to fill the gap by mapping organic waste sources, determining factors influencing waste producers' and collectors' knowledge, attitude, and practices of organic waste management using insects, establish the extent of the willingness to add value to insect products and map and characterize organic waste sources in Nairobi County, Kenya.

1.3 Research Objectives

1.3.1 General Objective

To contribute to sustainable waste management using insects through a bio-circular economy approach in Nairobi County, Kenya.

1.3.2 Specific Objectives

i. To characterize and map organic waste sources in Nairobi County, Kenya.

ii. To determine the factors influencing knowledge, attitude, and practices of organic waste producers and collectors towards recycling organic waste using insects in Nairobi County, Kenya.

iii. To establish the willingness level of organic waste producers and collectors to add value to the segregated organic waste to insect products in Nairobi County, Kenya.

1.4 Research Questions

i. What are the locations and characteristics of organic waste sources in Nairobi County, Kenya?

ii. What factors influence the knowledge, attitude, and practices of organic waste producers and collectors towards organic waste management using insects in Nairobi County, Kenya?

iii. How willing are the organic waste producers and collectors to add value to the segregated organic waste to insect products in Nairobi County, Kenya?

1.5 Justification of the Study

Municipal solid waste management is a problem in most developing countries. This is mainly due to high population growth, poor infrastructure, urban planning, and implementation of set policies. This problem results in landfills and poor utilization of resources since the space occupied by waste could be used more efficiently. Organic waste reduction can help promote food security. Reducing losses and waste in agricultural and food systems could relieve part of the pressures on scarce resources and enhance food security as consumers will benefit by saving the money which they can use elsewhere (on food or non-food products) and it lowers the price of the remaining food that is consumed in the market (Rutten, 2013).

Even when food availability and affordability is a challenge, poor consumption patterns, low shelf life of agricultural products, and damage during transport encourage food insecurity. Poor waste management leads to soil degradation, negatively affecting urban agriculture. It also leads to climate change negatively due to the release of methane gas that pollutes the environment. Most waste management practices put in place end up failing because of poor organizational structures. There have also been cases of the reluctance of city council waste collectors to aggregate waste, while private collectors charge high costs that are not affordable by most residents resulting to illegal dumpsites or burning of waste. The relationship between private collectors, who mostly add value to organic waste, and public collectors has not been clearly established. However, there have been cases of private collectors not getting enough support from the city council who oversee waste collection and management in Nairobi.

Organic solid waste segregation, which could make waste recycling easier, is also barely practiced. Segregated organic waste allows direct treatment and recycling into Agri-economically viable products while taking into consideration the environmental aspect and contributing to a circular economy. Achieving organic solid waste management will contribute towards achieving Nairobi CADP 2022/2023 and Kenya's Vision 2030 on implementing waste management systems in cities, towns, and urban areas. The study also aligns with the National Solid Waste Management Strategy (NSWMS) by directly feeding into Kenya's National Solid Waste Management Strategy that contains goals of minimizing waste generation, recycling and recovery of resources. Since embracing organic waste disposal through insect-based value addition, the study supports upfront conservation techniques that mimic the NSWMS's intentions of improving resourceful waste management in Kenya.

In addition, it supports the Kenya Climate Change Act (2016). This research is relevant to combating climate change by decreasing methane emissions as a powerful GHG originating from organic waste in landfills. When segregation and insect-based recycling are used, organic wastes can be turned into a few valuable products and the volume of wastes that are produced can lowered and the negative effects that they could have on the environment can also be lowered. This is in line with Kenya's climate change policies such as the Climate Change Act that requires scaled down of greenhouse gases and encouragement of low emission, climate vulnerable development trajectories. Thus, combining these efforts with sustainable environmental policies, the study goes beyond the issues of waste management and relates to the consumption and production practices targeted by the guidelines at the national and international levels. It shall also promote attaining the sustainable development goals of number 12 of ensuring sustainable consumption and production patterns, 11 of sustainable cities and communities, and 13 of climate action by reducing the release of methane gas to the environment.

The study characterized and mapped organic waste sources in Nairobi County, determined the factors influencing knowledge, attitude, and practices of waste collectors and producers towards waste management using insects, and evaluated how willing they were to add value to the segregated organic waste to insect products.

1.6 Scope and Limitation

The study focused on Nairobi County since it produces the most waste due to the high population, and increased industrialization. It targeted waste producers; food processors, animal feed millers, pig and poultry farmers, commercial horticultural farms, and households and waste collectors as they are key stakeholders in organic waste management. Organic waste was used as it forms the highest percentage of waste. Waste management using insects was chosen because insect protein is highly nutritious and can provide a high-quality protein source for animal feed and fertilizer. Its numerous uses also make it more sustainable compared to other methods. The study focused on mapping organic waste sources, establishing knowledge, attitudes, and practices of waste producers and collectors towards organic waste management using insects and determining their willingness to add value to the segregated waste to insect products. The study was likely to be constrained by the failure of waste producers and collectors to give accurate information due to lack of proper record-keeping on generated waste. Probing was, however, used to curb this.

1.7 Operational Definition of Terms

Attitude- a feeling or opinion about something or someone, or a way of behaving that is caused by this

Insect products- products made from insects such as insect feeds, and fertilizers.

Mapping- the identification and characterization of organic solid waste segregation, waste streams, and establishing their potential GPS estimates

Organic waste- any material that is biodegradable and comes from either a plant or an animal.

Biodegradable waste is organic material that can be broken into carbon dioxide, methane or simple organic molecules.

Small population: A population with less than 100 persons

Urban farming- the production, distribution, and marketing of food and other products within the geographical limits of a metropolitan area

Value addition- the extra value created over and above the original value of something. It is the economic enhancement that a company gives its products or services before offering them to the consumer, which justifies why companies can sell products for more than they cost the company to produce

Waste- materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose.

Waste management- involves the processes of waste segregation, reduction, reusing, and recycling

Waste recycling- the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products

Waste reduction- the practice of preventing waste by decreasing or eliminating the amount of materials initially used.

Waste reusing- is the practice of using a material repeatedly in its current form.

Waste segregation- the sorting and separation of waste types to facilitate recycling and correct onward disposal

Willingness- consent or readiness to do something. An inclination or preference.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview of Mapping and Characterization of Organic Waste Sources

Solid waste generation rates and characteristics vary from country to country and are strongly correlated with factors such as socioeconomic status, public opinion, cultural customs, energy availability, geographic location, characteristics of local services, time of year, laws, etc (Srivastava *et al*., 2023). The lack of important solid waste management infrastructure, low coverage of solid waste collection, pollution from uncontrolled waste dumping, ineffective public services, unregulated and uncoordinated private sector, and low coverage of solid waste collection are the main characteristics of Nairobi's solid waste situation, which could be taken to generally represent Kenya's status (Njoroge *et al*., 2014). In Nairobi, there are more than 200 solid waste groupings, including Kamukunji, Dagoretti, Makadara, Lang'ata, Embakasi, Dandora, and Industrial Area (Kuria & Muasya, n.d.). They are however not specific on the waste type in these areas and those that have are yet to be mapped in a virtual map.

Most of these organizations are formally recognized as private collectors and rubbish picker groups. In Kayole, various waste types and volumes have been established. The appropriate facilities that compost, recycle, or recover the various waste types have also been located. Additionally, a spatial structure has been developed to make it easier to collect and move garbage, directing each sort of waste to the proper location for composting, recycling, or recovery (Kinyanjui, 2005). It was discovered that the area's wastes could be managed locally. The food and beverage sector, paper industry, agriculture, and households all produce organic waste streams.

In addition to residential waste, industrial waste, commercial waste, waste from construction and demolition projects, and waste from hospitals, schools, and road sweeping are all considered to be municipal solid waste. Household garbage makes up most municipal solid waste (Shi *et al*., 2021). The composition of household waste is more complex when compared to other waste sources, which presents more challenges for urban management.

Because socioeconomic and cultural factors affect patterns of consumption and production, the rate and type of solid waste generated varies among nations and regions. It is thus essential to comprehend the patterns of waste generation in both national and local contexts while accounting for socioeconomic considerations. Planning and actions related to waste management are informed by this understanding (Ngoc & Schnitzer, 2009). Estimating the required manpower, machinery, and supplies requires accurate data on solid waste generation and waste treatment techniques. Such information is useful in designing waste disposal systems, establishing general waste management policies and strategies, and determining the size and placement of garbage collection and segregation facilities (Ezeah & Roberts, 2012).

2.2 Knowledge, Attitude, And Practices of Waste Management

Understanding public concerns, preferences, knowledge, and behaviour is the first step toward achieving integrated municipal solid waste management (Chung & Lo, 2004). Public education and encouraging citizens to participate in the design of household recycling procedures are the most economical ways to reduce household waste (De Feo & De Gisi, 2010). Furthermore, the success of home recycling initiatives is significantly impacted by residents' involvement in the source separation process (Keramitsoglou & Tsagarakis, 2013; Krook *et al*., 2007). Therefore, it is important to test and conduct comprehensive theory-based surveys to understand the mechanisms underlying citizen participation in waste management programs.

Waste sorting at the source has primarily been done at the pilot program level in poor nations. As a result, it hasn't been broadly embraced on a bigger scale. Convenience is one element that influences recycling behaviour as well as garbage sorting practices, according to several research (Vicente & Reis, 2008). Internal variables, such as attitude, beliefs, and responsibilities, are intrinsic aspects that have an impact on an individual's engagement. External considerations, like the availability of garbage sorting facilities, are those that either encourage or dissuade an individual from participating. Among the sociodemographic parameters are things like income, age, education level, and gender.

People with higher education may participate in separation activities at a lower rate because they are more likely to be employed and have better jobs. They might earn more money if they get employment. Higher-income households are less likely to consider using recyclables from the solid waste stream to supplement their income (Ekere *et al.*, 2009). The public's general perception of waste collection, disposal, and treatment is negative (Liyala, 2011; Oberlin, 2011). The incapacity of urban governments to implement current waste management legislation contributes to the widespread lack of responsible waste management participation in urban areas (Liyala, 2011).

As several scholars have pointed out, there are additional detrimental aspects of culture and attitude that have occasionally hindered the crucial component of public engagement (Kaseva & Rotich *et al.,* 2006; Mbuligwe, 2005; Palczynski, 2002; Yhedgo, 1995). Waste management socio-cultural and attitude concerns can be gradually resolved by raising community awareness through public education, and economic issues can be resolved by creating employment possibilities within the waste management industry.

Education is a tool for transforming societies' resource management, particularly the handling of waste, by imparting knowledge, changing attitudes, and developing skills.)Education has a crucial role in advancing sustainable development and enhancing individuals' ability to tackle environmental and development-related concerns (Salequzzaman *et al*., 2001). The educational curriculum expands upon the information, morals, abilities, experiences, and resolve of human potential required to address waste management concerns on both a personal and a community level.

SWM participation rates can be negatively affected by complex SWM programs, which some residents may not understand (Purcell & Magette, 2010). Accordingly, the most often used factors include the person's income level, gender, age, and education (Pakpour *et al*., 2014; Saphores *et al.,* 2006). In developing nations, efforts to enhance solid waste management (SWM) have primarily concentrated on economical waste management techniques alongside source reduction, separation, and recycling (De Feo & De Gisi, 2010; Krook *et al.,* 2007). The adoption of recycling programs in these nations has faced social hostility despite the benefits they offer, such as low public awareness and engagement in recycling efforts (Jamshidi *et al.,* 2011).

Investigating the potential for the 3Rs and composting in urban waste management is necessary if urban communities are to reduce waste production while simultaneously generating social and economic benefits (such as a clean and healthy neighborhood or the sale of recyclable or recycled materials). Mbeng *et al.* (2009) proposed that for communities to effectively implement sustainable waste management practices, awareness programs should be easily understood and accessible. This will help people in urban areas view waste as valuable resources rather than as something worthless.

2.3 Willingness to Add Value to Segregated Waste

Nairobi's total solid waste reuse and recycling output is between 100 and 150 tons per day, or roughly 3.7% of all garbage produced (Allison, 2010). The amount of uncollected rubbish per day drops to 2,540 tonnes if recyclables and reusables are collected before final collection. This could be presumed to have been primarily disposed of inappropriately by collectors or owing to non-collection in methods like burning and illegal/indiscriminate disposal (Njoroge *et al.,* 2014). Ineffective policies by county governments on waste management have led to emergence of the informal sector and non-governmental agencies volunteering to engage in waste management practices. These are mostly encouraged by market forces as they are parallel with existing control policies (Thomas, 2008). Low willingness to participate in public management concerns is influenced by several reasons, including the low

GDP per capita, high levels of illiteracy, and a low standard of life with poor income (Okot-Okumu, 2012). All these elements working together, along with the shortcomings of the urban council that result in poor management, have caused waste to build up in neighborhoods, endangering the environment and raising the possibility of disease outbreaks including cholera, diarrhea, and parasites.

2.4 Empirical Review

2.4.1 Mapping and Characterizing Organic Waste Sources and Collection In Nairobi County

Organic waste sources can be broadly categorized as agricultural waste, food waste, animal waste, and yard waste. Agricultural waste refers to the residues and by-products from agricultural activities such as crop production, livestock farming, and forestry. This waste can be generated from crops, animal feed, and animal bedding. The studies used descriptive statistics. According to a study by Chaudhary and Garg (2023), the major sources of agricultural waste include crop residues (50-70%), animal waste (10-20%), and agro-industrial residues (10-20%). Food waste is discarded food that is no longer suitable for human consumption. This can include scraps from food preparation, spoiled or expired food, and leftovers.

According to a report by the Food and Agriculture Organization (FAO) of the United Nations (2013), food waste is generated at all stages of the food supply chain, including production, processing, distribution, and consumption. Animal waste is manure, urine, and other waste products produced by animals such as cows, pigs, and chickens. According to a study by He *et al.* (2020), the major sources of animal waste include dairy farming, beef production, and pig farming. Yard waste refers to the organic waste generated from gardening and landscaping activities. This can include grass clippings, leaves, branches, and other plant materials. According to a study by Vengris *et al*. (2018), the major sources of yard waste include residential properties, public spaces such as parks and golf courses, and commercial landscaping.

Mapping organic waste sources in Kenya involves identifying the geographical distribution and density of organic waste generation from various sources. A study by Obiero *et al.* (2020) mapped the distribution of food waste in Nairobi, the capital city of Kenya, and found that the highest density of food waste was generated in the central business district and residential areas. They also identified the types of food waste generated and the factors influencing their generation. On the other hand, Okello *et al*. (2020) mapped the distribution of agricultural waste in western Kenya and found that the major sources of agricultural waste were maize stalks, bean stems, and cowpea stalks. They also identified the areas with the highest density of agricultural waste generation. Wambua *et al.* (2020) mapped the distribution of animal waste in Machakos County, eastern Kenya, and found that the highest density of animal waste was generated in areas with high livestock populations. They also identified the types of animals that generated the most waste as poultry, pigs, cattle, aquaculture, sheep and goats respectively.

A study by Obiero *et al.* (2019) mapped the distribution of yard waste in Kisumu, a city in western Kenya, and found that the highest density of yard waste was generated in residential areas. They also identified the types of yard waste generated and the factors influencing their generation, the types of yard waste were leaves, grass clippings, tree branches and twigs, garden waste, and other yard debris. The greatest factor was seasonal changes.

There are three basic ways to collect waste: hiring labour, the informal primary or pre-collection phase, which involves moving waste from homes to community collection locations (such as skips, bunkers, or open roadside), and collecting waste from households (Okot-Okum, 2012). Secondary phase collection is primarily handled by formal organizations like urban councils and commercial operators, and it occurs from community transfer points to landfills or final disposal locations. Most private operators gather wastes that come straight from the source (door to door). Waste is collected by private companies at agreed-upon prices with each client.

Community markets and hospitals continue to mostly rely on urban council collection of waste, while industries and retail centers typically hire private waste collectors to collect waste from their business premises. Additional methods of collection include a "summon to bring" system, in which a truck is positioned somewhere, and people are called to deliver rubbish to the truck by hooting on the horn. There are differences in the frequency of home waste collection between high- and low-income households. The frequency of waste disposal by high-income groups is three times per week determined by the frequency of most contractors that is between two and three times per week, roughly (Kaseva & Mbuligwe, 2005; Okot-Okumu & Nyenje, 2011). The urban council spends a lot of time collecting and manually loading waste onto vehicles.

According to many urban councils in developing nations, the percentage of waste collected ranges from 35 to 68 (Palcznki, 2002; Scheinberg, 2011; Suriyadi *et al*., 2000; Vidanaarachchi *et al*., 2006). Compared to the past, when solid waste collection was solely the responsibility of the urban governments, the entry of private operators has resulted in higher levels of collection (Kaseva & Mbuligwe, 2005; Oberlin, 2011; Okot-Okumu & Nyanje, 2011).

But most of the reported collection initiatives only cover wastes that have arrived at transfer points, or community collection stations. This indicates that a larger proportion of urban solid waste ends up in the environment rather than at the authorized disposal locations.

In metropolitan areas, open dumping is the most popular means of disposing of waste (Oberlin, 2011; Okot-Okumu & Nyenje, 2011). Communities without access to transfer stations turn to open disposal techniques, such as irresponsible disposal, burning, burying, and using wastes as animal fodder. The careless disposal of waste on open lots, road verges, and storm drainage channels has resulted in a widespread problem with littering. The improperly disposed waste blocks stormwater. In addition to creating floods, drains are unhealthy and disgusting.

Private firms frequently provide services to institutions including universities, schools, hospitals, and corporate complexes; those that are not served by them bring their waste to designated community collection points on an individual basis. Waste collection services are rarely provided to the urban poor because of inadequate infrastructure, impassable roads, and municipal governments' negligence. In East African metropolitan centres, waste collection is determined by the income level of the service area rather than the overall amount of waste created (Kaseva & Mbuligwe, 2005; Okot-Okumu & Nyenje, 2011). When it comes to garbage collection, those depending on private operators are more satisfied than those depending on city councils.

Only a small portion of the waste produced daily in most urban areas is collected and disposed of properly. For instance, in the cities, data on Nairobi, Kampala, and Dar es Salaam respectively are gathered at 45% (Rotich *et al.*, 2006), 43% (Okot-Okumu, 2008; Okot-Okumu & Nyenje, 2011), and 30% (Oberlin, 2011). Solid waste collection generally occurs in urban areas and affluent neighborhoods, yet even in these areas it is not consistent. Open trucks, trailers, and covered compressor trucks are common forms of collection and transportation. Waste on transit are frequently discovered, leading to issues with littering, odors, and poor aesthetics.

A study by Henry *et al.* (2006) noted that due to easier access, central business areas (CBDs) and wealthier communities are where local authorities typically focus their limited services. Interviewees from the community cited the inability of the local government to provide timely collection services for the improper dumping of MSW in pathways, riversides, and road reserves.

2.4.2 Knowledge, Attitude, and Practices Towards Waste Management

The public's knowledge and attitude regarding the recycling of solid waste is the first step in the proper utilization of resources, leading to people's cooperation and the development of recycling programs (Almasi *et al.,* 2019). This is because recycling has many advantages, including lowering the amount of solid waste that is landfilled, lowering the cost of waste disposal, and saving energy and natural resources. To effectively teach people and enhance the solid waste recovery plan, it is therefore possible to gain a deeper understanding of their knowledge and attitudes. Numerous research on people's attitudes, practices, and understanding about recycling has been carried out in different countries.

Knowledge is recognized as a significant and influencing aspect in practices and, in many cases, it helps to assure the success of recycling programs by facilitating their implementation (Bortoleto *et al.,* 2012). This idea is that an appropriate understanding of tangible influences behaviour, is fundamental to the formulation of policies. Amouei *et al*. (2016) however demonstrated that even while most people knew a lot about waste recycling, they did not implement it correctly. According to Yukalang *et al*. (2018), a major contribution to solid waste recycling may be made by providing ongoing and organized training through educational approaches and by having waste separation organizations.

Demographic variables such as age, marital status, education, and occupation had a big impact on KAP (Mangiri *et al*., 2017; Shorofi & Arbon, 2017). Depending on age, gender, and occupation, the research in Abadan showed that people's knowledge and attitudes about reduction, separation at the source, and recycling are good, but their performance is poor. As a result, putting in place home waste management training programs can significantly improve people's practices (Babaei *et al.,* 2015). Matsumoto presents an empirical review of studies conducted at the home level to determine the association between sociodemographic factors and the amount of recycling and trash reduction activity (Meneses & Palacio, 2005). Previous studies, according to Akil *et al*. (2015) found a relationship between gender and income and trash separation behaviour, whereas other studies found no association between gender and recycling activities. Others likewise found no connection between income and recycling practices. According to the findings of other studies, they were unable to generalize the sociodemographic factors impacting the public's acceptance of garbage sorting at the source.

According to There is a high likelihood that households would embrace a garbage sorting program (Setiawan, 2020). The biggest barriers to household garbage sorting at the source were mixed collection and transit (26%), a lack of sorting infrastructure (23%), and a lack of time (22%). The socioeconomic elements that are most frequently connected with citizens' opinions and attitudes toward environmental policies are educational attainment and income. The following variables affect how garbage sorting obligations are perceived: gender, monthly income, and existing sorting techniques (Setiawan, 2020). Age, years of education held by household heads, and family relationships are the other three variables that have little bearing on how well a household understands its duty to sort waste.

The absence of a significant correlation between age and waste recycling behaviour supports the finding that age does not influence one's understanding of the responsibility for waste sorting (Setiawan, 2020). Others agree that the number of family members has no bearing on how much waste is recycled in a household and vice versa. The lackluster outcome of schooling supports the conclusions of numerous other researchers. Female respondent was discovered to be highly significant and positive at 1% (Setiawan, 2020). This suggests that the likelihood of sorting rubbish was higher for female respondents. This conclusion could be explained by the fact that women are more involved in the disposal of domestic waste.

The response from the responder with a monthly income of above six million rupiahs was favourable and noteworthy at the 5% level. This suggests that the likelihood that the respondent recognizes the responsibility of waste sorting increases with monthly income. The likely explanation for this finding is that individuals with higher incomes may be more likely to have access to information. Years of schooling held by household heads, family members, present sorting practice, and comprehension of the duty-related waste sorting all significantly influenced public acceptance of garbage sorting. This study's findings about education support earlier research by others, which found that those with higher education levels may not necessarily engage in more recycling-related activities (Setiawan, 2020). More family-oriented households are more accepting of the source-based waste sorting policy. This study supports earlier research's results that the number of people living in a household significantly affects how waste is recycled.

Furthermore, their research shows that households that have already performed waste sorting and comprehend the sorting requirement are more accepting of the waste sorting regulation. Gender, age, and monthly income were the only three independent variables that were not statistically significant. This finding supports earlier research by several researchers that suggests age does not always affect waste recycling actions. The activity is more familiar to those who regularly sort their rubbish. As a result, people who have used garbage sorting techniques are more likely to receive their homes' acceptance (Setiawan, 2020). Public acceptance of garbage sorting is also influenced by the public's understanding of households' sorting obligations. A favourable and significant finding of 10% was made for a respondent who understood the sorting requirement.

In Kampala, Uganda, residents were surveyed to find out how they felt about segregating their household solid trash. The study used descriptive statistics for analysis and found out that 40% of respondents thought it was a good idea, while 60% said they opposed it because it would be time-consuming and messy (Banga, 2011). Therefore, this should be done at the recycling centers or the landfill. Most households segregated waste because doing so allowed them to make money. These are thought to make up 70.1%. The waste was sorted by the other houses so that it could be disposed of effectively and used to generate manure. These made up 22.8% and 7.2% of the households, respectively. Banana and potato peelings (81.7%), broken and entire bottles (18.3%), and plastic bags (17.6%) were the materials most separated by households.

Since homes do not view beer and soda bottles as waste, they are not included in the bottles. Banana and potato peelings are either given free in exchange for removing solid waste or sold to urban farms. They occasionally feed their own animals with the peelings as well. Only 4.7% of the households dig a hole for the peelings (Banga, 2011). Most homes that reported using waste separation claimed to segregate waste into distinct sorts before disposing of it in various rubbish bags (some of the separated solid waste is put in different corners not necessarily in plastic bags or containers). After combining the garbage, they do not separate it (Banga, 2011). They claimed that the goods they believe can be recycled or utilized again are not mixed in with the other trash.

Those homes who have enough yard space typically put trash in the backyard and remove plastics once the trash has dried. Because they use it to fuel their charcoal fires and for 'sanitary' reasons, households claim they do not throw away paper. They asked households if they knew of any recycling facilities nearby or where they could take their recyclable rubbish for sale. Knowledge about these centres was present in 70% of the families. In fact, 65% of individuals who knew about the recycling centres had donated recyclables to them.

Additionally, households were questioned about their participation in waste recycling initiatives. None of the homes recycled any of their rubbish. They weren't recycling since they didn't know how to, which prevented them from doing so (Banga, 2011). Some homes claimed to separate the organic material and dump it in a pit, but they were unaware of the process used to turn the garbage into manure. The justifications provided by families for not engaging in any kind of trash separation activity. These included the following: separation takes a lot of time (39.6%), there isn't a market for recyclable waste (38.7%), they can't afford separate bins for separated waste (28.1%), they don't see the value in separation because the waste is dumped all at once in a truck or at shared containers (8.1%), and there isn't enough room (5.4%). Other homes claimed that because they already paid for waste pickup, they did not separate the solid waste. Therefore, they did not understand why they should try to separate rubbish (Banga, 2011).

They questioned households that did not separate their waste before disposal to find out what would motivate them to do so. Fifty percent said they can only separate waste if there is a market for it, forty-seven percent said they can only separate waste if someone else is also doing it, and two percent said they can only separate waste if everyone else is doing it (Banga, 2011). The results of the logistic regression analysis show that gender, awareness of recycling activities in the area, household income, and education explain household waste separation behavior. This study used logistic regression to understand how different household characteristics explain household behavior in solid waste separation (Banga, 2011). At the 5% confidence level, gender is adversely and strongly associated with solid waste separation. As a result, women are more prone than males to separate solid trash. This practice is most likely a result of the fact that women typically make decisions about what is valuable and what is trash in the home (Whitmarsh *et al*., 2018).

Additionally, research from Pakistan, Bangladesh, and Ho Chi Minh City revealed that women in the home were more involved in source separation than men were (Beall, 1997; Du, 1995). When Ekere *et al*. (2009) investigated the separation of crop waste in Uganda, they obtained comparable findings. At the 10% confidence level, the association between income and waste segregation is unfavorable and significant. This suggests that trash separation is less common in homes with high incomes. This is most likely because households with higher incomes can afford to pay for waste collection services (Banga, 2011). Therefore, they do not perceive a need to separate the garbage before disposal. Second, most people who separate rubbish do so to collect recyclables for sale and to make some money.

According to research by Laor *et al*. (2018), only 59% of Northern Thai people practiced moderate MSW management, compared to 73% of locals who had high knowledge levels. According to Zand *et al.* (2020) results, only 46.0% of the women had moderate practice with MSW management, while 69.6% and 72.9% of the women had appropriate knowledge and attitude, respectively. In conclusion, appropriate practice was not always the result of having sufficient knowledge and a positive attitude. In-person training, however, had a beneficial impact on women's source separation and solid waste recycling practices. Research also demonstrated that, in developed countries, pro-environmental attitudes and subjective standards, as opposed to financial incentives, are more effective at encouraging participation in recycling activities (Khan *et al*., 2019; Viscusi *et al.,* 2011).

For households with high incomes, this activity is not crucial. According to research by Ali (1997) and Furedy (1992), low-income households sell a disproportionately higher proportion of their post-consumer household goods than wealthy households. In Uganda, however, Ekere *et al*. (2009) discovered a favorable correlation between income and crop waste separation. They also considered the household head's level of education. Those with no education or only primary-level education were more likely to separate solid waste than those with tertiary education. There was no correlation between education and the separation of crop waste in Uganda.

Finally, they discovered that household behavior toward solid waste separation depends on awareness of recycling operations. The separation of solid waste in a household is greatly influenced by the local community's awareness of recycling efforts (Babaei *et al*., 2015). This may be the case because individuals are aware that there would be a market for their sorted waste. The results, however, indicate that whether a home decides to separate its solid waste or not is not significantly influenced by having a yard, the respondent's age, or the size of the household.

According to Gilli *et al.* (2018), households' attitudes and behaviors have a significant impact on how well waste reduction, separation, collection, and recycling programs work. According to research by Laor *et al*. (2018), just 59% of Northern Thai people practiced moderate MSW management, compared to 73% of locals who had high awareness levels. Age and educational attainment were determined to be important variables influencing their contribution to MSW management. Research has demonstrated that in developed countries, pro-environmental attitudes and subjective standards, as opposed to financial incentives, are more effective at encouraging participation in recycling activities (Khan *et al*., 2019; Viscusi *et al*., 2023).

On training, teachers can give learners a solid foundation in knowledge and an understanding of the issues surrounding developing environmental challenges through formal education (Laor *et al.,* 2018). However, inaccurate opinions that teachers convey to their students may result in misunderstanding about them, which could have serious repercussions in the future. According to research by Martínez-Borreguero *et al.* (2022), educators in underdeveloped nations are not well-versed in waste management and do not fully comprehend the material they are teaching. This is due to the lack of a regulated waste management curriculum in most of the nation's post-secondary educational institutions that train future educators. Research by Galarpe and Heyasa (2020) shows that instructors in poor nations have unfavorable waste management habits because they lack awareness and expertise in this area.

According to a study by Zhang *et al*. (2020), training programs could be used to integrate sustainability and education. The cost of trash operations can be positively impacted by the involvement of educators, students, and communities, and technology investments can guarantee long-term advantages for the environment, sustainable development, and CP in developing nations (Li & Qamruzzaman, 2023). Most developing countries have witnessed environmental destruction because of a lack of practical environmental expertise. Most educators in developing nations lack environmental or SWM-related practical knowledge, which has a detrimental impact on students' attitudes and environments of knowledge.

Early experiences have an impact on children's cognitive and emotional development as well as the formation of long-lasting environmental attitudes and behaviors, according to various research. According to a study by Wallis and Loy (2021), youngsters learn about environmental challenges and how humans and the environment interact. Studies conducted by Tikka *et al.* (2020) show that attitudes and awareness of the environment are influenced by education. Due to instructors' lack of understanding, most learners in developing nations lack the practical information necessary to enable the implementation of proper waste management in their classrooms and, at home, to influence their family's knowledge.

Most developing nations have included environmental education into the curriculum in recent years, but teachers' actual knowledge of the subject is still somewhat limited. Consequently, in most developing nations, this has led to gaps that result in lower criteria for waste management for sustainability. According to a case study by Panko and Sharma (2016), involving students in environmental education's practical aspects, such as garbage management, improves their comprehension of the larger concept of the information and attitudes that need to be learned. When deliberate effort is made to expand the curriculum levels of education and teachers, providing the essential training in practically transmitting knowledge and raising awareness in students, sustainable and effective waste management can be performed within developing countries. Very few studies have been done on specific waste management methods such using insects.

2.4.3 Willingness to Add Value to Segregated Waste

Scavengers and reusable garbage collectors on the streets of residential neighborhoods in China frequently gather recyclable materials from daily use at the source (Balasubramanian, 2018). Residents can either deliver recyclables to the servicing sites themselves or sell them to customers who knock on doors. The buyers then resell the products to a local recycling center, where they are sorted and sent to industries as raw or processed materials. Due to the lack of government recycling programs in China, recycling and resource recovery are typically carried out by the "informal" sector. This activity occurs at all levels and throughout the waste management stream, and it has a significant impact on how the waste stream moves (Balasubramanian, 2018).

In Nairobi, the informal sector waste collectors oversee waste collection, segregation, and recycling (Wilson *et. al*.,2006). They treat the waste as an ore. The type of waste collected by informal waste pickers is determined by use or amount of income attached to it. They mostly do it for the purpose of sale and earning money (Longe *et.al*., 2009). The demand for recyclable materials within the industries act as a pull factor for informal waste picking and the unemployed see it as an employment opportunity. However, Bisong and Ajake (2001) stated informal waste pickers as street families, or the homeless who are associated with crime especially in the slums.

Most informal and private sector recycling and waste management actors pursue financial gain (Cheng & Urpelainen, 2015; Kazuva *et al*., 2018). As a result, waste fractions with greater market values, such as premium plastics and metals, are typically collected and taken for recycling, leaving the biodegradable fraction behind (Hettiarachchi *et al*., 2018; Kaza *et al*., 2018). Valuable wastes, like plastics, cardboard, and scrap metal, are segregated at the source, during transit, at transfer stations, and at disposal locations (Okot-Okumu, 2012). Since there is no waste separation for organic waste at the source, it is challenging to collect and effectively use the biodegradable part (Hettiarachchi *et al*., 2018).

Additionally, it is believed that the expense of processing this portion exceeds the value of the items produced, deterring actors from managing biowaste (Lohri *et al*., 2014). Thus, the overall volume of biowaste arriving at landfill and dump sites keeps rising (Komakech *et al*., 2014; Kazuva, 2017). According to Katinas *et al*. (2019), and Torres-León *et al*. (2018), biowaste contains useful resources like nutrients (such as carbs, fibre, proteins, and lipids) and energy. Muiruri *et al.* (2020), state that irresponsible waste management approaches by the Nairobi County Government as well as reluctance to pay private garbage collectors and the high cost of disposal services charged by private garbage collectors are among the challenges faced in the county's waste management. The reluctance to pay contracted private garbage collectors could be among the reasons for the rise of informal waste handlers.

Most of the studies used descriptive statistics for analysis thus not outlining clearly a relationship between the factors influencing knowledge, attitude and practices, willingness to add value, and examining if a relationship could exist among the dependent variables.

2.5 Theoretical Framework

Possible theories in line with this study were behavioural economics theory and random utility theory. However, behavioural economics theory is limited by focusing on specific behaviours and may not be able to explain broader social or economic trends (ElHaffar *et al.,* 2020). This can make it difficult to develop comprehensive policies that address larger issues. This study was thus based on the random utility theory where; given the principle of utility-maximizing behaviour, the probability of choosing a choice alternative is then equal to the probability that its utility exceeds that of all other choice alternatives in the choice set (Burg *et al*., 2021). In this case, the waste producers and waste collectors chose whether to practice organic solid waste management using insects or not. Their choice was dependent on the amount of satisfaction or benefit they got from practicing organic solid waste management using insects.

2.5.1 Random Utility Theory

The difference between the utility from practicing organic waste management using insects and not practicing can be denoted as M^*, such that utility maximizing waste producers and collectors practice organic waste management using insects if utility gained from practicing is greater than not practicing ($M^* = U_P - U_N > 0$). Since utilities are unobservable, they can be expressed as a function of observable elements in a latent variable model.

$M^* = \beta Z + £ M = 1 \text{ if } M^* = 0$……………………………………………………….…………….(1)

Where M is a binary indicator variable that equals 1 if waste producer and collector practices, and zero if otherwise. β is a vector of explanatory variables and £ is the error term.

Following the discussion above, practicing organic waste management using insects protects waste producers and collectors from environmental pollution, have economic benefits from recycling the waste such as increased income employment creation, reduction of landfills, which can be used more effectively for example, the space be used for urban farming. Assuming the variable of interest is maximum utilization of landfills, poverty reduction and environmental protection, a linear function of a dummy variable, practicing organic solid waste management along with a vector of other explanatory variable (X) leads to the equation;

$Y = yX + ϭ M + £$ ……………………………….……………….…………………….….(2)

Where Y represent outcome variables, M is an indicator variable for practicing organic solid waste management using insects, ϭ vectors of parameters to be estimated, and £ the error term. The contribution of practicing organic waste management using insects is measured by the estimates of the parameter ϭ.

The practicing decision was likely to be influenced by unobservable characteristics and motivation that may be correlated with the outcome of interest (maximum utilization of landfills, poverty reduction and environmental protection).

2.6 Conceptual Framework

To successfully map and characterize organic waste sources, amount of waste collected, type of organic solid waste (kitchen refuse, slaughterhouse waste/ meat, human waste), and sources of organic solid waste (household, commercial, institutional, or street waste) were considered. There was a host of socioeconomic factors such as age, gender, level of education, waste unit size, which influenced knowledge, attitude, and practices towards organic solid waste management using insects and willingness to add value to the segregated organic solid waste to insect products.

Other factors influencing knowledge, attitude, and practices of organic waste management using insects are training, information on segregation, technologies of segregation, incentives, separate bins, pay for waste collection, frequency for waste collection, recycling services, forms of recycled organic products, marketability of recycled goods, ways to reduce waste, alternatives, awareness on waste recovery, current use of waste.

There were institutional factors such as incentives for waste management, availability of market for recycled organic solid waste, availability of separate bins, frequency of waste collection, availability and reliability of waste collection services, training on importance of organic solid waste management, current use of waste/ current condition for waste management in Nairobi, availability of recycling services, amount of waste available for recycling, cost and benefit of organic solid waste value addition which if positive were thought to encourage organic waste segregation and management, and value addition to insect products.

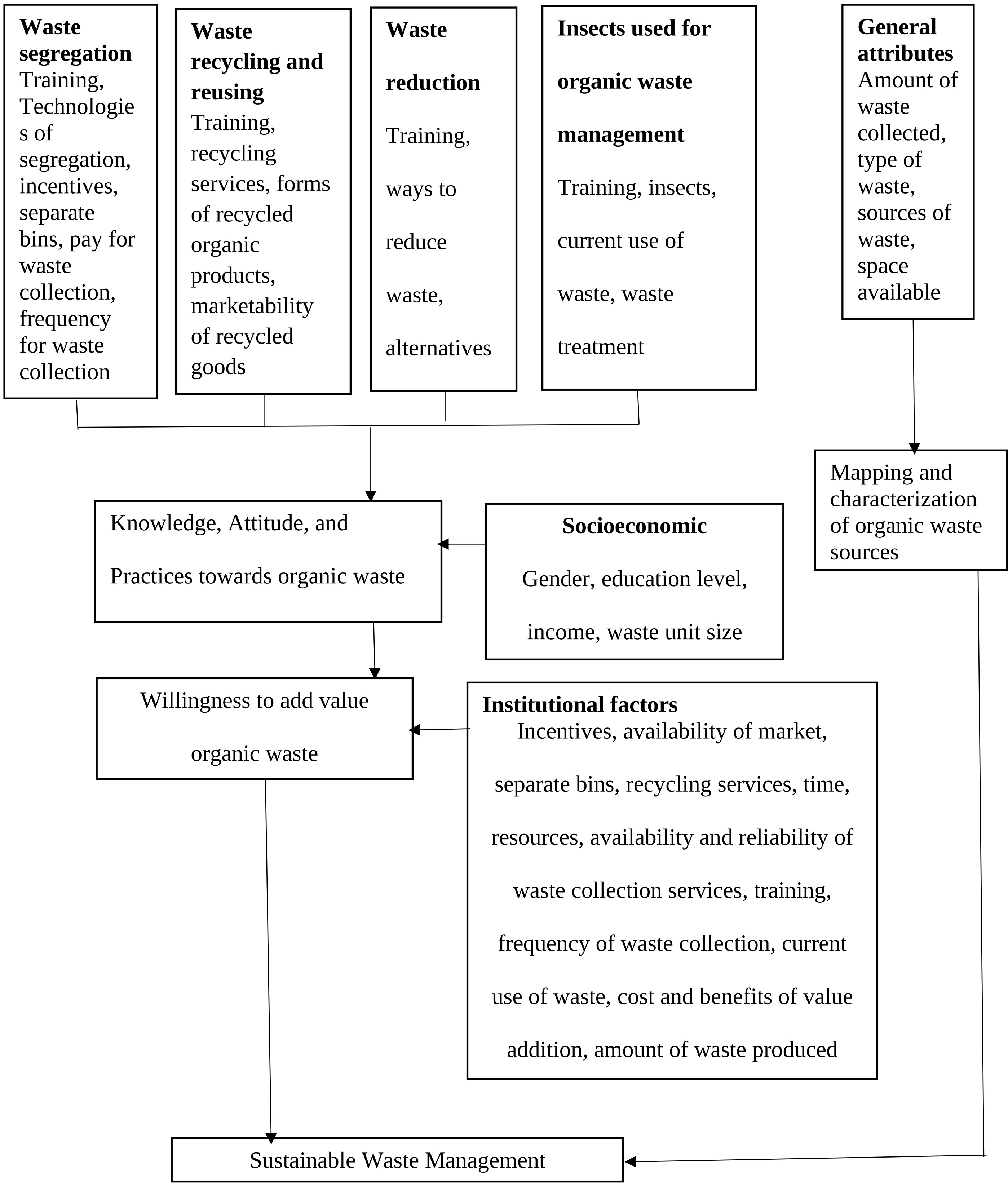


Figure 1: Conceptual Framework

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The research was conducted in Nairobi County, Kenya. By 2019, it had over 4.3 million inhabitants, a quarter of Kenya's urban population (KNBS, 2019). It covers an area of about 700km^2 at the Southeastern end of Kenya's agricultural heartland. Its altitude is 1600 to 1850 m above sea level. It incorporated the 17 sub-counties of Nairobi: Westlands, Dagoretti North, Dagoretti South, Lang'ata. Kibra, Roysambu, Kasarani, Ruaraka, Embakasi South, Embakasi North, Embakasi Central, Embakasi East, Embakasi West, Makadara, Kamukunji, Starehe, Mathare.

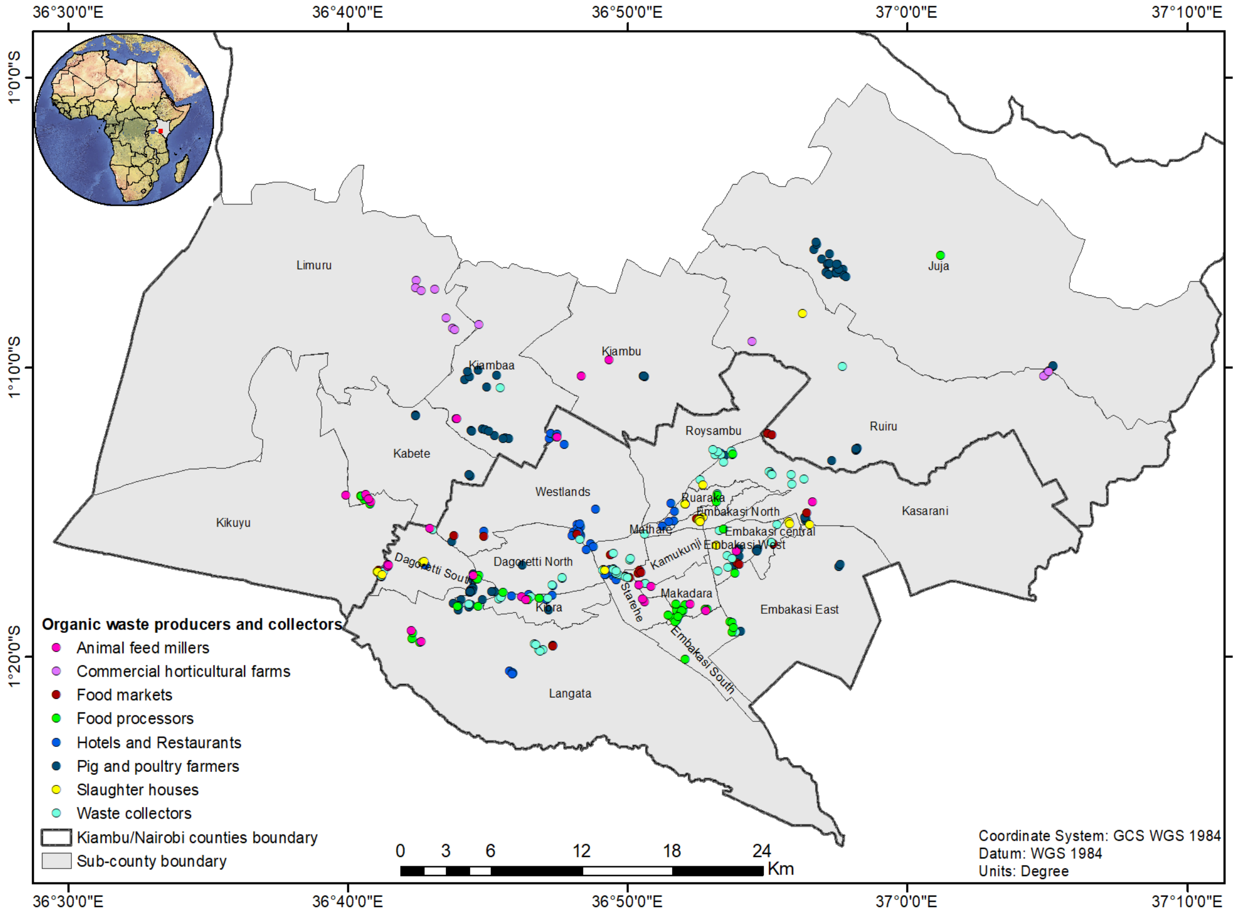


Figure 2: Map of the Study Area

Source: Catography by Data Management, Modelling, and Geo-Information (DMMG) Unit

3.2 Research Design

The study adopted a cross-sectional research design where data was collected at a single point in time. This was important to this study as it saved time, was cost-effective, and adequate information from different respondents was collected within a short time. It also enabled data collection that measured the prevalence of all factors in the study.

3.3 Sampling Technique

A stratified multistage sampling technique was used to select the organic waste producers and collectors. In the first stage, Nairobi city was purposively selected due to its high volume of waste generation. In the second stage, organic waste producers were stratified according to waste streams (fruit waste, vegetable waste, flesh waste, crop residues, animal manure, dairy products, baked wastes, and food remains). In the third stage, a sample size was allocated for each stratum using a probability proportion to size (PPS) sampling approach. For the waste collectors, a simple random sampling technique was used to select the respondents from the same area as the producers.

The study used primary data which was collected from these respondents using a pre-tested semi-structured questionnaire. Pretesting was done in Kiambu County, as it shares similar characteristics with Nairobi County in terms of organic waste generation. The face-to-face interviews were administered to the person responsible for organic waste production or collection. The data collected included respondents' socioeconomic characteristics, waste production, segregation, disposal, collection, and recycling methods, incentives gained, and waste treatment methods used. Also captured during the survey included the waste producers and collectors' knowledge, attitude, and practices towards the use of insects to manage the waste and their willingness to add value-segregated organic waste. Census and Survey Processing System (CSPro) tool was used for data collection, while Stata was used for data analysis.

3.4 Sample Size Determination

Since the study incorporates a large population, sample size was determined using Eq. (3) (Cochran, 1963).

$$n = \frac{z^2.p.q}{e^2} \quad (3)$$

where *n* is the sample size, *p* is the sample proportion (*q = 1-p*), *z* is the standard variate at a given significance level () and *e* acceptable error (precision).

To attain a sample size of 485 (Eq. (1)), we used 95% confidence level, *z* of 1.96, and desired margin of error € of 0.05. This sample size was large enough to draw generalization on the population with +/-5%.

$$n = \frac{1.96^2 X 0.5 X 0.5}{0.05^2} = 384 \quad (4)$$

The study assumed a non-response rate of 26%, with the nature of respondents being commercial businesses, therefore concluded to having a sample size of 485 respondents. The additional respondents were to increase the precision of the results in case of incomplete interviews or missing data from the selected sample. This means that the study satisfied Mugenda and Mugenda (2008) who argue that in a study, if the response rate is over 70%, it can be said to be good. The sample consisted of 56 hotels, 34 slaughterhouses, 44 food processors, 25 animal feed millers, 22 markets, 13 commercial horticultural farms, 82 pig and poultry farmers, 151 households, and 58 waste collectors. The sub-counties from which the household sample was selected were purposely selected because of their high waste generation within the county.

Table 1: Proportionate sampling of households

Sub-County	**No. of respondents**
Lang'ata	20
Kasarani	32
Dagoretti North	35
Kibera	6
Embakasi South	31
Westlands	21
Total	151

Table 2: Distribution of respondents

Waste stream	Sample size
Waste Collectors	59
Hotels	56
Food processors	44
Slaughterhouse	34
Feed millers	25
Markets	22
Pig and poultry farmers	82
Commercial Horticultural Farmers	13
Households	151
Total	485

3.4 Data Collection and Analysis

The study used primary data which was collected from organic waste producers and waste collectors. A pre-tested semi-structured questionnaire was used to get information such as types of organic solid waste, waste management interventions, sources of waste, amount of waste collected, sex, education level, years of experience, awareness of usefulness of organic waste, and use of insects to manage organic waste. Information on knowledge, attitude, and practices was captured using KAPs scores. Cs Pro toolkit was used to collect data, and STATA was the analytical software used to clean and analyze the data collected.

3.5 Analytical Framework

Descriptive statistics was used to characterize and map organic waste sources in the first objective. KAPs score was used to establish the organic waste producers and waste collectors' knowledge, attitude, and practices towards organic waste management using insects; Logistic regression to analyze the influence of the independent variable on knowledge, attitude, and practices separately, and multinomial logit model on analysis of total KAPs score against the independent variables. Two models, Logit and Multinomial Logit, were used in one objective since binary logit was used as to influence the dependent variable in the multinomial logit. The Tobit model was used to analyse the organic waste producers' and collectors' willingness to add value to the segregated waste to insect products.

3.5.1 To Map and Characterize Organic Waste Sources in Nairobi County

Descriptive statistics were used to analyse qualitative and quantitative factors such as types of organic waste, sources of organic waste, and amount of organic waste collected. These factors aided in characterizing and mapping organic waste sources. Their GPS coordinates were recorded and presented as a virtual map. The mean, median, standard deviations, percentages and crosstabs will be used for analysis.

3.5.2 *To Establish the Knowledge, Attitude, And Practices of Waste Producers and Waste Collectors Towards Organic Solid Waste Management Using Insects*

This objective could be analyzed using Likert Scale or KAPs Scores. However, Likert scales are more inclined on attitude, opinions, and perceptions but may not be the best option for measuring knowledge and practices related to a specific issue (Barratt & Sibley, 2019). The study thus adopted KAPs scores guided by Onsomu (2016).

3.5.2.1 Knowledge, Attitude, and Practices Scores Measurement

A series of questions depicting the knowledge, attitude, and practices towards organic waste management using insects of the organic waste producers and waste collectors were used to develop scores on respective categories. They were based on (1) technologies of segregation (3 tier bins, smart bins, sensor-based automated bins, and robot-based segregation), (2) methods of disposal (landfills, waste pit, burning, burying, trash bag and bin), (3) forms of recycling (composting it to manure or fertilizer, direct animal feeds, biogas, vermicomposting, insect feeds, and briquette), (4) specific insects used for organic waste management (black soldier flies, crickets, mealworms, cockroaches), and (5) ways of waste reduction (increasing shelf life of products, regulation of consumption patterns, and controlling pests). Each of the attributes and sub-attributes had a dichotomous response: if they know, 1, and if they do not, 0. For a respondent to be considered knowledgeable, they had to attain a score of three or more out of four and six sub-attributes for attributes 1-3, one (for specific insects- attribute 4) and two (for ways of waste reduction- attribute 5). There were also direct questions, like if they knew any training offered on organic waste management using insects.

Knowledge score: To prompt organic waste producers and collectors' knowledge on organic waste management, they were asked on; 1) Knowledge about organic waste segregation, 2) Knowledge about organic waste recycling and reusing, 3) Knowledge about organic waste reduction, and 4) Knowledge about various insects used in organic waste management. Knowledge about organic waste segregation was further broken down into seven attributes, knowledge about organic waste recycling and reusing was broken down into four attributes, knowledge about organic waste reduction was broken down into four attributes, while knowledge about insects used in organic waste management was broken down into four attributes. Each of the attributes had a dichotomous response; if they know, 1, and if they do not, 0. For an organic waste producer/ collector to be considered knowledgeable, they had to attain a score of three or more. Those with 2 or below were considered not knowledgeable.

The overall knowledge score will be a dichotomous variable, (1= knowledgeable, 0= not knowledgeable), and will be used as an endogenous variable in a binary logistic model. The model assumes no collinearity among explanatory variables; linearity of independent variables, and log odds though the response and explanatory variables are not required to be linearly related. It also requires a significant sample size.

The function form will be denoted as.

KSp= f (Ts, Tr, Is, Fr, Mr, Rs, Wr, Cu, Aw, Iwt, Pwd, Asb, Mwd, Fwc, Iwm)…………………………………………………………………………………...….(5)

KSc= f (Ts, Tr, Is, Fr, Mr, Rs, Wr, Cu, Aw, Iwt, Asb, Dds, Mwd, Iwm)……………………………………………………………………………………….(6)

KSp was knowledge score for organic waste producers, while KSc was knowledge score for organic waste collectors.

Where KS is knowledge score; Ts=technologies for segregation, Tr= training, Is= information of segregation, Fr= forms of recycled organic waste, Mr=marketability of recycled waste, Rs=recycling services, Wr= ways to reduce the waste, Cu= current use of waste, Aw= awareness on various insects used in organic waste management, and Iwt= information on waste treatment, Asb= availability of separate bins, Mwd= method of waste disposal, Iwm= incentives for waste management. For specifically organic waste collectors, there was Dds= distance to waste disposal sites, and for waste producers, Pwd= payment for waste disposal, and Fwc= frequency of waste collection.

Attitude score: To achieve the attitudinal score, organic waste producers and collectors were asked questions with different attitude attributes. Four attitude characteristics that were; attitude towards organic waste segregation, recycling and reusing, reduction, and using insects to reduce organic waste were assessed. The overall attitude score was the sum of the four characteristics. For a respondent to be termed as having a positive attitude they had to attain a score of or greater than 2. Those with 1 or less were concluded as having an unfavorable attitude.

The overall attitude score was a dichotomous variable, (1= favorable, 0= unfavorable), and were regressed against explanatory variable in a binary regression. The function form was denoted as.

ASp= f (Ts, Tr, Is, Fr, Mr, Rs, Wr, Cu, Aw, Iwt, Pwd, Asb, Mwd, Fwc, Iwm)……………….(7)

ASc= f (Ts, Is, Tr, Fr, Mr, Rs, Wr, Cu, Aw, Iwt, Asb, Dds, Mwd, Iwm) …………………….(8)

ASp was attitude score for organic waste producers, while ASc was attitude score for organic waste collectors.

Where AS is attitude score; Ts=technologies for segregation, Tr= training, Is= information of segregation, Fr= forms of recycled organic waste, Mr=marketability of recycled waste, Rs=recycling services, Wr= ways to reduce the waste, Cu= current use of waste, Aw= awareness on various insects used in organic waste management, and Iwt= information on waste treatment, Asb= availability of separate bins, Mwd= method of waste disposal, Iwm= incentives for waste management. For specifically organic waste collectors, there was Dds= distance to waste disposal sites, and for waste producers, Pwd= payment for waste disposal, and Fwc= frequency of waste collection.

Practices score; To attain the practices score, organic waste producers and collectors were asked questions addressing organic waste management practices using insects. The practices were grouped in four groups: 1) practices towards organic waste segregation, 2) practices towards organic waste recycling and reusing, 3) practices towards organic waste reduction, and 4) practices towards use of various insects for organic waste management. Practices towards organic waste segregation were further broken down into seven attributes, practices towards organic waste recycling and reusing were broken down into four attributes, practices towards organic waste reduction were broken down into four attributes, while practices of using various insects were broken down into four attributes.

Each of the attributes had a binary response. Respondents with a score of three or more were considered adopters of practice, while those with two and less were considered otherwise. The overall score that was used in a regression against independent variables was as;

PSp= f (Ts, Tr, Is, Fr, Mr, Rs, Wr, Cu, Aw, Iwt, Pwd, Asb, Mwd, Fwc, Iwm) …………. (9)

PSc= f (Ts, Tr, Is, Fr, Mr, Rs, Wr, Cu, Aw, Iwt, Asb, Dds, Mwd, Iwm) ………………. (10)

PSp is practice score for organic waste producers, while PSc is practice score for organic waste collectors. PS is practice score; Ts=technologies for segregation, Tr= training, Is= information on segregation, Fr= forms of recycled organic waste, Mr=marketability of recycled waste, Rs= recycling services, Wr= ways to reduce the waste, Cu= current use of waste, Aw= awareness of insects used for organic waste management, and Iwt= information on waste treatment, Asb= availability of separate bins, Mwd= method of waste disposal, Iwm= incentives for waste management. For specifically organic waste collectors, there was Dds= distance to waste disposal sites, and for waste producers, Pwd= payment for waste disposal, and Fwc= frequency of waste collection.

Results from overall knowledge score, overall attitude score, and overall practice score were used to generate overall KAP score for both organic waste producers and collectors. A matrix with 8 probable combinations of knowledge, attitude, and practices will be generated. The combinations could be (1= no attribute at all, 2= all attributes, 3= knowledge and practice, 4= knowledge and attitude, 5= attitude and practice, 6= practice only, 7= attitude only, 8= practice only).

` The combinations were used to estimate the KAP score which was a categorical response variable with 8 possible responses that could be used in a multinomial regression. The generic functional form was expressed as.

KAPp= f (Ts, Is, Fr, Mr, Ar, Wr, Cu, Aw, Iwt, Pwd, Asb, Mwd, Fwc, Iwm)…………..(11)

KAPc= f (Ts, Is, Fr, Mr, Ar, Wr, Cu, Aw, Iwt, Asb, Dds, Mwd, Iwm)………………….(12)

Where KAPp was the Knowledge, Attitude, and Practices score for producers, KAPc was the Knowledge, Attitude, and Practices score for collectors; and ; Ts=technologies for segregation, Is= importance of segregation, Fr= forms of recycled organic waste, Mr=marketability of recycled waste, Ar=availability of recycling services, Wr= ways to reduce the waste, Cu= current use of waste, Aw= awareness of insects used for organic waste management, and Iwt= information on waste treatment, Asb= availability of separate bins, Mwd= method of waste disposal, Iwm= incentives for waste management. For specifically organic waste collectors, there was Dds= distance to waste disposal sites, and for waste producers, Pwd= payment for waste disposal, and Fwc= frequency of waste collection.

A logit regression model was used to model the three binary responses of knowledge, attitude, and practices separately with; knowledge score (1= knowledgeable, 0= otherwise), attitude score (1= positive attitude, 0= otherwise), and practices score (1= favorable practices, 0= otherwise). This is because the dependent variable was binary/dichotomous in nature where outcomes can take only two values, yes or no. Multivariate logit would only be used when the dependent variable (KAP scores) is continuous or ordinal in nature i.e, when KAP scores represent a range of values or are measured on a scale. Adopted practices were the favorable practices.

Logistic regression was used to analyze the influence of the independent variables (socioeconomic factors, number of trainings attended, amount of kgs produced/ collected, years of waste collection) on knowledge, attitude, and practices (Almasi et al., 2019, Babaei et al., 2015). The respondent can be knowledgeable or not knowledgeable, having a positive attitude or negative, practicing or not practicing. Following McFadden (1974), since the dependent variable Y is discrete; the probability that respondent ***i*** is knowledgeable, has positive attitude, and practices organic waste management using insects can be modelled as.

Pr (Y_{ij} = knowledgeable, positive attitude, and practicing) = exp(βX_i)/ 1 + exp(βX_i) (13)

The subscripts *i* and *j* denote respondent and respondent's knowledge, attitude, and practices. (1=knowledgeable, positive attitude, practicing, 0=otherwise) respectively. Equation (3) is the reduced form of the binary logit model, where the *xi* is the vector of explanatory variables (socioeconomic, trainings, amount of waste) for the *i*th respondent.

The probability that respondent ***i*** is not knowledgeable, has negative attitude, and is not practicing can therefore be modelled as.

Pr (Y_{ij} = not knowledgeable, negative attitude, non-practicing) =1/ 1 + exp (βX_i) (14)

For households:

Y_i = β_0+ β_1 *Sex* + β_2 *Age* + β_3*Years of schooling* + β_4 *Average monthly income* + β_5 *No. of persons in waste production unit* ++ β_{10} *No. of trainings attended* + β_{11} *Amount they produce* + μ_i

For waste collectors:

Y_i = β_0 + β_1 *No. of persons in waste production unit* + β_6 *No. of trainings attended* + β_7 *Amount they collect* + β_8 *Years of waste collection* + μ_i

For other waste producers:

Y_i = β_0 + β_1 *No. of persons in waste production unit* + β_6 *No. of trainings attended* + β_7 *Amount they produce* + μ_i

Additionally, marginal effects were estimated to measure effects of changes in any explanatory variable on the predicted probability of being knowledgeable, having a positive attitude, and practicing, while holding other explanatory variables constant.

The logistic regression took the form of.

$$P_i = (y_i = j|x_i) = \frac{exp^{(xi\beta j)}}{1+exp^{(xi\beta j)}} \qquad (15)$$

Where x_i is a vector of independent variables described earlier, β_j is a parameter to be estimated, different for each covariate, and P = (y = j) is the probability a respondent choosing an alternative. For efficient interpretation of the model coefficients, a log likelihood function was introduced to obtain the marginal effects on choice probabilities (Abdi, *et.al.*, 2015). The model was estimated using Maximum Likelihood Estimation and first order conditions was as.

$$\frac{\partial inl}{\partial \beta} = \sum_{i=1}^{n} \sum_{j=1}^{m} \frac{Yij}{Pij} \frac{\partial \, in \, Pij}{\partial \beta} \quad \ldots\ldots(16)$$

Where P_{ij} is a function of independent variables and their parameters.

Table 3: Description of achieving knowledge, attitude, and practices score

Attribute	**Sub-Attributes**	**Knowledge/Attitude/Practice Score**	**Pooled/Overall score**
Technologies of segregation	• 3-tier bins, smart bins • Sensor-based automated bins • Robot-based segregation	If you know > 1 technology, and practice at least 1. Attitude=Yes/No	Similar for all attributes. Average percentage score for the three respondent categories (households, waste collectors, and other waste producers)
Methods of disposal	• Landfills • Waste pit • Burning • Burying • Trash bag and bin	If you know >3 methods and practice at least 1 Attitude=Yes/No	
Forms of recycling	• Composting it to farmyard/green	If you know > three forms of recycling and practice at least 1	

Attribute	Sub-Attributes	Knowledge/Attitude/Practice Score	Pooled/Overall score
	manure or fertilizer • Direct animal feeds • Biogas • Vermicomposting • Insect feeds • Briquette	Attitude=Yes/No	
Ways of waste reduction	• Increasing the shelf life of products • Regulation of consumption patterns • Controlling pests	If you know >1 way of waste reduction, and practice at least 1 Attitude=Yes/No	
Specific insects used for organic waste management	• Black soldier flies • Crickets • Mealworms • Cockroaches	If you know >1 insect, and practice at least 1 Attitude=Yes/No	
Importance of waste segregation		• Knowledge=Yes/No • Attitude=Yes/No • Practices =Yes/No	
Ways of waste treatment		• Knowledge=Yes/No • Attitude=Yes/No • Practices =Yes/No	
Incentives gained from organic waste		• Knowledge=Yes/No • Attitude=Yes/No	

Attribute	Sub-Attributes	Knowledge/Attitude/Practice Score	Pooled/Overall score
management using insects		• Practices =Yes/No	
Trainings offered		• Knowledge=Yes/No • Attitude= Yes/No • Practice= Yes/No (Attended at least one training)	
No. of times waste is collected/Payment for waste.		• Knowledge=Yes/No • Attitude=Yes/No • Practices =Yes/No	
Impact of distance on waste segregation		• Knowledge=Yes/No • Attitude=Yes/No • Practices =Yes/No	
Overall knowledge/attitude/practice score		If the respondent scored positively (Knowledgeable, positive attitude, and practicing) in 5 and above attributes out of the possible 11	

3.5.2.2 Multinomial Logit

The multinomial logit model was used to analyze the three categories of the scores simultaneously against the independent variables (socioeconomic, training, amount of waste) based on literature. Given that the dependent variable was a discrete outcome with more than two outcomes, the multinomial logit model was used to assess the determinants of respondent`s categorization as being knowledgeable and having a positive attitude, being knowledgeable and practicing, being knowledgeable, having a positive attitude and practicing (All), or having none of the positive attributes. The multinomial logit model is used in studies involving the dependent variable with multiple outcomes (Gujarati, 2004). In the multinomial logit, one of the nominals (All) characterized categories was nominated as reference and log odds for all other categories estimated to the reference (Williams, 2018). The estimated multinomial logit for this study will be;

$$P_{ij} = P\,(y_i = j/j{=}j \text{ or } 0) = \frac{exp^{(xi'\beta j)}}{\sum_{j=1}^{m} exp^{(xi'\beta j)}} \quad (17)$$

Where x_i is a vector of independent variables β_j is a parameter to be estimated, different for each covariate. The model was also estimated using maximum likelihood estimation method and its first order condition was given as;

$$\frac{\partial inl}{\partial \beta} = \sum_{i=1}^{n} \sum_{j=1}^{m} \frac{Yij}{Pij} \frac{\partial\, in\, Pij}{\partial \beta}$$

(18)

Table 4: Description of variables for knowledge, attitude, and practices towards organic waste management using insects

Variable	Description of variables and unit of measurements	Hypothesized sign
Dependent Variable		
Knowledge score	1= knowledgeable, 0= not knowledgeable	+
Attitude score	1= positive attitude, 0= negative attitude	+
Practice score	1= good practices, 0= bad practices	+
KAP Score	1= no attribute at all, 2= all attributes, 3= knowledge and practice, 4= knowledge and attitude, 5= attitude and practice, 6= practice only, 7= attitude only, 8= practice only	+
Independent Variables		
Technologies of segregation	1=Yes/Positive, 0=No/Negative	+/-

Variable	Description of variables and unit of measurements	Hypothesized sign
Forms of recycling waste	1=Yes/Positive, 0=No/Negative	+/-
Recycling services	1=Yes/Positive, 0=No/Negative	+/-
Ways to reduce waste	1=Yes/Positive, 0=No/Negative	+/-
Current uses of waste	1=Yes/Positive, 0=No/Negative	+/-
Awareness of insects used for value addition	1=Yes/Positive, 0=No/Negative	+/-
Waste treatment	1=Yes/Positive, 0=No/Negative	+/-
Incentives for waste management (monetary and on-monetary)	1=Yes/Positive, 0=No/Negative	+/-
Availability of separate bins	1=Yes/Positive, 0=No/Negative	+/-
Pay for waste disposal	1=Yes/Positive, 0=No/Negative	+/-
Training attendance	1=Yes/Positive, 0=No/Negative	+/-
Methods of waste disposal	1=Yes/Positive, 0=No/Negative	+/-
Frequency of waste collection	1=Yes/Positive, 0=No/Negative	+/-
Age	Continuous	
Average monthly income	Continuous	
Education level	Continuous (Years)	
No. of persons in waste production and collection site	Continuous	

Variable	Description of variables and unit of measurements	Hypothesized sign
Sex	Categorical (Male or Female)	

3.5.3 *To determine the willingness of waste producers and collectors to add value to the segregated organic solid waste to insect products*

Tobit model was used to analyse factors influencing willingness to add value segregated organic waste to insect products and the extent of willingness. Descriptive statistics were used to discuss the factors affecting willingness. The censored regression model is viewed effectively as a hybrid between a standard regression model and a binary model (Doughtery, 2003). It assumed that factors influencing willingness to add value segregated organic waste to insect products simultaneously affect the extent of willingness.

The hypothesized relationship was.

$Y_i^{*} = \beta_0 + \beta_i X_i + \mu_i$

Where $Y_i = \begin{cases} Y_i^{*} & \text{if } Y_i^{*} > T \text{ (left censoring)} \\ T & \text{if } Y^{*} \leq T \end{cases}$

T is the lower boundary and assumed a value of 0 if the respondents were not willing to add value to segregated organic waste. Y_i is the observed dependent variable (amount of waste they are willing to add value to) while Y_i^{*} is the latent variable. X_i represents the covariates that influence the dependent variable, β is the parameter to be estimated and μ is the error term.

The empirical method used to estimate the will to add value and the extent of value addition among the respondents was given as.

For households.

$Y_i^{*} = \beta_0 + \beta_1$ Sex+ β_2 Age+ β_3Years of schooling+ β_4 Average monthly income+ β_5 No. of persons in waste production unit+ β_6 Availability of market+ β_7 Availability of recycling services + β_8 Productive current use of waste+ β_9 cost effectiveness+ β_{10} No. of trainings attended+ β_{11} Amount they produce+ β_{12} Knowledge + β_{13} Attitude + β_{14} Practices + μ_i

For waste collectors.

$Y_i^{*} = \beta_0 + \beta_1$ No. of persons in waste production unit+ β_2 Availability of market+ β_3 Availability of recycling services + β_4 Productive current use of waste+ β_5 cost effectiveness+ β_6 No. of trainings attended+ β_7 Amount they produce + β_8 Years of waste collection + β_9 Knowledge + β_{10} Attitude + β_{11} Practices + μ_i

For other waste producers.

$Y_i^* = \beta_0 + \beta_1$ No. of persons in waste production unit+ β_2 Availability of market+ β_3 Availability of recycling services + β_4 Productive current use of waste+ β_5 cost effectiveness+ β_6 No. of trainings attended+ β_7 Amount they produce + β_8 Knowledge + β_9 Attitude + β_{10} Practices + μ_i

Table 5: Description of variables for willingness to add value to segregated organic waste

Variable	**Description of variables and unit of measurements**	**Hypothesized sign**
Dependent Variable		
Willingness to add value	Dummy=1 if willing, 0 if not willing	
Extent of value addition	Continuous	
Independent Variables		
Sex	Categorical	(Male or Female)
Education level	Continuous	+/-
Income	Categorical	+/-
Waste unit size	Continuous	+/-
Incentives for waste management	Yes/No	+/-
Availability of market for recycled organic solid waste	Yes/No	+/-
Current use of waste	Yes/No	+/-
Availability of recycling services	Yes/No	+/-
Cost and benefit of organic solid waste value addition	Yes/No	+/-
Training on waste management	Yes/No	+/-
Number of trainings attended	Continuous	+/-
Amount of waste to be added value	Kgs	+/-
Amount of waste generated	Kgs	+/-
Knowledge	Positive/negative	+/-
Attitude	Positive/negative	+/-
Practices	Positive/negative	+/-

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Characterization of Organic Waste Producers and Collectors

4.1.1 Hotels

On average, each hotel produced approximately 111.80 kgs of organic waste per day (Table 6). The most produced waste by hotels was mostly other food waste (40%), followed by vegetable waste (21. 43%), then flesh waste (5.36%) and lastly fruit waste (1.79%). At least 85.71% of the hotels did not consider the waste they produce a problem while 14.29% admit is a problem. Most of them (91.07%) paid for waste collection while 8.93% did not. 94.12 % paid for private waste collection while 5.88 % relied on public collection services. 60.00 % of those who did not pay for collection sell their waste mostly to pig and poultry farmers while 40% recycle their waste.

About 55.36% did not separate their waste while 44.64% separated their waste (Table 6). Separation was mainly done by a paid worker. 90.32% of those that did not separate the waste pointed out they pay for waste collection thus didn't see the need to while 6.45% cited lack of interest and 3.23% argued its time consuming. Most of the hotels used trash bags and trash bins to dispose of their waste. Only 1.79% disposed it on landfills and the reason is because they use it in their land later.

As indicated in Table 6 below, 92.86% did not practice any form of recycling while 5.37% composted it to manure or fertilizer and 1.79% used the waste as animal feeds. None of the hotels interviewed use any insect to practice organic waste management nor practice waste treatment. To reduce the amount of waste they produce, they increased shelf life of their products using technology such as refrigeration and also regulated consumption patterns by cooking on order. Only 14.29 % had undergone training on using insects to manage organic waste. It was a one-time training.

On willingness to add value, 69.64% said they were not interested in adding value segregated waste using insects while 30.36% were interested. Most of the hotels mentioned they would like to stick to their line of business while some argued that there was a long line of bureaucracy that should authorize before they start adding value to the segregated waste to insect products.

4.1.2 Food Processors

As shown in Table 6 below, on average, each food processor produced approximately 183.08 kgs of organic waste per day. The most produced waste by food processors was crop residues (27.27%), fruit waste (20.45%), dairy products (15.91%), vegetable and baked waste (13.64%), flesh waste (4.55%), animal manure and other kitchen wastes (2.27%).

About 84.09% of the processors did not consider the waste they produce a problem while 15.91% consider it a problem. Most, 61.36% did not pay for organic waste collection while 38.64% paid for it. They only paid for private waste collection. Around 51.85% of those that did not pay said they sell their organic waste mostly to pig farmers, 33.33% give them out for free, and 14.81% recycled their waste. As in Table 6 below, 86.36% separated their waste while 13.64% did not separate it with 50% of them saying they paid for waste collection thus didn't see the need to separate, 33.33% lacked interest to separate and 16.67% argue it was time consuming to do so. Separation was mainly done by all in the company.

Most food processors used trash bags and trash bins to dispose their waste, 25% use waste pits while 20.46 % use landfills. About 72.73% did not utilize any form of recycling, 25% used their waste as animal feeds and only 2.27% used it as compost manure or fertilizer (Table 6). None of them used insects to manage their organic waste. Most increased shelf life of the foods to minimize on waste. Approximately 97.73% did not practice waste treatment and only 2.27% did. At least 86.36% said they were interested in adding value-segregated waste using insects while 13.64% were not interested. None has attended any training using insects for organic waste management.

4.1.3 Animal Feed Millers

As shown in Table 6 below, on average, each animal feed miller produced approximately 139.94 kgs of organic waste per day. The most produced waste by animal feed millers was crop residues (100%). About 80% did not consider the waste they produced a problem while 20% said it was a problem. Approximately 76% did not pay for organic waste collection while 24% did. They mostly paid for private collection (83.33%). The main reason given by those that did not pay is they sold their waste (42.11%), 31.58% recycled their waste, 15.79% gave out their waste for free, and 5.26% did not see the need and cited the collection services are unreliable so no point of paying for them. About 64% separated their waste while 36% did not. Separation was mainly done by a paid worker. 5.56% lacked interest to separate the waste, 22.22 % termed it time consuming and the others said they paid for waste collection thus did not see the need.

As in Table 6, most animal feed millers used trash bags and trash bins to dispose of their waste, while some relied on waste pits and landfills. About 64% did not recycle their waste, 32% regenerated animal feeds while 4% compost the waste to manure or fertilizer. Approximately, 96% did not use insects to add value to their waste while 4% used black soldier flies and crickets. To reduce their waste, they mostly controlled pests. About 96% did not practice waste treatment while 4% did. None has attended any training using insects for organic waste management.

Approximately 68% said they were interested in adding value segregated waste using insects while 32 % were not interested. Some mentioned insects such as BSF have a high fat content which discourages its use while some preferred to collaborate with an insect rearing company and outsource the dried insects from them instead of rearing the insects themselves.

4.1.4 Markets

As indicated in Table 6 below, on average, each market produced approximately 1828.57 kgs of organic waste per day with most waste being during the wet season. The most produced waste by markets was vegetable waste (54.55%), followed by fruit waste (27.27%), flesh waste from meat markets (9.09%), and crop residues 4.55%. About 81.82% considered the waste they produce a problem while 18.18% say it was not a problem. They termed it a problem mainly during rainy seasons as there was excess food thus excess waste. Around 54.55 % paid for organic waste collection while 44.45% did not. They mostly paid for public collection (66.67%) included in cess they pay the county government. They, however, complained that collection is delayed and not done in time as they can last up to a month or more without waste being collected.

The main reason given by those that did not pay is they give out their waste for free (60%), 30% sold their waste to pig farmers, 10% recycled their waste. About 68.18% did not separate their waste while 31.82% did. Separation was mainly done by a paid worker. Among the reasons for not separating, 40% pay for waste collection thus did not see the need, 33.33 % termed it time consuming, 13.33% lacked separate bins and lacked interest respectively.

Most markets used trash bags and trash bins to dispose of their waste, while some relied on waste pits and landfills. Most, 54.55%, did not recycle their waste, 40.91% recycled it as animal feeds while 4.55% composted the waste to manure or fertilizer. They did not use insects to add value to their waste. They reduced their waste by increasing the shelf life of their products and none treated their waste. Approximately 68.18% said they were however interested in adding value segregated waste using insects while 31.82% were not interested. None had attended any training using insects for organic waste management.

4.1.5 Slaughterhouses

As shown in Table 6 below, on average, each slaughterhouse produced approximately 1078.72 kgs of organic waste per day. The most produced waste by slaughterhouses is flesh waste (76.47%), and animal manure (23.53%). 64.71 % considered the waste they produced a problem while 35.29 % say it is not a problem. Most, 52.94 %, did not pay for organic waste collection while 47.06% do. 50% paid for public collection and 50% for private collection. The main reason given by those that did not pay is they give out their waste for free (94.44%), and 5.56% sold their waste. About 64.71% did not separate their waste while 35.29 % separated. Separation was mainly done by males. 58.33 % paid for waste collection thus did not see the need, 33.33% lacked interest and 8.33 % termed it time consuming.

Most slaughterhouses used trash bags and trash bins to dispose their waste, while some relied on waste pits. They did not recycle their waste. Also, none had attended any training using insects for organic waste management. They also did not use insects to add value to their waste. They reduced their waste by increasing shelf life of products. About 70.79% of the slaughterhouses did not treat their waste while 29.41% treated theirs. Most, 52.94%, said they were, however, interested in adding value segregated waste using insects while 47.06% were not interested.

4.1.6 Commercial Horticultural Farms

As in Table 6 below, on average, each commercial horticultural farm produced approximately 308.35 kgs of organic waste per day. The most produced waste by commercial horticultural farms was crop residues (53.85%), and vegetable waste (46.15%). None considered the waste they produced a problem. Also, none paid for organic waste collection. The main reason given by those that did not pay was 76.92 % recycled their waste while 23.08% sold their waste. About 69.23% separated their waste while 30.77% did not. Separation was mainly done by a paid worker. Those that did not separate their waste termed lack of interest as the main reason.

Most commercial horticultural farms used trash bins and waste pits to dispose of their waste. To reduce their waste, they controlled pests and increased the shelf life of their products. About 69.23% of the farms did not treat their waste while 30.77% treated theirs. Most, 62.5 % had undergone training on using insects to manage organic waste. Although they did not use insects to add value to their waste, about 61.54% said they were interested in adding value segregated waste using insects while 38.46% were not interested. Those that were not interested said they already use their waste as compost or sell it.

4.1.7 Pig and Poultry Farmers

As shown in Table 6 below, on average, each pig or poultry farmer produced approximately 85.95 kgs of organic waste per day. The most produced waste by pig and poultry farmers is animal manure (98.78%), and crop residues (1.22%). Approximately 82.19% did not consider the waste they produced a problem while 17.81 % say it was a problem. On payment for waste collection, 98.63% did not pay for organic waste collection while 1.37% do. They only paid for private collection. The main reason given by those that did not pay is 69.44 % recycled their waste, sold their waste (23.61%), 4.17 % did not see the need, 1.39% gave out their waste for free, and 1.39% said paying for waste collection was expensive. About 90.41 % separated their waste while 9.59 % did not. Separation was done by all. Around 57.14% lacked interest in separating the waste, while the others termed it time consuming and requiring too much space.

Most pig and poultry farmers used waste pits to dispose of their waste. They recycled their waste by composting it to manure. Only 45.07% had undergone training on using insects to manage organic waste (Table 6). Most, 89.04%, did not use insects to add value to their waste, 10.59% used black soldier flies, crickets (4.04%), mealworms (3.36%), and cockroaches (2.38%). To reduce their waste, they mainly regulated consumption patterns of their animals. Most, 76.71% of the farmers did not treat their waste while 23.39% treated theirs. About 89.04% said they were interested in adding value segregated waste using insects while 10.96% were not interested. Most pig and poultry farmers were willing to add value to their organic waste to insect products to substitute the high cost of feeds.

4.1.8 Households

As in Table 6 below, on average, each household produced approximately 1.53 kgs of organic waste per day which is slightly higher than the predicted 1.42 kgs by 2025 (World Bank, (2012). It is also unexpected with the increasing cost of living in the country. It can however be linked to storage (preference for fresh produce, poor storage skills, poor storage management), serving food (using large plates, uniform portion sizes), food preparation (overcooking, not using leftovers, poor cooking planning) and shopping style (poor planning, impulse buying, buying large quantities of food) as by (Stockli *et al*., 2018). Each household had approximately 4 people.

The most produced waste by households is other kitchen waste such as food peelings (80.82%), vegetable waste (19.18%). Most, 90.44 %, did not consider the waste they produce a problem while 9.46 % said it was a problem. About 50.68 % paid for organic waste collection while 49.32% did not. Most, 97.33%, paid for private collection and 2.67% for public collection. The main reason given by those who did not pay is that the services were not available. Most also complained that public collection service is unreliable thus opting for private collection. This supports Mugo *et al.* (2022) who stated inadequate infrastructural waste management facilities such as treatment and disposal infrastructure, unreliable and irregular waste collection patterns lead to littering and physical accumulation of solid waste in Kenya.

Waste collection was mainly done once a week. About 64.86 % separated their waste while 35.14% did not separate (Table 6). Separation was mainly done by all. Some apartments had separate bins for different types of waste bins (green waste, general waste, and mixed recycling) to encourage separation while some only had one trash bag per week for use thus it was difficult to separate. Approximately 67.31 % of those that did not separate pay for waste collection thus do not see the need, while the others lack interest. A study by Okot-Okumu (2012) showed that rich households store their household waste in bins, while low-income households store it in sacks, plastic bags, cut jerry cans, and cardboard boxes.

Most of the domestic waste storage containers used by low-income households —such as sacks, polythene bags, and boxes—are also disposed of with the waste. There is notreally sorting done per se; instead, households separate the parts of wastes that are valued, like vegetables and food leftovers (used for animal feeds, sold, or given away occasionally), plastic bags, glass and plastic bottles, tins, and scrap metal for sale, from the waste that is typically stored in mixtures. Wastes that have been sorted or separated are either recycled on-site or sold to mobile buyers who then resell them to middlemen who supply recycling companies. Additionally, waste is separated at dump sites, in transportation to the landfill, and at transfer stations (such as road verges, skips, and bunkers).

Most households use trash bags and trash bins, waste pits and landfills to dispose of their organic waste while 47.3% of the households burn their other wastes (Table 6). About 47.97% did not recycle their waste while those who did mostly used it by composting it to manure or fertilizer or animal feeds. Only 10.13% had undergone training on the use of insects for organic waste management. Most, 97.97%, did not use insects to add value to their waste, 5.82% used black soldier flies and crickets (2.68%) respectively. To reduce their waste, they mainly regulated consumption patterns and increased shelf life of their foods. About 95.95% of the households did not treat their waste while 4.05% treated theirs. Approximately 55.41 % were willing to add value segregated waste to insect products while 44.59% were not.

There was a weak positive correlation between gender and age with separation of organic waste. Most females do waste separation supporting Ekere *et al.* (2009) who argued that women are most likely to carry out waste separation. A weak positive relation between average monthly income and payment for waste collection supports Long *et al*. (2009) who revealed that higher income earning persons paid for waste collection whereas more low-income earners did not as they term it expensive and opted for other ways of disposal supporting. There is however no correlation between income earned and amount of waste generated.

4.1.9 Waste Collectors

On average, a waste collector collected approximately 21.67 tonnes of waste daily (Table 5). This confirms Nokele (2022) revelation that a considerable proportion of the solid waste generated in urban areas, ranging from 30% to 40%, remains uncollected considering the 2400 tonnes waste generation estimate by World Bank. About 87.93% of waste collectors separated their waste while 12.07% did not separate. Separation was mainly done by paid workers. Among those that did not separate their waste, 57.14% lacked interest, 28.57% lacked space, and 14.29 % termed it time consuming.

Most waste collectors used landfills as their method of disposal. About 55.17% did not recycle their waste while those who do mostly used it as animal feeds (38%), composting it to manure or fertilizer (3.39%) insect feeds and biogas (1.72%) respectively (Table 6). Only 15.17% had undergone training on using insects to manage organic waste. Approximately, 98.28% did not use insects to add value to their waste, while 12.07%% used black soldier flies. About 96.55% of the waste collectors did not treat their waste while 3.45% treated theirs. Most, 84.48%, were willing to add value segregated organic waste to insect products while 15.52% were not.

For all respondents, it is important to note that the individual barriers, such as laziness or lack of interest, could sometimes outweigh environmental concerns. The people’s perceptions regarding the role of institutions, like in this case organic waste producers’ perception towards waste collectors’ roles, could influence susceptibility of responsible institution addressing environmental problems. Also, Nixon and Saphores (2009) stated practical barriers including the lack of time or storage space for recyclable materials, could limit information or personal physical limitations to recycle.

Table 6: Characterization of organic waste producers and collectors

Variable		Hotel	Food Processors	Animal Feed Millers	Markets	Slaughterhouse	Commercial Horticultural Farms	Pig and poultry farmers	Households	Waste collectors
Amount of waste produced daily (kgs)		111.80	183.08	139.94	1828.57	1078.72	308.35	85.95	1.53	21.67 tonnes collected/day
Most produced waste (%)	Vegetable waste	21. 43	13.64		54.55		46.15			
	Baked waste		13.64							
	Fruit waste	1.79	20.45		27.27					
	Flesh waste	5.36	4.55		9.09	76.47				
	Other kitchen waste	40	2.27						80.82	
	Crop residues		27.27	100			53.85	1.22		
	Dairy products		15.91		4.55					
	Animal manure		2.27			23.53		98.78		
Is waste a problem (%) (NO)		85.71	84.09	80	18.18	35.29	100	82.19	90.44	

Variable		Hotel	Food Processors	Animal Feed Millers	Markets	Slaughterhouse	Commercial Horticultural Farms	Pig and poultry farmers	Households	Waste collectors
Payment for waste collection (%) (PAY)	I pay for waste collection	91.07	61.36	76	54.55	42.06	0	1.37	50.68	
	Private	94.12	100	83.33		50		100	97.33	
	Public	5.88		16.67	66.67	50			2.67	
Reasons for not paying for waste collection (%)	They are not available								90	
	It is expensive							1.39	10	
	I/we recycle/ reuse/ recover our waste	40.00	14.81	31.58	10		76.92	69.44		
	I/we sell the waste	60.00	51.85	42.11	30	5.56	23.08	23.61		
	I/we give out the waste for free		33.33	15.79	60	94.44		1.39		
	I don’t see the need			5.26				4.17		

Variable		Hotel	Food Processors	Animal Feed Millers	Markets	Slaughterhouse	Commercial Horticultural Farms	Pig and poultry farmers	Households	Waste collectors
Waste separation (%)		55.36	86.36	64	31.82	35.29	69.23	90.41	64.86	87.93
Reasons for not separating	It's time consuming	3.23	16.67	22.22	33.33	8.33		21.43		14.29
	It requires much space							21.43		28.57
	I pay for waste collection thus not my business	90.32	50	72.22	40	58.33			67.31	
	Lack of interest	6.45	33.33	5.56	13.33	33.33	100	57.14	32.69	57.14
	Lack of separate bins				13.33					
Methods of disposal (%)	Land fills	1.79	20.46	2					5.86	100
	Waste pits		25	2		4	99	100		
	Burning								47.33	

Variable		Hotel	Food Processors	Animal Feed Millers	Markets	Slaughterhouse	Commercial Horticultural Farms	Pig and poultry farmers	Households	Waste collectors
	Trash bags and bins	98.21	54.54	96		96	1		46.81	
Forms of recycling (%)	Composting to manure or fertilizer	5.37	2.27	4	4.55		85	100	14.04	3.39
	Insect feeds									1.72
	Animal feeds	1.79	25	32	40.91		15		37.99	38
	Briquettes									1.72
	None	92.86	72.73	64	54.55	100			47.97	
Insects used for organic waste Management (%)	Black soldier fly			3				10.59	5.82	12.07
	Mealworm							3.36		
	Cockroaches							2.38		
	Crickets			1				4.04	2.68	
Waste treatment (%)			2.27	4		29.41	30.77	23.39	4.05	3.45

Variable		Hotel	Food Processors	Animal Feed Millers	Markets	Slaughterhouse	Commercial Horticultural Farms	Pig and poultry farmers	Households	Waste collectors
Ways to reduce organic waste (%)	Regulating consumption patterns	50						100		
	Increasing shelf life of products	50	100		100	100	50			
	Controlling pests			99			50			
Attended training (%)		14.29					62.5	45.07	10.13	15.17
Willingness to add value (%)		69.64	86.36	68	68.18	52.94	61.54	89.04	55.41	84.48

4.2 Popularity of Insects

The most known insects were black soldier flies (33.8%). According to Rindhe *et al.* (2019), its larvae exhibit a faster conversion rate of organic waste compared to worms typically used in vermicomposting. A group of 2,000 larvae has the capacity to consume approximately one kilogram of household food waste daily. Studies indicate that the larvae possess natural antibiotics that function as growth promoters in animal feed (Newton *et al*., 2008). Apart from the larvae, the residue produced during controlled larval rearing can be utilized for soil improvement thus its popularity

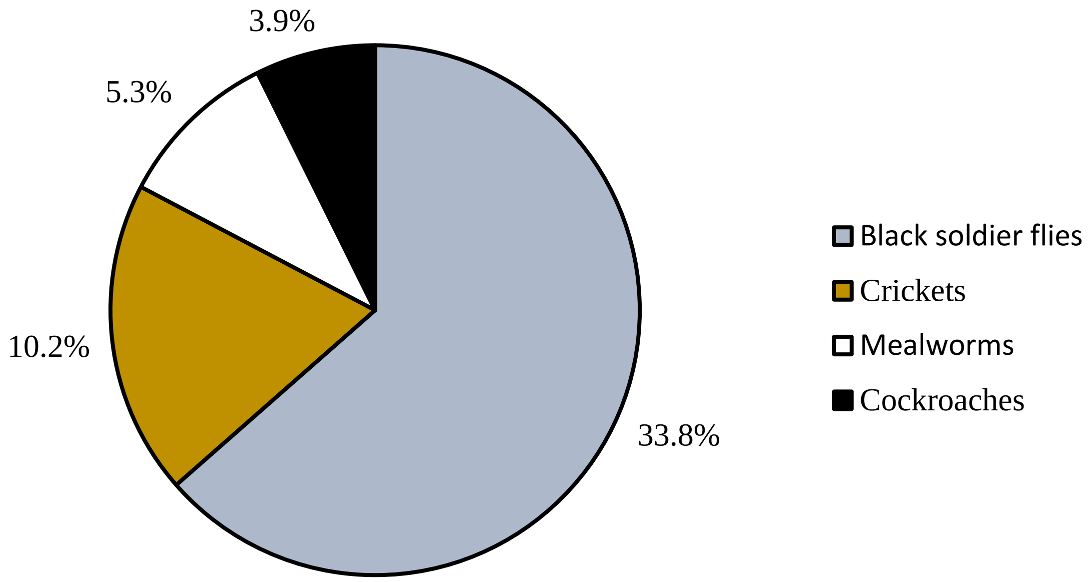


Figure 3: Popularity of Insect Species Used for Organic Waste Management

4.3 Knowledge, Attitudes and Practices Towards Organic Waste Recycling Using Insects

From the results in Table 7 below, there is an indication that even though most people are knowledgeable and have a positive attitude toward organic waste management using insects, very few practice it. Our findings are supported by Veldkamp *et al*. (2022) who found that insect farming is limited by low production space especially in urban areas, inadequate technology, data and guidance, and the presence of insect pests and diseases, high cost of inputs and costs, low demand due to lack of customer acceptance and prices, and inaccessibility to finance. There is also a lack of understanding regarding chemical and microbiological food safety hazards, as well as measures to manage them.

Additionally, there are concerns about allergenicity for both workers and consumers. Lastly, regulatory challenges involve legal restrictions and difficulties associated with acquiring operational licenses for insect production. There is also a very weak positive correlation between knowledge and practice (r = 0.07), while there is a weak one between knowledge and attitude (0.20) and a weaker one between attitude and practice (r = 0.16). However, a weak negative relationship was noted in the relationship between attitude and food handling practices. These results indicate that high knowledge of food waste generation as a factor may not help change the attitude patterns and practices of food service operators in food waste mitigation.

Table 7: Organic waste management KAPs scores per variable and overall attributes

Outcome	Households (n=151)	Waste collectors (n=58)	Waste producers (n=276)	Pooled sample (n=485)
Knowledge on technologies of segregation	21.7	23.3	27.2	23.2
Knowledge on methods of disposal	90	92	92	91.9
Knowledge on forms of recycling	65	76	83	75.8
Knowledge on insects used for organic waste management	2.3	7.7	9.5	6.3
Knowledge on ways of waste reduction	93.8	93	93	93.1
Knowledge on importance of organic waste segregation	83	92	94	90.6
Knowledge on organic waste recycling services	57.5	64.3	67.3	62.9
Knowledge on ways of waste treatment	22	35,3	34.6	32.8
Knowledge on incentives gained from organic waste management using insects	10.8	10.9	12,7	11.6
Knowledge on trainings offered on organic waste management using insects	6.8	9.7	7.8	7.9
Knowledge on waste collection	90.6	100	88	94.7
Knowledge on impact of distance on waste segregation	84.4	98	82.6	87.6
Overall knowledge outcome (1= Knowledgeable, 0=Not knowledgeable)	95.6	99.6	98.2	98.6
Attitude on technologies of segregation	57	63.2	65.4	60.5
Attitude on methods of disposal	61.3	65.8	67.1	65.2
Attitude on forms of recycling	79.5	92.7	94.8	89.8

Outcome	Households (n=151)	Waste collectors (n=58)	Waste producers (n=276)	Pooled sample (n=485)
Attitude on insects used for organic waste management	71.4	72.9	73.5	72.7
Attitude on ways of waste reduction	68.9	65	66.1	66.6
Attitude on importance of organic waste segregation	74.7	76.3	78.2	76.0
Attitude on organic waste recycling services	70.6	70.8	71.1	70.9
Attitude on ways of waste treatment	54.8	55.6	56.3	55.2
Attitude on incentives gained from organic waste management	58.4	57.6	59.2	58.3
Attitude on impact of training on organic waste management using insects	69.6	86.1	83.2	78.8
Attitude on impact of distance on waste segregation	85.6	89.1	88.5	87.0
Overall attitude outcome (1= Positive attitude, 0=Negative attitude)	79.4	80.1	82.1	80.0
Practices towards technologies of segregation	0	0	5.5	5.5
Practices towards methods of disposal	100	100	100	100
Practices towards forms of recycling	14.1	28.1	89.3	45.2
Practices towards insects used for organic waste management	0.33	1.3	3.8	2.0
Practices towards organic waste reduction	90.0	83.0	87.5	86.5
Practices towards organic waste segregation	48.1	40.5	92.3	60.3
Practices towards waste treatment	6.0	8.4	12.8	9.0
Practices towards incentives gained from organic waste management	5.2	6.8	6.9	6.3
Practices towards training on organic waste management using insects	3.9	5.8	5.0	4.9
Practices towards waste collection at least once a week	85.5	87.9	87.0	86.8

Outcome	Households (n=151)	Waste collectors (n=58)	Waste producers (n=276)	Pooled sample (n=485)
Practices towards distance on waste segregation	74.1	77.3	77.2	76.2
Overall practice outcome (1= Practices, 0=Doesn't practice)	56.5	58.3	57.4	57.4
KAP Categories				
All attributes	45.5	49.9	50.7	48.7
Knowledge and Attitude	30.9	31	1.1	31.0
Knowledge and Practices	7.0	8.0	8.7	7.9
Knowledge only	8.8	11.8	11.9	10.8
None at all				1.0

The KAPs scores for the different categories of respondents (Table 7) indicated that pig and poultry farmers practiced organic waste management using insects most (68.5%). A study by Abro et al. (2020) stated that insects have the potential to serve as high-quality feed. For instance, BSF is composed of 38.5–62.7% crude protein, 14.0–39.2% fat, and has a gross energy content of 5282 kcal/kg. The larvae are rich in essential micronutrients such as iron, calcium, and zinc, as well as crucial amino acids like lysine, threonine, and methionine, addressing major limitations in poultry diets based on cereals and legumes (Anyega, 2021; Dobermann *et al*., 2017; Halloran *et al*., 2017; INRA-CIRAD-AFZ, 2020; Khusro *et al*., 2012; Mwangi, 2019; Nyingi, 2019; Onsongo *et al*., 2018; Sumbule, 2019; Van Huis *et al*., 2013; Verkerk *et al*., 2007). Due to its elevated fat and energy content, BSF larvae could potentially replace conventional energy sources such as maize, which has a lower energy content (4450 kcal/kg of gross energy) compared to BSF larvae (Anand *et al*., 2008; INRA-CIRAD-AFZ, 2020). The integration of high-quality insect feeds has the potential not only to enhance productivity but also to reduce feed costs, subsequently lowering the prices of eggs and poultry meat.

Table 8: KAPs Scores for different categories of respondents involved in organic waste management

Respondent	Knowledge (%)	Attitude (%)	Practices (%)
Animal feed millers	100	68	56
Pig and poultry farmers	98.6	95.9	68.5
Slaughterhouses	97.1	82.4	50
Commercial horticultural farms	100	100	76.9
Markets	100	86.4	50
Food processors	100	56.8	45.5
Hotel	100	71.4	53.6
Waste collectors	100	82.8	50
Households	96.6	80.4	58.8

4.4 Logit Regression of The Factors Influencing Adoption of Insect-Based Technologies for Organic Waste Recycling Among Stakeholders

The respondents were categorized into households, waste collectors, and other producers. The other producers included hotels, markets, slaughterhouses, food processors, animal feed millers, commercial horticultural farms and pig and poultry farmers. During the analysis, some variables were interacted to uncover relationships and dependencies between them that may reveal hidden patterns of the variables (Gujarati, 2004).

4.4.1 Households

Our findings show that females are more likely to be knowledgeable on organic waste management using insects, and being a man reduces the odds of being knowledgeable by 22% (Table 9). Females were more likely to be knowledgeable on use of insects to manage organic waste as compared to men. This is contrary to findings by Seng *et al.* (2018) who suggested that knowledge on waste management does not vary between male and female.

Our study also shows that male respondents had a more positive attitude on organic waste management using insects than females. Being male increase the odds of having a positive attitude on organic waste management using insects by 3.8%. This agrees with Suleman *et al*. (2015) who found out that most people consider household waste management as the responsibilities of females. The more income one earned, the more knowledgeable they were and the better attitude they had on organic waste management using insects.

Income had a positive influence on knowledge level. An increase in one unit of income increases the odds of being knowledgeable on organic waste management using insects by 21%. Setiawan (2020) noted that the likelihood that a respondent recognizes the responsibility of waste sorting, an attribute of organic waste management increases with monthly income. This is because individuals with higher incomes may be more likely to have better access to information. The greater the number of persons in a household, the less likely they are to have knowledge on organic waste management because there's division of labor. The more the number of trainings a household attended, the less the likelihood to practice organic waste management using insects., contrary to other waste producers where increased number of trainings increased their likelihood, therefore the need for customized trainings.

4.4.2 Waste Collectors

We found that the more years spent in waste collection, the less the likelihood to practice organic waste management using insects and the more likely they are to have a negative attitude (Table 10). This could be because they mostly have access to larger spaces in the dumpsites unlike recent collectors who must be creative on how to dispose of their waste. (Ngunju, 2018). The results also showed that the higher the amount of organic waste collected, the less likely they are to be knowledgeable on organic waste management using insects. This could explain why there's an increase in landfills in Nairobi County due to poor waste disposal and high amounts of waste (Muiruri *et al*., 2020).

4.4.3 Other Waste Producers

The number of people in an organization and number of trainings they had attended influenced knowledge level. The higher the people and number of trainings attended, the lesser knowledgeable the organization was. In line with Debrah *et al*. (2021), a unit increase in number of employees in an organization and number of trainings attended increased the odds of being knowledgeable by 0.3% and 3%, respectively (Table 10). Producing more waste increased the chances of an organization practicing organic waste management using insects by 0.3% because the large amount of waste could be a problem thus seeking a way to manage it.

Table 9: Logit model results for factors influencing knowledge, attitude, and practices of organic waste producers and collectors towards using insects for organic waste management

Variable	Knowledge			Attitude			Practices		
	Odds Ratio	**Marginal Effect**	**Standard Error**	**Odds Ratio**	**Marginal Effect**	**Standard Error**	**Odds Ratio**	**Marginal Effect**	**Standard Error**
Households									
Sex	0.00007*	-0.22	0.0003	-1.32	0.038*	0.68	0.22	0.04	0.16
Age	1.4	0.007	0.79	1.65	0.069	2.5	2.7***	0.07	0.75
Average monthly income	7868.2**	0.21	25492.6	0.89	-0.015	1.73	6235.1	-0.19	22563.2
Years of schooling	2.2	0.02	4.7	20.7	0.42	68.7	2.4	0.01	4.6
Household size	0.20*	-0.04	0.17	1.04	0.006	0.16	0.27*	0.05	0.18
Number of trainings attended	0.37	-0.003	0.82	1.02e-08**	-2.5	6.24e-08	0.53**	-0.02	0.91
Amount they produce	0.89	-0.003	2.3	0.26*	-0.17	0.18	0.9**	-0.004	0.28
AgeXIncome*	0.21	-0.04	0.11	1.1	0.02	0.43			
GenderXAge*	16.7	0.07	14.2				15.5	0.55	14.9
GenderXSchool XTraining				0.88	-0.02	0.39			
TrainingXAmount				4525.04**	1.16	13776.9			

Variable	**Knowledge**			**Attitude**			**Practices**		
	Odds Ratio	**Marginal Effect**	**Standard Error**	**Odds Ratio**	**Marginal Effect**	**Standard Error**	**Odds Ratio**	**Marginal Effect**	**Standard Error**
AgeXYearsofschooling				0.73	-0.04	0.43			
AgeXTraining				1.06	0.008	0.39			
No. of observation	148	**Wald chi2(8)**	28.9	**No. of observations**	148	**Wald chi2(8)** 20.8	**No. of observations**	148	**Wald chi2(9)** 22.3
Log pseudolikelihood	-12.1	**Prob > chi2**	0.0007	**Log pseudolikelihood**	-64.2	**Prob > chi2** 0.005	**Log pseudolikelihood**	-88.4	**Prob > chi2** 0.008
Waste Collectors									
Years of waste collection	7.04**	0.26	4.9	0.0004**	-0.93	0.0012	-2.3*	0.10	-0.49
No. of trainings attended	2.3	0.11	1.7	0.04*	-0.38	0.064	0.89	0.04	0.071
Amount of kgs they collect	0.82*	-0.026	0.09	1.01	0.0016	0.40	0.48***	1.6	0.10
YearsXKg				1.01	0.0017	0.04			
TrainingXkg				1.02	0.002	0.15			
YearsXtrainings				1.9	0.08	0.82	1.5*	4.4	0.31

Variable		**Knowledge**			**Attitude**			**Practices**	
	Odds Ratio	**Marginal Effect**	**Standard Error**	**Odds Ratio**	**Marginal Effect**	**Standard Error**	**Odds Ratio**	**Marginal Effect**	**Standard Error**
No. of observations	58	**Wald chi2(5)**	30.2	**No. of observations**	58	**Wald chi2(4)** 44.1	**No. of observations**	58	**Wald chi2(7)** 17.8
Log pseudo likelihood	-24.5	**Prob > chi2**	0.0039	**Log pseudo likelihood**	-21.7	**Prob > chi2** 0.0016	**Log pseudo likelihood**	-34.8	**Prob > chi2** 0.0029
Other producers									
Number of persons in a unit	0.66***	0.003	0.07	1.9	0.10	1.12	1.62*	0.12	0.45
Number of trainings attended	0.02***	0.03	0.02	0.70	-0.06	0.44	1.40*	0.079	0.28
Amount they produce	1.5*	0.003	0.39	1.0	0.000095	0.00020	0.99	-7.69e-07	4.17e-06
AmountXTtraining	4.1***	0.01	1.6	1,04	0.008	0.099			
AmountXPeople				0.88	-0.21	0.07	0.95	-0.01	0.03
No. of observation	266	**Wald chi2(5)**	34.06	**No. of observations**	266	**Wald chi2(4) 12.67**	**No. of observations**	266	**Wald chi2(6)** 18.6

Variable	Knowledge			Attitude			Practices		
	Odds Ratio	Marginal Effect	Standard Error	Odds Ratio	Marginal Effect	Standard Error	Odds Ratio	Marginal Effect	Standard Error
Log pseudolikelihood	-9.1	**Prob > chi2**	0.0000	**Log pseudolikelihood**	-127.4	**Prob > chi2 0.0266**	**Log likelihood**	-1727.2	**Prob > chi2** 0.0501

* p≤ 0.05, ** p ≤ 0.01, ***p ≤ 0.00; *Note:* Other producers include hotels, markets, slaughterhouses, food processors, animal feed millers, commercial horticultural farms and pig and poultry farmers

4.5 Multinomial Logit Analysis of Factors Influencing Knowledge, Attitude, And Practices of Insect-Based Organic

4.5.1 Households

The knowledge, attitude, and practices score combine the individual three scores (knowledge, attitude, and practices). The older one was, the more likely they were to have all the positive attributes which thus indicates a gap in encouraging the youth to adopt this upcoming technology. A unit increase in average income earned increases the probability of having all attributes over having adequate knowledge and practice only by 7% (Table 11). Therefore, the more one earns, the less likely they are to have a positive attitude on organic waste management using insects and put it to practice. This contradicts with the findings of Ekere *et al.* (2009) who found out that higher-income households are less likely to consider using recyclables from the solid waste stream to supplement their income.

The number of persons in a household significantly influenced the level of knowledge, attitude and practices. A unit increase in number of persons in the waste production increases the probability of having all the attributes. This is because with many people in a household, there is a greater chance of division of labor thus encouraging specialization and making work easier.

4.5.2 Waste Collectors

The number of training programs a waste collector had attended significantly influenced the level of knowledge, attitude and practices. An increase in training programs attended decreases the probability of being knowledgeable and practicing over having all attributes (knowledgeable, positive attitude, and practicing). Therefore, the more training attended, the more likely a waste collector is to know, have a positive attitude, and practice organic waste management using insects. This collaborates with findings by Usman *et al*. (2023) who mentioned that training improves people's understanding and awareness of the detrimental impacts of environmental pollution.

Similar to training, the number of years one has been collecting waste also influenced their knowledge, attitude and practices. Collecting waste for more years increases the likelihood of a waste collector having all the attributes. This is because of the experience and exposure that comes over the years.

4.5.3 Other Waste Producers

It was found that all producers from hotels, markets, slaughterhouses, food processors, animal feed millers, commercial horticultural farms and pig and poultry farmers possessed at least one of the combined attributes. The more people there are in a waste unit, the less likely they are to be knowledgeable and have a positive attitude compared to having all the attributes. Therefore, entities with more employees are likely to practice organic waste management using insects compared to those with fewer employees. This is because when an entity has enough employees, there is likely to be a division of labor.

The more the amount they produce, the lesser the likelihood of only having knowledge and practice on organic waste management using insects compared to having all the attributes. Entities that produced more waste were more likely to have a positive attitude towards organic waste management using insects compared to those that produced less waste. This could be because a high amount of waste could be a problem, and thus, the needs to be a way to recycle it.

Table 10: Multinomial logit model results for factors influencing knowledge, attitude, and practices of organic waste producers and collectors towards using insects for organic waste management

Variable	Knowledge and Attitude			Knowledge and Practices			None		
	Coefficient	**Marginal Effect**	**Standard Error**	**Coefficient**	**Marginal Effect**	**Standard Error**	**Coefficient**	**Marginal Effect**	**Standard Error**
Households									
Sex	-1.821	0.042	0.811	-1.121*	-0.073	0.084	-16.321***	0.085	-0.846
Age	1.233	-0.014	0.123	-0.752*	-0.055	0.033	-1.028*	0.015	0.008
Average monthly income	0.431	0.006	0.932	1.125*	-0.074	0.116	-2.131	-0.074	0.009
Years of schooling	1.725	0.196	-0.431	1.632	0.054	0.157	0.564	0.085	0.002
Household size	-7.201***	-0.022	0.226	-0.757*	-0.052	0.045	-0.746*	-0.053	0.065
Training programs attended	0.553	-0.002	-0.147	-1.004*	0.016	0.083	-21.042**	0.015	0.824
Amount they produce	0.254	0.117	0.026	0.992	0.003	0.007	1.825	0.093	0.786
TrainingX Amount				3421.407	1.086	23496.213			

No. of observations	134	**Wald chi2(21)**	759.91						
Log pseudolikelihood	-117.423	**Prob > chi2**	0.0000						
Waste Collectors									
Years of waste collection	0.314	-0.093	0.671	8.238***	0.164	0.757	-0.859*	-0.173	0.848
Training programs attended	2.825	0.357	1.327	0.384	0.712	0.007	-0.418**	0.624	0.052
YearsXtraining	-0.321	-0.003	0.293	-7.315***	-0.147	0.636	-0.482*	-0.128*	0.475
Amount of kgs they collect	-0.456	-0.094	0.316	-0.375	-0.003	0.232	0.761	0.027	0.362
No. of observation	49	**Waldchi2(21)**	140.23						
Log pseudo-likelihood	-34.923	**Prob > chi2**	0.0000						
Other producers									
Number of persons in a waste production unit	-0.346*	-0.081	0.184	0.235	0.036	0.202	0.118	0.057	0.212

Training programs attended	-0.794	-0.136	0.887	-1.025	0.066	0.755	0.071*	-0.710	0.067
Amount they produce	0.237	0.064	0.154	-0.336*	-0.066	0.154	1.821	0.127	0.148
AmountXT training	-0.025	-0.014	0.168	0.241*	0.020	-0.201	0.283	0.045	0.176
AmountXPeople	0.146	0.045	0.136	0.244	-0.019	0.144	0.217	0.032	0.162
No. of observation	235	**Wald chi2(21)**	28.52						
Log pseudolikelihood	-213.834	**Prob > chi2**	0.0032						

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$: *Note:* Other producers include hotels, markets, slaughterhouses, food processors, animal feed millers, commercial horticultural farms and pig and poultry farmers

4.6 Willingness to Recycle Organic Waste Using Insect-Based Technologies

Descriptive statistics were used to discuss the factors affecting willingness. When the market is available for insect-based value-added organic waste products, 56.24% of the respondents were willing to recycle their segregated organic waste using insects. Alternatively, when they are currently using their waste productively, there are available recycling services, incentives for adding value segregated organic waste, and it is cost effective, 46.93%, 49.89%,50.11%, 49.47% respectively were willing to recycle their segregated organic waste using insects (Table 12). Therefore, if the respondents gain from recycling the segregated waste to insect products, and the market is available for the insect-based products, they were willing to engage in value addition. If not in a position to add value to the segregated organic waste to insect products themselves, 75.3% of the respondents were willing to sell their waste to potential buyers.

Table 11: Factors affecting willingness to add value segregated organic waste

Variable	Willingness (%)
Availability of market	56.24
Productive use of current waste	46.93
Availability of recycling services	49.89
Incentives for adding value segregated organic waste	50.11
Cost effectiveness	49.47

4.6.1 Households

Increasing household size by one person led to an increase of 7.5 kilograms of waste they are willing to add value to insect products. The findings agree with Xu *et al*. (2022)who noted that the higher the proportion of family members engaged in agricultural labor, the stronger their willingness to adopt organic waste recycling. Also, Setiawan (2020) noted that the number of family members influences the receptivity of recycling practices. The cost-effectiveness of using insects to recycle segregated waste also positively influenced the amount of organic waste a household would be willing to add value to an extra 33.3 kgs, similar to the availability of recycling services offered regarding waste recycling using insects.

Most waste recycling services are community-based and educate people on the importance of waste reduction and recycling, which would encourage further participation among households to add value-segregated waste to insect products. Also, when it is cost-effective to add value, more households will be willing to participate because of the extra benefit they get from the value addition. It is anticipated that the cost-effectiveness of value addition of organic waste to insect products will boost households' willingness to a greater extent, similar to incentives put in place. This indicates that favorable incentives, monetary and non-monetary, such as favorable policies, encourage value addition to segregated waste.

4.4.2 Waste Collectors

When there are incentives to be gained from adding value-segregated organic waste to insect products, the amount of waste that the collectors were willing to recycle into insect products increased by 42.6 tons. Also, a one-unit increase in years of waste collection results in an 8.6-ton increase in the amount of waste a waste collector is willing to add value to as in Table 13 below. An increase in practices and a positive attitude also results in an increase in the amount of waste a waste collector is willing to add value to. Like households, when given incentives to add value to segregated waste, waste collectors would be more willing to add value to segregated organic waste.

4.4.3 Other Waste Producers

An increase in the market led to an increase of 142.8 kgs of organic waste they were willing to recycle using insects per month. We noted that the more cost-effective the waste recycling process, the higher the quantities of organic waste the producers were willing to recycle using insects, i.e., an increase of 128 kgs per month. This is in line with Longe *et al.* (2009) who found that the type of waste collected by informal waste collectors is determined by use or the amount of income attached to it. Therefore, the solid waste management approach should be shifted towards looking at 'waste as a resource or income generator' to attract more collectors into the waste recycling process and ensure sustainable waste management through a circular economy.

An increase of one person in the waste production unit led to a 102 kg increase in the quantity of organic waste the actors are willing to recycle using insects per month. This can be attributed to the increased availability of labor. The influence of knowledge, attitude, and practices was also noted, where waste producers, similar to waste collectors, who had a positive attitude towards organic waste management using insects were willing to add value to an extra 103 kgs of segregated organic waste using insects.

Some producers who produce high amounts of waste, like markets and hotels, were not willing to add value to segregated organic waste but were willing to sell their waste or even give it out for free to those willing, such as pig and poultry farmers. Improving the culture of waste recycling using insect bioconversion requires deliberate efforts to establish teaching and demonstration centers to offer high-quality hands-on training and enable the acquisition of requisite knowledge and skills. Awareness and sensitization campaigns are warranted to demystify the myths and falsehoods about insect-based waste recycling and enhance technology uptake.

Table 12: Tobit model results of factors influencing willingness of organic waste producers and collectors and extent of recycling organic waste using insects

Variable	Coefficient	Marginal Effect (Dy/dx)	Std. err
Households			

Variable	Coefficient	Marginal Effect (Dy/dx)	Std. err
Gender	-1.263	-0.525	1.692
Age	-0.234	-0.097	0.063
Years of schooling	-0.527	-0.219	0.348
Monthly income	2.483	0.027	0.003
Number of persons in waste unit	24.939**	0.246	0.521
Training programs attended	-1.315	-0.547	0.916
Availability of market	5.890	0.450	0.171
Productive current use of segregated waste	-9.697	-0.033	3.067
Availability of recycling services	33.144*	0.787	3.256
Incentives for adding value	18.537*	0.711	2.644
Cost-effectiveness	11.964**	0.779	3.410
Knowledgeable	5.574	0.239	0.036
Attitude	7.466	0.311	2.686
Practices	2.807	0.117	1.763
Waste Collectors			
Availability of market	113.621	0.623	1.549
Availability of recycling services	-45.645	-0.384	0.131
Incentives for adding value	42.678**	0.621	2.448
Cost effectiveness	-12.692	-0.435	1.487
Years of waste collection	8.612*	0.536	3.321
Training programs attended	43.356	0.528	0.945
Knowledge	6.987	0.642	0.278
Attitude	7.692*	0.261	1.843
Practices	24.221*	0.158	2.354
YearXTraining	-7.156	0.274	0.778
Other Waste Producers			
Availability of the market	142.809***	0.582	1.421
Productive current use of segregated waste	118.232	0.638	1.568

Variable	**Coefficient**	**Marginal Effect (Dy/dx)**	**Std. err**
Availability of recycling services	-13.637	-0.273	1.282
Incentives for adding value	14.617	0.672	0.652
Cost effectiveness	128.531*	0.234	0.823
Training programs attended	13.254	0.865	0.119
Number of people in a unit	102.598***	0.104	2.435
Knowledgeable	29.154	0.351	3.675
Attitude	103.077*	0.912	1.438
Practices	-11.732	0.332	0.594

* $p \leq 0.05$, ** $p \leq 0.01$, ***$p \leq 0.001$; variable of reference; Amount they are willing to add value to. *Note:* Other producers include hotels, markets, slaughterhouses, food processors, animal feed millers, commercial horticultural farms and pig and poultry farmers

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Organic waste management remains a great challenge with people still using inappropriate disposal methods and even though using insects for it, they are a sustainable possible solution, their adoption rate is still low. Insect farming involves utilizing certain species of insects, such as black soldier flies or mealworms, to break down organic waste materials. The findings of this study show that being knowledgeable does not necessarily translate to more practice. In our case, people are aware of insect farming but do not practice it. Amount of waste produced or collected, number of persons in a waste unit, number of trainings attended, and socioeconomic characteristics were among the factors influencing the knowledge, attitude, and practices. From the characteristics of the organic waste producers and collectors, pig and poultry farmers practice insect farming to manage organic waste more compared to other respondents. The study underscores the pivotal role of quality training in influencing individuals' knowledge, attitudes, and behaviour toward insect-based organic waste management. Notably, the study highlights the profound impact of cost-effectiveness and availability of market on willingness to embrace insect-based waste management technologies. The implications of these findings are far-reaching. Policymakers and waste management practitioners could leverage these insights to design targeted educational programs and incentives that bridge knowledge gaps and promote the adoption of sustainable waste management practices. Furthermore, this research contributes a great understanding of the barriers and drivers associated with insect-based waste recycling.

Ultimately, addressing these research gaps and leveraging the influence of quality training and strategic incentives holds the potential to drive widespread adoption of insect-based waste recycling technologies. This could significantly mitigate environmental impacts, promote sustainable waste management, and safeguard planetary health.

5.2 Recommendations

i. To characterize and map organic waste sources in Nairobi County, Kenya:

They include putting forward specific strategies for the treatment of wastes depending on the distribution of organic waste on the map. First, promote localized organic waste management through the zoning of Nairobi according to waste type and quantity generated. This means that there is a possibility to design tactics for waste collection, processing or recycling that fit the specific condition of that area, thus minimizing the inefficiencies that may be experienced in the waste management systems. Finally, jack up policy formulation and endowment in waste disposal infrastructure for organic wastes and insect-base recycling centers especially in zones generating high wastes.

ii. To determine the factors influencing knowledge, attitude, and practices of organic waste producers and collectors towards organic waste management using insects:

To remove the barrier associated with the use of insect based organic waste management, proper sensitization needs to be made to get people to understand the importance of insect based organic waste recycling. Training needs should include specific contents on the insect's knowledge and aim to erase misunderstandings about the use of insects in waste management. Also, promote the impact of radical positive attitudes and practices by adding incentives and support framing. Such methods include offering subsidies, financial incentives or providing technical support to producers and collectors of organic wastes to enhance the use of insect techniques. Finally, address social acceptance to insect farmers and consumers by partnering with organizations that are within the community.

iii. To establish the extent of the willingness of organic waste producers and collectors to add value to the segregated organic waste to insect products in Nairobi County, Kenya:

Enhance the development of a market for insect-derived goods through training in the techniques of adding value to waste through animal feed, or by processing the waste for use as organic fertilizers. Emphasis on the economic returns of insect products in order to boost people's interest in participating. Also, establish open markets and, where necessary, source funding for the producers and collectors of organic waste willing to add value. Overcoming barriers then could involve providing incentives for chemical farmers so that they link with local agricultural businesses or export markets for insect-based products. Finally, support pilot programs to prove that insect farming can still turn a profit with waste source materials. Promising examples such as successful farmers, can increase spread and exemplify how effective these approaches are even under less-than-ideal circumstances.

5.3 Areas of Further Research

Following the high knowledge, positive attitude, and great willingness to adopt organic waste management using insects but low practices, further research can be carried out on the financial benefits of managing waste with insects. Examine whether implementing such technologies is generally cost-effective and investigate any possible financial incentives that can motivate companies and individuals to spend money on insect-based recycling methods.

Also investigate market dynamics and insect-based waste management technology availability in greater detail, perform a thorough analysis of the current insect-based waste management training initiatives and examine the program's efficacy in filling up the knowledge gaps found in the study as well as its content and delivery strategies. This may entail comparing several training methodologies in order to pinpoint optimal ways.

It is also important to carry out more research on the influence of culture on the acceptance of insect-based technologies, examine cultural differences in perceptions of waste management using insects, and perform cross-cultural research to learn how different cultures and geographical areas may have different perspectives and acceptance. Lastly, examine current waste management guidelines and policies to find any obstacles or opportunities for the adoption of insect-based recycling technology.

REFERENCES

Abidin, N. N. Z., Zaki, M. A., & Ayuni, F. (2022). Knowledge, attitude and practices of food waste management among foodservice operators in Petaling Jaya Utara (Pju) 9 and 10, Selangor. *Journal of Sustainability Science and Management*, *17*(12), 89-104. http://doi.org/10.46754/jssm.2022.12.009

Abro, Z., Macharia, I., Mulungu, K., Subramanian, S., Tanga, C. M., & Kassie, M. (2022). The potential economic benefits of insect-based feed in Uganda. *Frontiers in Insect Science*, *2*, 96-102. https://doi.org/10.3389/finsc.2022.968042

Abro, Z., Kassie, M., Tanga, C., Beesigamukama, D., & Diiro, G. (2020). Socio-economic and environmental implications of replacing conventional poultry feed with insect-based feed in Kenya. *Journal of Cleaner Production*, *265*, 12-16. https://doi.org/10.1016/j.jclepro.2020.121871

Akil, A. M., Foziah, J., & Ho, C. (2015). The effects of socio-economic influences on households recycling behaviour in Iskandar Malaysia. *Procedia - Social and Behavioral Sciences*, *202*, 124-134. https://doi.org/10.1016/j.sbspro.2015.08.215

Ali, S. M. (1997). Separation at source—A case study of Karachi. *Pakistan, UWEP, Armsterdam, Waste*.

Almasi, A., Mohammadi, M., Azizi, A., Berizi, Z., Shamsi, K., Shahbazi, A., & Mosavi, S. A. (2019). Assessing the knowledge, attitude and practice of the kermanshahi women towards reducing, recycling and reusing of municipal solid waste. *Resources, Conservation and Recycling*, *141*, 329–338. https://doi.org/10.1016/j.resconrec.2018.10.017

Anand, H., Ganguly, A., & Haldar, P. (2008). Potential value of acridids as high protein supplement for poultry feed. *International Journal of Poultry Science*, *7*(7), 722–725. https://doi.org/10.3923/ijps.2008.722.725

Anastasiou, A., De Valenca, A., Amare, E., De Oca, G. M., Widyaningrum, I., Bokhorst, K., & Liu, S. (2014). The role of urban agriculture in urban organic waste management in The Hague,Netherlands. *Wageningen: Wageningen University*.

Anyega, A.O., Korir, N.K., Beesigamukama, D., Changeh, G.J., Nkoba, K., Subramanian, S., Van Loon, J.J., Dicke, M., and Tanga, C. M. (2021). Black soldier fly-composted organic fertilizer enhances growth, yield, and nutrient quality of three key vegetable crops in sub-Saharan Africa. *Frontiers in Plant Science*, *12*, 68-72. https://doi.org/10.3389/fpls.2021.680312

Aryampa, S., Maheshwari, B., Sabiiti, E., Bateganya, N. L., & Bukenya, B. (2019). Status of waste management in the East African cities: Understanding the drivers of waste generation, collection and disposal and their impacts on Kampala city's sustainability. *Sustainability*, *11*(19), 55-63. https://doi.org/10.3390/su11195523

Asian Development Bank. (2011). Toward sustainable municipal organic waste management in South Asia. Mandaluyong, Philippines: *Asian Development Bank*.

Babaei, A. A., Alavi, N., Goudarzi, G., Teymouri, P., Ahmadi, K., & Rafiee, M. (2015). Household recycling knowledge, attitudes and practices towards solid waste management. *Resources, Conservation and Recycling*, *102*, 94–100. https://doi.org/10.1016/j.resconrec.2015.06.014

Banga, M. (2011). Household knowledge, attitudes and practices in solid waste segregation and recycling: The Case of urban Kampala. *Zambia Social Science Journal*, *2*, 4-8. https://scholarship.law.cornell.edu/zssj/vol2/iss1/4/

Barratt, M. J., & Sibley, C. G. (2019). *Attitude measurement*. Handbook of research methods in health social sciences. Springer.

Barry, T. (2004). *Evaluation of the economic, social, and biological feasibility of bioconverting food wastes with the black soldier fly (Hermetia illucens)*. University of North Texas.

Baud I, Johan P, Furedy C. *Solid Waste Management and Recycling; Actors, Partnerships and Policies in Hyderabad, India and Nairobi, Kenya*. The Geo Journal Library, 2016; 76. https://doi.org/10.1007/1- 4020-2529-7_11

Bakshi, M. P. S., Wadhwa, M., & Makkar, H. P. S. (2016). Waste to worth: Vegetable wastes as animal feed. *CABI Reviews*, 1–26. https://doi.org/10.1079/PAVSNNR201611012

Balasubramanian, M. (2018). Municipal solid waste management in India: Status, problems and challenges. *International Journal of Environment and Waste Management*, *21*(4), 253-256. https://doi.org/10.1504/ijewm.2018.10014607

Beall, J. (1997). Thoughts on Poverty from a South Asian Rubbish Dump: *Gender, Inequality and Household Waste*. *IDS Bulletin*, *28*(3), 73–90. https://doi.org/10.1111/j.1759-5436.1997.mp28003006.x

Beesigamukama, D., Tanga, C. M., Sevgan, S., Ekesi, S., & Kelemu, S. (2023). Waste to value: Global perspective on the impact of entomocomposting on environmental health, greenhouse gas mitigation and soil bioremediation. *Science of The Total Environment*, *902*, 166-167. https://doi.org/10.1016/j.scitotenv.2023.166067

Belluco, S., Halloran, A., & Ricci, A. (2017). New protein sources and food legislation: The case of edible insects and EU law. *Food Security*, *9*, 803-814.

Bisong, E. F., & Ajake, A. (2001). Solid Waste Management for sustainable Rural Development. In Bisong, EF (Ed), *Natural Resources Use and Conservation for sustainable Rural Development* (pp 101-145). BAAS International Company: Lagos.

Burg, V., Troitzsch, K. G., Akyol, D., Baier, U., Hellweg, S., & Thees, O. (2021). Farmer's willingness to adopt private and collective biogas facilities: An agent-based modeling approach. *Resources, Conservation and Recycling, 167* (2021), 5-9. https://doi.org/10.1016/j.resconrec.2021.105400

Chaudhary, M., & Garg, A. P. (2023). Agricultural residue to wealth: Strategies and planning. *Agrica*, *12*(1), 16–33. https://doi.org/10.5958/2394-448X.2023.00002.0

Cheng, J. Y. K., Chiu, S. L. H., & Lo, I. M. C. (2017). Effects of moisture content of food waste on residue separation, larval growth and larval survival in black soldier fly bioconversion. *Waste Management, 67,* 315–323. https://doi.org/10.1016/j.wasman.2017.05.046

Chia, S. Y., Macharia, J., Diiro, G. M., Kassie, M., Ekesi, S., van Loon, J. J. A., Dicke, M., & Tanga, C. M. (2020). Smallholder farmers' knowledge and willingness to pay for insect-based feeds in Kenya. *PLoS ONE*, *15*(3), 1–25. https://doi.org/10.1371/journal.pone.0230552

Chung, S.-S., & Lo, C. W. H. (2004). Waste Management in Guangdong Cities: The waste management literacy and waste reduction preferences of domestic waste generators. *Environmental Management*, *33(* 5), 69-73. https://doi.org/10.1007/s00267-004-0020-2

Chung, S., & Poon, C. (2001). Characterisation of municipal solid waste and its recyclable contents of Guangzhou. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *19*(6), 473-485. https://doi.org/10.1177/0734242x0101900603

Čičková, H., Newton, G. L., Lacy, R. C., & Kozánek, M. (2015). The use of fly larvae for organic waste treatment. *Waste Management, 35*, 68–80. https://doi.org/10.1016/j.wasman.2014.09.026

Cortes Ortiz, J. A., Ruiz, A. T., Morales-Ramos, J. A., Thomas, M., Rojas, M. G., Tomberlin, J. K., Yi, L., Han, R., Giroud, L., & Jullien, R. L. (2016). Insect mass production technologies:. In A.T. Dossey, J.A. Morales, & M.G. Rojas (Eds.), *Insects as Sustainable Food Ingredients* (pp.153–201). https://doi.org/10.1016/B978-0-12-802856-8.00006-5

Debrah, J. K., Vidal, D. G., & Dinis, M. A. P. (2021). Raising awareness on solid waste management through formal education for sustainability: A developing countries evidence review. *Recycling*, *6*(1), 6-8. https://doi.org/10.3390/recycling6010006

De Feo, G., & De Gisi, S. (2010). Public opinion and awareness towards MSW and separate collection programmes: A sociological procedure for selecting areas and citizens with a low level of knowledge. *Waste Management*, *30*(6), 958–976. https://doi.org/10.1016/j.wasman.2010.02.019

Dennison, G. J., Dodd, V. A., & Whelan, B. (1996). A socio-economic based survey of household waste characteristics in the city of Dublin, Ireland; Waste composition. *Resources, Conservation and Recycling*, *17*(3), 227–244. https://doi.org/10.1016/0921-3449(96)01070-1

Diener, S., Studt Solano, N. M., Roa Gutiérrez, F., Zurbrügg, C., & Tockner, K. (2011). Biological treatment of municipal organic waste using black soldier fly larvae. *Waste and Biomass Valorization*, *2*(4), 357–363. https://doi.org/10.1007/s12649-011-9079-1

Dobermann, D., Swift, J. A., & Field, L. M. (2017). Opportunities and hurdles of edible insects for food and feed. *Nutrition Bulletin*, *42*(4), 293–308. https://doi.org/10.1111/nbu.12291

Donnini Mancini, S., Rodrigues Nogueira, A., Akira Kagohara, D., Saide Schwartzman, J. A., & De Mattos, T. (2007). Recycling potential of urban solid waste destined for sanitary landfills: The case of Indaiatuba, SP, Brazil. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *25*(6), 517–523. https://doi.org/10.1177/0734242X07082113

Dou, Z., Toth, J. D., & Westendorf, M. L. (2018). Food waste for livestock feeding: Feasibility, safety, and sustainability implications. *Global Food Security*, *17*, 154–161. https://doi.org/10.1016/j.gfs.2017.12.003

Drechsel, P., & Kunze, D. (2001). *Waste composting for urban and Peri-urban agriculture: Closing the rural-urban nutrient cycle in sub-Saharan Africa*. Food & Agriculture Org.

D’Souza, C., Taghian, M., Lamb, P., & Peretiatko, R. (2007). Green decisions: Demographics and consumer understanding of environmental labels. *International Journal of Consumer Studies*, *31*(4), 371–376. https://doi.org/10.1111/j.1470-6431.2006.00567.x

Dubbeling, M., Bucatariu, C., Santini, G., Vogt, C., & Eisenbeiß, K. (2016). City region food systems and food waste management. *Linking urban and rural areas for sustainable and resilient development. Eschborn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*.

Du, P. T. (1995). *The Determinants of Solid Waste Generation, Reuse, and Recycling by Households in Ho Chi Minh City, Vietnam* (Doctoral dissertation, Asian Institute of Technology, Bangkok, Thailand).

Ekere, W., Mugisha, J., & Drake, L. (2009). Factors influencing waste separation and utilization among households in the Lake Victoria crescent, Uganda. *Waste Management*, *29*(12), 3047–3051. https://doi.org/10.1016/j.wasman.2009.08.001

Ezeah, C., & Roberts, C. L. (2012). Analysis of barriers and success factors affecting the adoption of sustainable management of municipal solid waste in Nigeria. *Journal of Environmental Management*, *103*, 9–14. https://doi.org/10.1016/j.jenvman.2012.02.027

ElHaffar, G., Durif, F., & Dubé, L. (2020). Towards closing the attitude-intention-behavior gap in green consumption: A narrative review of the literature and an overview of future research directions. *Journal of Cleaner Production, 275*, 122-126. https://doi.org/10.1016/j.jclepro.2020.122556

FAO. (2017). *The future of food and agriculture. Trends and challenges*. Food and Agriculture Organization of the United Nations. http://www.fao.org/3/a-i6583e.pdf. Accessed on 26.2.2019.

Furedy, C. (1992). Garbage: exploring non-conventional options in Asian cities. *Environment and Urbanization*, *4*(2), 42-61.

Galarpe, V. R. K. R., & Heyasa, B. B. L. (2017). Solid waste management response of selected public secondary school science teachers. *International Journal of Advanced and Applied Sciences*, *4*(7), 110-115.

Gitonga, S. K. (2014). *Sustainable urban design approach for Dump site rehabilitation: Case of decommissioning Dandora Dump site for urban park* (Doctoral dissertation, University of Nairobi).

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., Pretty, J., Robinson, S., Thomas, S. M., & Toulmin, C. (2010). Food security: The challenge of feeding 9 billion people. *Science*, *327*(5967), 812–818. https://doi.org/10.1126/science.1185383

Government Of India, Ministry of Urban Development. (2016). *Municipal Solid Waste Management Manual*. . https://mohua.gov.in/upload/uploadfiles/files/Part2.pdf

Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste Management*, *33*(1), 220–232. https://doi.org/10.1016/j.wasman.2012.09.008

Gujarati, D. N. (2004). *Basic Econometrics Fourth Edition*. Magraw Hill Inc.

Halloran, A., Hanboonsong, Y., Roos, N., & Bruun, S. (2017). Life cycle assessment of cricket farming in north-eastern Thailand. *Journal of Cleaner Production*, *156*, 83–94. https://doi.org/10.1016/j.jclepro.2017.04.017

Hanboonsong, Y. (2010). *Forest insects as food: Humans bite back*. Food and Agricultural Organization of the United Nations, Bangkok.

Hardouin, J., & Mahoux, G. (2003). Insect Animal Husbandry-Breeding and Utillization for the Benefit of Humans and Other Animals. *Bureau for exchange and distribution of information of the mini-livestock (BEDIM)*.

Haregu, T. N., Ziraba, A. K., Aboderin, I., Amugsi, D., Muindi, K., & Mberu, B. (2017). An assessment of the evolution of Kenya's solid waste management policies and their implementation in Nairobi and Mombasa: Analysis of policies and practices. *Environment and Urbanization*, *29*(2), 515-532. https://doi.org/10.1177/0956247817700294

Henry, R. K., Yongsheng, Z., & Jun, D. (2006). Municipal solid waste management challenges in developing countries – Kenyan case study. *Waste Management*, *26*(1), 92-100. https://doi.org/10.1016/j.wasman.2005.03.007

Hettiarachchi, H., Meegoda, J., & Ryu, S. (2018). Organic waste Buyback as a viable method to enhance sustainable municipal solid waste management in developing countries. *International Journal of Environmental Research and Public Health*, *15*(11), 24-29. https://doi.org/10.3390/ijerph15112483

INRA-CIRAD-AFZ, 2020. Feed Composition Table. Maize grain (*Zea mays L.).* Institut national de la recherche agronomique (NRA), Agriculutral Research for Development (CIRAD) and French association for animal production (AFZ). https:// www.feedtables.com/content/maize

Ikiara, M. M., Karanja, A. M., & Davies, T. C. (2004). Collection, transportation and disposal of urban solid waste in Nairobi. *Solid Waste Management and Recycling*, *76*, 61-91. https://doi.org/10.1007/1-4020-2529-7_4

Isibika, A., Simha, P., Vinnerås, B., Zurbrügg, C., Kibazohi, O., & Lalander, C. (2023). undefined. *Science of The Total Environment*, *858*, 159-165. https://doi.org/10.1016/j.scitotenv.2022.159985

JICA, 2010. *Preparatory Survey for Integrated Solid Waste management in Nairobi City in the Republic of Kenya*, Final Report

Katinas, V., Marčiukaitis, M., Perednis, E., & Dzenajavičienė, E. F. (2019). Analysis of biodegradable waste use for energy generation in Lithuania. *Renewable and Sustainable Energy Reviews*, *101*, 559-567. https://doi.org/10.1016/j.rser.2018.11.022

Kasozi, A. (2010). *Applications Of Systems Thinking in Integrated Solid Waste Management Planning For African Cities: The Case Of Nairobi, Kenya*. (Master's thesis, University of Cape Town). http://hdl.handle.net/11427/4394

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a waste 2.0: a global snapshot of solid waste management to 2050*. World Bank Publications.

Kazuva, E. N. (2017). Determinants of individuals willingness to use economic instruments for solid waste management in Dar es Salaam: The case of Mwananyamala and Mikocheni wards. *International Journal of Environmental Sciences & Natural Resources*, *4*(4), 117-136.

Keramitsoglou, K. M., & Tsagarakis, K. P. (2013). Public participation in designing a recycling scheme towards maximum public acceptance. *Resources, Conservation and Recycling*, *70*, 55–67. https://doi.org/10.1016/j.resconrec.2012.09.015

Kenis, M., Koné, N., Chrysostome, C. A. A. M., Devic, E., Koko, G. K. D., Clottey, V. A., Nacambo, S., & Mensah, G. A. (2014). Insects used for animal feed in West Africa. *Entomologia*, *(2)*2, 109-113 . https://doi.org/10.4081/entomologia.2014.218

Khan, H. A., Akram, W., Shad, S. A., Razaq, M., Naeem-Ullah, U., & Zia, K. (2013). A cross sectional survey of knowledge, attitude and practices related to house flies among dairy farmers in Punjab, Pakistan. *Journal of Ethnobiology and Ethnomedicine*, *9*(1), 80-85. https://doi.org/10.1186/1746-4269-9-18

Khusro, M., Andrew, N. R., & Nicholas, A. (2012). Insects as poultry feed: a scoping study for poultry production systems in Australia. *World's Poultry Science Journal*, *68*(3), 435-446.

Kimani, S. K. (2021). Exposure to pollutants and health of women waste pickers at Dandora Dumpsite in Nairobi, Kenya. *Int J Innov Res Dev 10* (6), 99-103 https://doi.org/10.24940/ijird/2021/v10/i6/JUN21049.

Kinuthia, P. K. (2005). *Urban Solid Waste Management System Using Geographic Information Systems (GIS): A Case Study of Kayole-Soweto, Nairobi* (Doctoral dissertation, University of Nairobi).

Komakech, A. J., Banadda, N. E., Kinobe, J. R., Kasisira, L., Sundberg, C., Gebresenbet, G., & Vinnerås, B. (2014). Characterization of municipal waste in Kampala, Uganda. *Journal* *of the Air & Waste Management Association*, *64*(3), 340-348. https://doi.org/10.1080/10962247.2013.861373

Kothari, C.R. (2004). *Research Methodology: Methods and Techniques*. New Age International.

Krook, J., Mårtensson, A., & Eklund, M. (2007). Evaluating waste management strategies—A case of metal-contaminated waste wood. *Resources, Conservation and Recycling*, *52*(1), 103–118. https://doi.org/10.1016/j.resconrec.2007.03.002

Kuria, D., & Muasya, R. (n.d.). *Mapping of Waste Pickers and Organizations supporting Waste Pickers in Kenya.* Women in Informal Employment Globalizing and Organizing.

Lanarc, H. (2013). *Urban Farming Guidebook*. https://www.researchgate.net/publication/295854210

Laor, P., Suma, Y., Keawdounglek, V., Hongtong, A., Apidechkul, T., & Pasukphun, N. (2018). Knowledge, attitude and practice of municipal solid waste management among highland residents in Northern Thailand. *Journal of Health Research*, *32*(2), 123-131.

Lee, D., Kung, K., & Ratti, C. (2015). *Mapping the Waste Handling Dynamics in Mombasa Using Mobile Phone GPS* [Paper presentation].

Lim, W. M. (2022). The sustainability pyramid: A hierarchical approach to greater sustainability and the United Nations sustainable development goals with implications for marketing theory, practice, and public policy. *Australasian Marketing Journal*, *30*(2), 142-150. https://doi.org/10.1177/18393349211069152

Lohri, C. R., Camenzind, E. J., & Zurbrügg, C. (2014). Financial sustainability in municipal solid waste management – Costs and revenues in Bahir DAR, Ethiopia. *Waste Management*, *34*(2), 542-552. https://doi.org/10.1016/j.wasman.2013.10.014

Longe, E. O., Longe, O. O., & Ukpebor, E. F. (2009). *People's Perception on Household Solid Waste Management in Ojo Local Government Area in Nigeria*. *Scientific Information Database*. https://www.sid.ir/paper/563273/en

Li, L., Zhao, Z., & Liu, H. (2013). Feasibility of feeding yellow mealworm (Tenebrio molitor L.) in bioregenerative life support systems as a source of animal protein for humans. *Acta Astronautica*, *92*(1), 103–109. https://doi.org/10.1016/j.actaastro.2012.03.012

Liu, J., Huang, S., & Wang, Y. (2023). Study of Farmers' Willingness to Participate in Environmental Governance Based on Recycling, Reduction and Resourcing. *Sustainability*, *15*(14), 10-15. https://doi.org/10.3390/su151410850

Li, Q., & Qamruzzaman, M. (2023). Innovation-Led Environmental Sustainability in Vietnam—Towards a Green Future. *Sustainability*, *15*(16), 12-18. https://doi.org/10.3390/su151612109

Martínez-Borreguero, G., Naranjo-Correa, F. L., & Mateos-Núñez, M. (2022). Cognitive and Emotional Development of STEM Skills in Primary School Teacher Training through Practical Work. *Education Sciences*, *12*(7), 470-473. https://doi.org/10.3390/educsci12070470

Mbata, K. J., Chidumayo, E. N., & Lwatula, C. M. (2002). Traditional regulation of edible caterpillar exploitation in the Kopa area of Mpika district in northern Zambia. *Journal of Insect Conservation*, *6*, 115-130.

McFadden, D. (1974). The measurement of urban travel demand. *Journal of Public Economics*, *3*(4), 303-328.

Meneses, G. D., & Palacio, A. B. (2005). Recycling behavior. *Environment and Behavior*, *37*(6), 837-860. https://doi.org/10.1177/0013916505276742

Menyuka, N., Bob, U., & Sibanda, M. (2018). *Potential for organic waste utilization and management through urban agriculture*. https://doi.org/10.22004/AG.ECON.284779

Mickael, D. (2016). Categorization and sorting for waste management. *International Journal of Waste Resources*, *6*(2), 1-7. https://doi.org/10.4172/2252-5211.1000227

Mlček, J., Rop, O., Borkovcova, M., & Bednářová, M. (2014). A comprehensive look at the possibilities of edible insects as food in Europe-a review. *Polish Journal of Food and Nutrition Sciences*, *64* (3), 147-157.

Moreki, J., & Tiroesele, B. (2012). Termites and earthworms as potential alternative sources of protein for poultry. *International Journal for Agro Veterinary and Medical Sciences*, *6*(5), 368-376. https://doi.org/10.5455/ijavms.174

Morris, B. (2008). Insects as food among hunter-gatherers. *Anthropology Today*, *24*(1), 6–8. https://doi.org/10.1111/j.1467-8322.2008.00558.x

Mugo, K. K., Gichanga, J. M., Gatebe, E., & Njogu, P. M. (2022). Assessment of the safety and health hazards in existing dumpsites in Kenya. *Proceedings of the Sustainable Research and Innovation Conference*,46-49. https://sri.jkuat.ac.ke/jkuatsri/index.php/sri/article/view/185

Muiruri, J., Wahome, R., & Karatu, K. (2020). Assessment of methods practiced in the disposal of solid waste in Eastleigh Nairobi County, Kenya. *AIMS Environmental Science*, *7*(5), 434-448. https://doi.org/10.3934/environsci.2020028

Muniafu, M., & Otiato, E. (2010). Solid Waste Management in Nairobi, Kenya. A case for emerging economies. *Journal of Language, Technology & Entrepreneurship in Africa*, *2*(1), 342–350. https://doi.org/10.4314/jolte.v2i1.52009

Musyoka, M. A. (2019). *Assessment Of Community Perception, Policies and Land Use Factors In Relation To Climate Change Processes In Nairobi City* (Doctoral dissertation, JKUAT-IEET). http://hdl.handle.net/123456789/5193

Mwangi, K. W. (2019). *Growth Performance Of Indigenous Chicken Fed On Diets Containing Black Soldier Fly Larvae Meal*. (Master's thesis. Kenyatta University)

Nabegu, A. B. (2010). An Analysis of Municipal Solid Waste in Kano Metropolis, Nigeria. *Journal of Human Ecology*, *31*(2), 111–119. https://doi.org/10.1080/09709274.2010.11906301

Nandan, A., Yadav, B. P., & Bose, D. (2017). Recent scenario of solid waste management in India. *World Scientific News*, *66*, 56–74.

Närvänen, E., Mesiranta, N., Mattila, M., & Heikkinen, A. (Eds.). (2020). *Food Waste Management: Solving the Wicked Problem* (1st ed. 2020). Palgrave Macmillan. https://doi.org/10.1007/978-3-030-20561-4

National Environment Management Authority. (2015). *The National Solid Waste Management Strategy*. https://meas.nema.go.ke/pops/download/National-Solid-Waste-Management-Strategy-_2.pdf

Newton, G. L., Sheppard, D. C., & Burtle, G. J. (2008). Research Briefs: Black Soldier Fly Prepupae—A Compelling Alternative to Fish Meal and Fish Oil. *Aquaculture*, *24*, 103-109.

Ngoc, U. N., & Schnitzer, H. (2009). Sustainable solutions for solid waste management in Southeast Asian countries. *Waste Management*, *29*(6), 1982–1995. https://doi.org/10.1016/j.wasman.2008.08.031

Ngunju, P. W. (2018). *Municipal Solid Waste Management: Contribution And Challenges Of Private Solid Waste Management Companies In Nairobi County, Kenya*. (Doctoral dissertation, University of Nairobi).

Njoroge, B. K., Kimani, M., & Ndunge, D. (2014). Review of Municipal Solid Waste Management: A Case Study of Nairobi, Kenya. *International Journal of Engineering And Science*, *4*(2), 16-20. http://erepository.uonbi.ac.ke/bitstream/handle/11295/92590/Njoroge_Review%20of%20municipal%20solid%20waste%20management:%20a%20case%20study%20of%20Nairobi,%20Kenya.pdf?sequence=1

Nyakeri, E. M., Ogola, H. J. O., Ayieko, M. A., & Amimo, F. A. (2017). Valorisation of organic waste material: Growth performance of wild black soldier fly larvae (*Hermetia illucens*) reared on different organic wastes. *Journal of Insects as Food and Feed*, *3*(3), 193–202. https://doi.org/10.3920/JIFF2017.0004

Nygren, M. (2014). *One Man's Trash Is Another Man's Treasure*. (Master's thesis. Lund University).

Nyingi, D. W. (2019). *Insect Feed Utilization In Layer Diets: Effects On Performance And Egg Quality In Improved Indigenous Chicken*. (Master's thesis,. Kenyatta University)

Ojha, S., Bußler, S., & Schlüter, O. K. (2020). Food waste valorisation and circular economy concepts in insect production and processing. *Waste Management, 118*, 600-609. https://doi.org/10.1016/j.wasman.2020.09.010

Okello, A. O., Nzuma, J. M., Otieno, D. J., Kidoido, M., & Tanga, C. M. (2021). Farmers' Perceptions of Commercial Insect-Based Feed for Sustainable Livestock Production in Kenya. *Sustainability*, *13*(10), 7-9. https://doi.org/10.3390/su13105359

Onsomu, C. B. (2016). *Knowledge, Attitude, Practice and Ex-ante Adoption of Integrated Pest and Pollination Management (IPPM) Innovation Among Avocado Growers in Kenya* (Master's thesis, University of Nairobi).

Onsongo, V. O., Osuga, I. M., Gachuiri, C. K., Wachira, A. M., Miano, D. M., Tanga, C. M., Ekesi, S., Nakimbugwe, D., & Fiaboe, K. K. M. (2018). Insects for Income Generation Through Animal Feed: Effect of Dietary Replacement of Soybean and Fish Meal with Black Soldier Fly Meal on Broiler Growth and Economic Performance. *Journal of Economic Entomology*, *111*(4), 1966–1973. https://doi.org/10.1093/jee/toy118

Palczynski, R. J., & Scotia, W. N. (2002). Study on solid waste management options for Africa. *African Development Bank*, *131*, *1-4*.

Pandyaswargo, Jagath Dickella Gamaralalage, Liu, Knaus, Onoda, Mahichi, & Guo. (2019). Challenges and an implementation framework for sustainable municipal organic waste management using biogas technology in emerging Asian countries. *Sustainability*, *11*(22), 3-8. https://doi.org/10.3390/su11226331

Parfitt, J., Barthel, M., & Macnaughton, S. (2010). Food waste within food supply chains: Quantification and potential for change to 2050. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *365*(1554), 3065–3081. https://doi.org/10.1098/rstb.2010.0126

Pakpour, A. H., Zeidi, I. M., Emamjomeh, M. M., Asefzadeh, S., & Pearson, H. (2014). Household waste behaviours among a community sample in Iran: An application of the theory of planned behaviour. *Waste Management*, *34*(6), 980–986. https://doi.org/10.1016/j.wasman.2013.10.028

Panko, M., &Sharma, R. (2016) Integrating Waste Management and Pollution Control in Tertiary Vocational Education Programmes: Case Studies. *Int. J. Inf. Educ. Technol.*, *6*, 228–231.

Poma, G., Cuykx, M., Amato, E., Calaprice, C., Focant, J. F., & Covaci, A. (2017). Evaluation of hazardous chemicals in edible insects and insect-based food intended for human consumption. *Food and Chemical Toxicology*, *100*, 70–79. https://doi.org/10.1016/j.fct.2016.12.006

Qdais, H. (1997). Analysis of residential solid waste at generation sites. *Waste Management & Research*, *15*(4), 395–406. https://doi.org/10.1006/wmre.1996.0095

Qu, X., Li, Z., Xie, X., Sui, Y., Yang, L., & Chen, Y. (2009). Survey of composition and generation rate of household wastes in Beijing, China. *Waste Management*, *29*(10), 2618–2624. https://doi.org/10.1016/j.wasman.2009.05.014

Rindhe, S. N., Chatli, M. K., Wagh, R. V., Kaur, A., Mehta, N., Kumar, P., & Malav, O. P. (2019). Black Soldier Fly: A New Vista for Waste Management and Animal Feed. *International Journal of Current Microbiology and Applied Sciences*, *8*(01), 1329–1342. https://doi.org/10.20546/ijcmas.2019.801.142

Rumpold, B. A., & Van Huis, A. (2021). Education as a key to promoting insects as food. *Journal of Insects as Food and Feed*, *7*(6), 949–953. https://doi.org/10.3920/JIFF2021.x007

Rutten, M. M. (2013). What economic theory tells us about the impacts of reducing food losses and/or waste: implications for research, policy and practice. *Agriculture & Food Security*, *2*, 1-13.

Sabiiti, E. N. (2011). Utilising agricultural waste to enhance food security and conserve the environment. *African Journal of Food, Agriculture, Nutrition and Development*, *11*(6), 3-5.

Sadh, P. K., Duhan, S., & Duhan, J. S. (2018). Agro-industrial wastes and their utilization using solid state fermentation: A review. *Bioresources and Bioprocessing*, *5*(1), 97-108. https://doi.org/10.1186/s40643-017-0187-z

Salemdeeb, R., Zu Ermgassen, E. K. H. J., Kim, H. M., Balmford, A. & Al-Tabbaa, A. (2017). Environmental and health impacts of using food waste as animal feed: A comparative analysis of food waste management options. *Journal of Cleaner Production*, *140*, 871–880. https://doi.org/10.1016/j.jclepro.2016.05.04

Saphores, J.-D. M., & Nixon, H. (2014). How effective are current household recycling policies? Results from a national survey of U.S. households. *Resources, Conservation and Recycling*, *92*, 1–10. https://doi.org/10.1016/j.resconrec.2014.08.010

Scheinberg, A. (2011). *Value added: Modes of sustainable recycling in the modernisation of waste management systems*. Wageningen University and Research.

Semiyaga, S., Okure, M. A., Niwagaba, C. B., Katukiza, A. Y., & Kansiime, F. (2015). Decentralized options for faecal sludge management in urban slum areas of sub-Saharan Africa: A review of technologies, practices and end-uses. *Resources, Conservation and Recycling*, *104*, 109-119. https://doi.org/10.1016/j.resconrec.2015.09.001

Seng, B., Fujiwara, T., & Spoann, V. (2018). Households' knowledge, attitudes, and practices toward solid waste management in suburbs of Phnom Penh, Cambodia. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *36*(10), 993–1000. https://doi.org/10.1177/0734242X18790800

Setiawan, R. P. (2020). Factors determining the public receptivity regarding waste sorting: A case study in Surabaya city, Indonesia. *Sustainable Environment Research*, *30*(1), 4-6. https://doi.org/10.1186/s42834-019-0042-3

Simatele, D. M., Dlamini, S., & Kubanza, N. S. (2017). From informality to formality: Perspectives on the challenges of integrating solid waste management into the urban development and planning policy in Johannesburg, South Africa. *Habitat International*, *63*, 122-130. https://doi.org/10.1016/j.habitatint.2017.03.018

Simelane, T., & Mohee, R. (Eds.). (2015). *Future directions of municipal solid waste management in Africa*. Africa Institute of South Africa.

Singhirunnusorn, W., Donlakorn, K., & Kaewhanin, W. (2012). Contextual Factors Influencing Household Recycling Behaviours: A Case of Waste Bank Project in Mahasarakham Municipality. *Procedia - Social and Behavioral Sciences*, *36*, 688–697. https://doi.org/10.1016/j.sbspro.2012.03.075

Sogari, G., Amato, M., Biasato, I., Chiesa, S., & Gasco, L. (2019). The Potential Role of Insects as Feed: A Multi-Perspective Review. *Animals*, *9*(4), 119-125. https://doi.org/10.3390/ani9040119

Stöckli, S., Niklaus, E., & Dorn, M. (2018). Call for testing interventions to prevent consumer food waste. *Resources, Conservation and Recycling*, *136*, 445–462. https://doi.org/10.1016/j.resconrec.2018.03.029

Srivastava, V., Vaish, B., Singh, R. P., & Singh, P. (2020). An insight to municipal solid waste management of Varanasi city, India, and appraisal of vermicomposting as its efficient management approach. *Environmental Monitoring and Assessment*, *192*(3), 191-198. https://doi.org/10.1007/s10661-020-8135-3

Srivastava, R. K., Shetti, N. P., Reddy, K. R., Nadagouda, M. N., Badawi, M., Bonilla-Petriciolet, A., & Aminabhavi, T. M. (2023). Valorization of biowastes for clean energy production, environmental depollution and soil fertility. *Journal of Environmental Management*, *332*, 117-127. https://doi.org/10.1016/j.jenvman.2023.117410

Sumbule, E.K., Ambula, M.K., Osuga, I.M., Changeh, J.G., Mwangi, D.M., Subramanian, S., Salifu, D., Alaru, P.A.O., Githinji, M., Van Loon, J.J.A., Dicke, M., & Tanga, C.M. (2021). Cost-effectiveness of black soldier fly larvae meal as substitute of fishmeal in diets for layer chicks and growers. *Sustainability, 13,* 1–20. https://doi.org/10.3390/su13116074

Suleman, D., Simon, M., & Richard, A. (2015). Residents' perceptions and attitudes towards urban solid waste management in the Berekum Municipality, Ghana. *Oguaa Journal of Social Sciences*, *7*(2), 25-37.

Supriyadi, S., Kriwoken, L. K., & Birley, I. (2000). Solid waste management solutions for Semarang, Indonesia. *Waste Management & Research: The Journal for a Sustainable Circular Economy*, *18(6)*, 557–566. https://doi.org/10.1177/0734242X0001800606

Tanga, C. M., Egonyu, J. P., Beesigamukama, D., Niassy, S., Emily, K., Magara, H. J., Omuse, E. R., Subramanian, S., & Ekesi, S. (2021). Edible insect farming as an emerging and profitable enterprise in East Africa. *Current Opinion in Insect Science*, *48*, 64–71. https://doi.org/10.1016/j.cois.2021.09.007

Tikka, P. M., Kuitunen, M. T., & Tynys, S. M. (2020). Effects of educational background on students' attitudes, activity levels, and knowledge concerning the environment. *Journal of Environmental Education*, *31*(3), 12–19. https://doi.org/10.1080/00958960009598640

Timmermans, A. J. M., Ambuko, J., Belik, W., & Huang, J. (2014). *Food losses and waste in the context of sustainable food systems*. (HPLE report / High Level Panel of Experts on Food Security and Nutrition; No. 8). CFS Committee on World Food Security HLPE. https://edepot.wur.nl/309118

Thomas-Hope, E. M. (1998). *Solid waste management: Critical issues for developing countries*. Canoe Press.

Torres-León, C., Ramírez-Guzman, N., Londoño-Hernandez, L., Martinez-Medina, G. A., Díaz-Herrera, R., Navarro-Macias, V., Alvarez-Pérez, O. B., Picazo, B., Villarreal-Vázquez, M., Ascacio-Valdes, J., & Aguilar, C. N. (2018). Food waste and byproducts: An opportunity to minimize malnutrition and hunger in developing countries. *Frontiers in Sustainable Food Systems*, *2*, 7-9. https://doi.org/10.3389/fsufs.2018.00052

Truong, L., Morash, D., Liu, Y., & King, A. (2019). Food waste in animal feed with a focus on use for broilers. *International Journal of Recycling of Organic Waste in Agriculture, 8(4)*, 417–429. https://doi.org/10.1007/s40093-019-0276-4

United Nations Environment Programme. Division of Early Warning. (2011). *UNEP year book 2011: Emerging issues in our global environment*. UNEP/Earthprint.

Van Huis, A. (2003). Insects as food in sub-Saharan Africa. *International Journal of Tropical Insect Science*, *23*(03), 163-185. https://doi.org/10.1017/s1742758400023572

Van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., Vantomme, P., 2013. *Edible Insects: Future Prospects for Food and Feed Security (No. 171)*. Food and Agriculture Organization http://www.fao.org/docrep/018/i3253e/i3253e.pdf

Van Itterbeeck, J., & van Huis, A. (2012). Environmental manipulation for edible insect procurement: a historical perspective. *Journal Of Ethnobiology And Ethnomedicine*, *8*, 1-7.

Van Veenhuizen, R. (2006). Cities farming for the future. *Cities farming for future, Urban Agriculture for green and productive cities,(p 2-17). RUAF Foundation, IDRC and IIRP, ETC-Urban agriculture, Leusden, The Netherlands*.

Veldkamp, T., Meijer, N., Alleweldt, F., Deruytter, D., Van Campenhout, L., Gasco, L., Roos, N., Smetana, S., Fernandes, A., & Van Der Fels-Klerx, H. J. (2022). Overcoming Technical and Market Barriers to Enable Sustainable Large-Scale Production and Consumption of Insect Proteins in Europe: A Susinchain perspective. *Insects*, *13*(3), 28-31. https://doi.org/10.3390/insects13030281

Verkerk, M. C., Tramper, J., Van Trijp, J. C. M., & Martens, D. E. (2007). Insect cells for human food. *Biotechnology Advances*, *25*(2), 198–202. https://doi.org/10.1016/j.biotechadv.2006.11.004

Verner, D., Roos, N., Halloran, A., Surabian, G., Ashwill, M., Vellani, S., & Konishi, Y. (2021). *Insect and Hydroponic Farming in Africa: The new circular food economy*. World Bank Publications.

Vicente, P., & Reis, E. (2008). Factors affecting the selective sorting of waste. Waste Management & Research: *The Journal for a Sustainable Circular Economy, 26(2),* 140-146. https://doi.org/10.1177/0734242x07077371

Vidanaarachchi, C. K., Yuen, S. T. S., & Pilapitiya, S. (2006). Municipal solid waste management in the Southern Province of Sri Lanka: Problems, issues and challenges. *Waste Management*, *26*(8), 920–930. https://doi.org/10.1016/j.wasman.2005.09.013

Viscusi, W. K., Huber, J., & Bell, J. (2023). Changes in household recycling behavior: Evidence from panel data. *Ecological Economics*, *208*, 107-119. https://doi.org/10.1016/j.ecolecon.2023.107819

Wadhwa, M., & Bakshi, S. P. M. (2013). *Utilization of fruit and vegetable wastes as livestock feed and as substrates for the generation of other value-added products.* RAP Publication 2013-04 (FAO). http://www.fao.org.webtranslatewidget.systransoft.com/docrep/018/i3273e/i3273e.pdf

Waithanji, E., Affognon, D. H., King'ori, S., Diiro, G., Nakimbugwe, D., & Fiaboe, K. K. M. (2020). Insects as feed: Gendered knowledge attitudes and practices among poultry and Pond Fish farmers in Kenya. *NJAS: Wageningen Journal of Life Sciences*, *92*(1), 1–15. https://doi.org/10.1016/j.njas.2019.100312

Wang, Y.-S., & Shelomi, M. (2017). Review of Black Soldier Fly (Hermetia illucens) as Animal Feed and Human Food. *Foods*, *6*(10), 91-97. https://doi.org/10.3390/foods6100091

Wang, H., Rehman, K. U., Liu, X., Yang, Q., Zheng, L., Li, W., Cai, M., Li, Q., Zhang, J., & Yu, Z. (2017). Insect biorefinery: A green approach for conversion of crop residues into biodiesel and protein. *Biotechnology for Biofuels*, *10*(1), 304-310. https://doi.org/10.1186/s13068-017-0986-7

Wang, Y., Wu, S., Zhuang, Y., Wu, W., & Chen, Y. (2008). Source separation of household waste: A case study in China. *Waste Management, 28(10),* 2022-2030. https://doi.org/10.1016/j.wasman.2007.08.012.

Whitmarsh, L. E., Haggar, P., & Thomas, M. (2018). Waste reduction behaviors at home, at work, and on holiday: What influences behavioral consistency across contexts? *Frontiers in Psychology*, *9*, 17-23. https://doi.org/10.3389/fpsyg.2018.02447

World Bank, 2005. *Waste Management in China: Issues and Recommendations*. Urban Development Working Papers 9. East Asia Infrastructure Department

World Bank. (2012). *What a Waste: A Global Review of Solid Waste Management*. https://openknowledge.worldbank.org/entities/publication/1a464650-9d7a-58bb-b0ea-33ac4cd1f73c

Williams, R. (2018). *Multinomial Logit Models: Overview*. https://www3.nd.edu/~rwilliam/stats3/Mlogit1.pdf.

Wilson, D. C., Velis, C., & Cheeseman, C. (2006). Role of informal sector recycling in waste management in developing countries. *Habitat International, 30*(4), 797-808. https://doi.org/10.1016/j.habitatint.2005.09.005

Wunderlich, S. M., & Martinez, N. M. (2018). Conserving natural resources through food loss reduction: Production and consumption stages of the food supply chain. *International Soil and Water Conservation Research*, *6*(4), 331–339. https://doi.org/10.1016/j.iswcr.2018.06.002

Xu, R., Zhan, Y., Zhang, J., He, Q., Zhang, K., Xu, D., Qi, Y., & Deng, X. (2022). Does Construction of High-Standard Farmland Improve Recycle Behavior of Agricultural Film? Evidence from Sichuan, China. *Agriculture, 12(10),* 16-22. https://doi.org/10.3390/agriculture12101632

Yen, A. L. (2009). Edible insects: Traditional knowledge or western phobia? *Entomological Research*, *39(5)*, 289–298. https://doi.org/10.1111/j.1748-5967.2009.00239.x

Yuan, Y., Xu, M., & Chen, H. (2022). What factors affect farmers' levels of domestic waste sorting behavior? A case study from Shaanxi province, China. *International Journal of Environmental Research and Public Health*, *19*(19), 121-126. https://doi.org/10.3390/ijerph191912141.

Zand, A. D., Heir, A. V., & Tabrizi, A. M. (2020). Investigation of knowledge, attitude, and practice of Tehranian women apropos of reducing, reusing, recycling, and recovery of urban solid waste. *Environmental Monitoring and Assessment*, *192*(7), 48-51. https://doi.org/10.1007/s10661-020-08445-5

Zhang, T., Shaikh, Z. A., Yumashev, A. V., & Chłąd, M. (2020). Applied Model of E-Learning in the Framework of Education for Sustainable Development. *Sustainability*, *12*(16), 64-69. https://doi.org/10.3390/su12166420

APPENDICES

Appendix A- Questionnaire

A. QUESTIONNAIRE IDENTIFICATION

I am Teresia Gathoni Wamwondwe, pursuing an MSc. Degree in Agricultural Economics at Egerton University. I am researching on **Knowledge, Attitude, And Practices Of Organic Waste Management using Insects And Willingness To Add Value To Segregated Organic Waste to insect products In Nairobi County, Kenya**. The purpose of this study is purely academic.

MODULE 0: CONSENT AND IDENTIFICATION

I humbly request you to take part in this interview since the information you will provide will assist in meeting my study objectives. I assure you that your information will be treated as confidential as possible. Thank you.

Name of interviewee……………………………………………………………

Name of interviewer/ Enumerator……………………………………………

Questionnaire number………………………………………………………….

Instructions: Please tick the bracket (s) that correspond(s) to the correct answer, unless special instructions are given

1. Are you a waste producer or waste collector?

[ ] Waste producer [ ] Waste Collector

2. Place of residence/ Area of operation

____________________ Sub-county, ________________ ward.

MODULE 1: SOCIOECONOMIC CHARACTERISTICS

3. Gender

1= Male, [ ] 0 = Female, [ ]

4. Age (Years)
5. Number of people in waste production unit
6. Educational Qualification

[ ] no schooling [ ] Secondary [ ] Degree

[ ] Primary [ ] Diploma [ ] Other ________________

7. Average monthly income (KES)

[ ] 0- 10,000 [ ] 60,001-70,000

[ ] 10,001- 20,000 [ ] 70,001- 80,000

[ ] 20,001- 30,000 [ ] 80,001- 90,000

[ ] 30,001- 40,000 [ ] 90,001- 100,000

[ ] 40,001- 50,000 [ ] Above 100,000

[ ] 50,000- 60,000

MODULE 2: WASTE PRODUCTION AND COLLECTION

8. How many years have you been doing waste collection?
9. Tick your waste stream (s)and approximate amount of organic waste produced per week

Waste stream	Approximated waste kgs produced per week
Food processors	
Animal feed millers	
Pig and poultry farmers	
Commercial horticultural farms	
Households	

10. Which is the most common type of organic waste that you produce (Specific)
11. Considering the amount of waste types, are they a problem?

[ ] Yes [ ] No

10) Who handles the waste in your unit

Males	
Females	
All	

11) In your opinion, who should be responsible for handling waste in your unit?

Males	
Females	
All	

12) How often per week is waste collected and disposed?

Once [ ] Twice [ ] Three times [ ] Four times [ ] Five times [ ] Six times [ ] Daily [ ]

None [ ]

13) How often per week would you like waste to be collected and disposed?

Once [ ] Twice [ ] Three times [ ] Four times [ ] Five times [ ] Six times [ ] Daily [ ]

None [ ]

14) Do you pay for organic waste collection?

[ ] Yes [ ] No

15) i) If yes, do you pay for private or public waste collection services?

[ ] Private [ ] Public

ii) Why?

16) If no, why don't you pay for them?

i) They are expensive [ ]

ii) They are not available [ ]

iii) They are not reliable [ ]

iv) They are free [ ]

v) 1/ we recycle/reuse/recover our waste [ ]

vi) I don't see the need [ ]

MODULE 3: WASTE SEGREGATION

17) Do you separate organic waste?

18) If yes, who does the waste separation?

i) Males

ii) Females

iii) Paid worker

19) If no, please tick reasons for not separating the waste

i) It's time consuming

ii) It requires much space

iii) I pay for waste collection thus not my business

iv) Lack of interest

v) Lack of separate bins

KAPs

KAPS	**Questions**
Knowledge score	
Knowledge on organic waste segregation, recycling and reusing, reduction, and recovery	**Technologies of segregation** 3 tier bins Smart bins Sensor based automated waste segregator Intelligent trash bin

	Routes optimization Robot based segregators **Methods of waste disposal** Land fills Waste pits Burning Burying **Forms of recycling waste** Vermicompost Composting to manure or fertilizer Insect feeds Animal feeds Briquettes None **Insects used for organic waste management** Black soldier fly Mealworm Redworm Cockroaches Crickets None **Ways to reduce organic waste** Regulating consumption portions Increasing shelf life of products Controlling pests Others (State)
	Are you informed on importance of waste segregation?
	Do you know any organic waste recycling services?
	Do you know any ways of waste treatment?

	Do you know any incentives for organic waste management using insects?
	How many trainings have you attended on organic waste management using insects?
	Do you know how many times waste is collected in your unit?
	Do you know distance to waste disposal point impacts waste segregation?
Attitude score	
Attitude towards organic waste segregation, recycling and reusing, reduction, and recovery	Perception towards organic waste segregation, recycling reusing, and reduction using insects
	Do you think waste segregation technologies help in organic waste management using insects?
	Do you think methods of waste disposal affect organic waste management using insects?
	Do you think forms of waste recycling improve waste management?
	Do you think awareness of insects to use for waste management improve organic waste management using insects?
	Do you think ways to reduce organic waste improve organic waste management using insects?
	Do you agree training on organic waste management helps improve organic waste management using insects?
	Do you agree information on importance of waste segregation help improve organic waste management using insects?

	Do you agree organic waste recycling services help improve organic waste management using insects?
	Do you agree waste treatment help improve waste management using insects?
	Do you agree incentives for waste management help improve organic waste management using insects?
	Do you agree the number of times waste is collected in your unit help improve organic waste management using insects?
	Do you agree distance to waste disposal point impacts waste segregation?
Practices score	
Practices of organic waste segregation, recycling and reusing, reduction, and recovery	**Which of these technologies of segregation do you use?** 3-tier bins Smart bins Sensor based automated waste segregator Intelligent trash bin Routes optimization Robot based segregators None **Which of these methods of waste disposal** **do you use?** Land fills Waste pits Burning Burying **Which of these forms of recycling organic waste do you practice?** Vermicompost

	Composting to manure or fertilizer Insect feeds Animal feeds Briquettes None **Which of these insects do you use for organic waste management?** Black soldier fly Mealworm Redworm Cockroaches Crickets None **Which of these ways to reduce organic waste do you practice?** Regulating consumption portions Increasing shelf life of products Controlling pests Others (State)
	Do you teach on importance of waste segregation?
	Do you practice of waste treatment?
	Do you receive any incentives for organic waste management?
	How many trainings have you attended on organic waste management using insects?
	Do you pay for waste collection?
	How many times is waste collected in your unit?
	Do you consider distance to waste disposal point when practicing waste segregation?

20. Given the following factors, would you be willing to add value to the segregated organic waste?

Factor	Yes	No
Availability of market of segregated waste		
Productive current use of segregated organic waste		
Availability of recycling services		
Incentives for adding value to segregated waste		
More benefits than cost for organic waste segregation		

a) If your answer was yes above, how many kgs of segregated organic waste would you be willing to add value to weekly when there is;

Available market for segregated waste	
Productive current use of segregated organic waste	
Available recycling services	
High benefits than cost for organic waste segregation	

21. If not in a position to directly add value, would you sell your segregated organic waste to other companies/ stakeholders?

22. To what extent would you add value to the segregate organic waste?

i. Food products,
ii. Animal feeds,
iii. Fertilizers,
iv. Bioplastics
v. Cosmetics.
vi. Other (State)

23. Rank the following based on the influence it has in your choice above? (1= biggest influence, 5-=least influence)

a) Amount of waste generated

b) Amount of space available

c) Amount of time available

d) Amount of resources available

e) Marketability of the goods

The END.

Thank you so much for your participation

Appendix B- List of Respondents

List of Respondents

Feed millers	**Commercial Horticultural Farms**
1.Unga Farm Care	AAA Growers
2.Tarime Suppliers	Aquila Development
3.Stemark Animal Feeds	Caly Flora
4.Benchmark Animal Feeds	Winchester Farm Limited
5.Shakers Animal Feeds	Muteero Farms
6.Rogmer Feeds	Kranian Farms
7.Pioneer Feeds Limited	The Strawberry Farm
8.Ongata Vision Chicks and Feeds	Mlango Farm
9.Njuga Consolidated	
10. Zinex Millers	**Waste Collectors list sent as a protected PDF file thus unable to copy**
11.Bill and Bill Millers Ltd	
12. Belfast Millers LTD	
13. Farvet Animal Feed Centre	
14. Animal World Feeds Ltd	
15. Omega Feeds Ltd	
16. Mwema Animal Feeds and Raw Materials	
17. Pangani Animal Feeds	
18. Elite Animal Feeds Pellets Kenya	
19. Happy Feeds	
20. Pembe Flour Mills Limited	
21. Joelize Bonemeal Ltd	
22. Mombasa Maize Miller	
23. Killymaa Animal Feeds	
24. Kitale Feeds	
25. Haymaster Animal Feeds	

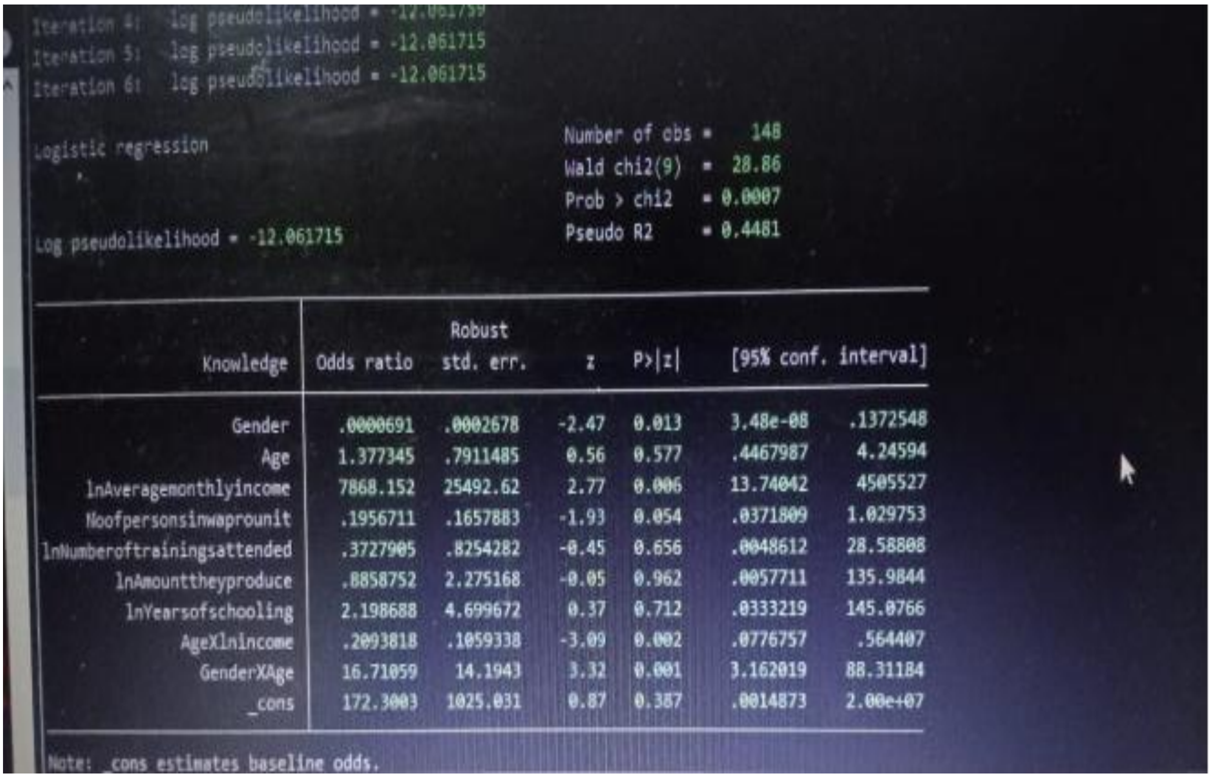
26. Sirari Feed Millers	

Food Processors **Pig and poultry Farmers**

Farmer's Choice
Sabibu Beaverages
Go Foods Limited
Frigoken Limited
Ian Mwaniki
Roy Maingi
Hayanga Nature Kitchen
Oscar Food Limited
Food Practicals Limited
Rasmi and Zada Flour Ltd- **Allied Warehouse**
Manji Food Industries
The Good Food **Company Ltd**
Proctor and Allan **E.A Ltd**
Spice World Ltd
PJ Products Ltd
DPL Festive Ltd
Nestle Food Kenya
Pembe Flour Millers
Jafa Product Kenya
Timiza Foods Ltd
Precious Bakers Ltd
Kevian Kenya Ltd
Cresonmun Foods Ltd
Azuri Health Ltd
Lactamama Food Processor
Italian Market Ltd
Honey Care **Africa**
Bee and **Honey Centre**
Duara Foods
Jimmsy Foods
Wanji Food **Limited**

Prosoya Kenya **Ltd**
Daima Ltd
Grainstar Ltd
Kwanza Tukule **Ltd**
Premier Millers **Ltd**
Ecozym Ltd
White Dezert
Anita Waihuini
Brian Karoki Pork **Processors**
Ultra Food Company
Samwa Natural Foods

Appendix C- Key data analysis output for objective two



Iteration 4: log pseudolikelihood = -12.061759
Iteration 5: log pseudolikelihood = -12.061715
Iteration 6: log pseudolikelihood = -12.061715

Logistic regression

Number of obs = 148
Wald chi2(9) = 28.86
Prob > chi2 = 0.0007
Pseudo R2 = 0.4481

Log pseudolikelihood = -12.061715

Knowledge	Odds ratio	Robust std. err.	z	P>|z|	[95% conf.	interval]
Gender	.0000691	.0002678	-2.47	0.013	3.48e-08	.1372548
Age	1.377345	.7911485	0.56	0.577	.4467987	4.24594
lnAveragemonthlyincome	7868.152	25492.62	2.77	0.006	13.74042	4505527
Noofpersonsinwaprounit	.1956711	.1657883	-1.93	0.054	.0371809	1.029753
lnNumberoftrainingsattended	.3727905	.8254282	-0.45	0.656	.0048612	28.58808
lnAmounttheyproduce	.8858752	2.275168	-0.05	0.962	.0057711	135.9844
lnYearsofschooling	2.198688	4.699672	0.37	0.712	.0333219	145.0766
AgeXlnincome	.2093818	.1059338	-3.09	0.002	.0776757	.564407
GenderXAge	16.71059	14.1943	3.32	0.001	3.162019	88.31184
_cons	172.3003	1025.031	0.87	0.387	.0014873	2.00e+07

Note: _cons estimates baseline odds.

Logistic regression

Number of obs = 58
Wald chi2(6) = 15.59
Prob > chi2 = 0.0162
Pseudo R2 = 0.1052

Log pseudolikelihood = -21.725637

Attitude	Odds ratio	Robust std. err.	z	P>|z|	[95% conf.	interval]
lnYearsofwastecollection	.0004345	.0012642	-2.66	0.008	1.45e-06	.1302643
Nooftrainingsattended	.0428586	.0641658	-2.10	0.035	.0022786	.8061478
lnAmtofkgstheycollect	1.013676	.3975056	0.03	0.972	.4700096	2.186209
YearXTraining	1.933522	.8192184	1.56	0.120	.8427559	4.436053
YearXlnkg	1.014572	.0362834	0.40	0.686	.9458931	1.088238
TrainingXlnkg	1.018294	.145802	0.13	0.899	.769123	1.348188
_cons	376413.3	1765310	2.74	0.006	38.3428	3.70e+09

Note: _cons estimates baseline odds.
Note: 0 failures and 1 success completely determined.

. estimates table, star(.1 .05 .01)

Iteration 4: log pseudolikelihood = -177.19707
Iteration 5: log pseudolikelihood = -177.1746
Iteration 6: log pseudolikelihood = -177.17429
Iteration 7: log pseudolikelihood = -177.17429

Logistic regression

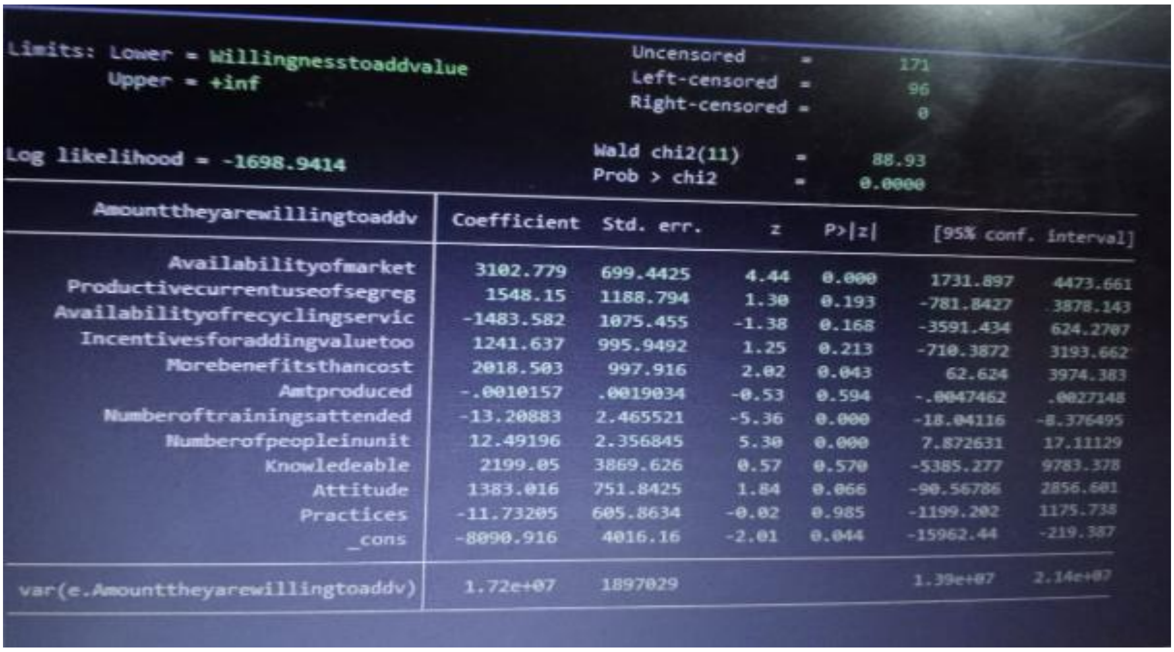
Number of obs = 266
Wald chi2(4) = 9.48
Prob > chi2 = 0.0501
Pseudo R2 = 0.0262

Log pseudolikelihood = -177.17429

practices	Odds ratio	Robust std. err.	z	P>|z|	[95% conf.	interval]
Amtproduced	.9999968	4.17e-06	-0.78	0.437	.9999886	1.000005
Numberoftrainingsattended	1.396481	.2797609	1.67	0.096	.9429997	2.068039
lnNumberofpeopleinunit	1.6243	.4545055	1.73	0.083	.9386122	2.810986
lnAmtproducedXpeople	.9548079	.0296657	-1.49	0.137	.8983991	1.014759
_cons	.6767644	.244147	-1.08	0.279	.3337039	1.372504

Note: _cons estimates baseline odds.

Appendix D- Key data analysis output for objective three



Limits: Lower = Willingnesstoaddvalue
Upper = +inf

Uncensored = 171
Left-censored = 96
Right-censored = 0

Log likelihood = -1698.9414

Wald chi2(11) = 88.93
Prob > chi2 = 0.0000

Amounttheyarewillingtoaddv	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
Availabilityofmarket	3102.779	699.4425	4.44	0.000	1731.897	4473.661
Productivecurrentuseofsegreg	1548.15	1188.794	1.30	0.193	-781.8427	3878.143
Availabilityofrecyclingservic	-1483.582	1075.455	-1.38	0.168	-3591.434	624.2707
Incentivesforaddingvaluetoo	1241.637	995.9492	1.25	0.213	-710.3872	3193.662
Morebenefitsthancost	2018.503	997.916	2.02	0.043	62.624	3974.383
Amtproduced	-.0010157	.0019034	-0.53	0.594	-.0047462	.0027148
Numberoftrainingsattended	-13.20883	2.465521	-5.36	0.000	-18.04116	-8.376495
Numberofpeopleinunit	12.49196	2.356845	5.30	0.000	7.872631	17.11129
Knowledeable	2199.05	3869.626	0.57	0.570	-5385.277	9783.378
Attitude	1383.016	751.8425	1.84	0.066	-90.56786	2856.601
Practices	-11.73205	605.8634	-0.02	0.985	-1199.202	1175.738
_cons	-8090.916	4016.16	-2.01	0.044	-15962.44	-219.387
var(e.Amounttheyarewillingtoaddv)	1.72e+07	1897029			1.39e+07	2.14e+07

Appendix E- Paper under journal review for objective two and three

Manuscript Number: **CLWAS-D-24-00192**

Knowledge, Attitudes, Practices, and Willingness to Use Insect-Based Technologies for Organic Waste Management

Dear Dr Muriithi,

Your above referenced submission has been assigned a manuscript number: **CLWAS-D-24-00192**.

To track the status of your manuscript, please log in as an author at https://www.editorialmanager.com/CLWAS/, and navigate to the "Submissions Being Processed" folder.

Thank you for submitting your work to this journal.

Kind regards,
Cleaner Waste Systems

Appendix F- Conference Paper

- **ICAE 2024, New Delhi, India-** Teresia G. Wamwondwe[1,2], Beatrice W. Muriithi[1*], Hillary K. Bett[2], Dennis Beesigamukama[1], Shaphan Y. Chia[1], Perpetual Gakeni[1,2], Chrysantus M. Tanga[1] **Knowledge, Attitudes, Practices, and Willingness to Use Insect-Based Technologies for Organic Waste Management**