AN ASSESSMENT OF SOCIO-ECONOMIC FACTORS INFLUENCING ELECTRONIC WASTE MANAGEMENT IN KISUMU CENTRAL BUSINESS DISTRICT, KISUMU CITY, KENYA.

BY

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DECLARATION

Declaration by student:

I declare that the work presented in this thesis is my original work and has not been presented for the award of a degree in any other University. All sources of information have been acknowledged appropriately.

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We, the undersigned, confirm that the work reported in this thesis was carried out under our supervision, and this has been submitted with our approval as academic supervisors.

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ABSTRACT

The ever increasing levels of electronic waste (e-waste) and limited capacities for disposal and recycling have worsened e-waste management considering only 10% of e-waste is properly managed globally. In developed countries, e-waste management is guided by extended producer responsibility frameworks that ensure e-waste collection and recycling through consumer participation whereas, in Asia and Africa e-waste is managed through inefficient solid waste systems resulting to degradation of the environment. The downstream e-waste management sector is informal with no regulations to ensure proper management yet, recyclers' capacity to efficiently manage e-waste is not known. Studies have shown socio-economic factors and awareness levels influence participation in e-waste recycling however, socio-economic factors have greater influence. Despite this important link, there is hardly any empirical data on this relationship regionally. The success of a recycling system depends on the active and sustained participation of citizens in the correct separation and collection of waste. Therefore, the purpose of this study is to assess the influence of socio-economic factors on e-waste management in Kisumu Central Business District (CBD) where electronic and electrical equipment use is pervasive. The specific objectives of this study were to; examine the influence of occupation type on e-waste management and e-waste generation in Kisumu CBD, investigate the influence of education level on e-waste recycling in Kisumu CBD, establish the influence of income level on e-waste recycling in Kisumu CBD and to assess the influence of technical training on e-waste recovery and refurbishment in Kisumu CBD. The study adopted a cross-sectional research design and the units of analyses were EEE consumers and technicians. A sample of 290 consumers was derived from a population of 1,193 businesses and 39 technicians derived from 44 repair shops operating within Kisumu City CBD. The respondents were selected through systematic random sampling. Primary data was collected through questionnaires, key informant interviews and observations. E-waste management practices, preferred scheme of recycling and willingness to participate in e-waste recycling was assessed. Linear regression technique was used to determine willingness to participate in recycling, and binary logistic regression was used to determine e-waste management. Results show that consumers are willing to pay (WTP) not more than 5% of the cost of electronic and electrical equipment cost, the average production of e-waste per person in the CBD is 0.8 Kg/year and 'deposit-refund' drop-off scheme is the most preferred collection method. Consumers in professional services have the highest likelihood of not managing e-waste with an odds ratio of 0.61 ($p<0.0001$) and wholesale business were the lead producers of e-waste accounting for (29.57%) of 1.07 tonnes/year produced. Education levels and income levels of consumers had significant associations ($p=0.0008$ and $p<0.0001$ respectively) in predicting WTP, an increase in income led to 38.8% increase in WTP in comparison to education level at 35.4%. Willingness to drop-off (WTD) was only predicted by income levels ($p=0.0001$) with an increase in income level leading to 43.3% increase in WTD. The technical training of the technicians influenced e-waste recovery outcomes, but refurbishment was not significant. Therefore, occupation, income levels and education levels of consumers should be factored in designing of an e-waste management system in Kisumu CBD. There is need for civil education on e-waste management especially on consumers in professional services; recycling levy should not exceed 5% of the cost of the equipment to guarantee participation from all groups and there is need for capacity building of technicians by original equipment manufacturers to enable them to de-manufacture recyclables from e-waste and also, incentives should be given for collection of non-recyclables.

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LIST OF ABBREVIATIONS AND ACRONYMS

CBD Central Business District

CED Consumer Electronic Device

EEE Electronic and Electric Equipment

EMPA Swiss Materials Science and Technology Research Institute

EoL End of life management

ICT Information and Communication Technologies

MCK Municipal Council of Kisumu

MSW Municipal Solid Waste

PC Personal Computer

TV Television

UNEP United Nations Environment Programme

WEEE Waste Electrical and Electronic Equipment

WTD Willingness to drop-off e-waste at recycling at a centre

WTP Willingness to pay for e-waste recycling

WORKING DEFINITION OF TERMS

Business: Refers to an office, restaurant business, retail or wholesale shop enterprise

Curbside recycling: Monthly curbside pick-up of e-waste for a flat fee. All Electronic and Electrical Equipment consumers pay regardless of use.

Consumer: can either be an individual or a corporate organization that owns a device which falls into one of the e-waste categories and which he considers to have ceased to be of any value to him

Deposit-refund program: Consumers pay a deposit when purchasing new electronics. On return to a retail location for recycling, consumers receive a refund. A small fee is subtracted from the deposit to finance this program.

Drop-off recycling: An environmental handling charge (EHC) is collected on all new retail consumer electronic sales. Funds are used to finance recycling programs at regional centers.

Electrical equipment: Refers any machine powered by electricity and have a variety of electrical components and often a power switch..

Electronic equipment: Refers to an equipment that involves the controlled conduction of electrons (especially in a gas or vacuum or semiconductor) e.g. amplifier, audio and sound system, cassette player, CD player, Cathode Ray Oscilloscope etc.

E-waste: Refers to discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets, and refrigerators. It includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal.

E-waste management: Refers to the process of controlling e-waste, it includes the process of generation, handling, storage, collection and transportation, minimization and final disposal.

Extended Producer Responsibility (EPR): This is an environment protection strategy that makes the producer responsible for the entire life cycle of the product, especially for take back, recycle and final disposal of the product.

Jua Kali: It is an informal sector that covers all small-scale activities that are normally semi-organized, unregulated, use low and simple technologies, and employ few persons.

Penetration rate: Installed units of EEE per capita.

Producer Responsibility Organization (PRO): This is a delegated extended producer responsibility (EPR) by the producer to a third party, which is paid by the producer for spent-product management

Recycling: Refers to the processing of used materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution and water pollution by reducing the need for "conventional" waste disposal or producing a new product from a recyclable material.

Recycler: Refers to a person who engages in treating or processing (of used or waste materials) to make them suitable for reuse.

Refurbisher: Is a person who renovates or processes e-waste for reuse, but does not include telecommunications carriers, telecommunications manufacturers, or commercial mobile service providers with an existing recycling programme.

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CHAPTER ONE

1. INTRODUCTION

1.1 Background to the Study.

Electronic waste (e-waste) is a generic term encompassing various forms of electronic and electric equipment (EEE) that are old, end of life appliances and have seized to be of any value to the owner, e-waste infamously represents the fastest growing waste stream (Fraige *et al.,* 2012 and Qu *et al.,* 2013). This has been attributed to rapid technology development which has accelerated the pace of industrialisation and marketing (Wang e*t al.,* 2008). The fast-developing technology has changed the society and purchasing habits and also resulted to an increase in production of superfluous EEE products. Electronic functionality within consumer electronics has been dynamic and a fast moving field, characterised by advancing technology and price reduction to support increasing demand (Darby & Obara, 2005). This has led to an increase in production of EEE which is causing unwanted pollution, depletion of natural resources, and damage to the Earth and its environment.

The growth in electrical and electronic equipment (EEE) can be viewed as the outcome of the advancement in technology which has brought great convenience to the daily life. Electrical and electronic equipments are made up of a multitude of components, some valuable such as copper (Cu), silver (Ag), gold (Au) and palladium (Pd) that can be recovered. It also has toxic substances such as lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As), selenium (Se) among others that would have an adverse impact on human health and the environment if not handled properly after being abandoned (Wang *et al.,* 2012). For instance, 215 tonnes of computer waste contains on average 2 tonnes of arsenic, 3 tonnes of mercury and 10 tonnes of lead which is enough to contaminate 225 million litres of ground water (Steubing, 2007 and Fraige *et al.,* 2012). Therefore recycling of e-waste is required to garner double value of both environmental protection and resource conservation. In Kenya however, there is still a

shortage of appropriate management policies and infrastructure specific to this waste stream as it cannot be managed effectively using solid waste channels.

During the last decade, large amounts of e-waste have been rapidly piling up in emerging economies both from growing domestic consumption as well as imports and a study by UNEP (2012) estimate approximately 50 million tons of e-waste is produced each year. However, a paltry 10% is properly recycled and recovered due to cost of recycling and limited management options (Nixon *et al.*, 2009). Due to the difficulty and cost of recycling used electronics as well as the demand for raw material for reproduction in the developing countries, large amounts of obsolete electronics have been smuggled into developing countries such as China, India, and Kenya, where lower environmental standards and working conditions enable processing e-waste more profitable, but also bring great damage to the local environment (Wang *et al.*, 2008). The amount of e-waste getting into developing countries from the European Union and other developed countries is significant but current strategies for management are not known.

To address the challenge in e-waste management, the European Union (EU) has implemented two pieces of legislations; The Directive on waste electrical and electronic equipment (WEEE Directive, 2002/96/EC) and the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive, 2002/96/EC) to improve the environmental management of WEEE (Wang *et al.*, 2012 and Striecher-Porte & Geering, 2010). These legislations have paved way for financing e-waste management through Extended Producer Responsibility (EPR) framework that states producers and importers should extend their responsibility to reclaiming e-waste (Yin *et al.*, 2013). Sweden was the first country to have an extended producer responsibility as an environmental goal in 1990, and EPR for electronic products become mandatory in 2001 (Cohen *et al.*, 2006). This shows

e-waste regulations are fairly recent and developing countries are catching up as is the case with Kenya's which has a draft policy on e-waste (NEMA, 2010). Studies on e-waste management are needed to help operationalize the policies.

However, beyond the producers and importers, EEE consumers play an important role in e-waste recycling (Hicks *et al.,* 2005). The consumer is the nexus between the EEE producers and e-waste recyclers; consequently there is great need to understand factors influencing their participation in e-waste management. According to Ongondo & William (2011a) e-waste recycling is influenced consumer variables such as socio-economic characteristics, environmental attitudes and beliefs. These factors have been explored in e-waste systems in the European Union (EU), United States of America (USA) and Australia (Darby & Obara, 2005; Nixon *et al.,* 2009; Saphores *et al.,* 2012; Saphores *et al.,* 2007 and Rolls *et al.,* 2009). However, not much is known about influences of these factors on e-waste management in developing countries considering, Ogondo and William (2011a) acknowledge there is global disparity in e-waste management influenced by the differences in affluence.

Socio-economic characteristics of consumers such as age, gender, income and education levels play important roles in willingness of the general public. Studies on determinant of consumer participation in recycling in China (Yin *et al.,* 2013) and Macau (Song *et al.,* 2012) have shown willingness to pay (WTP) for recycling is influenced by education level and income level with an increase in both leading to an increase in WTP. In Macau the residents' WTP was estimated by the logistic regression method and in China, a multinomial logistic regression was used and the studies revealed education level, and income levels had positive relationship with willingness of the consumer in recycling, though the study in China focused on mobile phones only. In Australia, WTP was high among young people, women and the more educated with higher incomes (Rolls *et al.,* 2009). However, a study by Nixon et al.,

(2008) found an inverse relationship between household income and WTP with individual with lower income being more WTP compared to households in middle and upper income classes. Education levels was significant with college educated individuals accepting higher levels of recycling inconvenience for a unit recycling cost increase. These studies were done at household level and have shown socio-economic factors being determinants to WTP. Domestic e-waste has been highlighted in a number of studies, however, the commercial sources and management of e-waste is yet to be done in Kisumu City. A report by UNEP (2007) posits that businesses, government departments and municipal offices to be the earliest adopters of information and communication technology and equipment yet not much is known about the consumer factors influencing management of e-waste in a developing country context.

In California, Saphores *et al.*, (2006) found that gender and education levels were determinants willingness to drop off e-waste at recycling centers (WTD) but not income levels whereas, Darby & Obara (2005) investigated consumers' likelihood to participate in disposal of small e-waste at collection centres in United Kingdom and Wales found income was a determinant to WTD with lower income individuals being less likely to visit civic amenity site to dispose their e-waste compared to respondents with higher income. These studies were done in developed e-waste management systems with mature e-waste collection mechanisms however, some authors find a positive association between socio-economic factors and recycling but others disagree. The effect of these socio-economic factors is ambiguous. This show that even within developed e-waste system, predicting consumer WTP and WTD should be done with care as each city has its character. Therefore, implementing e-waste guidelines and frameworks should be informed by case studies. Kenya is in the process of implementing e-waste guidelines (NEMA, 2010) yet studies are not conclusive on consumer participation in the e-waste system.

To develop an effective waste management strategy for a given region, it is important to know the amount of waste generated and the composition of the waste stream (Bandara *et al.*, 2007). Past research has shown that the amount of waste generated is proportional to the population and the average mean living standards or the average income of the people. In addition, other factors may affect the amount and composition of waste. These are climate, living habits, level of education, religious and cultural beliefs, and social and public attitudes (Bandara *et al.*, 2007). Although models are available to predict e-waste generation patterns in developed countries (Manhart *et al.*, 2013), very little research has been done so far to develop models applicable in developing countries.

The purpose of WEEE recycling is to diminish solid waste, reduce land fill, retrieve material and recover energy etc. In Europe, the governments carry out e-waste recycling mainly for the incentive of reducing land fill due to scarcity of land (Wang et al., 2008). Differently in most developing countries, e-waste recycling is regarded as a fine way to reclaim secondary material for production. South Korea, Taiwan, and southern China all excelled in finding "retained value" in used goods, and in some cases have set up billion-dollar industries in refurbishing used ink cartridges, single-use cameras, and working Cathode Ray Tubes (CRTs) (NEMA, 2010). However, Streicher-Porte & Geering (2010) noted in China, there is low awareness on the risks of exposure to hazardous compounds by refurbishers as they employ rudimentary methods in e-waste management. In Ghana and Nigeria, employment opportunities in downstream e-waste management exist for university graduates with technical background or persons who went through the sector's apprenticeship system. However, recycling is characterised by poor environmental practices that has led to high concentration of heavy metals in the soil and dust sample where e-waste are being dismantled (Manhart *et al.*, 2011 and Ofudje *et al.*, 2014).

Apart from e-waste dumping, e-waste output has increased in Africa due to a growing economy and an increasing urban population. For instance, estimates indicate 40,000 tonnes of e-waste were generated in Morocco, in South Africa e-waste from homes is approximated between one to two million units of EEE and in Kenya, about 11,400 tonnes is produced per year (Blaser, 2011; Finlay & Lietchi, 2008 and NEMA, 2010). In Kenya, the increase is attributed to mobile phone revolution, planned transition to digital TV broadcasting and dumping of EEE in the guise of donations (Shahonya, 2011). A substantial proportion of the ICT equipment imported is either knock offs or second hand devices that drive the consumer into frequent replacements leading to a pile-up of discarded gadgets (Kamau, 2010). There are few formal e-waste refurbishing plants, in Nairobi there a non-governmental project called Computer for Schools-Kenya (CfSK) program that refurbishes computers and has a daily capacity is 2,000 units, but manages only 500 computers due to low awareness and challenges in take-back collection systems (Anyango, 2010). Other forms of e-waste have no takeback mechanisms and the capacity to manage them is left to the informal sector whose capacity to refurbish e-waste is not known.

A report by UNDP (2005) assessing industrialisation and human development found the structure of industry in Kenya emphasises on low technological products, and is characterised by simple equipment and limited skill requirements for entry. In Nairobi, downstream e-waste refurbishing is done in Ngara area where most of the technicians went through technical colleges (Waema & Mureithi, 2008). Studies by Waema & Mureithi (2008) and Manhart *et al.*, (2011) have highlighted that technical training of refurbishers' and recyclers' offers opportunities in e-waste management however, the capacity to recover, recycle and refurbish e-waste has not been determined. Furthermore, environment and safety concerns have been raised. Anyango (2010) reported in Nakuru town, there were about 17 refrigerator technicians and almost all had little

knowledge of the hazards associated with coolants when recycling compressors in refrigerators as one technician died after inhaling CFC gas as he siphoned the compressor.

Kisumu produces about 400 tonnes of waste daily with a collection efficiency of 20% and 60-65% of the waste produced is organic (Munala, 2009 and UNDP, 2005). Waste management is characterised by insufficient financial outlays, lack of political and institutional support for waste management and consumers have poor attitude towards environmental cleanliness and absence therefore a lack of systematic approach towards waste management (Kibwage & Onyango 2008). With these challenges in SWM and gaps identified in e-waste management, there is need for a comprehensive strategy based on facts obtained from an empirical study as it is impossible to juxtapose relationship due to ambiguity in outcomes in previous studies on factors influencing e-waste management. Therefore this study sought to assess the influence of socio-economic factors on e-waste management in Kisumu CBD where there is high penetration of EEE and the study also looked at downstream actors to highlight prevalent end of life management of electronic waste.

1.2 Problem Statement

Production of electric and electronic equipment is the fastest growing manufacturing activity globally. Cities are facing great challenge with respect to e-waste management as they constitute a high concentration of population and economic activities leading to increase in material and energy consumption. However, only 10% of e-waste is properly managed worldwide. In developed countries, e-waste management is based on industry frameworks that ensure e-waste is separated from solid waste. However, until recently, African countries are in setting up policies to address this waste segment but determinants of participation in e-waste management are yet to be determined.

Though many researchers have shown consumers' internal factors such as socio-economic and demographic factors, attitudes and beliefs influence participation in e-waste recycling, there is barely any study done regionally showing this relationship. Studies have linked socio-economic factors to having a greater influence on consumers' willingness to recycle e-waste compared to demographic; factors such as income, gender, age, education levels and occupation influence willingness to pay (WTP) for recycling and Willingness to drop-off (WTD) e-waste at recycling centres.

Among the socio-economic factors, some have greater influence on recycling outcomes than others. Studies have shown each city has its peculiar characteristic to factors that have greatest influence. In some cases income, occupation and education levels have shown positive relationship in other cases negative or no significant relationship with willingness to recycle e-waste. Therefore, relationships cannot be juxtaposed when deciding on frameworks for e-waste management and this means each city/town needs its own assessment on factors that have greater influence on e-waste management.

Since available data on e-waste management in Kenya has focused on the general outlook with prominence given to Nairobi city; there is a need to identify factors that influence e-waste management in other cities that produce significant amount of e-waste considering the proposed e-waste guidelines (2010) requires participation from consumers through payment and dropping off e-waste at recycling centres.

Studies show downstream e-waste management offers opportunities for employment to graduates with technical background or persons who went through the sector's apprenticeship system in developing countries. In Kenya, e-waste management is dependent on the informal sector. However, not much is known about the capacity of the technicians in recovery and

refurbishing e-waste as studies in Nairobi have shown the sector is dominated by with individuals with technical training. In Kisumu city, no study has been done linking socio-economic factors to e-waste management yet, the CBD of Kisumu City is the regional hub of commerce and trade therefore has a high penetration of electronic and electrical equipment (EEE). End of life management and factors influencing participation in management of these EEE should be determined.

1.3 Objective of the Study

The main objective of this study is to assess socio-economic factors influencing electronic waste management in Kisumu Central Business District. The specific objectives are;

1. To examine the influence of Occupation on e-waste management and generation in Kisumu CBD.
2. To investigate the influence of education levels on e-waste recycling in Kisumu CBD.
3. To establish the influence of income levels on e-waste recycling in Kisumu CBD.
4. To assess the influence technical training on e-waste recovery and refurbishment in Kisumu CBD.

1.4 Research Questions

This study will address the following questions:

1. What is the influence of Occupation on e-waste management and generation in Kisumu CBD?
2. What is the influence of Education levels on E-waste recycling in Kisumu CBD?
3. What is the influence of Income levels on E-waste recycling in Kisumu CBD?
4. What is the influence of technical training on e-waste recovery and refurbishment in Kisumu CBD?

1.5 Justification of the Study

The production of electric and electronic equipment is the fastest growing manufacturing activities globally. Kisumu city faces great challenge with respect to waste as it constitutes a high concentration of population, economic activities and material and energy consumption. Kisumu CBD has high penetration of electronic and electric equipments as it hosts the regional commerce, administration, trade and other socio-economic activities that are reliant on ICT equipments and other consumer electronic devices (CED).

Opportunities for e-waste management in Kisumu city looks grim as there are no laws and frameworks specific to this waste segment. NEMA has proposed e-waste guidelines that are centered on consumer participation; a number of e-waste management options have been given however, the best approach for consumer engagement in e-waste management should be determined once the guidelines come to law and domesticated in Kisumu city. There is need to survey consumer practices and assess factors influencing their willingness to participate in end-of-life management of e-waste.

The influence of socio-economic factors on e-waste management has been highlighted in a number of studies. It is important to establish the correlation between socio-economic factors and e-waste management by not only focusing on the consumers who are engaged at the pre-treatment stage of waste management through e-waste collection and facilitation for recycling, but also looking at the downstream actors' capacity to treat the e-waste through material recovery and refurbishment. The study findings can provide an important source of information for policy makers and other stakeholders on e-waste management, create awareness on the potential benefits and hazards associated with e-wastes as well as contribute to academia.

1.6 Scope and Limitations

The research was limited to collecting data from formal businesses in Kisumu CBD. Informal businesses were not surveyed as the sample population was determined by registered businesses in Kisumu Municipality and the data was sourced from the registry department. The study was done in the CBD therefore the results on penetration of EEE and generation rates of e-waste should be inferred for only commercial e-waste.

The study was limited in its scope of electronic and electrical equipments used by consumers as only information and communication (ICT) equipment were assessed and they were; TV, landlines telephones, laptop computers, desktop computers, printers and photocopiers.

Recovery of e-waste focused on recovery of electronic and electric fractions (capacitors, fuses, transistors, conductors etc.) and printed circuit boards (PCBs) only. Therefore, other recyclables such as metals and plastics were not used to evaluate the capacity of technicians to recover e-waste.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Introduction

This section gives an overview of existing information relevant to this study and seeks to unveil knowledge gaps that are worth to be further researched and need attention. The section highlights how e-waste management practices are influenced by socio-economic factors that are determinants to environmental standing. In addition the theoretical framework guiding the study is given.

2.2 Influence of Occupation on e-waste management and generation.

The success of any city's waste management program is directly related to the accuracy of waste composition and quantity information (Afroz *et al.,* 2011 and Bandara *et al.,* 2007). The amount of waste generated is proportional to the population and the average mean living standards (Bandara *et al.,* 2007). Most waste management studies done in developing countries are generic in the outlook of waste generation; waste characterization is broad and done using two strata, inorganic and organic waste. For instance, a study by Afroz *et al.,* (2011) looking into the composition of municipal waste in Bangladesh, Dakar city established that the consumers' occupation activities, lifestyles, and education and income levels influence generation rates and composition of waste. The study found that waste composition varies not only between countries, but also between individual cities and even communities within a city. According to UNEP (2011), 10% of solid waste produced globally is e-waste however; few studies have attempted to characterize e-waste generation in relation to socio-economic factors.

Diamantopoulos *et al.,* (2003) survey in Britain profiling green consumers investigated the influence of social class on different environmental domains such as environmental

knowledge, concern for environment quality and likelihood to participate in green activities. The consumers were ditochomised into white or blue collar workers. White collar workers were found to be better informed about green issues. However, there was little support between white- and blue-collar workers with recycling behavior. The study classified occupation longitudinally and had only two groups. The classification of occupation limits its application in identifying which specific occupation class is not likely to participate in e-waste recycling.

Laissaoui & Rochat (2008) study in Morocco, focusing on Casablanca, Fez and Meknes cities, assessed the penetration of EEE while considering companies. Their findings showed average number of computers per employee was 0.48; however this masked major differences between different sectors. Companies in the technology sector had the highest penetration rate (80%), while companies in the primary sector and the service and transport sector came in second with a level of equipment per employee of more than 50%. The construction and public works sector is the least equipped, with just 20%. This was a pioneer study in Africa that highlighted the high penetration of EEE in the commercial set-up; many studies in e-waste management have focused on household (domestic) e-waste. Classification of e-waste and generation by Laissaoui & Rochat (2008) was the first attempt regionally to classify e-waste as per the different occupations in the city. There is no account of e-waste generation as per the economic activities in cities locally yet such information can help in planning for e-waste management.

A survey in Casablanca city revealed that businesses are aware of the environmental hazards linked to e-waste and that e-waste can be profitably recycled. The form of managing this waste differs according to the size of the company and how organised it is. Small and

medium enterprises (SME) generally sell their e-waste by auction, or dispose of it mixed up with other waste. Companies in the technology sector (call centres, banks, etc.) return computer equipment to the reseller, trading it in against the purchase of new equipment, thus avoiding accumulating equipment while ensuring that they always have the most up-to-date equipment. Large companies, meanwhile, usually store their e-waste until a solution for its reuse and/or sustainable disposal is found (Laissaoui & Rochat, 2008). This study highlights a very important link between e-waste management and occupation (economic sector); there is need for such a study locally to identify which occupations have the highest likelihood to produce e-waste.

In Nigeria's Oyo state, the quantity and rate of solid waste generation is dependent on the age, location, occupation and amount charged for waste collection were determinant factors for using public waste collection (Babayemi & Dauda, 2009). Likewise in Dar-es-Salaam city, waste generated is influenced by socio-economic status, measured as a combination of income, occupation and education of consumers and e-waste comprises of 2% of all solid waste produced (Senzige *et al.*, 2014). The researchers showed how waste quantity is influenced by socio-economic status, occupation being amongst them however; the focus was on domestic sources of waste. Few studies have been done looking at commercial sources of waste and e-waste is an emerging phenomenon in waste management considering UNEP (2011) report showing it is the fastest growing waste stream.

UNEP (2011) reports that e-waste management process is a challenge in the business sector in developing countries where government departments, private sector offices, municipal offices were among the earliest users of information technology and information technology products and today it accounts for a sizable amount of total installed Information

Communication and Technology (ICT) equipment. In Uganda and Kenya, substantial fraction of computer equipment entering re-use stems from large companies and the government departments (Wasswa & Schluep, 2008; Waema & Mureithi, 2008 and Steubing, 2010). The same trend was observed in Chile where the flow of computer equipment is from the principal first users, larger businesses and the government, to the principal second users, households and Small and Medium Enterprises (SME), which are, as a consequence, the most important disposer groups (Stuebing, 2010). However, these studies looked at mass flows of e-waste not considering the individual characteristics of EEE consumers in respect to the socio-economic groups as per the various occupations and activities in the cities which is critical when planning for e-waste collection mechanisms.

The methodology for e-waste flows in baseline studies associated with Swiss Materials Science and Technology Research Institute (EMPA) in developing countries; Kenya, Uganda, China and South Africa (Wasswa & Schluep, 2008; Waema & Mureithi, 2008; Eugster *et al.*, 2004 and Finlay & Lietchi, 2008) overly relied on secondary sources of data and upstream stakeholders (customs office, government agencies, importers of EEE etc) interviews to establish e-waste generation. Therefore, the generation rates were overly qualitative. The consumers' (individual) were not assessed therefore, application of such data in planning for an e-waste management system should be used with caution as it does no depict accurate quantitative measure of e-waste generated from actual e-waste producers. In the CBD

Waema & Mureithi (2008) and Waswa & Schluep (2008) assessed e-waste management in Nairobi and Kampala cities respectively. The studies identified the primary producers of e-waste as Government departments and large organisations. A substantial number of ICT equipment re-used by small and medium enterprises from the principal first users, who were large businesses and the government institutions. These studies illustrate corporate consumers

are having highest penetration of EEE yet dispose low amounts of e-waste. The end of life management of e-waste for secondary consumers who majorly constitute of SMEs need to be addressed considering CBK, WB & FSD Kenya (2015) reported that over 80% of the Kenya's population is employed in SME and a majority of the SMEs are located in the CBD of many cities.

2.3 Influence of Education level on e-waste recycling.

In developed e-waste systems in the Europe and United States of America, studies have linked socio-economic factors, demographic attributes, attitudes and beliefs to e-waste management. In some studies, socio-economic factors such as gender, age, and income and education level have been noted to have significant associations with the behavior and willingness of the general public towards adoption of recycling schemes (Saphores *et al.*, 2012 and Song *et al.*, 2012). However, there is paucity of data on factors influencing e-waste recycling in developing countries, Pérez-Belis *et al.*, (2015) did an in-depth literature analysis on trends and evolution of e-waste with a review of over 307 articles but only six studies were captured from Africa and the studies were in Nigeria and South Africa. According Ikiara *et al.*, (2004) lack of data on the key factors influencing waste management have hindered designing an effective waste collection system.

A nationwide survey in Australia using random parameter logit model found willingness to pay (WTP) for recycling schemes was higher among younger and more educated individuals and the results did not differ significantly among the five sampled cities in the study (Rolls et al., 2009). Similarly, Colesca *et al.*, (2014) found education had modest influence on WTP of e-waste in Romania. They argue that highly educated individuals are more environmentally conscious and more likely to participate in e-waste recycling. The same was validated by Zarnikau (2003) that found WTP for green power by consumers was high as prescribed in

well-established "green consumer" profile: educated, affluent, and under 55 years. These relationships are not quite consistent with as studies by Laroche (2001) study on WTP for environmental friendly products as education level was not a predictor. Wang *et al.,* (2011) study in Beijing city found no association of education levels with WTP whereas in Macau city, education was a determinant (Song *et al.,* 2012). The effect of education levels on WTP is ambiguous: Some suggest that more education contributes to recycling, but not others.

Ogondo & William (2011a) acknowledge there is global disparity in affluence therefore, differences in e-waste management however, studies linking socio-economic factors to e-waste recycling have been done in developed e-waste systems. For instance, Saphores *et al.*, (2006) study on households in California and willingness to drop-off (WTD) e-waste at recycling centers; found education level as a key predictor. Still in California, Nixon *et al.*, (2009) found college-educated individuals accepted higher levels of recycling inconvenience for a unit recycling cost increase. Studies focusing on waste recyclables such as glass, paper and plastics have also shown different relationships between the consumer willingness to drop-off e-waste and education levels, early studies by Owens *et al.,* (2000) and Scott (1999) showed positive relation and concluded an increase in the level led to an increase in WTD, however, some suggest education plays no role in WTD waste. For instance Corral-Verdugo, (1997) and Werner & Makela, (1998) found no relationship, these studies were done in developed e-waste systems and just as WTP, education of consumers exhibits ambiguous effect on WTD. Therefore consumer groups are expected to exhibit differences; therefore these relationships cannot be applied in determination of key predictors to e-waste recycling. Therefore, each system needs its own analysis.

According to Diamantopoulos *et al.,* (2003), the better-educated tend to score higher on all components of the environmental domain, probably reflecting the fact that ‘‘the very nature

of ecology with its complex interactions between organisms and environment serves to make its subject matter difficult to understand and assimilate. Diamantopoulos *et al.,* (2003) found individuals with 'O' level education or above undertake more recycling activities. Therefore it is suggested that the higher-educated understand the issues involved more fully and, hence, are more concerned about environmental quality and more motivated to participate in environmentally responsible behaviors.

In Eldoret town, household education has a positive and significant effect on willingness to pay. The positive coefficient of education suggests that the educated are WTP than the less educated (Sumukwo et al., (2012). This relationship was also corroborated in a study in Kampala city (Banga *et al.,* 2011). This is consistent with economic theory as highly educated households are more likely to be aware about health implications of unclean environment. However, these studies were done at household level; studies have ignored the commercial waste stream. In the CBD, there are a number of businesses that use an array of EEE, however the influence of education levels on WTP for e-waste recycling has not been explored in regionally and in Kisumu City.

2.4 Influence of Income levels on e-waste recycling.

Waste management is generally a public good that cannot be optimally provided under the present market conditions since the commodity is characterized by non-competing consumption and non-excludability (Sumukwo *et al.,* 2012). Solid waste collection and disposal services require a different market situation from the ordinary market pricing mechanism to achieve optimal resource allocation as environmental services are often underpriced or non-priced. Therefore optimum pricing for this services has to be determined for by the internalisation of costs. Studies have addressed this component in waste management by investigating consumer's willingness to pay for waste management

(Sumukwo *et al.,* 2012 and Kipkoech 2012) however, these studies have focused on solid waste which is broad therefore not effective in predicting participation in e-waste recycling locally. A number of e-waste management surveys have shown associations (positive, not significant, negative) between income levels and WTP but the studies have failed to show the trend in e-waste management due to uncertainty in the predictions.

In California, Nixon & Saphores (2007) study on the household's WTP for the expansion of the WEEE recycling infrastructure income was amongst the most significant factors explaining WTP. The schemes for e-waste management differ and in a later study by Nixon *et al.,* (2009) still in California, realized lower income households require less compensation on recycling cost for increased recycling inconvenience. Lower income households are more likely to rate their local environmental quality as poor or fair, so their WTP for e-waste recycling may reflect a desire to prevent additional degradation of their local environment.. Diamantopoulos *et al.,* (2003) noted that large majority of environmental studies focusing on socio-demographic characteristics and profiling green consumers' are US-based.

In Australia, survey results show there was positive influence in income level with WTP, as income rose, there was an increase in WTP (Rolls *et al.,* 2009) however, in some studies income is not a significant factor influencing WTP as shown by Manneti *et al.,* (2004) and Owens *et al.,* (2001) in Belfast city findings that regardless of demographic characteristics or geographic location, most respondents appear willing to pay for improved environmental quality, although not necessarily at the socially optimum level. Their study focused on WTP for green products and it is worth noting consumers in developed countries have a higher level of environmental consciousness compared to developing countries where studies are scarce.

A national survey of U.S. households found that the strongest predictors of willingness to recycle WEEE are environmental beliefs and social expectations. Household income did not matter in explaining household behavior (Saphores *et al.*,2012). In his earlier study in California, Saphores *et al.,* (2006) found income was not significant in explaining the willingness to recycle e-waste in comparison to other socio-economic factors such as gender, education, convenience, and environmental beliefs. A study on the same population by Nixon *et al.,* (2003) study was contradictory as it revealed that lower socio-economic groups were more willing to recycle their e-waste at a greater cost and inconvenience. It has been suggested that low-income families perceive the environmental quality of their surrounding is "poor," lending urgency to environmental issues (Nixon *et al.,* 2007).

Colesca *et al.,* (2014) found a weak correlation between income levels and e-waste recycling attitude. The analysis showed that people with higher levels of income are more positive with the idea of recycling. Electronic equipment replacement is costly and higher-incomes individuals can afford to buy new products. From another point of view, using EEE for longer period minimizes cost for individuals with lower income. However, it is worth noting the welfare levels in Romania are modest in comparison to most European Union states.

The issue of household participation in WEEE recycling schemes in developed nations is widely explored. Darby & Obara (2005) investigated the attitudes of consumers toward the disposal of small WEEE in the UK, the study found significant differences in behavior depending on the annual income of households. Those with lower incomes are less likely to visit civic amenity sites to dispose of small WEEE than respondents with higher incomes. In another study by Saphores *et al.,* (2006) found significant factors which explain the willingness to drop-off e-waste at recycling centers are gender, education, convenience, and

environmental beliefs but not income or political affiliation. Both studies were done in developed countries yet there are disparities in willingness to recycle e-waste.

A study in Eldoret town found out that income level affected household solid waste management and this was attributed to the cost of solid waste management expensive (Kipkoech, 2014). The household member's authority over monetary spending seems to influence the willingness to pay patterns. The influence of income level on waste management in Kisumu municipality has not been established, studies in western Kenya have focused on solid waste as the cases above, no study has focused on e-waste considering the ambiguity of the influence of income on e-waste as some authors find a positive association between income and recycling (Song *et al.,* 2012 and Caplan *et al.,* 2002) but others disagree (Garces *et al.,* 2002; Saphores *et al.,* 2006 and Saphores *et al.,* 2012).

2.5 Technical training influence on e-waste management

Developed e-waste systems are highly specialization in recycling, infrastructure for e-waste collection and laws governing specific e-waste segments. In the European Union, the e-waste infrastructure and capacity building is financed through extended producer responsibility (EPR) systems that focus on e-waste collection and the role of Original Equipment Manufacturers (OEM) is setting up the infrastructure and training recyclers (Laissaoui and Rochat, 2008). Despite the advancement, only one-third of generated WEEE is collected and treated according to the stipulated procedures in the UK (Ongondo & Williams, 2011a).

In developing countries, there are a number of drawbacks in e-waste management relating to unhealthy conditions of informal recycling, inadequate legislation and poor awareness amongst the e-waste recyclers (Joseph, 2007). For instance, in China there is a well-established re-use market, the challenge is in the recycling as the capacity of material

recovery and recycling is focused on valuable fractions only, hazardous and worthless material is disposed without adherence to environmental standards (Stricher-Porte & Geering, 2010).

Studies in Africa found electronic technicians represent an important link in the overall organizational chain of this sector, the informal sector in Ghana and Nigeria has had a positive impact on e-waste minimization but at a greater environmental cost (Manhart *et al.,* 2013 and Widmer *et al.,* 2005). In-depth socio-economic studies in Nigeria and Ghana on the operations and sustainability of the refurbishing and e-waste recycling sectors found stake holders in downstream e-waste management do not address the dangers posed to humans and the environment (UNEP, 2011). This is typical in many African countries where adherence to environmental standards is poor (Manhart *et al.,* 2013).

A report by UNEP (2011) in Lagos Nigeria, two refurbishing clusters; Ikeja computer village and Alaba international market have achieved high levels of professionalism and gained regional importance by supplying refurbished equipment, these two markets feature about 5,500 small enterprises with around 15,000 technicians and sales personnel. Many of these workers have a comparably high education and most of them went through a sector-specific apprenticeship system lasting between two and five years. It is notable that many of these enterprises are registered with the local authorities and pay taxes to local and regional administrations. Therefore, the refurbishing sector operates partly under formal conditions. The activities are indirectly linked to the e-waste recycling sector, as the business outputs are functioning products rather than raw materials. This is an indication that under formal arrangement, there is reduction in e-waste. Currently little is known about the downstream e-waste sector in Kisumu as no study has been done to determine the level of technology and expertise.

The nature of jobs in the refurbishing and e-waste recycling sector in Accra, Ghana is currently fulfilled by low-skilled workers and they employ interns for tasks ranging from learning and conducting technical work to typical household task. The recyclers are generally aware of the hazardous nature of improper e-waste recycling activities, but do not have any specific solutions against the problem. The stake holders in downstream e-waste management are principally interested in learning new skills and upgrading technology and knowhow needed to raise their standards of work and living but there is lack of capacity stemming from limited resources (Prakash *et al.,* (2009).

In Ethiopia, repair shops repair the EEE manually and if the equipment cannot be repaired, the repair shops usually negotiate to buy it from the owners to use it as a source of spare parts. The technicians prefer storing non-functional computers and other EEE or to dispose of them along with other municipal waste. Most of them were also willing to pay for a pickup service, but they do not care whether the e-waste is actually disposed of properly (Manhart *et al.,* 2013) This attitude might root in a lack of awareness regarding the hazardous nature of many e-waste components and low technical capacity.

In Kenya, it is evident that the majority of the unemployed are absorbed in the informal sector referred to as *Jua Kali*. This includes informal businesses working in the fields of waste collection and ICTs. Due to the sector's lack of proper legislation, it is prone to exploitation and poor working environments as it is unregulated and tends to use simple technologies and employ few people (Waema & Mureithi, 2008). Few technicians have working knowledge on e-waste management in Kenya, over 91.7 per cent of e-waste handlers do not know the precautionary measures of handling e-waste and lack gear for handling this waste segment (Waema & Muriethi, 2008). Though Waema & Mureithi (2008) study gives a good insight into the e-waste situation in Kenya however, the study focused on Nairobi city,

but it formed the basis for a country wide baseline therefore, the recommendations have limitations to Kisumu city due to different socio-economic setup.

Technology development in e-waste management is driven by the private sector and NGOs with the green agenda. In Morocco and Kenya there are NGOs working in refurbishment of computers (Blaise, 2011 and Waema & Mureithi, 2008). They have invested in relevant technology and have the requisite capacity to handle e-waste effectively but their impact is yet to be felt on a large scale as such programs are based in the capital cities. Schluep *et al.*,(2009) acknowledges that amongst the key features in realization of sustainable e-waste management are technology and skills but in e-waste management in developing countries is defined through lack of environmental standards, unregulated informal sector, lack of collection infrastructure, low skills and awareness.

Joseph (2007) points out that environmentally sound recycling of e-waste requires sophisticated technology and processes which are not only expensive, but also need specific skills and training for the operation. The level of management in many developing systems is not known as there are no formal recycling facilities out of Nairobi city. Even in Nairobi, the e-waste system is dominated by the *jua kali* sector due to ease of entry and exit and the use of low end technology (Waema & Mureithi, 2008). Because of limited resources, this sector has strived to maximize on the little they have therefore, their technical capacity to effectively manage is based on their technical training however, not much is known because the informal nature of the downstream sector.

2.6 Gaps identified from literature review

Studies have identified government departments and business community as the primary e-waste producers. However the results are too generic as the penetration rates and e-waste

generation have not been highlighted. E-waste generation in terms of different economic activities within cities has not been assessed yet UNEP (2011) acknowledges that there are significant quantities of commercial e-waste within our cities. Data on EEE penetration in with regards to occupation is vital in not only projection of future e-waste flows, but also planning for current mitigation strategies. Recent studies have focused on domestic e-waste where there is paucity of data on EEE penetration in developing cities. Kisumu City CBD has recorded tremendous growth in terms of business and commercial activities that utilize a number of EEE; however there is no data on penetration rate and generation of e-waste.

The effect of education and income on recycling of e-waste is ambiguous; some suggest that more education contributes to recycling but not others. The influence of income has shown significant association with a number of recycling scheme but failed in explaining consumer behavior in other schemes. Considering almost all studies reviewed were from developed e-waste systems, the lack of clear predictable outcomes on willingness to pay for recycling (WTP) and willingness to drop-off e-waste at recycling centres (WTD) shows that each city has its own unique characteristics. However, most have been done in developed e-waste systems. Few researchers in Kenya has attempted to correlate socio-economic factors with e-waste recycling considering plans are under way to introduce e-waste management regulations.

Though there have been several studies in the past which explore the critical factors affecting willingness to participate and pay for recycling in developed countries, little is known about consumer willingness to participate in recycling of e-waste in the context of a developing country. Research on the contextual pro-environmental WEEE disposal behavior in Kenya is hardly available.

In most developing cities, e-waste management has grown organically from the scrap sector; however the capacity to manage e-waste is yet to be determined. Most studies have highlighted there is low awareness levels of hazards associated with e-waste however, studies in developing e-waste systems are yet to look at the technological capacity of downstream e-waste handlers in e-waste reduction.

2.7 Conceptual Framework

E-waste management is dependent on consumer internal factors (Socio-economic factors and Awareness levels) and external factors (Legislation, infrastructure, product design) in which the system operates. However, greater influence is by socio-economic factors which include: occupation type, income level, education level and technical training that determine the willingness to participate in recycling and capacity to minimise e-waste getting into the dumpsite through recovery and refurbishing of EEE.

The independent variables are at two levels: pre-treatment level (consumers) and treatment level (technicians). Factors influencing the Willingness to recycle e-waste at pretreatment level include: Occupation type, income and education levels. These factors influence penetration of EEE, payment for services and perceptions of benefits and dangers e-waste poses. At treatment level, the technical training of the technicians will have an influence on the capacity to recover and refurbish e-waste. However, awareness levels and beliefs and attitude will intervene on decisions taken by stakeholders on end of life management of e-waste.

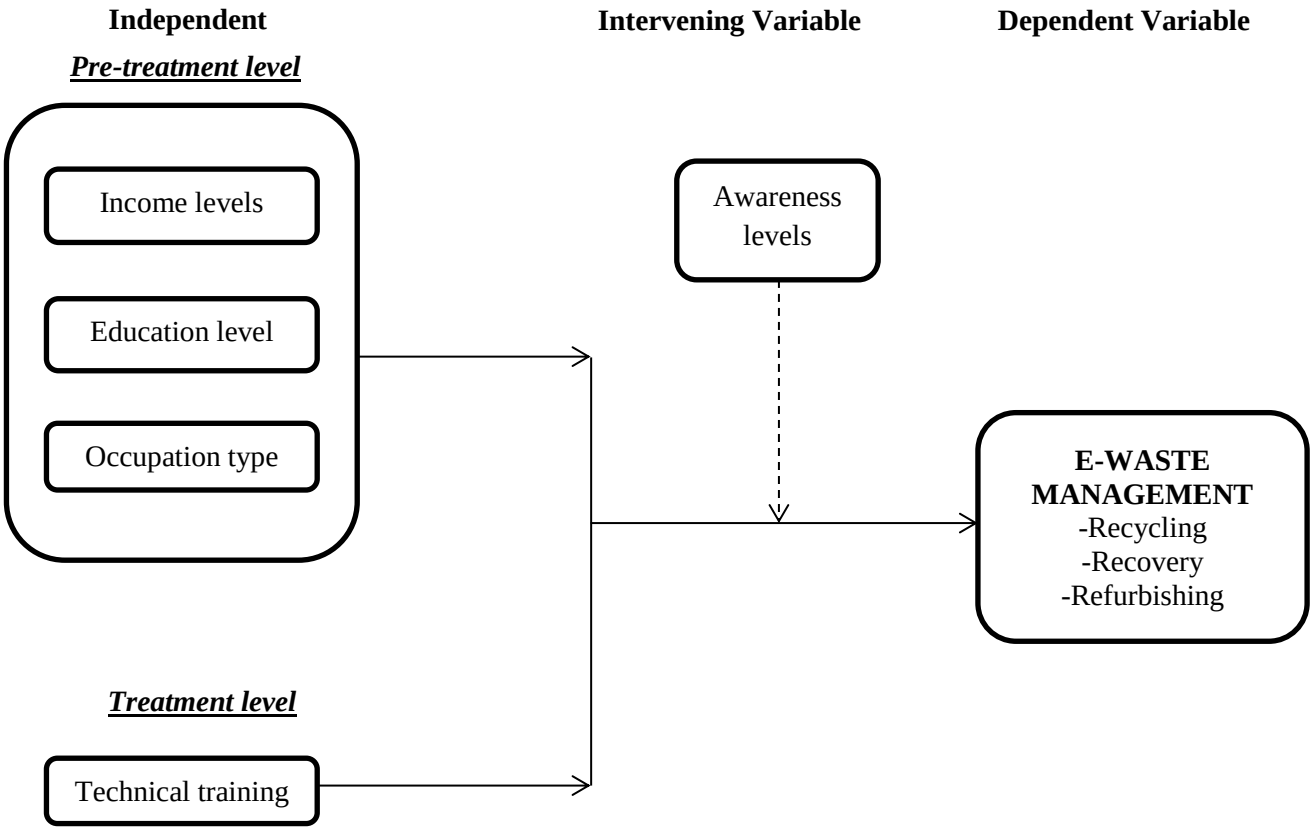

Figure 2.1 Conceptual framework

Source: Researcher (2016)

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter contains details about the various methodological procedures and techniques adopted in the collection, processing and analysis of the data. It gives information on the study area, research design, sampling procedures, the data collection instruments and the procedures of administration.

3.2 Study area

3.2.1 Location

Kisumu city stands on the eastern shores of Lake Victoria, at an altitude of 1160m above sea level (a.s.l.) and is situated approximately 00^0 06' South of the Equator and 34^0 45' East of Greenwich (www.kisumumunicipality.org). The CBD is approximately 69.5 hectares (see Fig 3.2) and the extent of the CBD was determined through a consultative process involving the Municipal planning officer and the Municipal Council Town manager/clerk.

3.2.2 Population

Kisumu city has a population of 131,062 male and 128,196 female and is ranked the third largest city in Kenya (Kisumu County Integrated Development Plan, 2013).The population density is 1,811.90 persons per square kilometre and the number of employed (age 5 and above) is 61,504 and 85,196 people are economically inactive and the annual population growth rate is 1.86% (KNBS, 2009 and CRA, 2013).

3.2.3 Economy and Development

Kisumu city is below the national average on most socio-economic indicators. The city has a score of 0.49 of Human Development Index (HDI) - a composite of life survivorship (health) dimension, education attainment and income against a national average of 0.56 (PAI, 2014).

The Kisumu CIDP (2013) identifies the young population and high unemployment as threats to development. The economic mainstay of the CBD is service industry and trade. The CBD hosts all major banks and serves as regional headquarters to a number of organizations such as Airtel, Safaricom, Multichoice, Lake Victoria Basin Commission; an East Africa Community organization. Other service related businesses are insurance firms such as Madison, Kenya Re-insurance and Jubilee having regional headquarters and liaison offices. Key government institutions such as the Ethics and Anti-corruption Commission and key institutions such as the Central Bank of Kenya (CBK) are located within the CBD. Also, the CBD has an array of retail shops with key activities relating to boutiques and apparel, electronic devices such as mobile phones and consumer electronics, hardware materials. A number of shopping malls and supermarkets are also available.

3.2.4 Education

The primary school completion rate is 88% while the transition rate to secondary school is 67.3%. The net primary school attendance is 76% while secondary is 18%. About 90% of women aged 15-24 are literate. Kisumu city records an adult literacy rate of 65.5% against a national average of 66.4 % (CRA, 2013 and KCIDP, 2013).

3.2.5 Kisumu CBD characteristics

Kisumu CBD is characterized by shops, offices, restaurants, and other business premises along the main street (Odinga Oginga street). Urban renewal is evident as old single user buildings are being demolished to give way to multipurpose high-rise buildings targeting the growing demand for office space and shops.

3.2.6 Environmental Issues

Major challenges facing the sector in Kisumu City include increased pollution from solid wastes such as polythene and plastic generated wastes, sand harvesting causing land

degradation, liquid and industrial waste disposal into the lake, water hyacinth and the hippo grass menace in Lake Victoria (KCIDP, 2013).

3.2.7 Employment

There is pressure on available employment opportunities in Kisumu City which are limited to commercial ventures and public service within Kisumu City CBD. The wage earners/ self-employed people in Kisumu account for 87.5 per cent of the labour force. Employment levels are skewed against female. The employment levels for the males are 89.4 per cent while for the female is 85 per cent relative to their labour force (KCIDP, 2013).The KNBS (2009) labour status (table 3.1) shows level of education and occupations. The variables, notably family business, family agricultural holdings, intern/volunteer, retired/homemaker, fulltime student, incapacitated and no work are tabulated.

Table 3.1 Overall Employment by Education levels in Kisumu County

Education level	None	Primary	Secondary+	Total
Work for pay	18.7	20.4	32.4	25.3
Family business	19.2	20.2	16.9	18.8
Agri. holding	33.8	25	11.8	20
Intern/volunteer	2.9	1.1	1.5	1.4
Retired/home maker	6.9	9.6	12.2	11.4
Fulltime student	21.9	16.1	1.3	13.1
Incapacitated	3.5	3.7	0.3	0.7
No work	8.4	8.1	8.3	8.2
Number of individuals	30,848	262,598	209,042	502,488

Source: KNBS & SID (2013).

In Kisumu City, 19% of the residents with no formal education, 20% of those with a primary education and 32% of those with a secondary level of education or above are working for pay. Work for pay is highest in Nairobi city at 49% and this is 17 percentage points above the level in Kisumu for those with secondary or above level of education (KNBS & SID, 2013).

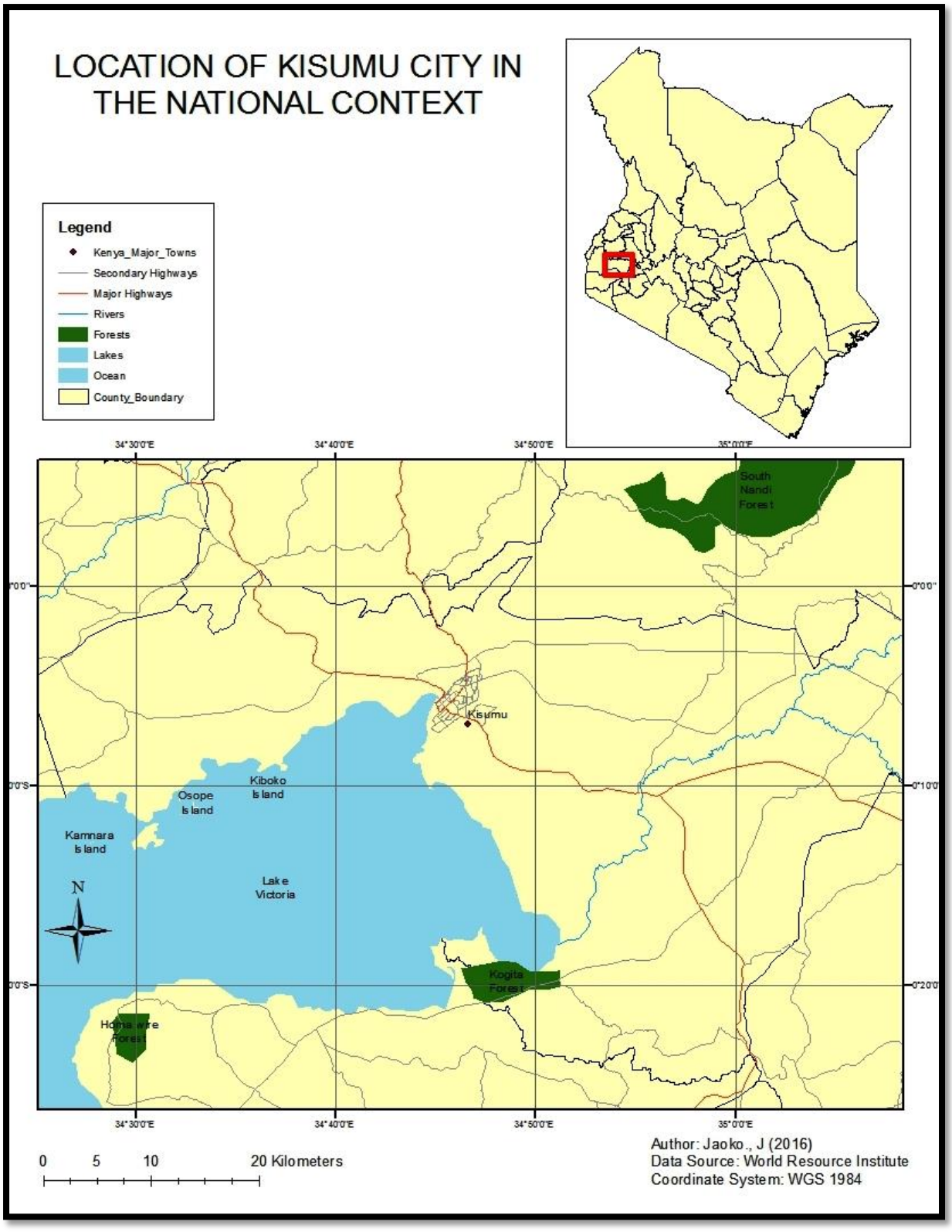

Figure 3.1 Location of Kisumu in the national context

Source: Researcher, (2016).

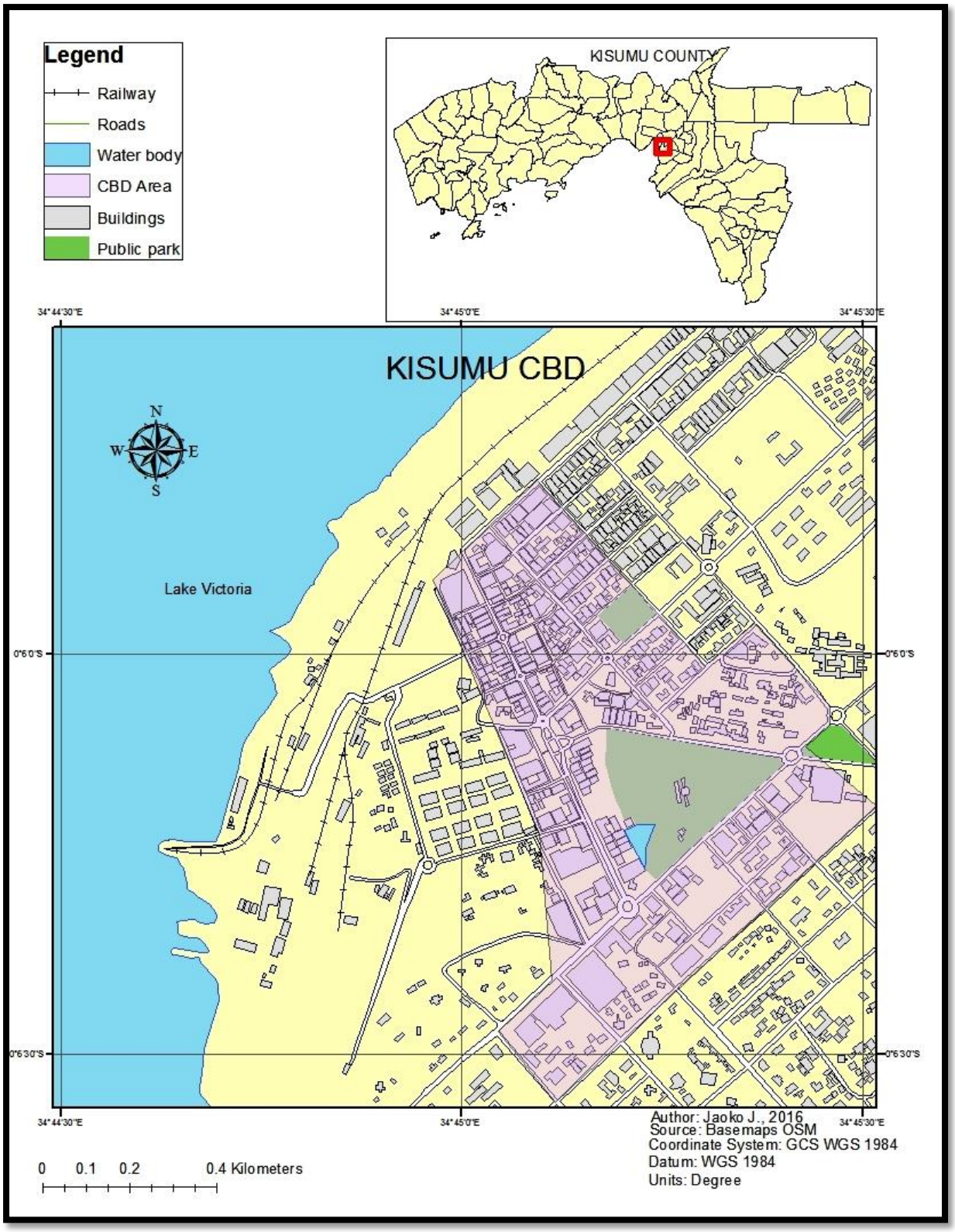

Figure 3.2 Map of Kisumu Central Business District.

Source: Researcher, (2016).

3.3 Research design

This was a cross-sectional study carried out on a one-off basis and focused on determining the relationship between e-waste management and socio-economic factors. The fieldwork was carried out in August 2013 and the study focused on the CBD area of Kisumu City. The units of analyses were consumers of electronic and electric equipment (EEE) in various businesses in the CBD and EEE technicians who were the downstream e-waste handlers in the CBD.

3.4 Study population and Sampling

3.4.1 Study population

The study population was considered based on pre-treatment (collection and disposal method) and treatment phases (recycling and recovery) in e-waste management and in order to meet the research objectives, two levels of data collection were considered. This was adopted from Kibwage (2002) study that had three levels: waste producers (consumer), waste treatment (recyclers, collectors, disposers) and policy makers. The business register from the Kisumu municipal revenue department was used to draw the sample frame. At the time the study was conducted there were 1,196 registered businesses and 44 were workshops in the CBD. Table 3.1 shows the proportional distribution of businesses in the CBD.

1) Pre-treatment level (consumers) - At this level, a population of 1,196 businesses as per the municipal registry was used to get workers.
2) Treatment level (technicians) - Data collection targeted all EEE technicians. As per the Kisumu municipal council registry, there were 44 registered EEE technicians.

Table 3.2 Distribution of businesses in Kisumu CBD

Business	Percentage
Retail and Wholesale	30
Medium and Standard lodging houses	5
Professional services	25
Small and large financial services	22
Hotel and restaurants	4
Contractors and Hardware shops	14

Source: Kisumu Municipal Council registry 2013/2014 financial year.

3.4.2 Sample size calculation

3.4.2.1 Consumers

To get the sample of workers to be surveyed, the sample size was calculated using Cochran's formula for finite population (Polonia, 2013).

$$n_0 = \frac{Z^2 \times p \times (1-p).}{e^2} \ldots\ldots\ldots\ldots\ldots 1$$

Where:

n_0 = sample size

Z^2 = the abcsissa of the normal curve that cuts of the α at the tails

e = the acceptable sampling error.

P = the acceptable proportion of an attribute that is present in the population

If there is no estimate available of the proportion of the target population assumed to have characteristics of interest, 50% should be used as recommended by Fisher *et al.*, (1983)

$$n_0 = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.5^2} = 384$$

To get adjusted sample for finite population, the following formula is applied:

$$n = \frac{n_0}{1+\frac{(n_0-1)}{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where:

n_0 = initial sample size

n = adjusted sample size

N = population size.

$$n = \frac{384}{1 + \frac{383}{1{,}193}} = 290$$

At 95% confidence level, n = 290 is the minimum sample size of workers for reliable results.

The stratified random sampling method was employed to carry out the survey due to the tremendous differences and heterogeneity among population groups. In sample survey, the population was divided into a finite number of disjointed subpopulations, namely, strata (Yin *et al.,* 2013). Our strata were the business classes as registered in the business registry in the revenue department. Finite population with 1,193 businesses was divided into 5 strata. The strata included retail and wholesale traders; professional services; financial and commerce; hospitality; and Construction and hardware businesses.

If the n_i business was taken from the stratum i in compliance with the principle of random sample, the finite population with n businesses is divided into k strata and the ith stratum possesses n_i elements.

Thus, the formula

$$n = \sum_{i=1}^{k} n_i \ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where: i = 1,2,….,k**.**

The sampling interval k

Strata of were listed and the k^{th} value determined. k denotes the sampling interval.

$k = \frac{N}{n_i}$……4

N-Population of the study

n_i- sample population of the study

$$k = \frac{1{,}193}{290} \cong 4$$

k^{th} value for all business categories was 4

From the sample list, the starting point was determined randomly by picking one chip of paper from a bag with chips numbered 1 to 4. Four (4) was the sample interval for businesses. The interviewer proceeded through the assigned section surveying every first, second, third, or fourth business unit depending on strata handled.

3.4.4.2 Technicians

In Kisumu CBD, the only e-waste management activity conducted with regards to application of technology in e-waste management is EEE repair for re-use and extension of life. A total of 44 repair shops are in operation within Kisumu CBD as per the KMC registry, the location of these enterprises was determined during the reconnaissance study and the exercise established majority were located along Oginga Odinga highway. A sample size of 39 at 95% confidence level was determined using Cochran's formula for finite population.

The k^{th} value was determined

$$\boldsymbol{k = \frac{44}{39} = 1.13}$$

The sampling interval was 1.

3.5 Data Collection Methods

3.5.1 Primary data

To collect primary data, the study used questionnaires and interview schedules, Key informant interviews, observation and photography methods.

3.5.1.1 Standard questionnaire and interview schedules

The data from the respondents was collected from businesses and workshops using questionnaires. The questionnaires were self-administered and the researchers were present to explain any issue that needed clarification.

The author designed and produced a draft questionnaire which was pre-tested on 11 workers and 4 technicians in the CBD. Therefore, on the basis of the pre-test, corrections were made on the questionnaire. The worker's questionnaire used in this study focused on the prevailing e-waste management practices and how they are influenced by socio-economic background. The technician's questionnaire looked at the skill level and how they influence end-of-life management of electronic and electric devices.

To make data collection more easier and faster, three enumerators were recruited who could easily communicate with the respondents in local language. The enumerators were given trained on how to collect accurate and valid data.

3.5.1.2 Key informant Interview

The researcher also designed a semi-structured interview tool in order to collect relevant data to compliment data collected through questionnaire. The tool was used to interview key informants in the waste management sector who included: The county Director of Environment, Dumpsite Manager, Town Manager/clerk, Town planner and the NEMA sub-county officer.

3.5.1.3 Photography

Observed scenarios relevant to this study were capture using a camera and the prevalent e-waste management practices were documented.

3.6 Data analysis and Results presentation

Summary of statistics was calculated for socio-economic factors (income levels, occupation type and education level) to examine the distribution. Also e-waste management practices, WTP, WTD and e-waste generation rates was calculated. The test for collinearity between the predictor socio-economic factors variables (education and income) was done and the Pearson's coefficient r^2=0.4 since a correlation coefficient of greater than 0.60 implies a moderate relationship between variables (Cohen, 1988), 0.60 was used as an indicator of the potential for multi-collinearity.

The data was analysed using descriptive and inferential statistics. Content analysis, frequency summaries and direct quotations were used in qualitative data analysis. The result is presented by use of text, frequency tables, charts and tables presenting results of significance of relationships between statistical test variables. Logistic Regression analysis was used to analyze socio-economic factors predicting participation in e-waste recycling and binary logistic regression was used to analyze the odds ratio for e-waste management and association were determined at 95% confidence level.

3.6.1 Socio-economic variables

The measure of socio-economic status was examined as a categorical scale (occupation) and ordinal scale (income and education levels). Education was ranked using Hollingshead index of social position. It has been noted by a number of studies, on theoretical terms, the occupational component is much more problematic to measure within the social structure as

it relies on a job title as an indicator (Cassedy *et al.*, 2013). For this reason occupation was determined using the classification used by the municipal registry department.

3.6.2 E-waste management

In this study, the dependent variable of study assesses the extent to which e-waste is disposed of properly based on a 5-point waste hierarchy (DEFRA, 2008). Disposal denotes the lowest score, whereas waste prevention denotes the highest score. That is, the initial score for proper e-waste disposal was based on the following ordinal scale varying from 1 to 5:

$$\boldsymbol{Initial\ score} = \begin{cases} \mathbf{1.\ Waste\ prevention} \\ \mathbf{2.\ Re-use} \\ \mathbf{3.\ Recycle} \\ \mathbf{4.\ Recovery/refurbish} \\ \mathbf{5.\ Disposal} \end{cases}$$

To determine the probability of participation among the different occupations, a binary output was formulated to improve frequency counts. Therefore, binary logistic regression analysis was done to evaluate the odds ratio of e-waste being managed. The independent variable was computed by defining the final score variable as shown below:

$$\mathbf{not\ managed} = \begin{pmatrix} \mathbf{thrown\ via\ solid\ waste\ channels} \\ \mathbf{stored} \end{pmatrix} = 0$$

$$\text{Managed} = \begin{pmatrix} \mathbf{Re-used} \\ \mathbf{Recycled} \\ \mathbf{Refurbished} \end{pmatrix} = 1$$

3.6.3 E-waste generation and penetration

Several methods have been suggested and used to estimate possible quantities of e-waste. This study utilized the consumption and use method. This method takes the average equipment of a typical electrical and electronic appliance in a sample unit as the basis for a prediction of the amount of e-waste produced and it has been used in the Netherlands to estimate the potential amount of WEEE. (Borthakur & Sinha, 2013 and Laissaoui, 2008);

WEEE generated per year;

$$WEEE = \frac{m_n \times hh \times r_n}{ls_n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots 5$$

m_n : average weight of equipment *n*

hh : number of sample units

r_n : penetration rate of equipment *n*

ls_n : average lifetime of equipment

The EEE penetration rate is defined by Fraige *et al.*, (2012) as the percentage of unit that has a particular EEE.

3.6.4 Participation in e-waste management

In order to elicit willingness to values for improved e-waste management a hypothetical market scenario was described. The willingness to pay for recycling (WTD) and willingness to drop-off e-waste (WTD) was ranked using a conjoint analysis approach (Breidert *et al.*, 2006), the ranks was on a five point Likert scale. The consumer was informed that a recycling programme that required them to pay an additional amount when purchasing a computer so as to minimise the accumulation of toxic substances in the environment and dumpsite once these equipments are disposed off through solid waste means. The maximum amount to be paid by the consumer in relation to cost of the mobile phone was given in interval scale dividing 100% in 5 scales.

3.6.5 Awareness levels

Awareness level scale comprising five items for consumers and three items for technicians regarding their awareness of benefits and hazards of e-waste and the policy framework of e-waste in Kenya (scored on five-point itemized category scales, anchored at 1 = ‘‘Have no idea’’ and 5 = ‘‘Very familiar’’).

3.6.6 Refurbishing and recovery of E-waste

The capacity to refurbish e-waste was measured by the capacity/ success rate of repair EEE of the particular equipment for instance, out of ten equipments received, how many were restored to a functional state. Recovery was measured by the frequency in percentage of much of electrical/electronic spare parts (EE fractions and PCBs) is recovered from end of life equipment used in equipment refurbishment instead of buying.

3.6.7 Technical training

Technical training was assessed as per highest level of training a technician underwent. However, in order to improve frequency counts, training was divided into a binary output with those that went through formal training after 'O' level (certificate, diploma and degree) were deemed to have 'technical training' and those who learnt through apprentice were classified as having 'no technical training'

3.7 Reliability and validity

Mugenda & Mugenda (2001) observed that an instrument may be constructed to measure a number of things, hence the validities and reliability of such instruments must be established. In order to ascertain the content, face validity and reliability of the questionnaire, it was presented to lecturers at the department of Environmental Science at Maseno University the developmental stages for scrutiny and advice and comments. The questionnaire was designed in such a way it related to the objectives. Studies by Canell *et al.,* (1989) on pretesting survey questions found a sample size of 10-100 respondents is sufficient to highlight problematic areas in a survey tool. Therefore, the tool was pretested on 15 consumers and 10 technicians of electronic and electrical equipment in the CBD. Necessary adjustments were made to the tool after pretest and this enabled the researcher to collect and analyze information relevant to this study.

3.8 Research Ethics

This study was done under the guidance of School of Environment and Earth Sciences. Interviewees received full explanation about the study including the purpose, process and benefits of the study. Informed consent was taken by the interviewees, considering: Willingness to participate; Freedom of withdrawal; confidentiality; convenience and assurance the data will not to be used for other purposes.

CHAPTER FOUR

4. RESULTS AND DISCUSSIONS

4.1 Introduction

The results of study presented in this chapter were from statistically analysed as described in Chapter 3 in this document. In most cases, frequency tables are supplemented by graphical depictions in order to provide a visual summary of proportions of various attributes.

4.2 Socio-demographic-economic characteristics of the respondents

A total of 286 (98%) complete responses from consumers were received from the survey. The prevalent educational level of the sample was higher education (diploma) with a mean for the respondents was 4.768±0.05 on a 7 point scale. Income level had a mean of 2.23±0.06 on a 5 point scale, which shows that majority of the respondents fall at Kes 10,001-25,000. Though studies that have shown general lower incomes in Kisumu's population where up to 50 % of Kisumu population is live below poverty line in Kisumu City (UN-HABITAT and Kisumu City Council, 2004). The discrepancy is attributable to the fact that this study was conducted in a formal set-up (CBD) where wages are higher and commensurate to skill levels.

Majority (55.2%) of the respondents was male and 44.8% were female. This shows employment is skewed against the female and a draft report by KCIDP (2013) showed that employment levels for the males are 89.4 per cent while for the female is 85 per cent relative to their labour force.

Table 4.1 Distribution of socio-economic characteristics of consumers

Socio-economic factors		N	%
Highest education attained	Primary level	1	0.4
	Secondary level	37	13.5
	Diploma	149	51.6
	Degree & post grad	99	34.9
Occupation	Retail & wholesale	83	29
	Financial services	65	22.7
	Prof services	70	24.5
	Hospitality	25	8.7
	Construction & hardware shops	43	15
Income levels	<kes10,000	65	22.7
	10,001-25,000	136	47.6
	25,001-35,000	49	17.1
	35,001-50,000	23	8
	kes 50,001>	13	4.5
Age	<18 years	2	0.7
	18-30 years	152	53.1
	31-40 years	97	33.9
	41-50 years	28	9.8
	50 years>	7	2.4
Gender	Female	128	44.8
	Male	158	55.2

Source: Researcher (2016)

4.2.1 E-waste management practices in Kisumu CBD

According to the Director of environment, there is no e-waste management infrastructure in Kisumu CBD, all efforts towards e-waste management are informed by current SWM practices and in-house strategies developed at organizational level. Figure 4.1 shows that avenues for e-waste management are varied amongst businesses though much of the waste is still in storage (61%). E-waste destined for re-use was either sold as second-hand goods (16%) or donated (2%) and (3%) were recycled. Another avenue for recycling was through return to seller for onward transition to recycling facilities and only (1%) of the business surveyed had such an agreement with EEE retailers. Disassembly for re-use of some part had

(2%) and the low frequency can be attributed to fact some of the WEEE have limited re-usability.

The high frequency of WEEE in storage reflects the situation in Nairobi city where much of the e-waste is in storage because of a lack of a policy and legislative framework, and the absence of practical e-waste management system (Waema and Mureithi, 2008). The same observation was made by Garcia (2011) findings that established 64% of mobile phone consumers' had them in storage due to lack of recycling opportunities. A study done in Kisumu County by Sije & Awour (2013) and Manhart *et al.*, (2013) revealed that emotional attachment to old electronic equipment and still consider them valuable and this is an impediment to disposal of e-waste; this explains the high frequency of e-waste in storage.

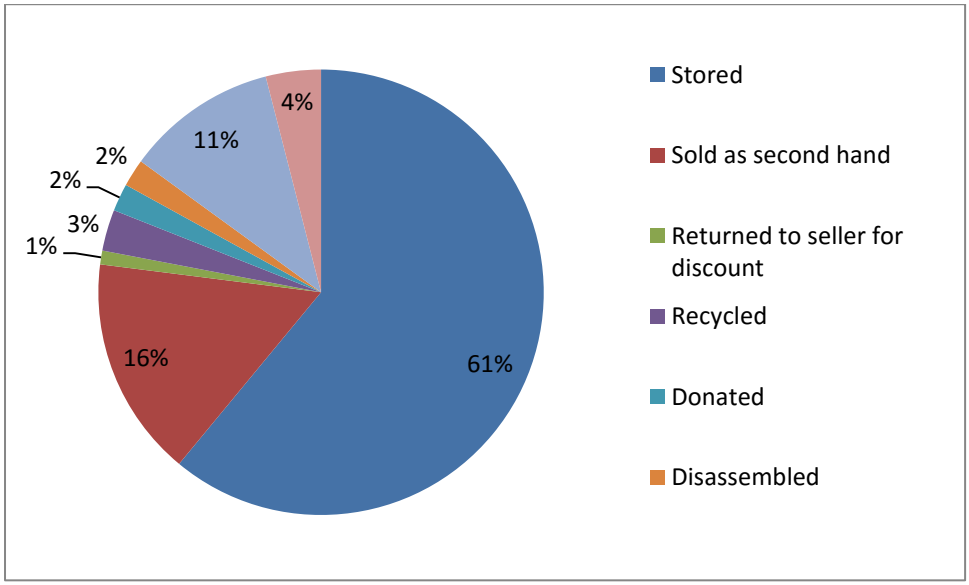

Figure 4.1 E-waste management practices in Kisumu CBD.

The only formal WEEE collection facility in Kisumu CBD was located at the Safaricom's customer service center in Nakumatt plaza. According to Safaricom office, the facility only is only meant for collection of mobile phones and their accessories which are taken to Nairobi for appropriate treatment. Therefore, other large EEE do not have a collection facility and this was cited by the Director of Environment and the NEMA office as an impediment to e-waste

management because the consumers and downstream actors have very limited options for e-waste disposal. The Safaricom representatives noted that the need for civil education as it was realised the collection facility was underutilised and misused as other forms of solid waste other than e-waste was collected in the facility.

Plate 4.1 a) E-waste disposal in Kisumu municipality dumpsite (7th August 2013). b) Small WEEE collection bin in Kisumu CBD (4th August 2013), Safaricom shop at Nakumatt plaza. c) E-waste in storage in Kisumu CBD (4th August 2013).

Table 4.2 Descriptive statistics for variables for assessing e-waste management

Variable	No. of items	N	Mean	S.D.
WTP	5	286	3.37	1.044
WTD	5	286	2.78	0.899
E-waste management	2	286	0.28	0.45
Awareness levels	5	286	1.73	0.35

A breakdown of study responses investigating into e-waste management (Table 4.2) shows that currently, not much of the e-waste generated is managed; majority of the workers interviewed predominantly fall at *'not managed'* at 72% with (n=286) averaging 0.28±0.45 . A greater part of the workers were willing to participate in e-waste management and breakdown of the result show that 78.3% of the respondent were willing to pay for recycling services and 21.7% were not. Willingness to drop-off e-waste at recycling centres had a lower frequency with 60.1% willing and 39.9% not willing. The awareness level of the workers on e-waste was observed to be low with (n=286) average 1.73±0.35, about 14.1% were aware on e-waste issues and problems concerning e-waste while the remaining have low and very low understanding of the problem.

4.3 E-waste management as influenced by Occupation

Management of e-waste was assessed by looking at practices adopted in relation to the e-waste hierarchy by businesses in the CBD. From the initial score of five, a binary output was formulated to determine whether e-waste is being managed or not. When e-waste was re-used, recycled, recovered and disposed through e-waste channels, then it was deemed to have been managed however, if the e-waste was disposed through solid waste channels or stored, then e-waste was deemed to have not been managed. The frequencies on e-waste management in table 4.3 shows construction and hardware sector and the financial sector as the most progressive occupations in e-waste management with 37.2% and 31.3% respectively and the hospitality sector hardly managed e-waste.

Table 4.3 Cross tabulation between current status of e-waste management and occupation

	Construction and HW	Financial services	Hospitality	Professional services	Retailer and wholesale	TOTAL
Not managed	27(62.8%)	57(68.7%)	24(96.0%)	45(76.3%)	53(69.7%)	206(72.0%)
Managed	16(37.2%)	26(31.3%)	1(4.0%)	14(23.7%)	23(30.3%)	80(28.0%)
	43(15%)	83(29%)	25(8.7%)	59(20.6%)	76(26.6%)	286(100%)

The low management practice by the hospitality sector is cause for concern considering hotels, lodgings and restaurants have high penetration of electronic devices such as T.V.'s and landline telephones for room service. The nature of electronic equipment used in the hospitality do not have good resale and re-use value, for instance, landline telephones have been replaced by mobile telephones and Cathode Ray Tube (CRT) television have now being replaced by digital television and this can be attributed to communication revolution over the past 15 years which has led to higher and a switch digital platform for television. Also, there are no facilities for collection of large EEE in the CBD, these factors can be attributed to poor management of e-waste. Sije & Awour (2013) realised that lack of incentives for dropping of e-waste at recycling centres by consumers and weak regulations that have not addressed the issue of e-waste have impacted negatively on e-waste management in Kisumu county, however their study focused on mobile phone dealers. The chi square test for association test showed significant associations between occupation and management of e-waste ($\chi 2=10.140$, n= 286, $p=0.038$) meaning occupation influenced e-waste management.

Table 4.4 likelihood ratio of test between occupation and e-waste management

Term	Odds Ratio	Coefficient	S.E.	Z-Statistic	P-Value
Financial services	0.8501	-0.1624	0.1730	-0.9385	0.3480
Hospitality	0.0768	-2.5666	0.4740	-5.4149	0.0000*
Professional Services	0.6160	-0.4845	0.1764	-2.7468	0.0000*
Traders	0.8745	-0.1341	0.1684	-0.7966	0.4257
Constant		-0.6760	0.1309	-5.1625	0.000

Final 2*Log-Likelihood 1781.01
Significant at 0.05*

The regression model in table 4.4 was weighted against awareness levels of the workers. From the analysis professional services and hospitality occupations had significant relationship with e-waste management $p < 0.0000$. All occupations have negative coefficients meaning the likelihood e-waste is not managed. The odds ratio for professional services is 0.616. This shows that occupations in professional services are 0.61 times likely to be inefficient in e-waste management in comparison to other occupations in the Central Business District. The hospitality sector has an odds ratio of 0.076; this indicates that the sector is 0.07 times likely to be inefficient in e-waste management in comparison to other occupation in the Central Business District. Diamantopoulos *et al.,* (2003) found contradicting results as there was little support between white and blue collar worker in recycling practices. The findings in this study show significant differences between professional services and hospitality. Professional services are 6 times likely to be inefficient in e-waste management in comparison to consumers in hospitality; this can be attributed to the nature of work as professional services may require more use of ICT equipments per capita in comparison to hospitality. In a typical office, a worker will use a variety of equipment in comparison to a person working in the hospitality sector. With limited options for e-waste recycling, professional services are most likely to manage e-waste inefficiently.

The construction and hardware sector was used base data in the model; the other two occupations did not have significant differences with e-waste management in the regression model. Financial sector comprises of banks and other large financial institutions that had some form of take back schemes with EEE suppliers and also, as noted by the Kisumu Director of environment, some of the institutions had initiated disposal through resale. Laissaoui & Rochat (2008) study also noted Banks had the most progressive management practices in Casablanca, they returned equipments to the reseller, trading it against the

purchase of new equipment. This is a typical practice in occupations in the technology sector due to high turn-over of equipment and also, most they are institutional consumers (banks, insurance companies etc.) unlike individuals in construction, professional services and traders who were noted to be individual consumer as a further breakdown business ownership found most of them were registered as proprietorships.

4.3.1 Occupation and e-waste generation rates

The EEE penetration rate and the average number of EEE per business are important factors in estimating the EEE consumption. The EEE penetration rate is defined by Fraige *et al.,* (2012) as the percentage of unit that has a particular EEE. Results from table 4.5 shows PC and printers have the high penetration rates at 71.5% and 63.3% respectively. This is not unexpected bearing in mind that the study was conducted in a business environment where these facilities are of high necessity. TV and photocopiers exhibited low penetration rates at 44.1% and 44.8% respectively. Shahonya (2011) noted the penetration rate for PCs increased dramatically over the years due to tax reliefs advanced towards ICT goods such as computers and mobile phones. Landline phones had significant penetration at 59.8% and this reflects ITU (2012) cited in Manhart *et al.,* (2013) development indicators which found mobile and telephone subscriptions to stand at 64.4% in Africa.

Table 4.5 EEE penetration rate in Kisumu CBD

Equipment	Penetration rate (%)	Average/business	Average life time (years)
PC	71.5	2.3	4
Laptop	55.9	1.64	3.6
Printer	63.3	1.19	3.6
Telephone	59.8	2.3	3.3
TV	44.1	0.82	3.8
Photocopier	44.8	0.68	3.5

Generation rates are critical in designing an e-waste management system and results are highlighted in table 4.6. The amount of e-waste produced annually were calculated using

standardized average weight of EEE as from EPA (EPA, 2008) and EMPA (Huisman, 2008) guidelines. From analysis, consumers in the CBD produce an average of 0.89 kg/year per head, a further break down reveals that a consumer in traders and wholesale produces 0.26 kg/year, financial services 0.19 kg/year, professional services 0.22 kg/year, hospitality 0.08 Kg/year and construction and hardware 0.13 kg/year

Table 4.6 E-waste generation rates per year in Kisumu CBD (Kgs/Year).

Equipment	Retail and Wholesale	Financial Services	Professional Services	Hospitality	Construction HW	Total
PC	150.43	111.93	126.77	46.17	76.06	511.36
Laptop	16.3	11.96	13.59	4.89	8.15	54.89
Printer	34.28	25.14	28.57	10.29	17.14	115.42
T.phone	5.44	3.99	4.53	1.61	2.72	18.29
TV	110.02	80.68	91.68	33	55.01	370.39
Total(kg)	316.47	233.7	265.14	95.96	159.08	1070.3

The study reveals that retail and wholesale sector generates bulk of the waste accounting for up to 30 % of e-waste. The findings are inconsistent with a UNEP (2011) study that found commercial offices having bulk of e-wastes in developing cities though the study did not give specific figures of generation and commercial office was too broad therefore making the conclusions too generic.

4.4 E-waste management as influenced by Education levels

The study looked at the influence of education levels on waste management; results from chi-square tests reveal no significant association between the current e-waste management practices and education levels (p=0.321). The breakdown of the responses show (Fig. 4.2) majority of the workers with education level, Degree> have 76% of their waste not managed in comparison to diploma and <O level who have 72% and 63% respectively.

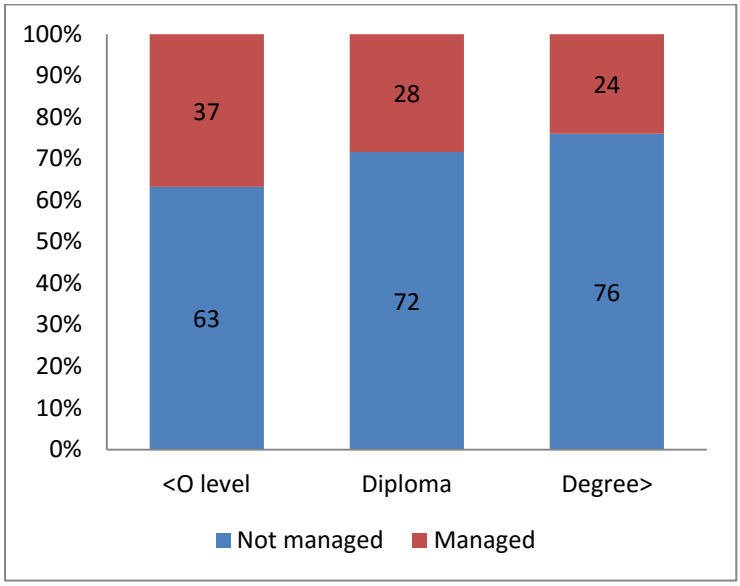

Figure 4.2 E-waste management and education levels

The NEMA sub-county officer noted that lack of management options for e-waste management, collection mechanisms and recycling facilities as the factor hindering e-waste management in Kisumu CBD. The Director of environment also attributed low financial outlays by the county government in the waste sector and currently, there is no facility provided by the county government for e-waste management in the CBD.

4.4.1 Willingness to pay for recycling and Education levels.

According to beneficiary pay principle, as the ultimate beneficiary of production and services, the consumer should be part of the charge for e-waste recycling and treatment (Yin *et al.,* 2013). However, figure 4.3 shows only 21.7% of the consumers acknowledged that they should be responsible for e-waste management however, a majority (40.5%) had the view that it is the government's responsibility to manage e-waste. 32.5% had the view that it was the responsibility of the original equipment manufacturers to manage e-waste.

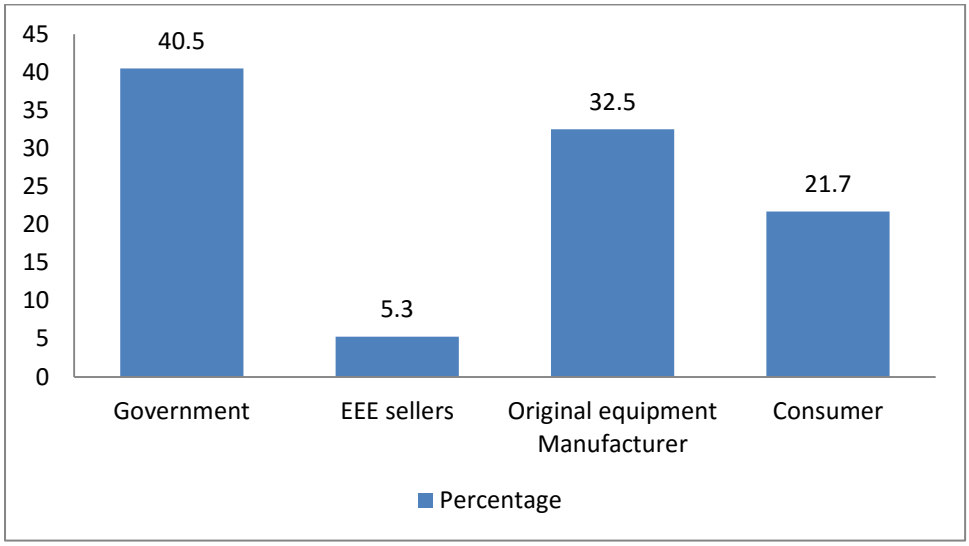

Figure 4.3 Responsibility for e-waste management

The study assessed the influence of education levels on willingness to pay for recycling as one of the avenues for e-waste management stipulated in the NEMA (2010) guidelines. Results (table 4.7) reveal that there is a decrease in willingness to pay for recycling across all education groups when the cost of recycling increases. However, individuals with Degree> have higher frequencies when the cost of recycling increased when compared with the other groups. A breakdown of the result show that when the cost of recycling was more than 15%, 14% of consumers with Degree> could accept this rate and 3.7% with college education could accept it and only 5.3% of consumers with O-level education and below could accept it. These findings concur with Yin *et al.,* (2013) survey that found there was higher willingness to pay for recycling with the more educated individuals and this was attributed to greater environmental awareness and knowledge on environmental issues.

Table 4.7 Willingness to pay of different education levels

	Category	0-5%	6-10%	11-15%	16-20%	More than 21%
	< O level	60.50%	26.30%	7.90%	5.30%	0%
	College	62.80%	25.70%	8.80%	0.70%	2%
	Degree>	50%	22%	14%	7.00%	7%
Average		57.77%	24.66%	10.23%	4.33%	3%

Results from linear regression (table 4.8) shows significant association between Willingness to pay for recycling and education and income, the regression model is significant (p=0.0008) with a r^2=0.30, Education level shows predicting power with an increase in education levels leads to 35.4% increase in WTP levels holding income level fixed. The finding is consistent with Laroche, (2001) study that found education level associate significantly with willingness to pay for ecologically safe (green) products though the study did not focus on e-waste.

Table 4.8 Likelihood test results for WTP.

Variable	Coefficient	95% C.L.	F test	P value
EDUCATION	0.345	0.194	19.0081	0.0008*
INCOME	0.388	0.284	53.5679	0.0000*
Constant	0.659	-0.116	2.8	0.0953

R^2=0.30
Significant at 0.05*

4.4.2 Willingness to drop-off e-waste and education levels.

The NEMA e-waste guidelines (2010) require the consumer to dispose e-waste at collection centres, takeback e-waste to the manufacturer or dump e-waste at licensed dumpsites. To assess compliance, this study analysed the willingness to drop off e-waste at e-waste recycling centres (WTD). Results from linear Regression analysis assessing the impact of education and income in predicting participation in e-waste drop-off are summarized in table 4.7. There is no significant association between WTD and education levels (F=2.7877, n=286, P=0.0961). This can be attributed to the low awareness levels exhibited across all education levels, there were no significant differences observed (p= 0.0743) as majority of the consumers were not aware of the NEMA 2010 regulations and were not aware of the dangers associated with poor disposal of e-waste. Studies done on participation towards setting up a solid waste recycling facility by Sumukwo *et al.,* (2012) and Banga *et al.,* (2011) found contradicting results as educated households are more likely to be aware about health implications of unclean environment therefore had higher likelihood. This shows that awareness to dangers posed by e-waste will have a great influence. As shown by the studies

aforementioned, once the consumer knows the implications, participation increases. Colesca *et al.,* (2013) study underlined the importance of education and the value of knowledge regarding the process of e-waste collection and recycling. If people are not informed about these issues then it is difficult to achieve the goal of a healthy e-waste management system. Improving knowledge on WEEE recycling represents a relatively easy way of action to improving willingness towards recycling.

Table 4.9 Likelihood ratio test results for WTD

Variable	**Coefficient**	**95% C.L.**	**F test**	**P value**
EDUCATION	0.177	-0.021	2.787	0.0961
INCOME	0.433	0.343	89.84	0.0000*
Constant	1.207	0.538	12.62	0.0004*

R^2=0.31
Significant at 0.05*

The findings also contradicts Nixon *et al.,* (2009) and Saphores *et al.,* (2006) studies that found Willingness to drop off e-waste at recycling centers was significantly influenced by education levels where lack of college education decreased the likelihood of dropping off e-waste. The general low awareness level amongst consumers as noted by the director of environment in the municipality is a contributing factor to the poor pro-environmental stand amongst consumers as he noted the drop-off facility (See plate 4.1b) for small e-waste next to Safaricom customer care centre in Nakumatt plaza was grossly under-utilized. Much of the waste collected in the facility was unrelated to its purpose.

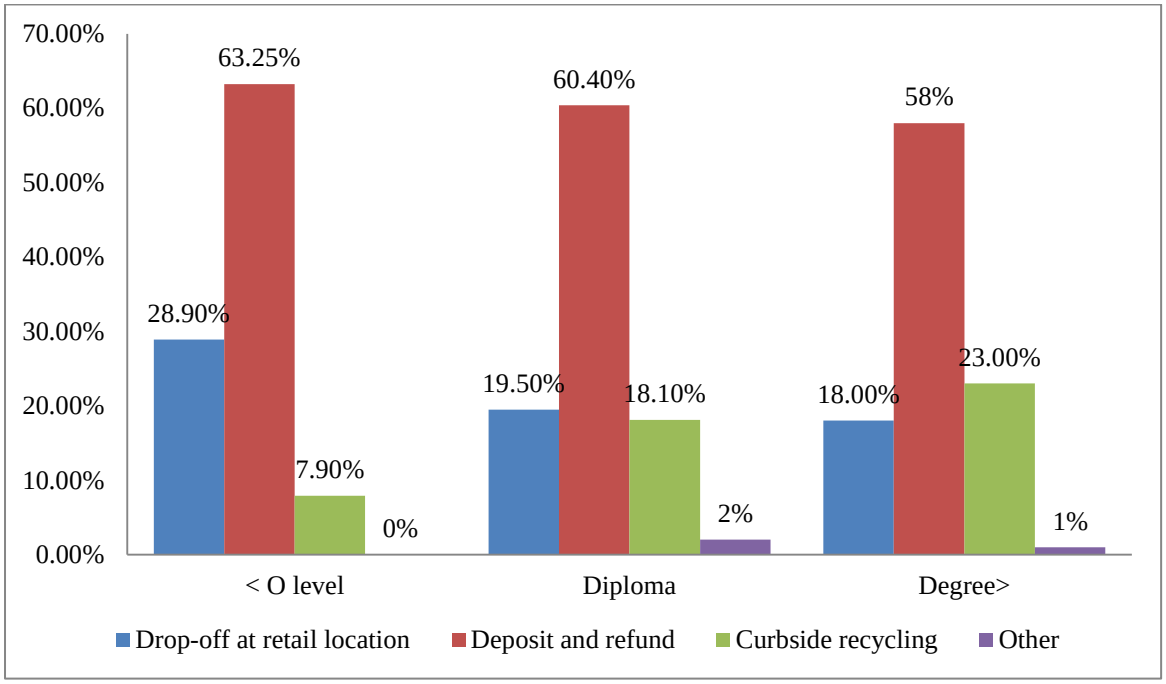

Figure 4.4 Preferred drop-off schemes for different education levels

The results in figure 4.4 shows that majority of the consumers preferred deposit and refund scheme which had a frequency of 63.25% for individuals with <O level and Diploma and Degree> had 60.40% and 58% respectively. A study by Cohen *et al.*, (2006) recommended curbside collection for picking and transporting e-waste due to a high correlation between convenience and high collection rates of recyclable materials, however, consumers are primarily utility maximizers motivated by costs and benefits therefore, deposit refund centers offer maximum benefit. Mannetti *et al*., (2004) study that purports recycling behavior can be modified through incentives; therefore of dropping-off e-waste at recycling centers without any gain on the part of the consumer influences participation irrespective of educational background.

4.5 E-waste management as influenced by Income levels

The study looked at the influence of income levels on e-waste management; results from chi-square tests reveal no significant associations between the current e-waste management

practices and education levels(p=0.133). The breakdown of the responses show (Fig. 4.5) majority of the workers with income level, 35,001> have 71.10% of their waste not managed in comparison to <10,000., 10,001-25,000., and 25,001-35,000 who have 61.50%, 76.60% and 73.90% respectively.

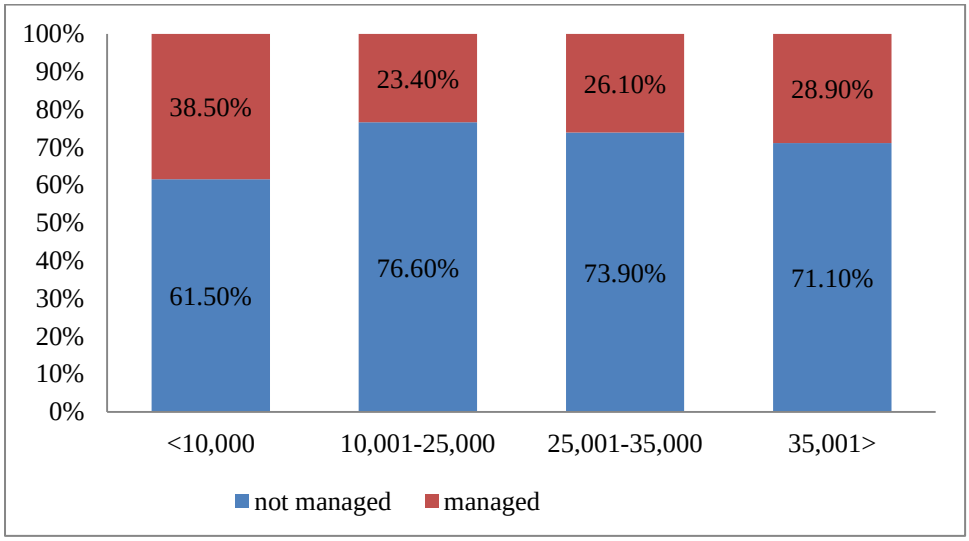

Figure 4.5 E-waste management and income levels

4.5.1 Willingness to pay for recycling and Income levels

The results in table 4.10 show a relationship between income levels and willingness to pay for recycling cost. A breakdown of the consumers WTP reveal that when presented with the choice of paying 0-5% of the cost of EEE as the recycling fee; the increase in income led to a decrease in willingness to pay for recycling at 5%. However, when presented with an option of paying 11-15%, as the income increases, WTP also increased. At 16-20%, only 1.5% of individuals earning Kes <10,000 were willing to participate and 2.2% for Kes 10,001-25,000 and Kes 25,001-35,000 whereas there were 13.2% of consumers at Kes 35.000> income level.

Table 4.10 WTP for different income levels

	Category	0-5%	6-10%	11-15%	16-20%	More than 21%
	< 10,000	78.50%	18.50%	1.50%	1.50%	0%
	10,001-25,0000	56.20%	32.80%	8.80%	2.20%	0%
	25,001-35,000	52.20%	13%	26.10%	2.20%	6.5%%
	35,001>	36.80%	18.4	13.20%	13.20%	18.40%
Average		55.90%	20.60%	12.40%	4.80%	6.20%

Monthly income was assessed to determine its influence on WTP using a linear regression. Results shows that income levels predict WTP (F=53.5679, n=286, *p*=0.0000). An increase of consumer's income level leads to increase of 38.8% in WTP. This is explained by the fact that individuals with higher income having more disposable income therefore are more likely to spare some resources for the improved environmental quality. The findings are in agreement with Omole and Alakide, (2013) study that found affordability as a consideration for willingness to participate in recycling programs due to the economic constraints especially in low-income households. Similar findings were realized by Yin *et al.,* (2013) study that not only found income as a predictor to willingness to pay for e-waste recycling, but also participation was guaranteed at 5% of the cost of mobile phones among all income groups in China. Also, the relation established in this study concurs with Colesca *et al.,* (2014) and Nixon and Saphores (2007) that also found income as a significant factor in explaining people's willingness to pay an advanced recycling fee for electronics.

4.5.2 Willingness to drop-off e-waste and Income levels.

The willingness to drop-off e-waste at recycling centres showed high levels of acceptance across all income levels with 60.1% of the consumers showing intent for dropping-off e-waste at recycling centres. Preliminary analysis for linear regression (Table 4.9) was done to ensure normality and linearity was not violated and it revealed that (F=89.84, n=286,

p=0.0000). Therefore income predicted willingness to drop-off e-waste at recycling centres as an increase in income levels leads to a 43.3% increase in willingness to drop-off e-waste at recycling centres. The findings are consistent with studies by Gamba & Oskamp, (1994) found a positive relationship between income levels and willingness to drop-off waste at recycling centers, however, the studies focused on solid waste.

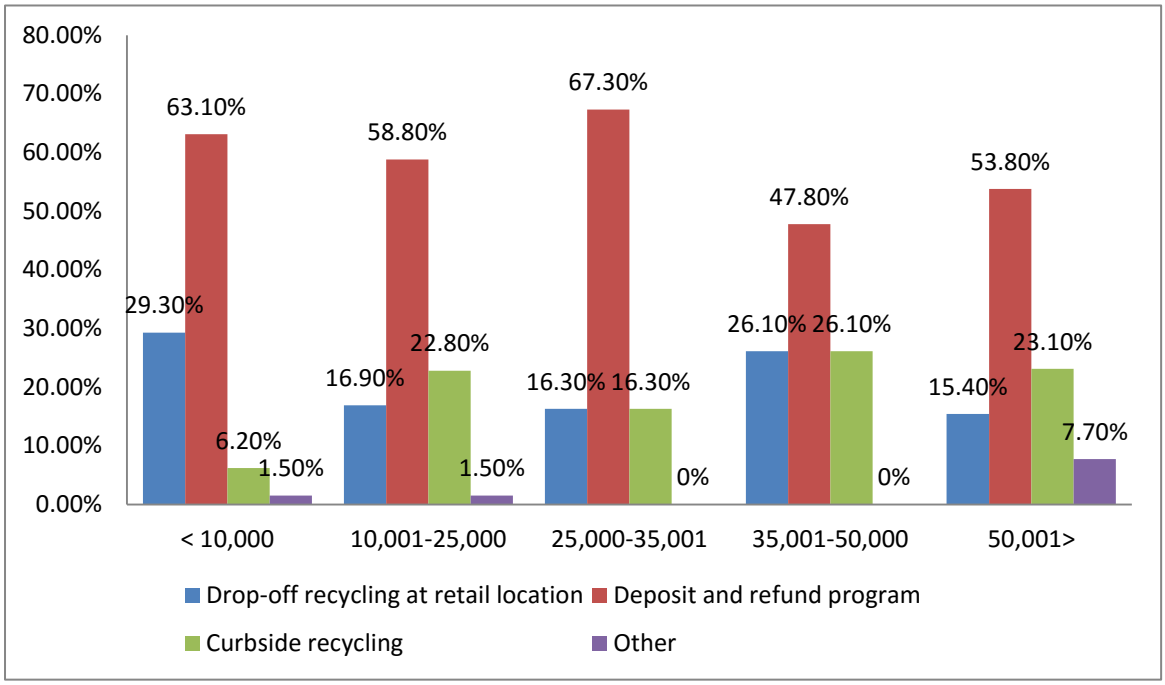

Figure 4.6 Preferred dropping off scheme of different income groups.

When it came to the most preferred drop-off scheme, figure 4.6 shows deposit and refund scheme was most preferred across all income groups and it averaged at 58.6%. Drop-off recycling at retail location had an average of 20.78% and curbside recycling had an average of 18.9%. Therefore, to enhance participation in e-waste management, setting up deposit and refund centres for e-waste should be considered as the optimum scheme for dropping off e-waste by consumers. This can be explained by the fact that the consumer directly gain from the e-waste.

4.6 Technical training and e-waste management

A total of 44 repair workshops were sampled in the CBD and only 35 technicians agreed to participate in the study and 4 technicians did not participate due to busy schedules. The survey results showed that (table 4.11) majority of the technicians had formal training (77.1%) with only 22.9% having learnt through apprenticeship. 51.4% had diploma qualification and 25.7% were at university level. The age distribution shows that age group 31-40 years was the majority with a frequency of 45.7%. Generally most of the technicians were young. On gender distribution 77.1% were male and 22.9% were female hence the downstream sector is male dominated. Majority of the technicians in the CBD were mobile phone technicians (40%), technicians handling consumer electronic devices (CED) account for 37.1%, and ICT devices were 22.9%.

Table 4.11 Distribution of socio-economic characteristics of technicians

Socio-Economic factor		**N**	**%**
Age	<18 years	0	0
	18-30 years	4	11.4
	31-40 years	16	45.7
	41-50 years	5	14.3
	50> years	10	28.6
Gender	Female	27	77.1
	Male	8	22.9
Technical training	No formal training	8	22.9
	diploma level	18	51.4
	university	9	25.7
Specialisation	Consumer EE	14	40
	Mobile phones	13	37.1
	Computer	8	22.9

Since there is no recycling facility within Kisumu CBD, most of the recovery and refurbishment of e-waste in the CBD are done by the technicians. The practice is demand driven where consumers take their faulty EEE for repair or for recycling and resale. The

Director of Environment acknowledged there was no formal management program within the municipality and studies by Waema & Mureithi (2008) and Schluep *et al.,* (2009) found no formal e-waste take-back and refurbishing facilities in Kenya.

The end of life management strategies for EEE adopted by technicians are highlighted in figure 4.7. The results show that 32% of e-waste is still in storage, 36% of the waste is sold as scrap. Selling as scrap provides the best alternative environmental and economically, studies by Manhart *et al.*, (2013) found the most prevalent practice by repairers was storing or disposing with solid. In Kisumu CBD, technicians dispose 27% of e-waste with Solid Waste and 4.5% is burnt. This contrasts with informal e-waste management systems in Ghana and Nigeria which dump off 90% of the WEEE through solid waste channels (Osibanjo & Nnorom, 2007) however, it is worth noting Accra and Lagos have far much higher e-waste generation rates and an established downstream e-waste sector.

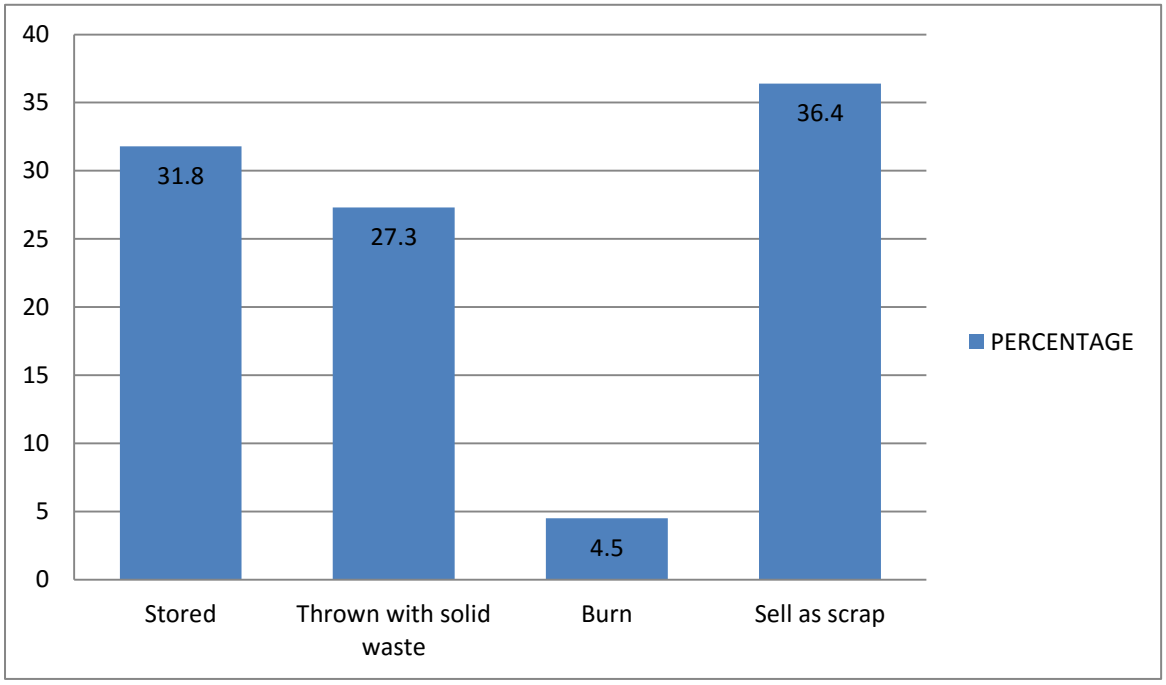

Figure 4.7 E-waste management by technicians.

4.6.1 E-waste management as influenced by technical background

On the aspect of occupational safety, no technician had measures to protect their health in relation to handling EEE considering it contains hazardous compounds. The use of gloves, dust coats and masks, safety boots was not observed in the workshops. Some workshops were too small and e-waste was cramped up leaving little working space for the technicians therefore exposing them to hazards. This is an indication that the handlers are not aware of the risks they are exposing themselves to. This is consistent with Waema & Mureithi (2008) and Manhart *et al.,* (2013) study that found most technicians having no working knowledge on e-waste handling and up to 91.7% of e-waste handlers in Nairobi did not know the protocols for handling e-waste and lacked safety gear.

On assessment of awareness levels (table 4.12) and technical training showed no significant association ($\chi 2$= 14.744, n=35, p=0.142). The study also established EEE specialisation did not influence awareness levels ($\chi 2$= 11.269, n=35, p=0.733). These finding is similar to the informal e-waste system in India where it was noted low awareness across all the downstream e-waste recycler and this was manifested in poor occupational health and environmental compliance (Sinha, 2004). This low standard of occupational safety and environmental compliance is related to lack of a policy framework and infrastructure for collection and disposal targeting e-waste. There are no regulations stipulating how e-waste is supposed to be collected, de-manufactured and disposed therefore leaving the door open technicians as the roles of the downstream actors have not been defined. Therefore no-one wants to incur the cost of proper disposal and when an EEE is deemed to be of no value to the repairers, they will be disposed using the most economical way considering their awareness level is low.

Table 4.12 Descriptive statistics for awareness levels

	Question	N	Mean	SD
1	Aware that e-waste contains toxic and hazardous substances such as Lead, arsenic, mercury?	35	2.63	0.731
2	Aware that e-waste contains valuable substances such as gold, silver and palladium	35	2.86	1.089
3	Aware of the NEMA (2010) e-waste guidelines requirements for recyclers	35	1.59	0.611

Scale: 1=Have no idea, 2=knowing very little, 3=know, 4=know quite well 5=very familiar

4.6.2 E-waste refurbishment

The capacity to refurbish e-waste was assessed and the technicians showed high success rates in repairing EEE. It was only mobile phone technicians who had lower success rate with 14.3% having a success rate at (0-20%). This can be attribute to shorter life spans of mobile phones, and the ever changing technology in the mobile phone sector as consumers change phones, and also an influx of knock-offs as reported by Kamau (2010). This makes refurbishing some mobile phones not profitable, technicians in computer category had highest frequencies in refurbishment and this can be linked to the design of PCs and laptops which have hardware that can independently function and have better re-use value compared to mobile phones. Studies by Laissoiu & Rochat (2008) found much of the equipments used aT secondary level were ICT and computers used by SMEs were bought from repairers who refurbished after buying from primary users who were the Government department and large companies in the technology sector.

Table 4.13 Estimation rates of refurbishment by specialisation.

Category	0-20%	21-40%	41-60%	61-80%	81-100%
Mobile phones	14.30%	7.10%	0%	0%	78.60%
Consumer electronic devices	0%	0%	7.70%	15.40%	76.90%
Computers	0%	0%	0%	12.50%	87.50%

A significant amount of EEE getting to technicians is refurbished and Chi-square test of association was performed and the technician were classified into two groups; ‘having

technical training' and 'no technical training' to improve frequency counts. There was no association at 95% C.I. ($\chi 2=8.54$, n=35, $p=0.07$). Therefore, the capacity to refurbish EEE is not influenced by technical training of the technician as highlighted by the high success rates (81-100%) by technician with no technical training in table 4.14. The differences observed is purely by chance.

Table 4.14 Estimation of refurbishment by technical training

Estimation of retrieved	**0-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
No technical training	2(40%)	2(50%)	0(0%)	4(20%)	2 (100%)
Technical training	3(60%)	2(50%)	4(100%)	16(80%)	0(0%)

4.6.3 E-waste recovery

When it comes to EEE recovery, majority of the technicians recovered parts from the e-waste which comprised of capacitors, fuses for re-use purposes. Figure 4.8 shows prevalence of material retrieved and 51% of recovered e-waste comprised electronic fractions. Metals accounted for 34% of material recovered and plastics had 6%. Few technicians had the capacity to recover printed circuit boards (PCBs) (9%). The type of EEE handled determines the material to be recovered. Consumer EE such as fridges and cookers have more residual value in metals in comparison to mobile phones whose residual value is mostly electronic parts. Plastics from e-waste do not present residual value from e-waste and observation made reveals that of all e-waste stocked in most repairs, plastic material and PCB's accounted the most.

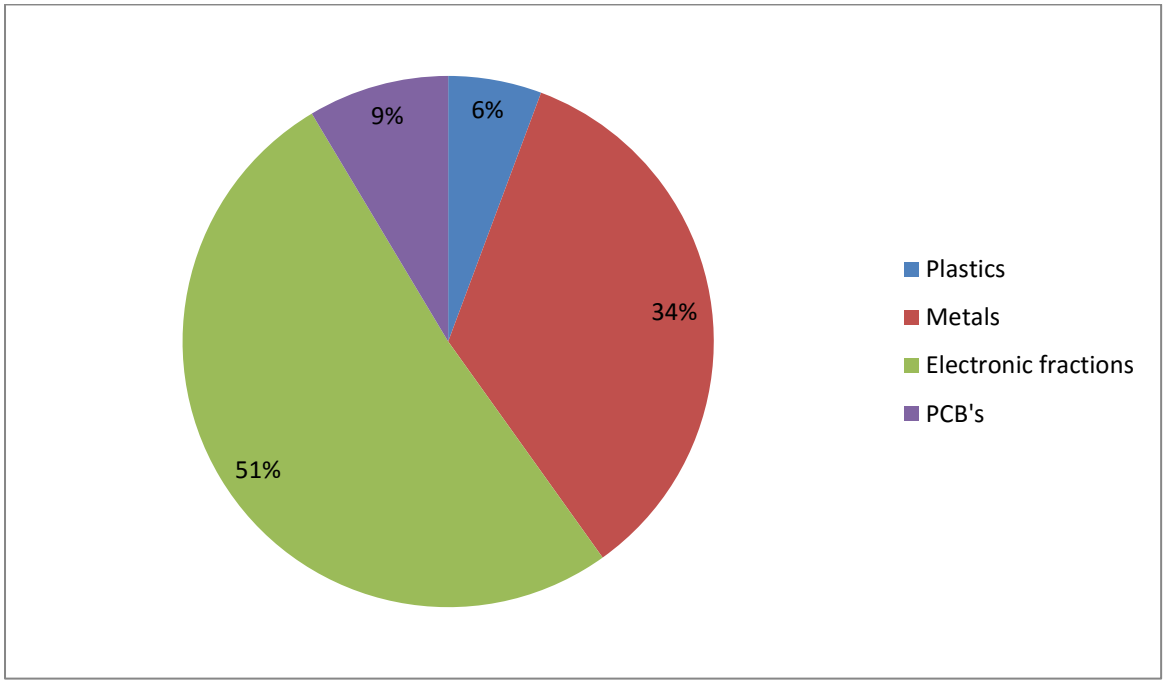

Figure 4.8 Material recovered from e-waste in Kisumu CBD.

The findings on recovery of e-waste in relation to specialisation (table 4.15) show low capacities in recovery of plastic and printed circuit boards across all groups. This is linked to the difficulty in re-usability of these components; there are no facilities that can offer utility for these components as is the case in developed e-waste systems where plastics and PCBs can be turned into energy through thermal plants. The low capacity to recover PCBs also related to lack of specialized equipment for de-manufacturing and retrieval of valuable materials for the PCBs, similar results were realised by Manhart *et al.*, (2013) and Ofudje *et al.*, (2014) that highlighted this challenge faced by repairers in downstream management.

Table 4.15 Recovery of e-waste by different specialization.

Category	Plastics	Metals	PCBs	Electronic fractions
Mobile phones	0%	50%	7.10%	42.90%
Consumer EE	15.40%	23.10%	7.70%	53.80%
Computers	0%	25%	12.50%	62.50%
Average	5%	33%	9%	53%

The technicians were assessed on their capacity to use recovered electronic fractions and PCBs from end of life equipment instead of purchasing new parts for repair work. Cross tabulation was performed (table 4.16) and the technicians had three values had frequencies 0-10%, 11-20% and 31-40%. Majority of the technicians 65.7% were able to recover 31-40% of their spare parts from end of life EEE, however, 71.4% of technicians who had technical training were capable of retrieving e-waste. From the table, majority of individuals who had technical training were in a position to recover e-waste. This concurs with Waema & Mureithi (2008) findings that found downstream e-waste vendors in Nairobi's Ngara area was dominated by individuals who had technical training in the field and had the capacity to retrieve EE fractions. E-waste recovery had significant associations with technical training ($\chi 2=9.35$, n=35, p=0.009).

Table 4.16 Recovery of EE fractions and PCBs by technical training.

	capacity of recovery			**Total**
	0-10%	11-20%	31-40%	
No technical training	2(100%)	0(0%)	8(34.8%)	10(28.6%)
Technical training	0(0%)	10(100%)	15(65.2%)	25(71.4%)
Count	2(5.7%)	10(28.6%)	23(65.7%)	35

However, according to the dumpsite manager, the capacity to recover e-waste is low and he attributed this to lack of laws addressing this waste sector therefore, the municipality cannot compel or register any stakeholder take responsibility for safe and sustainable management of e-waste. These findings are consistent with a study in New Delhi, where recycling is focused on valuable fractions only, hazardous and worthless material is disposed without adherence to environmental standards (Stricher-Porte & Geering, 2010). Therefore, challenge in the downstream sector is management of waste fraction that have no value to the technicians such as plastics and PCBs.

CHAPTER FIVE

5. SUMMARY, CONCLUSIONS AND RECOMMENDATONS

5.1 Summary

There is no formal e-waste management facility within Kisumu CBD, most of the e-waste produced from the Kisumu CBD is in storage and the only facility for e-waste collection has had negligible impact on e-waste collection as it is grossly underutilized.

Occupation influences e-waste management in the CBD; from regression analysis, the study found consumers in working in the professional services and hospitality sector were 0.61 and 0.07 times likely not manage e-waste respectively. E-waste generation was highest among retailers and wholesalers with and the PC had the highest penetration within the CBD.

Education levels was a predictive factor towards willingness to pay for e-waste recycling as revealed by Regression analysis (p=0.000081). Majority of the respondent were willing to pay 0-5% of the cost of the material to fund the e-waste program. On the other hand, willingness to drop-off e-waste was not influenced by education levels (p=0.096) however majority of the respondents (60.1%) were willing to drop off e-waste and deposit and refund drop-off was preferred by consumers in Kisumu CBD.

Income levels had significant association with WTP (p=0.0000) with an increase in the income level leading to a 38.8% increase in willingness to pay for recycling. Also, income levels also showed significant association with willingness to drop-off waste (p=0.0000), a unit increase in income level leading to an increase of 43.3% in participation WTD. Because of cost implication, consumers across all income groups preferred deposit and refund scheme as the drop-off scheme.

Technical training did not influence rate of refurbishment. All technical groups did not differ significantly when in so far as refurbishment of EEE was concerned (p=0.07) however, when capacity to recover waste fractions was assessed, individual with technical training had better outcome and the association was significant (p=0.009). They maximum frequency of recovered materials used by technicians is 40% and the rest of repair material is purchased.

5.2 Conclusions

Occupation is significant in determination of e-waste management and generation rates within the CBD. The PC has recorded the highest penetration rates across all occupations in the CBD and accounts a half of the e-waste being generated annually.

The study established education levels of consumers within Kisumu CBD has an influence on willingness to pay for recycling however, did not influence willingness to drop-off e-waste at recycling centres. Deposit and refund drop-off scheme was the most preferred across the education levels in Kisumu CBD.

The influence of income levels in e-waste recycling is significant when cost element is considered with the respondents willing to pay 5% of the cost of the EEE. the odds for paying for recycling schemes increased with income levels. Also, the likelihood to drop off e-waste at recycling centres also increased with income levels.

The influence of technological background of technician was a determinant factor in e-waste recovery but recovery was limited to only profitable parts as plastics and PCBs had low frequencies. The capacity to refurbish EEE is not determined by having formal technical training as individuals with no technical training background exhibited high success rates comparable to those who had technical training.

5.3 Recommendations

The study recommends:

1. Based on the findings, it is clear that consumers in professional services and hospitality sectors have the highest likelihood of not managing their electronic waste. Therefore when rolling the e-waste management plan for the city, these groups should be facilitated by provision of necessary collection bins for large electronic and electric equipment such as the PC.
2. The influence of education levels on willingness to pay for e-waste recycling was significant therefore; it is import for the policy stakeholders to come up with environmental education to enhance environmental awareness. This will play a role in shaping the attitude of the consumer towards e-waste recycling and also downstream e-waste handers who were not aware of the dangers they were exposing themselves to through poor handling of e-waste.
3. Income levels had strong association with both willingness to pay for recycling and willingness to drop-off e-waste at recycling centers. Individuals with higher income were more willing to incur addition cost for recycling compared to lower income groups, therefore to ensure participation from all income groups, recycling fees levied for setting up an e-waste collection program should not exceed 5% of the retail price of an electronic and electrical equipment to guarantee participation from all social-economic classes.
4. The capacity to recover e-waste is dependent on technical training; however e-waste recovery is limited to the items that have economic value to the technicians. Original equipment manufacturers should come up with take back schemes for non-recyclable fractions such as high density plastics and also, build capacity of technicians through setting up infrastructure and training on de-manufacturing of PCBs and complex

fractions such as cathode ray tubes (CRT).

5.4 Areas for further research

1. The study focus was on occupations registered in the CBD leaving out the informal sector commonly known as the *Jaukali* sector which is usually unregulated and has the potential of causing environmental pollution. There is need to determine e-waste management practices in occupation in the informal sector.
2. There is need for more in depth study need to establish whether if awareness levels, beliefs and attitudes have a greater influence or are correlated with education when assessing willingness to manage e-waste by consumers.
3. The study established that consumers are willing to pay a premium of not more than 5%, however, the payment vehicle needs to be established that will work in Kisumu city context.
4. The study focused on only one downstream actor, the formal refurbishers. Therefore, studies should be done to establish the capacity of the e-waste recyclers and collectors and assess health and environmental impacts of poor management of e-waste by the downstream actors.

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APPENDIX 1: Average Weight Index of EEE

EQUIPMENT	AVERAGE WEIGHT (kg)
Cathode Ray Tube <19 inches	18.47
Flat panel	13.06
Desktop computer	9.9
Notebook	3.5
Keyboard	1.3
Printer	6.5
Telephone	1
Television	31.6
Photocopier	66

Source: EPA (2008) & Huisman *et al.*, 2008

APPENDIX 2: Questionnaire for Consumers

Questionnaire Number:								
Date:	D	D	M	M	Y	Y	Y	Y

PART A: biographic information

Name of shop/office/hotel_____	Government ( ) Private co. ( ) NGO ( )International ( ) Informal business ( ) Other , Specify_____	
Age of the respondent *(please tick appropriately)*	1.Below 18 years	
	2.18-30 years	
	3.31-40 years	
	4.41-50 years	
	5. Above 50 years	
Gender *(please tick appropriately)*	1.Male	
	2.Female	
Highest level of education completed *(please tick appropriately)*	1.Never	
	2.Lower Primary	
	3.Upper Primary	
	4.Secondary level	
	5.College	
	6.University	
Sampled from *(please tick appropriately)*	1.Office	
	2.Shop	
	3.Hotel/restaurant	
Occupation *(please tick appropriately)*	1.Service provider	
	2.Businessman	
	3.Civil servant	
	4.Other, specify_____	
Position *(please tick appropriately)*	1.Owner/Partner	
	2.Manager/HOD	
Size of office/shop/hotel *(please tick appropriately)*	1.Less than 5 staff	
	2.With 10-20 staff	
	3.With over 20 staff	
Position held in the office/shop/hotel *(please tick appropriately)*	1.Employee	
	2.Casual	
	3.Manager	
	4.Owner	
	5.Other, specify_____	
How much do you earn in a month after tax *(please tick appropriately)*	1)Below 10,000	
	2)10,000-25,000	
	3)25,000-35,000	
	4)35,000-50,000	
	5)Over 50,000	

PART B: e-waste at workplace

	Please provide Yes or No answers to each of the following questions	Yes	No	Comments
1b.	Does your office/shop/hotel have a waste management plan			
2b.	If yes, do you implement the plan			
3b.	If yes, is e-waste part of the management plan?			
4b.	If no, do you intent to develop a plan in the future?			
5b.	Is your company/organisation ISO 14001certified?			
6b.	Does your company/organization have "Corporate Social Responsibility" (CSR) program related to 3R,cleaner production and product/waste minimization?			
7b.	Are you affiliated to any waste recycling organization			
8b.	Do you sort waste generared by your business/shop?			
9b.	Are you familiar with NEMA e-Waste guidelines?			
10b.	If yes have you implemented the directives in the guideline?			
11b.	Has sensitization ever been carried out by your organisation on waste management?			
12b.	if yes, was e-waste addressed?			
13b.	Do you keep inventories of the equipment you discard/dispose?			

ISO 14001 is an internationally accepted standard that sets out how you can go about putting in place an effective Environmental Management System (EMS). The standard is designed to address the delicate balance between maintaining profitability and reducing environmental impact

PART C: penetration of EEE

.	**How many of the following new or second hand equipment do you currently have?**	**New**	**Second Hand**
1c	Desktop computers (PC)		
2c	Notebook computers (Laptops)		
3c	Printers		
4c	Telephones		
5c	Televisions		
6c	Photocopier		
7c	Fax Machines		
8c	Others, specify		

PART D: AVERAGE USAGE IN YEARS				
Has your shop/office disposed any of the following equipment this year?		Yes	No	If yes, state no. of years used
1d.	Desktop computers (PC)			
2d.	Notebook computers (Laptops)			
3d.	Printers			
4d.	Telephones			
5d	Televisions			
6d.	Photocopier			
7d.	Fax Machines			
8d.	Others, specify			

PART F: Awareness

1f. Do you know e-waste contains toxic and hazardous substances such as Mercury, Lead and Arsenic?

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

2f. Do you know e-waste contains valuable substances such as Gold, Palladium or Silver

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

3f. Do you know the NEMA (2010) e-waste guidelines?

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

4f.Do you know the role of consumers stipulated in the NEMA e-waste guidelines?

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

5f. Do you know that e-waste can be recycled?

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

PART G: Willingness towards management of e-waste

1g. who do you think should take responsibility of e-waste recycling?

( ) Government

( ) Seller

( ) Original equipment manufacturer

( ) Consumer

2g.Do you agree that consumers are the ultimate beneficiaries of product and service, and should they afford a part of charge for the recycling of their waste mobile phones?

( ) Strongly disagree ( ) Disagree

( ) Neither disagree nor agree ( ) Agree ( ) Strongly agree

3g. If consumers have to part of recycling cost, what percentage can you accept?

Scenario to be given: For instance when you buy a compute at Kes 35,000r, how much are you willing to pay on top of the purchase price to minimise the pollution by toxic substances therein when disposed through solid waste channels (It contains lead, cadmium, mercury, arsenic, selenium among others that would have an adverse impact on human health and the environment if not handled properly after being abandoned)

( ) 0-5% ( ) 6-10%
( ) 11-15% ( ) 16-20% ( ) More than 21%

4g. Do you agree it is the responsibility of the consumer to drop of e-waste at recycling centres.

( ) Strongly disagree ( ) Disagree

( ) Neither disagree nor agree ( ) Agree ( ) Strongly agree

4h. Which mode of e-waste recycling would you prefer?

( ) Drop-off at retail centre ( ) Deposit and refund

( ) Curbside recycling ( ) Other._____

Thank you

APPENDIX 3: QUESTIONNAIRE FOR EEE TECHNICIANS

Part A: Biographic information

Name of Workshop		Tick
Age of the respondent ***(please tick appropriately)***	1.Below 18 years	
	2.18-30 years	
	3.31-40 years	
	4.41-50 years	
	5. Above 50 years	
Gender	1.Male	
	2.Female	
Highest level of education ***(please tick appropriately)***	1.No formal	
	2.Primary level	
	3.Secondary level	
	4.Diploma level	
	5.University	
	6.Other, specify	
Specialization	1.Consumer equipments(TV, DVD, HI-FI radio	
	2.White goods (Fridge,cookers,air conditioners)	
	3. Mobile phones	
	4.Computer and accessories	
	5. Other, specify	

Part B: Awareness

B1. Do you know e-waste contains toxic and hazardous substances such as Mercury, Lead and Arsenic?

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

B2. Do you know e-waste contains valuable substances such as Gold, Palladium or Silver

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

B3. Aware of the NEMA (2010) e-waste guidelines requirements for recyclers?

( ) Have no idea ( ) Knowing very little

( ) Know ( ) Knowing quite well ( ) Very familiar

Part C: Management of e-waste

C1. Does your workshop have a waste management plan? Yes ( ) No ( )

C2. Is e-waste part of the plan? Yes ( ) No ( )

C3. What do you do with obsolete and unserviceable equipment's and parts?

Please tick appropriately	
i. Store	
ii.Throw with general waste	
iii.Burn	

iv.Sell as scrap	
v.Other, specify	

C4. Do you have the capacity to recover materials from e-waste? Yes ( ) No ( )

If yes, which parts?

Please tick appropriately	
(i) Plastics	
(ii) Metals	
(iii) EE fractions (capacitors, resistor, etc)	
(iv) PCBs (mother board)	
Other, specify_____	

C5. How much of electrical/electronic spare parts (EE fractions and PCBs) (in percentage) do you recover from an end of life equipment to use in equipment/devices that you are repairing instead of buying brand new?

1) 10% ( ) 2) 20% ( )
3) 30% ( ) 4) 40% ( )
5) 50% ( ) 6) 60% ( )
7) 70% ( ) 8) 80% ( )
9) 90% ( ) 10) 100% ( )

C6. Out of ten (10) electronic or electrical equipment you receive, what percentage do you repair?

i) 0 -20% ( )
ii) 21-40% ( )
iii) 41-60% ( )
iv) 61-80% ( )
v) 81-100% ( )

C7. Have you and members of your workshop undergone any training on e-waste management? Yes ( ) No ( )

D. Work safety

To be observed.

Did you observe the use of the following personal protective equipments (PPE) in use by technicians?

PPE	**Tick**
1.Gloves	
2.Protective glass	
3.Dust coat/ Overall	
4.Helmet	
5. Adequate working space	

Thank you.

APPENDIX 4: Interview Guide for Key Informants

1. Has NEMA e-waste guidelines (2010) been effective in improving e-waste management? *Please explain*

2. Can Extended Producer Responsibility (EPR) be effective in ensuring proper e-waste management in the current socio-economic setup in Kisumu City? *Please explain*

3. Are the policies and framework inclusive of the downstream actors (collectors, recyclers and disposers) in e-waste management? *Please explain*

4. Are there business opportunities in e-waste management? , *please explain*

5. Who should be in charge of control and audit of the e-waste management system (financially and environmentally)? *Please explain*

6. What are the barriers in realization of an effective take back scheme in Kisumu City? *Please state three and explain*

7. Do you think e-waste producers are should pay for e-waste recycling schemes and e-waste collection as is the case with Solid Waste? *Please explain*

8. Do you think the consumers are aware of benefits and hazards of e-waste? *Please explain*

9. Under the current technological capacity, do you think downstream e-waste handlers have the capability required for proper e-waste management through recovery and refurbishment? *Please explain*