INVESTIGATION OF THE CURRENT STATUS OF ELECTRONIC WASTES, GENERATION AND MANAGEMENT: A CASE STUDY OF NAIROBI COUNTY

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Investigation of the Current Status of Electronic Wastes, Generation and Management: A Case Study of Nairobi County

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

I dedicate the thesis herein to the Almighty God as well as to the wonderful family; he has given me my wife and children. Nevertheless, I would also like to dedicate my work to my supervisors.

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DEFINATION OF KEY TERMS

The Basel Convention: Is an international treaty designed to reduce the movement of hazardous waste between nations, and specifically to prevent the transfer of hazardous waste from developed to less developed countries (Kummer, 1992)

The Bamako Convention: This was on the Ban on the Import into Africa and the Control of Trans boundary Movement and Management of Hazardous Wastes within Africa. It was adopted on January 29, 1991 and entered into force on April 22, 1998. As of March 2010, 33 African countries had signed the Convention and 24 had ratified it.

Collector: Means a person who receives e-waste directly from a residence for recycling or processing and or for reuse. It includes but is not limited to manufacturers, recyclers and refurbishes who receive e-waste directly from the public.

Environment: All living and non-living things that occur naturally on Earth.

Environment Impact Assessment (EIA): Is a systematic examination conducted to determine whether or not an activity or project will have any significant impacts on the environment, provide mitigation for the adverse impacts and optimize the positive impacts.

Electronic Equipment: Equipment that involves the controlled conduction of electrons especially in a gas or vacuum or semiconductor.

E-waste (Electronic waste): E-waste or Waste Electrical and Electronic Equipment (WEEE). It may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets and refrigerators.

Heavy Metal: Refers to any metallic chemical element that has a relatively high density ($76g/cm^3$) and is toxic or poisonous at low concentrations. Examples of heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb),(Hati,2009).

Information and Communication Technologies (ICT): Is an umbrella term that includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems as well as the various services and applications associated with them, such as videoconferencing and distance learning.

Producer Responsibility Organization (PRO): 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 process by which discarded materials are collected, sorted, processed and converted into raw materials which are then used in the creation of new products.

Sustainability: A pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations.

Re-use: Re-use of electrical or electronic equipment or its components is to continue the use of it (for the same purpose for which it was conceived) beyond the point at which its specifications fail to meet the requirements of the current owner and the owner has ceased use of the product.

Refurbish (Recondition): Refurbishment refers to any action necessary to restore a unit up to a defined condition, function and form that may be

inferior to a new unit. The term recondition is used synonymously for refurbishment.

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

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ABBREVIATIONS

BAN	Basel Action Network
CBO	Community Based Organizations
CCK	Communication Commission of Kenya
CCN	City Council of Nairobi
CFSK	Computers for School Kenya
CR	Collective Responsibility
CRT	Cathode Ray Tube
DDT	Dichlorodiphenyltrichloroethane
EASTD	East African Standard Newspaper
EC	European Commission
EEE	Electrical and Electronic Equipment
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EoL	End of Life
ESM	Environment Sound Management
EPR	Extended Producer Responsibility
EU	European Union
GSM	Globally System for Mobile Communication
LCD	Liquid Crystal Display
ICT	Information and Communication Technology
IPR	Individual Producer Responsibility
ISP	Internet Service Provider
IT	Information Technology
JICA	Japanese International Cooperation Agency
KEBS	Kenya Bureau of Standards
KNPC	Kenya National Cleaner Production Centre
KPA	Kenya Ports Authority

KRA	Kenya Revenue Authority
MICT	Ministry of Information, Communication and Technology
MPPI	Mobile Phone Partnership Initiative
MoEF	Ministry of Environment and Forestry
MSW	Municipal Solid Waste
NEMA	National Environment Management Authority
N**GOs**	Non-Governmental Organizations
NWSC	North West Stewardship Council
OECD	Organization for Economic Development
PAC	Practical Action Consultancy
PAK	Practical Action Aid Kenya
PCB	Printed Circuit Board
POPs	Persistent Organic Pollutants
PRM	Product Recovery Management
PPP	Polluter Pays Principle
RCRA	Resource Conservation and Recovery Act
TSDF	Treatment Storage and Disposal Facility
UNEP	United Nations Environmental Programme
WEEE	Waste of Electrical and Electronic Equipment

ABSTRACT

Electrical and Electronic waste (e-waste) is currently one of the fastest growing waste streams both in quantity and toxicity in Kenya and e-waste does not decompose leading to its cumulative increase with time. With increased international trade, change of technology and income levels, more e-waste is generated and without proper handling methods leading to unprecedented levels of water, soil and air pollution. The resultant e-waste could lead to increased exposure of human beings and animals to toxic and carcinogenic metals in the environment. The objective of this study was to determine the quantities, types and handling methods of e-waste generated and associated policy framework in Kenya. The study used a descriptive survey design, and to gather data questionnaires with both qualitative and quantitative variables, scenes observation and structured interviews were used. Data was analyzed using SPSS Version 20. The study revealed that main sources of e-waste originated from computers, fixed lines and mobile phones of which 10.8% of the 23,040 computers and 6.9% of 10,819 of fixed lines (telephones) and 3.2% of the 7,674 mobiles were obsolete. Generally selling of obsolete equipment as second hand was the main method of disposal of which 52% of mobile phones were sold, then 48% computers and 31% fixed lines, secondly storage was at 43%, 24% and 50% for computers, mobile phones and fixed lines respectively. Recycling followed whereby 7%, 10% and 10% for computers, mobile phones and fixed lines respectively. From this study 53% of the respondents indicated that they had no policy for handling e-waste. The methods of disposal in use were re-selling, keeping in store, recycling and dumping in dust bins which don't prevent release of toxic metals into the environment, hence putting the health and safety of the public and animals into risk.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The rapid growth in Information and Communications Technology (ICT) has led to a demand for more electrical and electronic equipment marking a new era in human civilization. In the 20th century the information and communication revolution has brought enormous changes in the way we organize our lives, our economies, industries and institutions(Chacko, 2012).

With the current increased economic growth, technology has become a vital integral part of our life activities. Its use has generated vibrant opportunities as well as challenges such as the enormous volumes of electronic waste (e-waste) generated and inappropriate e-waste disposal methods. The digital revolution that started in the 1970s has led to digitalization of traditional electrical products and significant proliferation of electronic devices. The consumptive lifestyles coupled with rapid technological development have quickened the pace at which electronic products are rendered obsolete.

Electronic waste or e-waste embraces various forms of electrical and electronic equipment that have ceased to be of any use to their owners (Mohan & Bhamawat, 2008**)**. Furthermore, many everyday commodities that were formerly considered electrical equipment such as refrigerators, household appliances and toys are becoming 'electronic' objects through the addition of programmable microprocessors (Hilty, 2005). At the same time these have led to the generation of massive amount of hazardous and other wastes which pose a great threat to the human health and environment (Agnthori, 2011).

E-waste is chemically and physically distinct from other forms of industrial wastes. The composition of e-waste is very diverse and differs in products across different categories. It contains more than 1000 different substances which fall under hazardous and non-hazardous categories (MoEF, 2008). Broadly it consists of ferrous and non-ferrous metals, plastics, glass, wood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about fifty percent of the e-waste followed by plastics twenty one percent, on-ferrous metals thirteen percent and other constituents (EC, 2003). Non-ferrous metals consist of metals like copper, aluminum and precious metals like silver, gold, platinum and palladium. These substances can be released to the environment upon incorrect disposal and thus posing a threat to human health and the environment.

E-waste is currently one of the fastest growing waste streams in the world in both quantity and toxicity. Kenya is no exception to this problem. Although many other countries and jurisdictions have been addressing the e-waste issue through the producer responsibility scheme (PRS) since the last century, Kenya has not been serious about it until very recently (the last decade). Recycling can recover reusable components and base materials especially copper and precious metals. However due to lack of facilities, high labor costs and tough environmental regulations, rich countries tend not to recycle e-waste. Instead it is either land filled or exported from rich countries to poor countries where it may be recycled using less developed techniques and little regard for workers safety of environmental protection (Cobbing, 2008).

The Basel Convention (1992) is an international treaty designed to reduce the movement of hazardous waste between nations and specifically to prevent the transfer of hazardous waste from developed to less developed countries. Athough illegal under the Basel Convention of 1992, e-waste exportation continues through clandestine operations,legal loopholes by countries that have not ratified the convention (UNEP, 2009).

The e-waste materials that cannot be reused are subjected to conventional recycling or disposal via landfill or incineration. Standards for both approaches vary widely by jurisdication whether in developed or developping countries. The complexity of the various items to be disposed off,the cost of environmentally approved recycling systemsand the need for concerned and concerted action to collect and systematically process the equipment are challenging (Kummer,1999). Recently the management of e-waste has become an important target for domestic and international material cycles from the viewpoints of environmental preservation, resource utilization, energy recovery among others.A guideline is required for structured and organised methodology to deal with e-waste management in Kenya and attain its major goal of conserving the environment to its natural standards.

1.2 Problem Statement

The rapid economic growth in Kenya and the expected increase in trans-boundary movement of electrical and electronic equipment are expected to generate enormous amount of e-waste. The generated E-waste is likely to pollute the environment by releasing hazardous materials into water, soil and air systems (Frazzoli, Orisakwe, Dragone, & Mantovani. 2010)**.**However to date there is no single research that has determined the type, sources and quantities of e-waste and their methods of handling in Kenya. This is in line with the Kenyan constitution of 2010 and vision 2030, where Kenya aims to have a clean, secure and sustainable environment by 2030.The problem of this study was to determine the types, sources, quantities of e-waste and their handling methods and policy in Kenya. The study was carried out in Nairobi County where the most e-waste is generated with Nyamira county being used as a control (Least e-waste generated).

1.3 Objectives

1.3.1 Broad Objective

The overall objective of this study was to determine the sources, types, quantities, of e-waste generated in Nairobi County and evaluate the current methods of handling and policies adopted in Kenya.

1.3.2 Specific Objectives

1. To determine the main types of e-waste currently in Nairobi county.

2. To determine the quantities and the current status of e-waste management in Nairobi county.

3. To evaluate the current policies and institutional mechanisms that is in place to address the e-waste problem in Kenya.

4. To develop a mechanism for handling e-waste in the country.

1.4 Justification

E-waste has become a global worry and in this context Kenya should be ready to prepare relevant policies, as well as create awareness on e-waste issues. E-waste is regarded as a waste problem which can cause environmental damage if not dealt with in an appropriate way. However the enormous resource impact of electrical and electronic equipment is widely overlooked. Modern electrical and electronics equipment can contain up to 60 different elements; some of which are hazardous and likely to be released to the environment hence the need for this study.

1.5 Scope and Limitations

The scope of this study was limited to Nairobi County (Appendix 1) to represent e-waste generation in an urban setting in Kenya. This was based on the premise that Nairobi is

the heaviest consumer of Information Communication Technology (ICT) products, actually the hub of business of the country and whichever-waste transacted will reflect the occurrence of all other parts of Kenya. The study covered information technology (IT) and telecommunication equipment particularly computers, mobile phones and fixed lines from which quantitative data was obtained. Quantitative data was not obtained on other types of e-waste although some other aspects were captured as shown in Appendix 5.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

It's of interest to note that currently there is the availability of countless number of electrical and electronic products. The growing dependence on these electronic products has given rise to a new environmental challenge of electronics waste (EPA, 2001). However, it is the rapid growth of computing that is driving the e-waste production. In the next five years, it is estimated that one billion computers will be retired worldwide (Ladou, 2008). E-waste is defined as any electrical equipment or appliances that are past their useful lives(Sihna et al, 2005; Iles 2004) also defines e-waste as being the result when consumer, business, and household devices are disposed or sent for recycling. Examples of e-waste are: televisions and monitors, computers, audio/stereo equipment, video cassette recorders, digital video disc players, video cameras, fixed lines, fax and copying machines, cellular phones, wireless devices, radio sets, Hi-fi recorders and videogame consoles (EPA, 2004; Frazzoli et al., 2010).

E-waste poses challenges distinct from many other types of wastes due to its content. Most electronic and electrical equipment contain hazardous materials such as antimony, arsenic, cadmium, chromium, cobalt, lead, mercury, selenium, and beryllium and brominated flame retardants (Lincoln, 2007; Bleiwas, 2001). Therefore mining e-waste for such metals can be more efficient than mining the earth. Despite the potential for inherent environmental benefit in mining e-waste, the high costs of separating the aggregated materials have limited the growth of its recycling markets (Fredholm, 2008). Thus in the absence of legislation e-waste recycling systems have been limited to high-value waste, with only limited voluntary consumer participation.

In the Waste Electrical and Electronic Equipment (WEEE) Directive, the European Union (EC, 2003) formally categorizes e-wastes into 10 categories as shown in Table 2.1.

Table 2.1: European Union of e-Waste Classification (WEEE directive)

Category	Examples
Large household appliances	Large cooling appliances, refrigerators, freezers, washing machines, clothes dryers, dish washing machines, cookers, electric stoves, electric hot plates, microwaves, electric heating appliances, electric radiators, beds, seating furniture, electric fans, air conditioner appliances.
Small household appliances	Vacuum cleaners, carpet sweepers, appliances used for sewing, knitting, weaving and other processing for textiles, irons and other appliances for ironing, mangling and other care of clothing, toasters, fryers, grinders, coffee machines and equipment for opening or sealing containers or packages, electric knives, appliances for hair-cutting, hair drying, tooth brushing, shaving, massage and other body care appliances, clocks, watches and equipment for the purpose of measuring, indicating or registering time, and Scales
IT and telecommunications equipment	Mainframes, minicomputers, printer units, personal computers, laptop computers, Notebook computers, Notepad computers, printers, copying equipment, electrical and electronic typewriters, pocket and desk calculators, presentation or communication of information by electronic means, user terminals and systems, facsimile, telex, fixed lines, pay fixed lines, cordless fixed lines, cellular fixed lines, answering systems and other products or equipment of transmitting sound, images or other information by telecommunications
Consumer equipment	Radio sets, television sets, video-cameras, video recorders, hi-fi recorders, audio amplifiers, musical instruments, and other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image than by telecommunications
Lighting equipment	Luminaires for fluorescent lamps with the exception of luminaires in households, straight fluorescent lamps ,compact fluorescent lamps, high intensity discharge lamps, including pressure sodium lamps and metal halide lamps, low pressure sodium lamps, Other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs
Electrical and electronic tools	Drills, saws, sewing machines, equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials, tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses, tools for welding, soldering or similar use, equipment for spraying, spreading, dispersing or other treatment of liquid or gaseous substances by other means, tools for mowing or other gardening activities
Toys, leisure and sports equipment	Electric trains or car racing sets, hand-held video game consoles, video games, computers for biking, diving, running, rowing, sports equipment with electric or electronic components and coin slot machines
Medical devices	Radiotherapy equipment, cardiology, dialysis, pulmonary ventilators, nuclear medicine, laboratory equipment for in-vitro diagnosis, analyzers, freezers, fertilization tests
Monitoring and control instruments	Smoke detector, heating regulators, thermostats, laboratory equipment
Automatic dispensers	Automatic dispensers for hot drinks, cans, solid products and money.

(Source: Hischier, Wäger, & Gauglhofer. 2005)

According to the EPA (2008), 3.16 million tons of e-waste in the U.S. was generated and only 430,000 tons or 13.6 % of this amount was recycled. The rest was trashed in landfills or incinerators. Unfortunately not all of the small percentage of e-waste collected by recyclers is being handled responsibly (Fredholm, 2008). Significant quantities of e-waste (80%) are exported to areas of the world with lax environmental, health and safety controls where the cost required to manually dismantle components is extremely cheap. Given the undocumented and in some areas illegal nature of such exports it is impossible to quantify the amount of e-waste which follows such undesirable paths (MoEF, 2008). In US, the total e-waste increased from 3.01 million tons of e-waste generated in 2007, but the recovery rate stayed at 13.6%. Some 20 to 50 million metric tons of e-waste are generated worldwide every year, comprising more than 5% of all municipal solid waste (Ashfaq et al, 2014). When the millions of computers purchased around the world every year (183 million in 2004) become obsolete they leave behind lead, cadmium, mercury and other hazardous wastes (Oteng-Ababio, 2012). In the US alone, some 14 to 20 million personal computers are thrown out every year (Baker, 2004). In the EU the volume of e-waste is expected to increase by 3 to 5 per cent a year. Developing Countries were expected to triple their output of e-waste by 2010 (Sharma, 2012).

The E-waste generated annually in Kenya are:11,400 tones from refrigerators,2,800 tones from TVs,2,500 tones from personal computers,500 tones from printers and 150 tons from mobile phones (Schluep,et al., 2008). The Government of Kenya is encouraged to take the necessary steps to ensure that in accordance with the waste hierarchy, reuse is prioritized by legislating reuse targets and standards to provide appropriate economic incentives to catalyse further investment in recycling and final disposal facilities (UNEP, 2010).However, it is the rapid growth of computing that is driving the e-waste production. In the next five years, one billion computers will be retired worldwide (Ladou, 2008).

The most common types of e-waste are cathode ray tubes and personal computers (Nnorom & Osibanjo, 2008).What distinguishes e-waste from normal solid waste is the high material complexity and toxicity. Most types of e-waste contain a combination of low and high value of hazardous materials like lead (Pb), mercury (Hg) and plastics (Realff*et al.* 2004).For example, Pb is considered a major element in the glass of CRTs, which is a part of monitors (Macauley Palmer, & Shih, 2003). Another component in many e-Wastes is printed wire boards (PWBs) which contain lead and brominated flame retardants (BFRs) (Niu & Li, 2007). These hazardous materials in the obsolete electronics can be released to the environment during disposal which can cause an adverse impact to human and environment.

Another difficulty facing the management of e-waste is the growing technology. As the technology is growing very fast, Nnorom and Osibanjo (2008) have shown that the life span of consumer of electronic products is getting shorter. Studies shown by Yla-Mella et al. (2004) showed that e-waste represent about 4% of the total volume collected by the municipal in the European Union (EU).

2.2 Handling E-waste

2.2.1 Storage

Storage is the action or method of storing e-waste for future use or the space available for storing it in a warehouse. Due to culture and other reasons so much e-waste is stockpiled awaiting re-use, recycling or disposal. This can be a time bomb at a certain point in time if not stored properly and shall lead to volume increase in return affecting environment and human health (Kutz, 2006). Due to presence of the toxic elements, it is all the more dangerous for the society to stock them without carrying out appropriate disposal (Chatterjee & Kumar, 2009).

2.2.2 Re-use

Reuse refers to the use again, especially after salvaging or special treatment or processing of e-waste. According to Terada (2011), re-use is a good way to lengthen a product's life span but it can also be abused either by rich countries dumping their waste in developing countries by legally as charity or illegally as waste. This shall have enormous effect to environment and human health.

2.2.3 Recycling

Recycling is the collection and often reprocessing of discarded materials for reuse. Electronics recycling is a misleading characterization of many disparate practices, including de-manufacturing, dismantling, shredding, burning or exporting. Recycling is mostly unregulated and often creates additional hazards itself. Hence its effect shall be increased to environment and human health (Terada, 2011). Primitive tools and methods often involve the open burning of plastic waste, exposure to toxic solders, acid baths to recover saleable materials and components from Waste Electrical and Electronic Equipment [WEEE] with little orno safeguards to human health and the environment which results in polluting the land, air and water due to river dumping of acids and widespread general dumping (Wath et al, 2010). Research done by Gavilan Orisakwe, Dragone, and Mantovani (2012) indicated that e-waste artisan recyclers are prone to suffer neurotoxicity due to continuous exposure and conditions where recycling takes place. In view of this it necessary to have an adequate e-waste management system, at the same time information should be provided to the population and the recyclers in the informal sector, about preventive actions that can be done to diminish health risks. In addition to the aforementioned, e-waste danger increases when dumped on streets, open dumpsites, near rivers, ridges or other sites where hazardous substances will integrate both the water and soil, where people obtain food.

2.2.4 Landfill-disposal

It is one of the most widely used methods for disposal of e-waste. In land filling, trenches are made on the flat surfaces. Soil is excavated from the trenches and waste material is buried in it, which is covered by a thick layer of soil. Modern techniques like secure landfill are provided with some facilities like, impervious liner made up of plastic or clay, leachate collection basin that collects and transfer the leachate to wastewater treatment plant. The degradation processes in landfills are very complicated and run over a wide time span. It has become common knowledge that even landfill leak (Sharma, 2012) and hence can cause a lot of damage to the environment and human health.

2.2.5 Incineration

It is a controlled and complete combustion process, in which the waste material is burned in specially designed incinerators at a high temperature (900-10,000 ˚C). Even with a modern incinerator there are gas emissions endangering environment and human health (Sharma,2012).

2.2.6 Export

According to Terada (2011), exporting of e-waste is cost effective for developed countries, but becomes a baggage to developing countries despite the fact that they do it for the benefit of recycling. It affects the environment and health in developing countries which lack proper structures to handle and manage e-waste.

2.2.7 Bioremediation

Bioremediation is a general concept that includes all those processes and actions that take place in order to bio transform an environment already altered by contaminants to its original status. Although the processes that can be used vary, they have the same principles, these processes include; the use of microorganisms or their enzymes that are either indigenous or are stimulated by the addition of nutrients or optimization of conditions, or are seeded into the soil (Sharma, 2012). With the contamination of

environments with heavy metals, such microorganisms could be used to bio remediate the soils to its original state this has been applied in the synthesis of copper nanoparticles from e-waste in India (Majumder, 2012).

2.2.8 E-waste disposal Methods

The main components of the e-waste collection system as discussed by UNEP (2005) include producer take-back schemes, municipal collection schemes and recycler/dismantlers collection schemes. Efficient e-waste management schemes have components of reuse and recycling that ensure that hazardous substances in e-waste are not damaged and thus do not pose a danger to the environment. According to UNEP (2005), the efficiency of the collection schemes are determined by accessibility and efficiency of the collection facilities, minimal product movement, minimal manual handling, removal of hazardous substance, separation of reusable appliances, adequate and consistent information to the user.

In designing an effective e-waste management system, Widmer (2005) lists a set of parameters which should be considered in designing an effective e-waste management system:

i. Legal regulations - deal with the level of details in the legislation. The legislations specify on the operational management of the system. System coverage deals with the type of responsibility allocated i.e. individual responsibility or collective responsibility. It also deals with an all-inclusive system that caters for all the product categories or have a differentiated system that covers each product differently under the e-waste umbrella.

ii. System financing - addresses the sources of financial resources that will run the system, external funding versus internal funding. In external funding the cost of collection and recycling are passed on to the product user or producer or the municipality. This is done through provision of funds for the products end of life

treatment whereas under internal funding the product generates funds for the collection and recycling.

iii. Producer responsibility - entails designing of a system that considers the amount of responsibility the producers should bear, the points in the system that the responsibilities apply and how the practical application of the responsibility will be carried out. The systems flexibility is also considered in that it allows for both individual responsibility and collective responsibility. The producer responsibility can be described as ensuring that compliance can be achieved through having checks and balances in the system that will prevent free riders, incorporate collection and recycling targets and have penalties in place for noncompliance. A system may have various degrees of such measures ranging from high, medium and low or in extreme cases none at all.

Basel convention on the control of trans-boundary movement of hazardous wastes and their disposal is a treaty which was designed to control and minimizes the trans-boundary movement of hazardous waste (Osibanjo, 2007). The informal recycling of e-waste in developing countries is emerging as a new environmental challenge for the twenty-first century (Osibanjo, 2007). The improper treatment methods and the huge amount of electronic waste moving into the developing countries poses a danger to human health and environment at large. For example, about 50 % of Kenya's computer market is estimated to be made up of second-hand computers and the country generates about 3,000 tons of computer associated e-waste yearly. There are severe environmental and insidious health impacts associated with poor disposal of e-waste such as open dumping in Dandora and Korogocho (UNEP, 2008).

2.3 Information & Communication Technology and E-waste generation

Information & Communication Technology (ICT) may be defined as computer hardware, software and telecommunications technology. Nowadays, ICT is the world's largest and fastest growing manufacturing industry. It has penetrated nearly every aspect

of modern life, and is positively affecting human life even in the most remote areas of the developing countries. The rapid growth in ICT has led to increased demand for electrical and electronic equipment (EEE), resulting in a higher production of e-waste (Babu et al., 2007). Leading to has led to rapid product obsolescence, discarded electronic equipment, and thereby also electronic waste, now recognized as the fastest growing waste stream in the industrialized world. The volume of e-waste generated is increasing by 10 per cent annually (Osibanjo, 2007). This waste stream causes environmental concerns globally due to resource and energy consumption, and improper management of e-waste, because the widespread usage of toxic chemicals in today's high-tech equipment make most of them hazardous wastes (Ramachandra,2008).

In Kenya ICT has not been fully embraced but there is a lot of emphasis for ICT in achieving Vision 2030. Compared to other peer countries in Africa, Kenya is one of the leading countries on ICT services. The Kenyan government has underscored universal access to ICT as a major objective of Vision 2030. It is expected that access to ICT will contribute to the country's economic growth by reducing transaction costs, increasing business efficiency, improving educational standards and ensuring accountability on the part of government officials. The Kenyan government also acknowledges that ICTs will increase the country's productivity and raise the competitiveness of local businesses in a knowledge-based economy. However this growth will equally result in increased production of e-waste that may require proper handling methods and policies.

The constitution of Kenya chapter 5 clearly states the importance of having clean environment hence e-waste should be clearly understood and properly taken care of. From EMCA(1999, section 98) no person shall distribute, sell, offer for sale, hold for sale, import, deliver for importation to, or receive from, deliver or offer to deliver to any other person any unregistered pesticide or toxic substance.

At the global level international trade of hazardous waste is regulated by the UN's Basel Convention. The growth rate of in use of IT in developing countries is increasing rapidly

as well. The reason is that the developing countries also want to compete and communicate in an increasingly globalized world (Sharma, 2012). Due to the fact that most people in developing countries, particularly in Africa and Asia cannot afford brand-new equipment, therefore, they depend more on second-hand or refurbished (Sharma, 2012), electrical and electronic equipment (EEE). Such as personal computers, accessories, mobile phones, which are mainly imported without confirmatory testing for functionality (Osibanjo & Nnorom, 2007).

With cheaper labor and relaxed environmental regulations in developing countries compared to developed countries, make repair and re-use of the old equipment feasible. As a result, large quantities of e-waste are presently being exported to Africa and Asia. E-waste management in these countries is handled through various low-end management methods such as traditional disposal in landfills, open burning and crude and 'backyard' recycling (Sharma, 2012).

2.4 Impact of e-waste on Human Health

E-waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominates flame retardants, beryllium, antimony and phthalates. Long-term exposure to these substances damages the nervous systems, kidney, bones, reproductive and endocrine systems (Saoji, 2012). Some of them are carcinogenic and neurotoxin (Saoji, 2012). A study conducted by Greenpeace in 2005 in electronic recycling yards in Delhi clearly indicates the presence of high levels of hazardous chemicals including dioxins and furans in the areas where this traditional recycling takes place. Disposal of e-wastes is a critical problem faced and poses a threat to both health and the ecosystem. Table 2.2 below shows some of the channels through which e-waste goes to the environment affecting human health.

Table 2.2: Effect of e-waste constituent on Health

Source of e-wastes	Constituent	Health effects
Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead (Pb)	• Damage to central and peripheral nervous systems, blood systems and kidney damage. • Affects brain development of children.
Chip resistors and semiconductors	Cadmium (Cd)	• Toxic irreversible effects on human health. • Accumulates in kidney and liver. • Causes neural damage. • Teratogenic.
Relays and switches, printed circuit boards	Mercury (Hg)	• Chronic damage to the brain. • Respiratory and skin disorders due to bioaccumulation in fishes.
Corrosion protection of untreated and galvanized steel plates, decorator or hardener for steel housings	Hexavalent chromium (Cr) VI	• Asthmatic bronchitis. • DNA damage.
Cabling and computer housing	Plastics including PVC	Burning produces dioxin. It causes • Reproductive and developmental problems; • Immune system damage; • Interfere with regulatory hormones
Plastic housing of electronic equipment and circuit boards.	Brominated flame retardants (BFR)	• Disrupts endocrine system functions
Front panel of CRTs	Barium (Ba)	Short term exposure causes: • Muscle weakness; • Damage to heart, liver and spleen.
Motherboard	Beryllium (Be)	• Carcinogenic (lung cancer) • Inhalation of fumes and dust. Causes chronic beryllium disease or beryllicosis. • Skin diseases such as warts.

Source: Electronics for you (2007; Borthakur & Singh, 2008

2.5 Impact of e-waste on Environment

Unlike many traditional wastes, the main environmental impacts of e-waste mainly arise due to inappropriate processing. Electronic devices contain a mix of materials, many of which are toxic and create serious problems if not handled properly (Charter, 2008). The processing of such e-wastes could cause serious risks to human health and the environment in developing countries (Li et al., 2008). In the processing of e-wastes, there is a potential to release substantial quantities of toxic heavy metals and organic compounds to the workplace environment, surrounding soils, and drainage water (Shen et al., 2009). However, both wastes and hazardous chemicals released during the processing are commonly handled with little regard for the health and safety of the workforce or the environment. According to Albright (2012), e-waste can enter living organisms, from food producing animals to humans, through the gastrointestinal tract as well as lungs and skin. Toxicants in e-waste are generally persistent organic pollutants (POPs), i.e. substances which are resistant to biodegradation have a strong tendency to bio accumulate in the food chain, and are prone to long-range transport (Frazzoli et al., 2010). Bioaccumulation means an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment. Chemical elements and organic pollutants may have different preferential environmental vectors according to their hydrophobic/lipophilic or hydrophilic/lyophobic nature and volatility. Higher volatility and degradability is reported for low molecular weight (LMW) naphthalene and phenanthrene (PAHs).

Figure 2.1 shows possible routes of exposure from contamination of environmental compartments: e-waste related mixtures of toxicants affect lands and rivers by both atmospheric movement (Yusof et al.,2005) particulate fall-out and water run-off from polluted soil and downstream transport of contaminated sediments in aquatic systems.

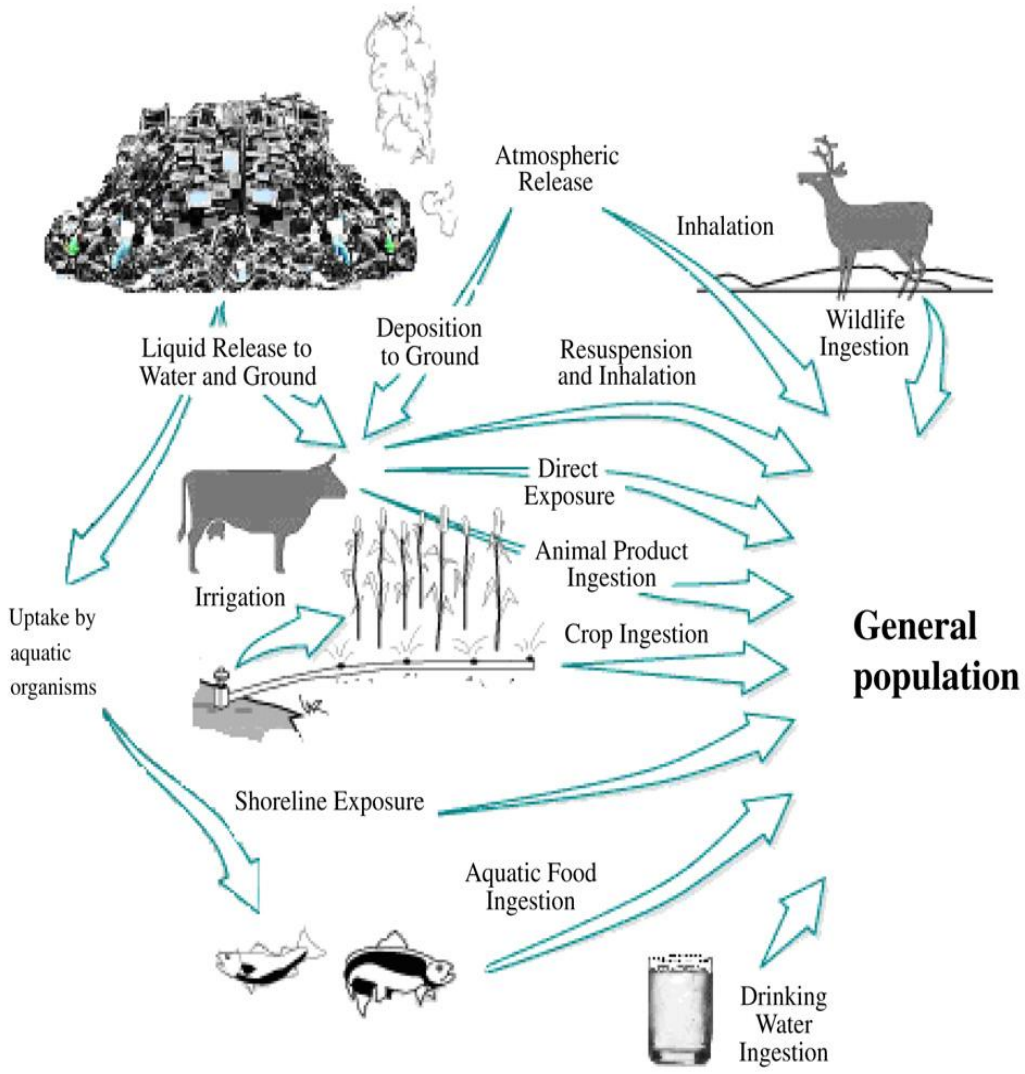


Figure 2.1: Exposure's routes and fate and behavior of e-waste related mixtures of toxicants in the environment, including contamination of food chain (Source: Frazzoli et al., 2010).

2.8 Global Scenario of e-waste

2.8.1 Current Situation

In 2006 the world's production of e-waste was estimated at 20-50 million tons per year (UNEP, 2006) representing 1-3% of the global municipal waste production of 1636 million tons per year (OECD, 2008).Electronics industry is the world's largest

and fastest growing manufacturing industry. Rapid growth, combined with rapid product obsolescence and discarded electronics is now the fastest growing waste fraction, accounting for 8% of all municipal waste in European Union (The Economist, 2005). In developing countries, on an average e-waste is equals to 1% of total solid waste and was expected to grow to 2% by 2010 (UNEP, 2009).

Economically, urbanization and the growing demand for consumer goods in different regions of the world have increased the demand and supply of electronic products (Babu et al., 2007). This leads to increase of e-waste. For example Robinson (2009) shows that computers, mobile fixed lines and television sets would have contributed 9.8 million tons in e-waste stream by 2015. These figures indicate that there was to be a rise of 4.2 million in e-waste stream from 2010 to 2015 resulting from only computers, mobile fixed lines and television sets (Asiimwe, 2012).It was estimated that computers, mobile phones and television sets would contribute 5.5 million tones to the e-waste stream in 2010,rising to 9.8 million tons in 2015(Cobbing, 2008).In rich countries, e-waste may constitute some 8% by volume of municipal waste (Widmer et al., 2005).

Further according to Kalana (2010) many consumers do not immediately dispose of or recycle used electronics since they think that the products still have value, However e-waste management which is relatively practiced by the industrial sector is not replicated at the at the domestic level where e-waste is generated.

E-waste recycling is becoming non-viable business in western countries due to high cost of labor, transportation and electric power among other factors. However, Switzerland is the first country in the world to develop and implement a well-organized and formal e-waste management system for collection, transportation, recycling and disposal of e-waste which use the legal and operational framework of the system based on the extended producer responsibility (EPR) model (Wath et al.,2010).The decreasing percentage of precious metal content in the modern electronics devices is the other concern for the viability of the business (Chatterjee & Kumar, 2009).

According to a research carried out by Wath et al. (2010) it was found out that managing the increasing quantity of e-waste effectively and efficiently in terms of cost and environmental impact is a complex task. Therefore series of actions aimed to prevent e-waste generation, management and final disposal can generate benefits both for municipalities and the environment, since by decreasing human health risks translates in better quality of life for populations. Additionally, if re-furbishing of EEEis still possible, it can bring economic benefits and local jobs. It will also reduce costs related to investment in mitigation of environmental damage as well as health (Gavilan et al., 2012).

The United States signed the Basel Convention (1992) but has not yet ratified it. Instead, the U.S. has entered into several bilateral agreements and one multilateral agreement governing the trans-boundary movements of waste for recovery purposes. It remains unclear if the U.S. intends on ratifying the Convention, although a 1998 report suggested that the U.S. was interested in ratifying the original treaty while ignoring the Basel Ban amendment (Terada, 2011) level some countries like Kenya lack a legal instrument that regulates the import of e-waste. A proposed *Waste Management Bill 2017* which would ban the importation and illegal trafficking of electronic and electrical waste from developed countries to Kenya, is being considered by the Kenyan legislature on the national (Terada,2011; Anyango & Mwololo, 2013).

The contribution of an item to the annual e-waste production, E (kg/year) depends on: the mass of the item, M (kg), the number of units in the service, N, and its average lifespan, L (years) as shown in Equation 1, (Cobbing, 2008).

$$E = \frac{MN}{L} \text{ ---------- } \textbf{Eqn. 1}$$

Computers which have an average life span of three years (Betts, 2008a), comprise a greater proportion of e-waste than refrigerators and ovens which have lifespan of 10-12

years. Certain e-waste types along with their mass and estimated life cycle are summarized in Table 2.4.

Table 2.4: E-waste Types and their Estimated Life Cycle

Item	Mass of item(kg)	Estimated life(years)
Personal computers(PC)[a]	25	3
Cell phone[b]	0.1	2
Photocopier[a]	60	8
Radio[b]	2	10
Television[c]	30	5
Video recorder and DVD player[b]	5	5
refrigerator[b]	15	7
microwave[b]	1	3
Fax machinea[b]	3	5
Air conditioner[b]	55	12
Electric cooker[b]	60	10
Food mixer[b]	1	5
freezer[b]	35	10
Hair dryer[c]	1	10
kettle[b]	1	3
Washing machine[b]	65	8

[a] (Bett, 2008a), [b] (Cobbing,2008), [c] (Li et al.,2009)

According to US Environmental Protection Agency (EPA, 2001), more than 3.2 million tons of e-waste ended up in landfill. European Council (EC, 2003) estimated that the volume of e-waste is rising by 3% to 5% per year, almost three times faster than municipal waste stream. Therefore, an urgent action is required in order to tackle this problem in Kenya.

2.8.2 E-waste Policy and Regulations

Internationally there are three existing *legislations and policy* related to e-waste, namely: *Silicon Valley Toxics Coalition,* which was formed in 1982. It is a diverse grassroots coalition that engages in research and advocacy and is organized around the environmental and human health problems caused by the rapid growth of the high-tech electronics industry. The other one is the *Basel Action Network (BAN),* which is a global

network of toxics and development activist organizations that share a vision of international environmental justice. The network seeks to prevent all forms of 'toxic trade' – in toxic wastes, toxic products and toxic technologies. The others are the *International Solid Waste Association* and the *Solid Waste Association of North America* (Pinto, 2008). Research conducted by Awadalla (2013) in the year 2007 found out that only 20% of respondents had an e-waste policy.

A major hurdle to the proper handling of E-waste on a global scale is, among others, a lack of policy frameworks on national, regional and global levels. There are three major challenges to the definition and implementation of policies:

i. a standard definition for e-waste is missing: consolidating a definition would enable the development of inventories (quantification and characterization),

ii. assessment of current management practices and definition of policies,

iii. difficulties in implementing existing regulations and lack of financing mechanisms (e.g. recycling fees, environmental taxes) for the development of E-waste management.

For India case they have a Draft Hazardous Materials (Management, Handling and Trans boundary movement) Rules, 2007 part of the Environment Protection Act, EPA(1986).It does not have a policy on e-waste, although some parts of computers could be considered as hazardous waste.

2.8.3 Future Situation

The global e-waste production is estimated to increase due to economic growth and the available technologies since the increased Global Domestic product (GDP) leads to increased purchasing of electronic goods and eventually to increased e-waste production. For any given country, the total number computers and other potential for e-waste items is strongly correlated with the country's GDP, because electrical and electronic items are essential for the functioning of all but the most unstable economies. The increasing economic growth is anticipated to reflect higher e-waste production.

Changes in technology will also affect the global mass of e-waste produced. Short innovation cycles of hardware have led to high turnover of devices. The lifespan of the central processing units in computers dropped from 4-6 years in 1997 to 2 years in 2005 (Babu et al., 2007).The average mass of 25 kg for a personal computer is indicative of a desktop computer with a Cathode Ray Tube (CRT) monitor, which represents most of the past and present computers in the e-waste stream. However the advent of Liquid Crystal Display (LCD) will reduce the average weight of a desktop. More significantly, the increasing prevalence of laptop and note book computers which weigh just 1-3kg, which will significantly reduce the average mass of discarded computers (Micklethwait, 2009).

According to the International Telecommunication Union (ITU), Africa is the world's fastest growing market for cell phones. In 2005, there are 51.8 million mobile subscribers, a staggering 1000% increase since 1998 and it was projected that by the year 2010, number of subscribers would have been in between 100-200 millions, It was estimated that in 2003, there were 62-million of TVs, 200-millions of radios and estimated number of PCs ranged from 1.5-7.5-million or anything between 1 per 500 people to 1 per 100 people. According to the Basel Action Network, as many as 400 thousand secondhand PCs are imported through Lagos in Nigeria each month and 1.2 to 1.5 million computers enter the South African market each year (Mohan & Bhamawa, 2008).With these increase in the number of cell phones, TVs, PCs, radios e-waste would increase posing a challenge to the county and country as a whole.

2.9 Kenyan Scenario of e-waste

As of 2008, the e-waste generated annually in Kenya are:11,400 tones from refrigerators,2,800 tones from TVs,2,500 tones from personal computers,500 tones from printers and 150 tons from mobile phones (Schluep,et al.,2008).

About 50 % of Kenya's computer market is estimated to be second-hand. The country generates about 3,000 tons of computer associated e-waste yearly. There are severe environmental and insidious health impacts associated with poor disposal of e-waste such as open dumping in Dandora and Korogocho (UNEP, 2008). UNEP has assisted in developing an Integrated Solid waste Management Strategy for Nairobi; the e-waste component has been identified in the strategy, but would need further proper treatment. Sustainable business opportunities would spur economic growth, market viability for e-services, affordable tools for small and medium enterprises (SMEs), and skilled workforce. Other advantages include reduction of e-waste disposal quantities, the release of harmful chemicals and lessening the negative health impacts and biodiversity loss. Given the increased pace of technological development and obsolescence, a lot of these appliances have a short life-expectancy and will, sooner rather than later, require sound re-use, recycle (Figure .2.2) and disposal solutions. Dumping or improper recycling of electronic waste causes serious environmental contamination, and while electronic goods are mostly used in the developed world, many end up in developing countries. Kenya is set to become the first East African nation to develop regulations on the management of electronic waste (UNEP, 2008).

Figure 2.2: An e-waste recycling centre in Nakuru Town.

2.9.1 E-waste Management in Kenya

Kenya is a developing country with a population of 38.6 million in the year 2009 (KNBS) and land area of 549,137 km^2 (KNBS, 2012). Waste management in Nairobi County is characterized by poor solid waste management, uncontrolled dumping leading to serious pollution problems, unregulated private sector participation in solid waste management, lack of solid waste management infrastructure, and lack of waste management policies and strong waste recycling and recovery industry (UNEP, 2005).

The per capita waste generation within urban areas ranges between 0.29 and 0.66kg/day (NCC, 2007). Japan International Corporation Agency (JICA, 1997) points out that on average 21% of the waste generated in urban centers emanates from industrial areas while 61% from residential areas, 6% from roads and the rest is not stated. It is estimated that Nairobi generates 1, 5000 tons of solid waste daily and only 25% of this waste is collected and sent to the Dandora dumpsite (UNEP, 2005). By the year 2010 the estimates of e-waste generated annually in Kenya were: 11,400tones from refrigerators, 2,800 tones from TVs, 2,500 tones from personal computers, 500 tones from printers, 150 tones from mobile phones (Hanne, 2010; UNEP, 2010).

The remaining waste is mostly composed of chemicals (salts, heavy metals, detergents and medical waste) is dumped in undesignated areas or in the rivers and wetlands. There are several illegal dumpsites emerging in Nairobi along the introduction of road, in residential backyards and commercial premises this has been attributed to the waste management regulations of 2006, there seems to be light fact that the end of the tunnel if only the regulations will be enforced (Khayanje, 2008). Dandora dumpsite has reached its full capacity (NCC, 2007).In the mid-1970s, the Nairobi City Council collected over 90% of all the waste generated (JICA, 1997).Collection percentage fell in the mid-1980s when the waste management attracted private sector due to the demand for municipal waste management. In 1998, there were 60private companies engaged in solid waste collection but they still could not manage to hit the90% collection mark (NCC, 2007).

These companies mostly operate in the high class and middle class residential areas where the people can afford to pay for the services while low income areas are generally not included in these schemes (JICA, 1997). The waste is collected and sent to the Dandora dumpsite (There is no waste segregation as all type of waste is disposed here ranging from hospital waste to household and industrial waste). The dumpsite has people trying to make a living from salvaging more than 30 different types of material mostly metals for use by the industries (JICA, 1997). Other than the scavengers there are gang like cartels who recover the recyclables oblivious of the contamination in the dumpsite and other dangers such as fires due to methane production. It is estimated that there are 600scavengers operating in organized groups that work at the dumpsites. The scavengers build squatter colonies within the dumpsite and anything within the squatter colony belongs to the scavenger and trespassing by another squatter colony is not taken, this shows the data situation in the country, the most extensive study on waste management was conducted in 1998 by JICA (Khayanje, 2008). Since then there has been no know comprehensive study conducted. Any new members or waste pickers face tough challenges of integrating into the existing system as they need to have established linkages to the recovered products market. The materials recovered by the scavengers are sold to middle men who have connections with the various industries. The middle men sell the recovered materials to the industries. Existing policy framework (EMCA, 1999) does not address e-waste management specifically. The lack of legislation on recycling of e-waste has resulted in some industries exploiting waste pickers and also importing waste materials into the country. Several industries encourage the setup of formal waste recycling firms. Such schemes cover both plastic and glass bottles. This is done mainly to improve the environment and to help generate income for the poor. At this point in time it is essential to note that the recycling trend is being embraced but at a slow pace as there are no incentives to the recyclers and it’s done by the youth groups in the slums.

The rapid population growth in Nairobi and the mushrooming of unplanned informal business has played a role in the increase of solid waste in the city. In a snap shot waste management in Kenya entails collection, transportation and open air dumping. There are a few private incinerators and the rest are owned by hospitals. The incinerators are not used in conversion of waste to energy as done in Europe. National Environmental management authority (NEMA) has regulations for solid waste and they are in the process of starting one for e-waste.

2.9.2 The Kenyan situation for future trends of e-waste

The first medium term plan of Vision 2030 recognizes the problem of lack of standardization for ICT components and systems being procured and installed and applied across the government ministries and departments. The result is accumulation of old electrical equipment in institutions and households. Some are arbitrarily disposed of in dumpsites that are intended for non-hazardous waste. Inappropriate disposal of e-waste leads to significant environmental problems but also to a systematic loss of secondary materials. There is need to put in place appropriate interventions to both protect human health and create opportunities for employment and wealth creation (Mureithi, Waema, Wanjira, Finlay, & Schluep 2008).

About 50 % of Kenya's computer market is estimated to be made up of second-hand computers and the country generates about 3,000 tones of computer associated e-waste yearly. There are severe environmental and insidious health impacts associated with poor disposal of e-waste such as open dumping in Dandora and Korogocho (UNEP, 2010).

As the way communications and business changes are conducted, so must be the global response to both these opportunities and challenges. As much of the planet's e-waste is unaccounted for, it is difficult to know exactly how much e-waste there. Moreover, the number and type of e-waste included in government-initiated analyses and collection

programmes differs across the world. According to the European Environmental Agency, e-waste is growing faster than any other type of waste, with an annual volume close to 40 million metric tons globally (Paerl & Huisman, 2008).

Due to cheap labor and lenient rules and regulations, e-waste is increasingly flooding in Asian countries illegally. Studies show that in 2005, European seaports illegally exported 47% of their wastes, including e-waste. U.K. in 2003 exported 23,000 metric tons of undeclared or 'grey' market e-waste to the Far East, India, Africa and China. USA, which is not a signatory to any international law banning the export of e-waste, exports 50-80% of the waste in this way and waste is separated before it is shipped and transferred through a difficult to trace series of buyers, sellers and brokers (Mohan, & Bhamawat , 2008).

Currently in Kenya, Nairobi alone has about 3.1 million inhabitants and the population that uses computers is approximately one third of the population (UNEP, 2010). With the short lifespan and fragility of computer hardware and related accessories, about 70% of computers acquired quickly become obsolete, making Kenya (like most of the developing countries) an ideal digital dumping ground (Odhiambo, 2009).

Therefore being a signatory to the Basel Convention the government of the Republic of Kenya should develop strategies and regulations to govern e-waste trade. In sub-Saharan Africa, Kenya is strategically placed and has been identified by dealers in computers and other electronics products as the gateway to Eastern Africa. This advantageous geographic position should make the country a leader in electronic waste management, since most countries that use Kenya's port of Mombasa to import their electronic products would use the same route to re-export (ship back) the respective wastes (Odhiambo, 2009).

Other factors which facilitate piling up of computer waste include rapid developments in the IT industry where desktops and laptops 'compete' to out phase each other. The Government of the Republic of Kenya has enacted "the electronic transaction draft bill"

that is intended to improve and/or increase the usage of computers within the government, Parastatal and other state corporation offices. Again most of the computers have almost reached their end-of-life (Odhiambo, 2009).

Some of the factors contributing to e-waste include:

a) Obsolete technology

Obsolescence in electronic equipment attributed to rapid speed of innovation and the dynamism of product manufacturing and marketing has resulted in a short life span for most electronics especially computer products. Short product life span coupled with exponential increase in demand of these products has led to drastic increase of e-waste.

b) Used electrical and electronic equipment's

E-waste materials are known to contain toxic constituents in their components such as lead, mercury, polychlorinated biphenyls among others. Their effects to the environment when not properly discarded cannot be underestimated. Therefore, proper information should be available through this study and others to enable policy makers and relevant institutions come up with proper handling and disposal guidelines.

c) **Lack of recycling infrastructure**

In Kenya, most e-waste materials end up in the informal manufacturing sector commonly known as Jua Kali. The infrastructure in the Jua Kali sector cannot handle the increasing amounts of e-waste in an environmentally sound manner. The potential of increased e-waste generation is apparent.

The e-waste problem in Kenya was brought to the spotlight in during the eighth Conference of Parties (COP 8) to the Basel Convention on Trans-boundary waste management that was held in Nairobi. Before that it was not considered urgent due to the assumed relatively low consumption of EEE and the general trend by households to

store EEE, reuse it or dump it along with the Municipal Solid Waste. There is a variety of EEE found in the country ranging from computers, cellular phones, televisions sets, refrigerators, and entertainment electronics amongst others.

The absence of a policy and legislative framework, and a practical management system, means that much e-waste remains in storage. It also means e-waste is often recycled or disposed of in an unsafe and unsustainable manner. This puts both recycler and local population at risk; residents near dump sites report waste fumes, chemical inhalation, and air and water pollution. However, with the right infrastructure, the volumes are manageable (Anyango & Mwololo, 2013).

The high price of new IT means there is strong demand for second hand computers and non-branded clones. Fifty per cent of Kenya's personal computers market is second hand but very few companies have a strategy to dispose of old technology (Mureithi et al., 2008). Around 60% of equipment given to beneficiary, such as schools, is beyond refurbishing when it is donated instead of being recycled (UNEP, 2010).

In Kenya the challenges are:

Lack of clear trade policies on second hand equipment

a. Increased quantities of counterfeit EEE
b. Significant amount of second-hand equipment in the market with short lifespan
c. Inadequate EHS regulatory and policy structures
d. Inadequate capacity of government agencies and facilities to deal with e-waste

Waste Electrical and Electronic Equipment Center (WEEE) is non-profit organization charged with collecting used gadgets for dismantling and recycling to make plastic chairs and poles. The mobile telephone industry is concerned about the rising toll of e-waste in Kenya and Safaricom Ltd is playing a leading role in this regard.

Generally the process in initiating, drafting and adopting WEEE regulations has been slow in Kenya. The Ministry of Environment and Mineral Resources, NEMA and industry drafted the *Environmental Management and Co-ordination (E-Waste Management) Regulations 2013* which were to provide an appropriate legal and institutional framework and mechanisms for the management of E-waste handling, collection, transportation, recycling and safe disposal of E-waste (Anyango & Mwololo, 2013). The *Waste Management Bill 2017 (*pending enactment by parliament*)* is another draft bill which was to establish appropriate legal and institutional framework for the efficient and sustainable management of waste in the framework of the green economy, the realization of Kenya Vision 2030 of zero waste goal, and the provision of a clean and healthy environment for all Kenyans for connected purposes.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This chapter outlines the methodology used in the study. Specifically it deals with research design, target population, sample size and sampling procedures, research instruments, validity and reliability of the instruments, data collection and data analysis procedures.

3.2 Research Design

This research study used a survey design. The survey method gathered data from a relatively large number of cases at a particular time using questionnaires with both qualitative and quantitative variables. Also scenes observation and structured interviews were administered. It focused on generalized statistics that result when data are abstracted from a number of individual cases. The design was the most appropriate for this study because it assessed the pertinent and precise information that pertains the current status of issues and further drew conclusions from obtained facts relating to the current e-wastes production, handling strategy that is employed in Kenya.

3.3 Target Population

The study targeted residents of the Nairobi County to represent “urban” since it had all classes of populations with a main focus on the electronic users. The respondents studied comprised various institutions, businessmen who repair the electronic equipment and also individual persons/families who use the items. Further, the Computer for Schools Kenya (CFSK), National Environmental management Authority (NEMA), Communication Commission of Kenya (CCK) among others provided the researcher with the necessary guidelines on how they disposed the e-wastes.

3.4 Research Instruments

The research employed a questionnaire with both closed and open-ended questions and structured interviews. The questionnaire was designed to acquire information on the e-waste production and handling methods put in place currently in Kenya.

3.5 Data Collection

Primary Data was collected through reviews of policies and laws in Kenya, interviews with the main stakeholders in policy, regulatory and operational areas of the e-waste scene; questionnaires were also administered to individuals identified using stratified random sampling for selected constituencies in Nairobi county and targeted the random sample.

3.6 Determination of the Sample Size

A sample population n_h was used in this study and was obtained from respondents of the eight constituencies of the Nairobi County using the proportional (purposive) random sampling technique as in equation 2 (Cobbing, 2008) in which N_h is population per constituency, N is total population for the eight constituencies, n is the sample size and n_h Is sampled size of the respondents. The population of the constituencies in county is as shown in Table 3.1

$$\mathbf{n_h} = \frac{N_h}{N} \times n \quad \textbf{----------eqn2}$$

Table 3.1: Sampling frame per constituency in Nairobi County

Name of the Constituency	Total population	Target household respondents	Sampled household respondents	Target businessmen/ traders	Sampled businessmen/ Traders	Target Institutions	Sampled institutions
Embakasi	925,775	47	38	17	12	23	15
Lang'ata	435,440	22	17	8	6	11	9
Dagoretti	329,577	17	14	6	4	8	8
Westlands	247,102	13	10	4	3	6	5
Starehe	301,519	15	12	5	4	7	7
Makadara	276,277	14	11	5	4	7	5
Kasarani	525,624	27	21	10	7	13	7
Kamukunji	282,962	15	11	5	4	7	6
Total	**3324276**	**170**	**134**	**60**	**51**	**82**	**62**

Source: Population and Housing Kenyan census results, 2009

Table 3.2: A summary of categories of the respondents from the survey in Nairobi County

S/No	Category	Target	Actual
1	Institutions	82	62
2	Individual households	170	134
3	Traders and businessmen	60	51

3.7 Testing and Administration of Questionnaires

The study carried out a pilot study to ascertain the validity and the reliability of the questionnaire before actual research. The pre-testing of the research instruments involved 20 respondents from one constituency which was not included in the final

sample. Data collection during the questionnaire testing was done to enhance consistency and accuracy. Data was collected on the variables such as e-waste activities, e-waste disposal and type of e-waste, dump site management and awareness.

- Establishing the main types of e-waste; questionnaires were administered to individuals, traders and institutions.
- Establishing the quantities and the current status of e-waste management; this was done by administering questionnaires to individuals, traders and institutions. Interviews and scenes observations were conducted.
- Establishing the current policies and institutional mechanisms that are in place to address the e-waste problem in Kenya; documents /policy reviews were done. Interviewing key informants in policy, regulatory and operational areas in e-waste was carried out.

3.8 Data Analysis

Qualitative data was coded and open ended questions were grouped together. Data was then analyzed through descriptive statistics (Frequency tables), contingency tables (Pearson's chi-square), and multinomial regression analysis. The raw data was analyzed by use of the IBM Statistical package for social sciences (SPSS) Version 20. The analyzed data results were reported through frequency distribution tables, graphs and pie charts where they represented the various variables describing the e-waste disposal in Kenya.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 The main types of e-waste currently in Nairobi County

Most institutions surveyed significantly owned computers (55.47%), fixed telephones (26.05%) and mobile phones (18.48%: Table 4.1). According to NEMA (2005), 1,513 tonnes of electronics entered the Kenya market. The consumer in addition to receiving 1,489.4 tonnes also received 151.3 tonnes from the second hand market.

Table 4.1: Type of equipment used by the institutions in Nairobi County

Equipment	Percent
Computers	**55.47**
Mobile phones	**18.48**
Fixed telephones lines	**26.05**
Total	**100.0**

It is estimated that Nairobi generates 15,000 tons (Kalana, 2010) of solid waste daily and only 25% of this waste is collected and sent to the Dandora dumpsite (this is an open dumpsite and covers 27 hectares) (NEP, 2005). Estimates of e-waste generated annually in Kenya are: 11,400 tonnes from refrigerators, 2,800 tonnes from TVs, 2,500 tonnes from personal computers, 500 tonnes from printers, 150 tonnes from mobile phones (Hanne, 2010; UNEP, 2010). Kenya has reached a mobile penetration rate of more than 63%, and an internet penetration of more than 18.6%, so a significant amount of e-waste is expected to be generated in this category.

In gathering information about e-waste in Kenya, data obtained from the survey indicated that most of the respondents were from private companies (27.42%) and the

rest were from other sectors in the following decreasing order: learning institutions (25.81%), government ministries (22.58%), Parastatal (12.90%), local authority (4.84%) and finally public companies and NGOs at 1.61% each (Table 4.2).

Table 4.2: Categories where the survey was carried in Nairobi County

	Frequency	**Percentage**
Government ministry	14	22.58
Learning institution	16	25.81
Local authority	3	4.84
NGO	1	1.61
CBO	2	3.23
Parastatal	8	12.90
Private company	17	27.42
Public company	1	1.61
Total	62	100.0

Most of the equipment were obtained from retail shops, imports and wholesalers (28.9%) while others were obtained from donations as shown in Table 4.3.

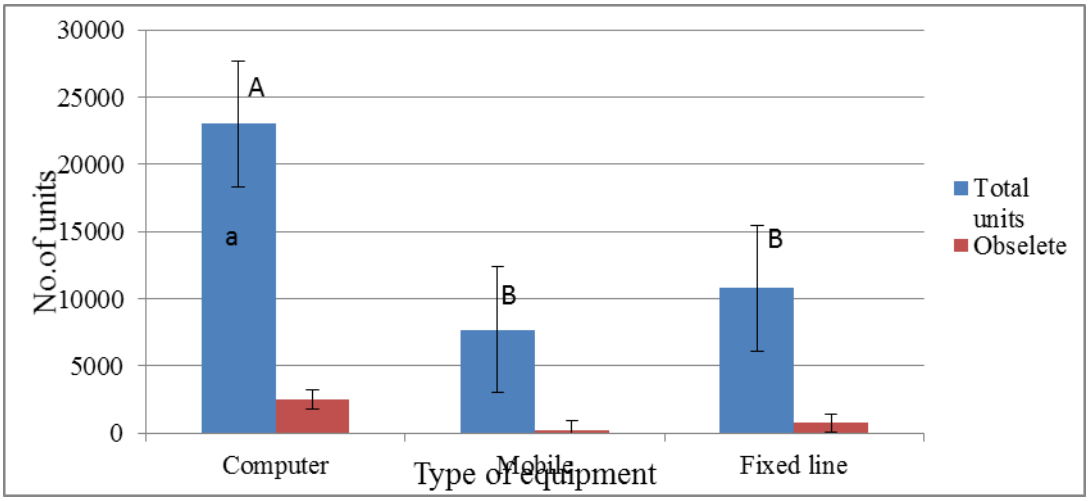
Table 4.3: Method of acquisition of the equipment in Nairobi County

Acquisition methods	Frequency	Percentage
Donations	2	3.23
Imports	7	11.29
Others	2	3.23
Retail shop	18	29.03
Retail shops or imports or wholesalers but with donations	6	9.68
Retail shops, imports and wholesalers	18	29.03
Wholesalers	9	14.51
Total	62	100.0

4.3 Quantities and current status of e-waste management in Nairobi County

The number of computers from the survey was 23040 of which 2498 were obsolete (Figure.4.1). There were 7674 mobile phones from the study and249 were found to be

obsolete. There were 10819 fixed lines of which 742 were obsolete. There was significant difference ($p<0.05\%$) between the number of computers that were absolute in relation to mobile phones and the fixed telephones.



The error bars represent standard error

Figure 4.1: Quantities of equipment in use and those that had become obsolete in Nairobi County

Results from the study indicate that 12% of mobile phones were in use for less than one year, while for the computers it was 8% and for fixed lines it was 2%. In addition, 48% of the computers were in use between 2-4 years, followed by 44% of mobiles and finally 35% of the fixed lines. 30% of the mobiles were in use for between 5-10years, while for computers it was 23% and for fixed lines it was 14% (Figure.4.2). People have different ways of using their equipment depending on their attitude and practices of usage. The duration of use depends on the lifespan of each electrical and electronic product as the duration of a product's life is estimated to be between 2 and 4 years for corporate users and 2 and 5years for domestic users (Shah & Singh, 2004). There were 22% of fixed lines in use between 10-20 years, while for computers it was 16%, and 10% for mobile phones. Globally the duration of used equipment depends on the lifespan of each

electrical and electronic product. Results from this study show that 27% of fixed lines were in use for over 20 years, followed by 7% of the computers and 4% of the mobile phones. This corroborates with the findings of Kalana (2010) that 2-4 years was the range of the period that mobile phones and computers were in use before being discarded.

This research finding is in agreement with another one which was conducted in Kenya (Sharma, 2012) who found that over 50% of consumers possessed computers for over 5 years after which they either gave them to friends or donated them to schools. In developed countries personal computers have an average life span of only 2 years. In the United States alone there are over 300 million obsolete computers (Baker, 2004).

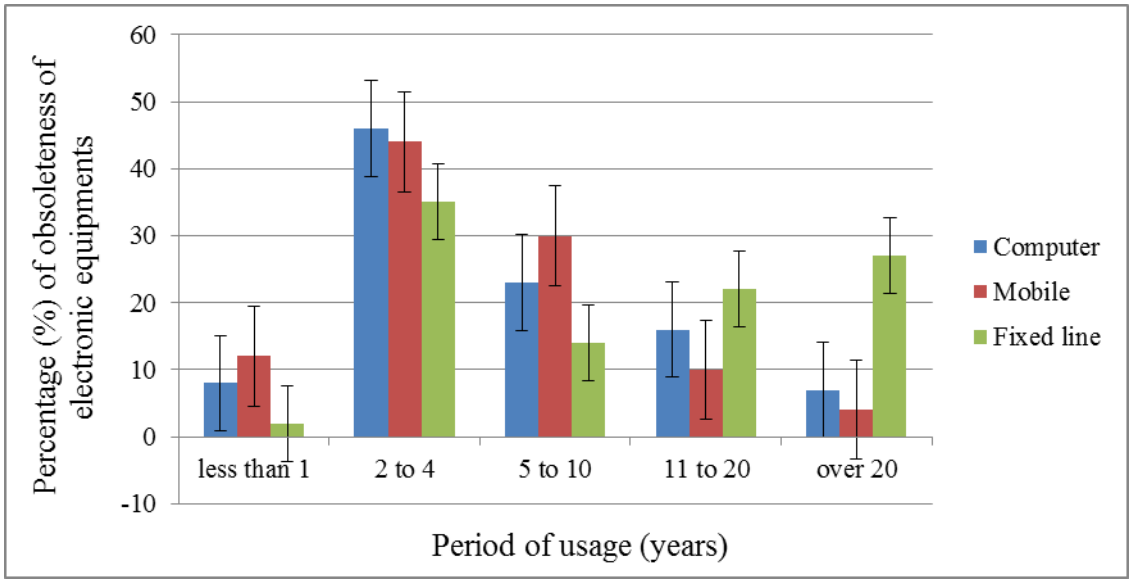


Figure. 4.2: Period of use for e-waste equipment in Nairobi County

*(*The error bars represent standard error*)*

The study established that 10.84% of the computers, 3.25% of mobile phones and 6.86% of fixed lines were obsolete (Figure.4.3).There was significant difference ($p<0.05$) between the number of computer and mobile phones that had become obsolete.

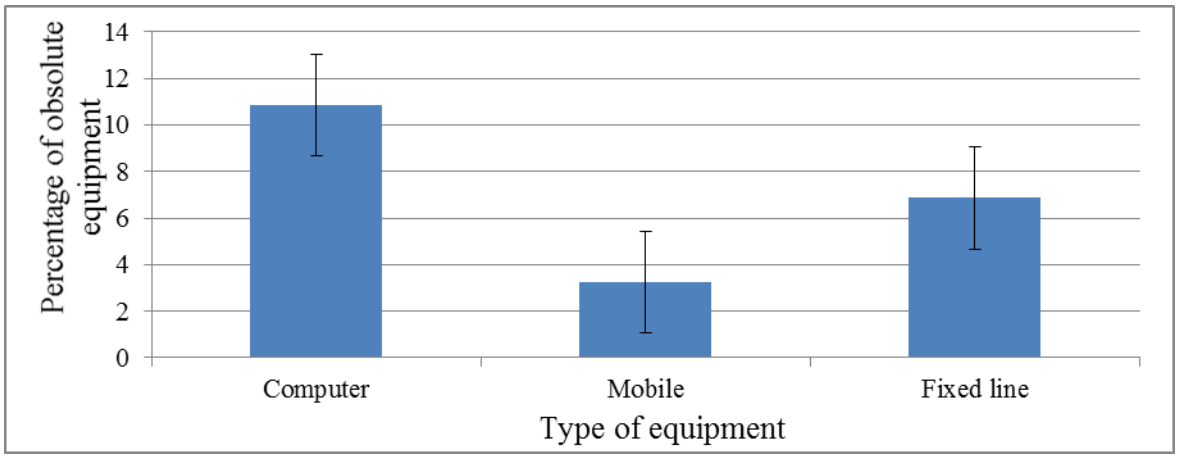


Figure 4.3: Type and percentage of obsolete equipment found out in Nairobi County (*The error bars represent standard error*)

From the study 12% of the fixed lines were made obsolete due to change of policy, while 8% and 2% of mobile phones and computers, respectively, were affected (Figure.4.4). The study established that 87% of the computers became obsolete due to malfunctioning while 52% and 46% of the mobile phones and fixed lines respectively were affected. It was established that 32% of the mobile phones were affected due to wearing out followed by 15% of the fixed lines and finally 8% of the computers. The results indicate that 27% of the fixed lines were obsolete by other reasons such as change in model or donations, followed by 8% of the mobiles and finally 3% of the computers. Generally malfunctioning was the main reason for obsoleteness, followed by wearing out. The results from this study are in agreement with research finding (Khetriwal,2009), who reported that 48% of respondents disposed of their electrical and electronic equipment because of malfunction during use, followed by the fact that its lifespan had elapsed and high cost of repairing the equipment at 46% and 37%, respectively. Due to increase of affordable new products and technological advancements, it is easier for individuals to purchase new goods rather than repair outdated products (Khetriwal, 2009).

Malfunctioning significantly ($p<0.05$) contributed to obsoleteness of electronic equipment than other factors in the study.

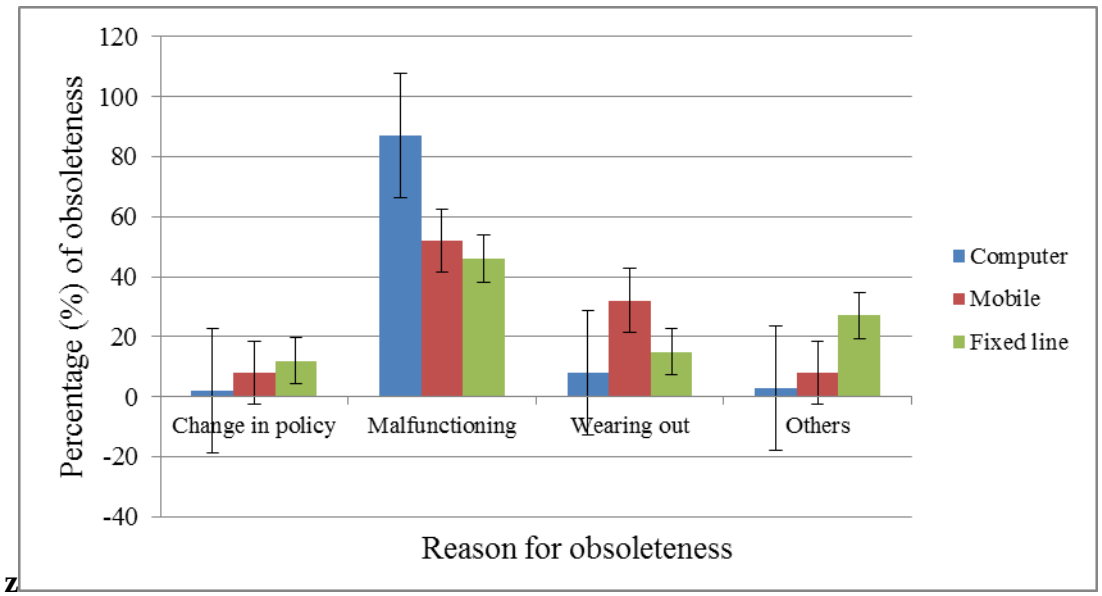


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Figure 4.4: Percentages of different reasons contributing to obsoleteness of electronic equipment In Nairobi County (*The error bars represent standard error***)**

In Nairobi less than 50% of fixed lines were kept in store, followed by 43% of the computers and 24% of the mobile phones. Furthermore, 10% of the fixed lines were recycled, followed by 10% of the mobiles phones and 7% of the computers. It was found that 52% of the mobile phones, 48% of the computers and 31% of the fixed lines were sold. It was established that 14% of mobile phones, 9% of the fixed lines and 2% of the computers were disposed into dust bins (Figure.4.5). Generally, selling was the main method of disposal of the equipment.

These research findings are in agreement with Khetriwal (2009) who reported that the preferred methods of e-waste disposal were storage and selling as secondhand equipment, at 48% and 37% respectively. Currently, there is a move to put in place a structured mechanism to handle e-waste from households and industries but its registration has not been done. According to Schluep (2008) most consumers store their

unused or broken electrical and electronic equipment for years before the equipment is resold or otherwise disposed. According to Lassana (2009) every year hundreds of thousands of old computers and mobile phones are dumped in landfills or burned in smelters. Thousands more are exported often illegally from the Europe, US, Japan and other industrialized countries to Asia and Africa.

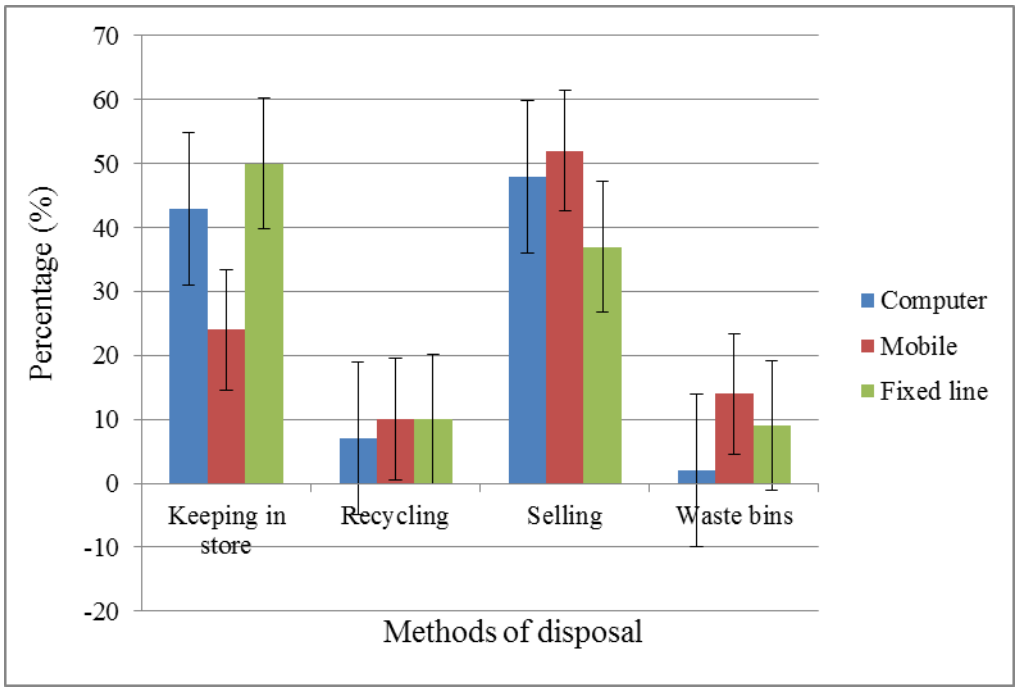

Figure. 4.5: Methods of disposal for computers, mobile phones and fixed lines in Nairobi County (*The error bars represent standard error*)

4.2 Methods of disposal for computers, mobile phones and fixed lines

Currently, some of the companies which embrace e-waste management are; Safaricom, Nokia, Hp and Samsung, for they have started collection centers for e-waste equipment (Figure.4.6).They have developed some mechanisms for handling e-waste from households. However there is structured mechanism is in place to handle e-waste generated from industries.

Figure 4.6: Safaricom's arrangement for e-waste collection at certain points

The study established that consumers imagine of the obsolete equipment being used in future and therefore they keep them in store (Figure.4.7)

Figure 4.7: Broken electronic equipment are kept in computer lab/ workshop in a Kenyan institution

It was found out that anon governmental organisation;Computer for Schools Kenya has arecyling programme(Figure.4.8).

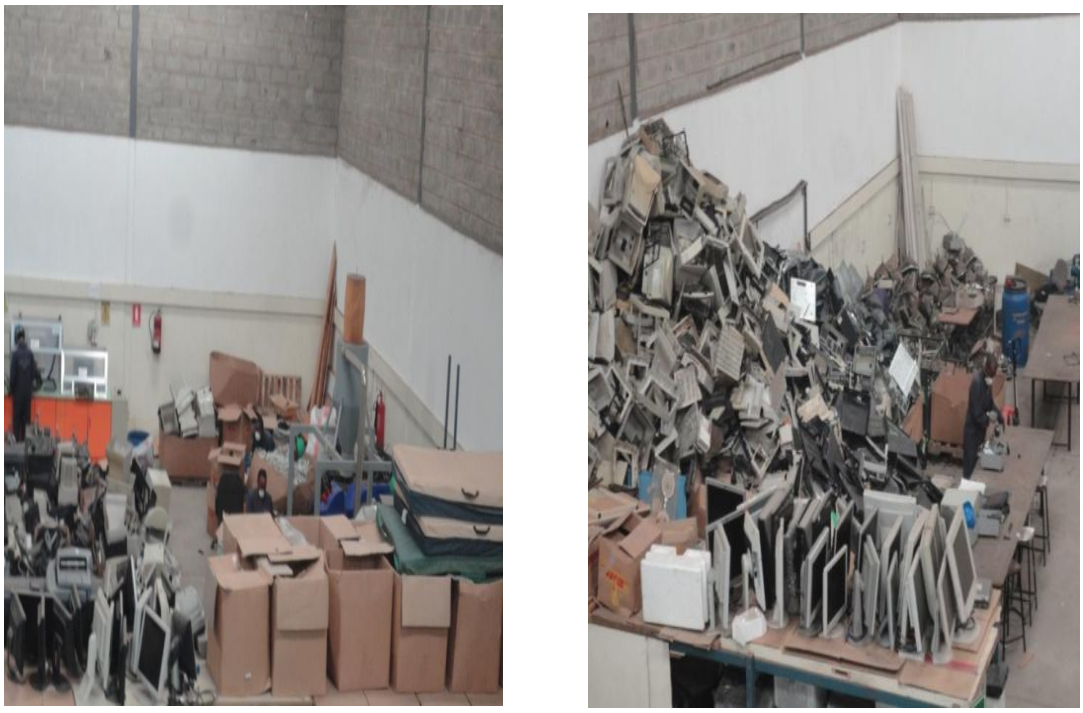

Figure 4.8: Storage and shredding of e-waste at the Computer for Schools Kenya stores

It was established that some of the e-waste kept in store in dustbins find its way to open dumpsite with other solid waste and fed by animals (Figure.4.9a and Figure 4.9b) or collected for some other use (Figure.4.10 a and b).

Figure 4.9(a): Animals feeding at dumping site near residential area in one of the areas surveyed.(b)the researcher Omari with Mr. Nyasiengu (the in charge of Dandora dumpsite) near the Dandora site entrance

Figure 4.10 (a): People eking a living by collecting plastic bottles from the Dandora dump site for sale. (b) The Dandora dumpsite which was started 30 years is now very deep.

The Dandora dumpsite which was started about 30 years ago has been zoned by some people for their own use and it has become impassable, not easy to carry out a study on e-waste as it was supposed to be.

Figure 4.11(a): The leaders playing pool in the Dandora dumpsite *(b)* A lorry stuck at Dandora dumpsite

4.3: Policy and legal framework

Results indicate that 53% of the institutions had no policy for handling e-waste, while 47% had a policy (Figure 4.12a). This is in agreement with the findings of Awadalla (2013) who reported that only 20% of respondents had an e-waste policy. A major hurdle to the proper handling of e-waste on a global scale is, among others, a lack of policy frameworks on national, regional and global levels. Therefore it is recommended that policies guiding e-waste generation and a cross boundary transfer be put in place.

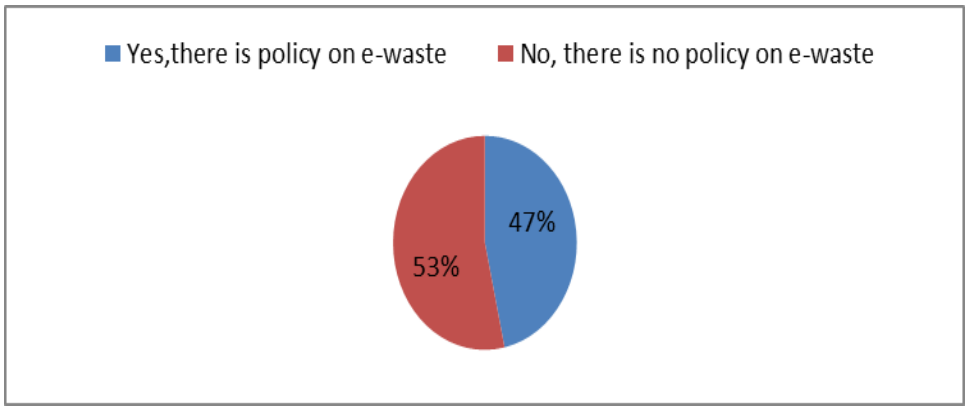

Figure.4.12a : E-waste policy in Nairobi County

From study it was found out that individual institutional e-waste policy content entailed 19.4% for recycling, 22.6% equipment reuse and 6% disposal to landfill (Figure.4.12b).

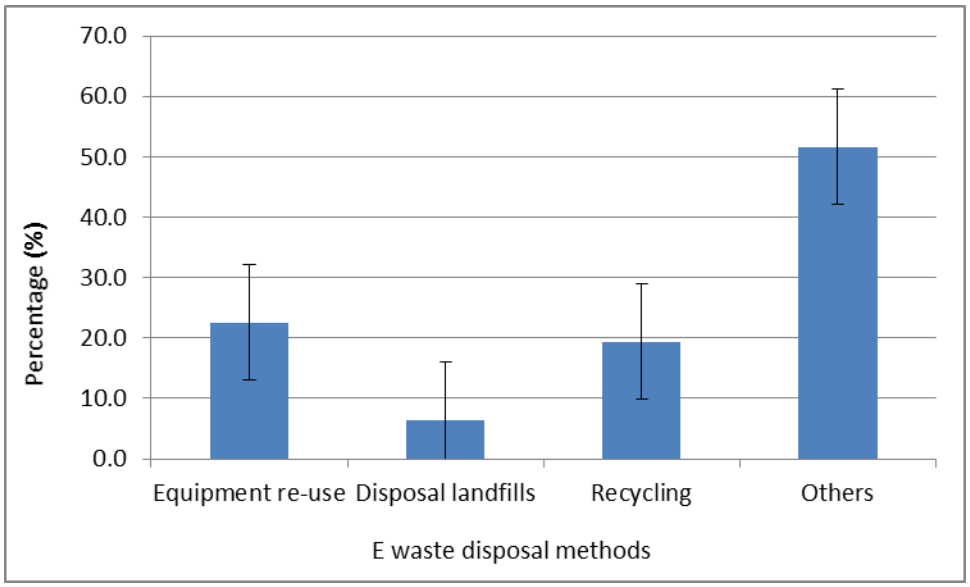

Figure. 4.12b: E waste policy handling methods in Nairobi County

The study established that 64% of the institutions had infrastructure in place for implementing the e-waste policy while 36% did not have (Figure 4.13a). According to Khetriwal, (2009) the lack of a safe e-waste recycling infrastructure in the formal sector and thus reliance on the capacities of informal sector may pose severe risks to the

environment and human health. However, collecting and pre-processing can be handled efficiently by the informal sector and can offer numerous job opportunities. The lack of international standards for simple but efficient e-waste management systems delays their implementation.

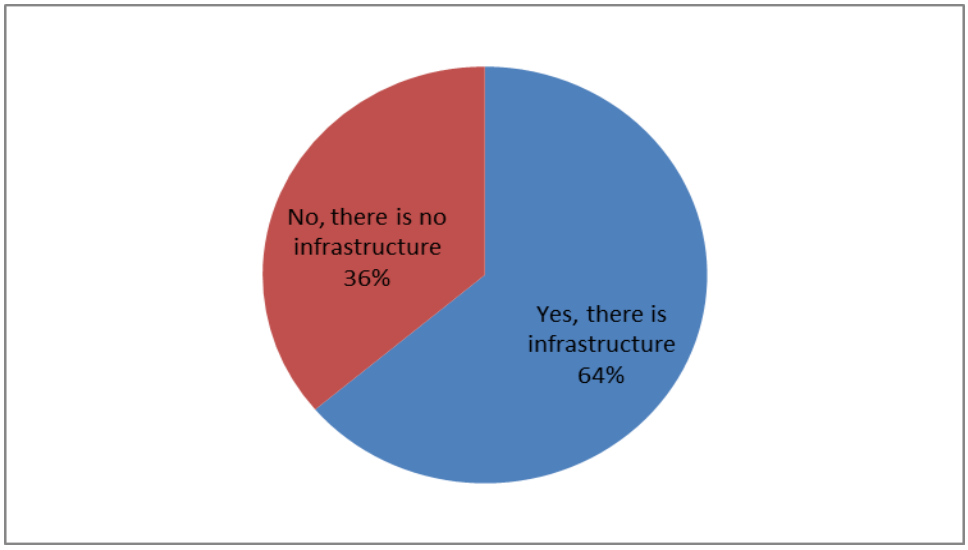

Figure.4.13a: Policy infrastructure for implementing e-waste policy in Nairobi County

Majority of the institutions (32%) reported that there wasn't adequate infrastructure for implementing e-waste policy, while 11% reported that the policy was least adequate, 30% reported it as averagely adequate, 22% being adequate and with only 5% of the institutions reporting it to be completely adequate (Figure. 4.13b).

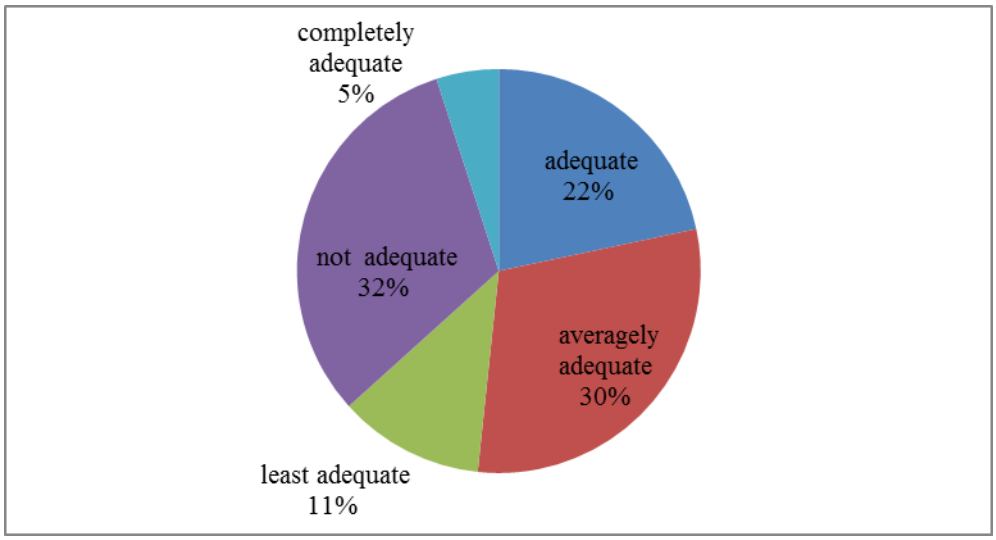

Figure 4.13b: Adequacy in percentage of the infrastructure for implementing e-waste policy in Nairobi County

4.4 Recommended strategies / mechanisms for dealing with/handling e-waste in the country as suggested by respondents

Majority of the respondents (35.6 %) from the study had firm conviction that there could be better ways for e-waste management (Table 4.4).Therefore it was only a matter of implementing appropriate policies and putting mechanisms in place to solve the e-waste problem.

Table 4.4:Perception on better ways of e waste management in Nairobi County

	Frequency	**Percentage**
	10	**8.5**
Average convinced	14	**11.9**
Convinced	42	**35.6**
Unconvinced	17	**14.4**
Very unconvinced	35	**29.7**
Total	118	**100.0**

In terms of the proposed measures for e-waste management, 22% was for establishing collection points and dumping places followed by recycling by authorized bodies which was 21%.It was found that enactment and implementation of policies was 10%,followed by government policies on e-waste management 9%,and public education on e-waste handling being 7%.Establishment of private firms for e-waste management and disposal 6% and resale 5%.Construction for stores recycling 4%, avoid importation of second hand equipment3% and proper e-waste disposal 3%. Training on e-waste handling 2%, donations to less developed countries 1.5% and repair and re-use 1.5% and those which were in negligible percentages were; classifying equipment at the point of sale, discouraging careless disposal, laws of age for electronic equipment to be imported and community fund for e-waste disposal. It was established from the study that there are several strategies for handling e-waste (Figure 4.14).

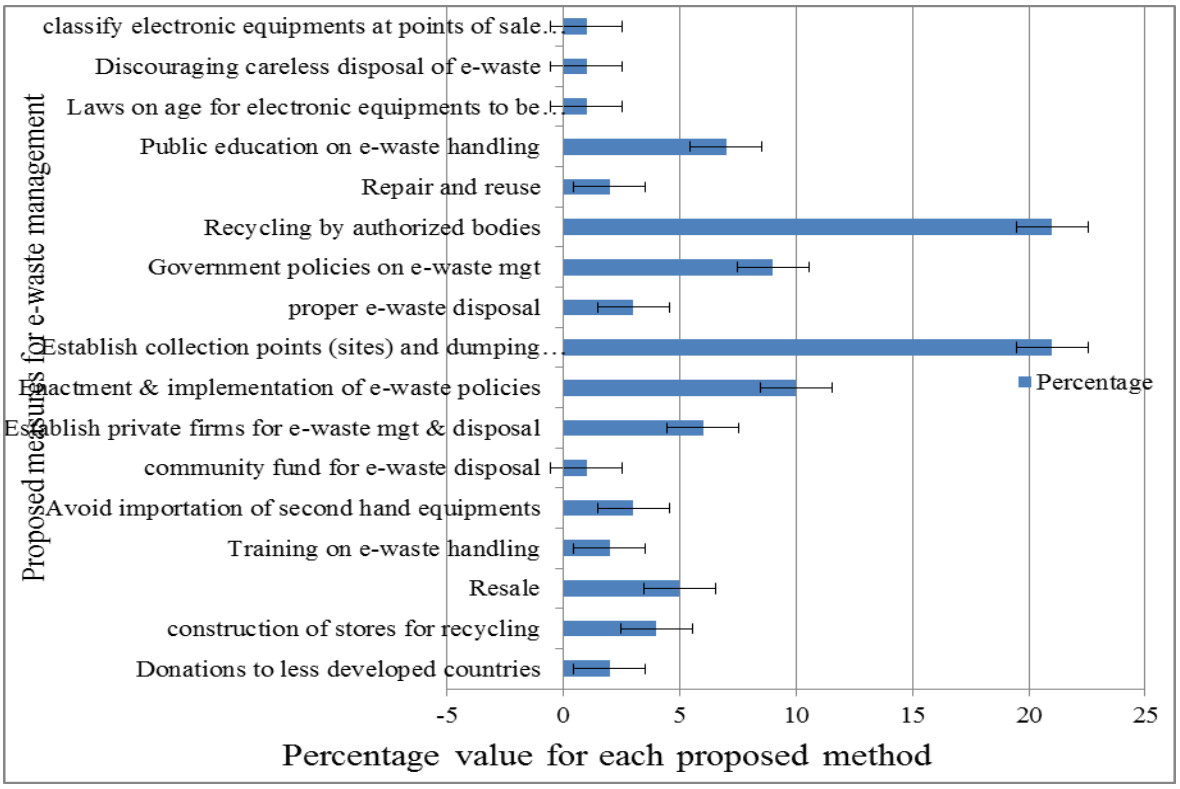

Figure 4.14: Strategies which were established by the study for e-waste handling in Nairobi County

The word obsolete is used by computer manufacturers to refer to hardware they no longer use for new products because a faster/better/cheaper one is available (Woerner, & Lehman, 1995). According to Khetriwal, Kraeuchi and Widmer (2009) obsolescence for electronic equipment is due to the introduction of newer gadgets coupled with rapidly falling prices. This observation is in agreement with research finding by Kalana (2010), who reported that users disposed of their electrical and electronic equipment because of malfunction during use. Some phone companies allow trade in (return old gadget add some money and get a new one) by the fact that its lifespan had elapsed or high cost of repairing the equipment. Due to increase in affordability of new products and technological advancements, it is easier to purchase new goods rather than repair outdated products. It is often much cheaper and more convenient to buy a new machine

to accommodate a newer generation of technology than it is to upgrade an outdated machine (Kalana, 2010).

This research finding was in agreement with another one which was conducted in Kenya by Schluep et al. (2008) who found that over 50% of consumers possessed computers for over 5 years after which they either gave them to friends or donated them to schools. In developed countries personal computers have an average life span of only 2 years. These research findings are in agreement with Kalana (2010) who reported that the preferred methods of e-waste disposal were storage and selling as secondhand equipment, at 48% and 37% respectively. From the study it was established that proven that most consumers store their unused or broken electrical and electronic equipment for years before the equipment is resold or otherwise disposed of which was in agreement with (Schluep et al., 2008). According to Lassana (2009) every year hundreds of thousands of old computers and mobile phones are dumped in landfills or burned in smelters. Thousands more are exported often illegally from the Europe, US, Japan and other industrialized countries to Asia and Africa.

Further according to Kalana (2010) many consumers do not immediately dispose of or recycle unused electronics since they think that the products still have value and e-waste management relatively was widely practiced by the industrial sector but, however it was at domestic or rather household level where management was a problem.

Research conducted by Awadalla (2013) in the year 2007 found out that only 20% of respondents had an e-waste policy. A major hurdle to the proper handling of E-waste on a global scale is, among others, a lack of policy frameworks on national, regional and global levels. There are three major challenges to the definition and implementation of policies: a standard definition for E-waste is missing: consolidating a definition would enable the development of inventories (quantification and characterization), assessment of current management practices and, finally, definition of policies; difficulties in implementing existing regulations; and lack of financing mechanisms (e.g. recycling fees, environmental taxes) for the development of E-waste management.

According to Khetriwal, et al., (2009) the lack of a safe WEEE recycling infrastructure in the formal sector and thus reliance on the capacities of informal sector may pose severe risks to the environment and human health. However, collecting and pre-processing can be handled efficiently by the informal sector and can offer numerous job opportunities and currently according to Post, Baud, and Furedy (2004) and Khan (2012). some organizations have partnered in providing training programmes on e-waste.

From the study the following strategies were established for handling e-waste:

a. **Classification of electronic equipment at point of sale**

California and Maine were the first US states to pass laws that established a mechanism for financing the collection and recycling of discarded electronics, commonly known as electronic waste or "e-waste." Certain electronics can be classified as hazardous waste at the point of disposal as defined under the federal Resource Conservation and Recovery Act (RCRA). California and Maine's laws were created to prevent these types of electronics from being sent to solid waste disposal facilities (Kang & Schoenung, 2005).

The E.U Directive (WEEE Directive) aimed at reducing the amount of waste electrical and electronic equipment that ends up in landfill. This goal was to be achieved by changes throughout the EEE product cycle including improved product design to ease dismantling, recycling and reuse and, more significantly, provision of national WEEE collection points and processing systems. The latter allowed consumers to put WEEE into a separate waste stream to other waste**,** resulting in it being processed, accounted for and reported to the national enforcement authority. The implementation of a national WEEE scheme required involvement from nationals and local government, EEE manufacturers, distributors, vendors and consumers. According to Sharma; Gupta, and

Sushil (2010) this is called comprehensive product coverage approach. There are several advantages associated with this approach. First, starting with broad product coverage would bring all the stakeholders to the table, eliminating the need to have to try to fit in new industry sectors later. Second, electronic and electrical equipment has the characteristic of convergence. Functions of products such as cameras, music systems and phones converge into a single product. In a comprehensive approach, the companies making these products are a part of the product recycling and stewardship plan from the beginning. Moreover, due to convergence, it is not always easy to determine the category a product fits into. Third, a comprehensive approach provides a higher volume of product to recyclers. This is likely to reduce costs, increase opportunities for creating uses for the recycled products and create markets to sell them at. Fourth, the creation of a recycling program requires administrative infrastructures. It might be more efficient to set up these administrative infrastructures, with associated costs, only once. Finally, educating the consumers or the disposer of the product is easier with a comprehensive list of products covered since consumers may not remember which items are allowed and which are not. To comply with WEEE regulations producers must join a Producer Compliance Scheme which provides a link between producers and environment agencies as well a number of services to enable WEEE to be effectively and economically recycled or reused. New WEEE placed on the market must be marked with certain information to allow for correct disposal by the end user. Also information must be made available to treatment facilities so new products can be efficiently reprocessed **(**E. U directive, 2002).

According to Secretariat (2011), many developed countries which are able to circumvent national legislations, export hazardous wastes including electronic wastes to the developing countries which are having neither the knowledge of the hazardous nature or having rudimentary knowledge, nor the capacity to dispose off the wastes safely. Normally the incoming electronic waste materials are scanned for its most valuable components and then sold in a store or to specially brokers. The rest of the material are broken down and sorted according to the type of waste e.g. circuit boards, wires & cables, plastics, cathode ray tubes (CRTs) and non-recyclables. These are sold to brokers who then ship them mainly to China or the South Asian countries.

b. **Discouraging careless disposal of e-waste**

In terms of discouraging careless disposal of e-waste, according to Swedish (2005) all households should easily be able to sort their e-waste and take it to a depot or have it collected, whether the waste falls under the municipality's public cleansing obligation or producer responsibility. The Government considers that it should be easier for households to sort their packaging and newspapers. The aim of further improvements made by producers and municipalities should be to ensure that collection is perceived as a system by consumers. According to Missouri Geological Survey-Dept. of Natural Resources (1977) businesses, charities, non-profits, schools, churches and public and governmental agencies in Missouri cannot legally discard certain electronics in Missouri landfills. They are required by federal and state law to properly manage certain unwanted hazardous electrical and electronic waste.

c. **Laws on age for electronic equipment to be imported**

In terms of laws on age for electronic equipment to be imported, some provisions contained in some specific policies in other countries enable import of e-waste. For instance, India's EXIM (export-import) policy allows import of the secondhand computers not more than 10 years old, besides letting computers in as donations. The

Foreign Trade (Development and Regulation) Act, 1992 provides for import of computers and peripherals from zones which have been set up primarily for export, i.e. EOU (Export Oriented Units), EPZ (Exports Processing Zones), STP (Software Technology Parks) and EHTP (Electronics Hardware Technology Parks) at a zero custom duty. These computers can be donated to the recognized non-commercial educational institutions, registered charitable hospitals, public libraries, public-funded research and development establishments and organizations of the Government of India and State/UT Governments (Secretariat, 2011).

d. **Public education on e-waste handling**

According to Davis and Heart (2009) there is need for education on e-waste in educating the public and decision makers on a continuous basis including raising awareness of health impacts of hazardous waste as well as the role that each of the stakeholders have to play. All stake holders need to know the existing global capacity building activities on e-waste including requirements of Basel Convention on e-waste, cooperation between customs and environmental authorities, recycle & reuse strategies and the globally economical sustainable recycling programs that emphasize job creation while protecting human and environmental health.

e. Repair and reuse of e-waste

In agreement with Gee (2003), a computer does not need to have the very latest specifications to still be useful. Affordable and environmentally-responsible reuse of electronic equipment can support technologically disadvantaged communities in developing world. This lengthens the lifespan of e-equipment and reuse means less production of new consumption goods which means less use of scarce resources and also less waste.

f. recycling of e-waste by authorized bodies

While recycling appears to be a safe method to utilize or dispose e-wastes, it can be a is leading characterization of disparate practices including dismantling, shredding, burning and exporting which are mostly unregulated and often create additional hazards itself. Recycling of hazardous wastes, even under the best of circumstances, has little environment benefit as it simply moves the hazards into secondary products that eventually have to be disposed off (Secretariat, 2011). On the other hand, recycling isn't just good for the environment but also good business practice. It is an important solution especially due the fact that e-waste contains many valuable and rare materials.

g. Government policies on e-waste handling

According to Ladou and Lovegrove (2008) the current e-waste recycling system is largely doomed to failure before the electronics products ever enter the marketplace. Electronics manufacturers resist or delay efforts to eliminate or substitute for hazardous materials and they are slow to design products for eventual ease of disassembly and recycling. In league with the industry, government fails to hold manufacturers responsible for end-of-life management of their products. Consumers assume an unspecified responsibility for electronics products, which they frequently must discard. The Government of Kenya has regulations through National Environmental Management Authority (NEMA) but they have no policy for e-waste and therefore the study recommends a clear policy on the same.

As the world begins to acknowledge the scope of the problem, China has initiated several policies to address the import of e-waste and its disposal Yusof et al.,2005). In conjunction with four other agencies, on January 2008 the Ministry of Environmental Protection issued the Announcement on Releasing the Catalogue of Solid Wastes Forbidden to Import, the Catalogue of Restricted Import Solid Wastes that Can Be Used as Raw Materials, and the Catalogue of Automatic-Licensing Import Solid Wastes that Can Be Used as Raw Materials. The catalogues collectively updated the previous list of

wastes that were banned for imports and that could be imported as raw materials under restricted conditions.

In Kenya Section 5 of the Waste Management Guidelines requires the waste generator to minimize waste and eliminate waste altogether as well as identifying and eliminating potential negative impacts of the product, enabling the recovery and reuse of the product, reclamation and recycling and incorporating environmental concerns in the design and disposal of a product (Herat, 2009). Sections 17-23 require the generators of hazardous waste to conduct an EIA and to label clearly "hazardous waste". The designated national authority uses Basel Convention guidelines and NEMA over sees the entire transport of such materials. Kenya currently does not have guidelines on e-waste but there are plans to revise the Waste Management Regulations 2006 to incorporate the e-wastes (Herat, 2009).

h. proper e-waste disposal

Concerning proper disposal of e-waste it has been realized that recycling facilities exist in developed countries and stringent measures have been taken by governments regarding disposal of e-waste. However according to Secretariat (2011) there are difficulties in implementing regulations and dealing with e-waste owing to increased activism by environmentalists and the high cost of recycling. Despite concerns on the issues of fraudulent traders and environmentally unsound practices, it has been easier and cheaper for these countries to ship e-wastes to the developing countries where access to and recycling of such discarded electronic goods make a good economic option. For both sides, it is profitable or a win-win situation.

i. Enactment and implementation of e-waste policies

In agreement with Terada (2011) on enactment and implementation of e-waste policies, the European Union (EU), Japan, South Korea, Taiwan, and several states of the USA have introduced legislation making producers responsible for products reaching the end of their lives. Ironically according to Laha (2014), one of the largest exporters of

hazardous waste, the United States has signed but has not yet ratified the Convention. Even countries (like Canada, Japan, Australia and South Korea) who are parties to the Convention often flout it since it is not legally binding. Regularly junk material are sent to developing world in the name of charity since unless destined to be recycled or disposed, EEE do not come under the Basel definition of hazardous waste. After the Basel Ban, previously obsolete items are now coming in under the guise of usable products which are exempted in the Ban. Another severe limitation is that scrap trade within Asia is not addressed by the Basel Ban. For all these reasons, the Basel Convention and the Ban remains largely ineffective despite being the sole international agreement of hazardous waste trade.

j. Regulating importation of second hand equipment

The need to regulate importation of second hand electronic equipment by fixing age limit just like for vehicles is urgent. There is an escalating global trade in obsolete, discarded computers and other e-waste collected in North America and Europe and sent to developing countries by waste brokers and so-called recyclers (Ladou & Lovegrove, 2008; Nelson et al., 2011). As much as 80% of the e-waste collected for recycling in the United States is not recycled domestically but is instead exported to developing countries (Ladou & Lovegrove, 2008).The United States and many other developed countries have exported e-waste primarily to Asia, knowing full well that it carried with it a real harm to the poor communities where it would be discarded. E-waste is shipped overseas for dismantling under appalling conditions contaminating the land, air, and water in China, India, and other Asian nations, Africa, and Latin America (Ladou & Lovegrove, 2008; Terada, 2011). In Africa, while there is a legal capacity and ability to repair and refurbish old electronics equipment, as much as 75% of the imports are not economically repairable or marketable. Consequently, the e-waste is inappropriately discarded and routinely burned (Ladou & Lovegrove, 2008).

k. .Resale of the e-waste

In agreement with Ladou and Lovegrove (2008) e-waste contains marketable products, including resalable electronics devices and recycled materials. However according to Terada (2011), after being sold to salvage companies and dismantled, the electronic devices release substantial quantities of toxic heavy metals and organic compounds into the surrounding soil, air and water. Therefore it recommended to be done with care and only by authorized authorities.

l. Construction of stores for recycling of e-waste

Currently around the world, the volume of obsolete computers and other e-wastes temporarily stored for recycling or disposal is growing at an alarming rate. The most common way of treating e-waste has been storing it in landfills, but it is replete with all the dangers of leaching. According to Secretariat (2011) presently there are 28 operational Treatment, Storage and Disposal Facilities (TSDFs) for hazardous waste management in USA. The rising quality of life and high rates of resource consumption patterns has had an unintended and negative impact on the environment through the generation of wastes far beyond the handling capacities of governments and agencies. Added to the burden of the management of hazardous municipal waste, the management of huge and growing quantities of electronic waste is emerging as one of the most important environmental problems of developing countries. An observation made by Secretariat (2011) is that the hazardous effects are far worse in the older or less stringently maintained landfills or dumpsites. Because of its hazardous nature, dumping in landfills have been banned in most of the states in the US and European Union.

m. Establishment of private firms for e-waste management and disposal

According to research done by Agamuthu and Victor (2011) there are 138 e-waste recovery facilities currently in Malaysia. 16 out of them are full recovery facilities while the rest are partial recovery facilities.

n. .Training on e-waste handling

From the research it was established that training for e-waste was very low (3%).Currently according to Post, Baud, and Furedy (2004). some organizations have partnered in providing training programmes on e-waste. For instance Computer Aid International, Waste Electronic and Electrical Equipment (WEEE) Centre in Kenya and Africa Programs for Computer Aid have partnered to create a professionally center for providing e-waste management training to bring awareness to disposal of electronic waste generated by old computers, TVs and mobile phones. According to Omieno (2013) Masinde Muliro University of Science and Technology in collaboration with ERMIS Africa, NEMA, and Computer for Schools and SHALIN are implementing a UNESCO-HP funded project on "Computer Supported collaborative E-Waste Management Research towards Developing a National E-Waste Management Strategy for Sustainable Development in Kenya". The project will utilize Grid Computing Technologies to link students and mentorship within Kenya and Diasporas to optimize on Brain Gain from the eminent Brain Drain phenomenon characteristic of most developing countries.

o. Donations to less developed countries

An observation made by Ramachandran (2008) is that donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time. But care should be taken while donating such items by ensuring that the items are in working condition. By donating used electronics, schools, non-profit organizations and lower-income families can afford to use equipment that they otherwise could not afford.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

From the research carried out by the researcher most institutions in Nairobi owned a combination of computers, mobile phones and telephones which were 56.6%. It was further established that in Nairobi and its environs about 10.84% of computers become obsolete annually. The major reason for obsolete was malfunctioning, followed by change of policy and finally by donating or selling. The average life-span of the equipment was found to be 2-4 years. The major methods of disposal were found to be selling followed by keeping in store. It was established that 53% of the respondents had no e-waste handling policy which means that e-waste has not been taken seriously and hence e-waste is expected to be huge problem in future. From the study it was found out that majority of the institutions had collecting and dumping their e-waste as their first priority followed by recycling.

5.2 Recommendations

1. It is recommended that the Government put in place regulations for the age limit (just as it is for vehicles) of the electrical and electronic equipment to be imported to avoid some which have become so old and when imported they become a baggage of e-waste. Government Ministries should have a regulation of disposing its computers after three years of use rather than keeping them in store.

2. It is recommended that the government and other institutions make donations of the e-waste. Preventing e-waste generation is the first option where waste can be reused instead. For example, old or unwanted electronics can be donated for

reuse to those who cannot afford them. Also donating can extend the product 'life' and maintain them from going to waste that soon.

3. The public education and training on e-waste should be a policy to all institutions.
4. Creation of public awareness.
5. Trade in should be encouraged.
6. The Government to create enabling environment for recyclers
7. The Government should discourage careless disposal by having strict rule and regulations for the same as found from the above discussions.
8. The Government should have e-waste policy in order to harmonize various regulations relating to components of waste management in the country avoid duplication of regulations that may be contradictory in nature and also make them comprehensive.

5.3 Suggestions for future research

E-waste management is an emerging problem in Kenya just like in the rest of the Sub Sahara

Africa existence of little or no data makes it hard to assess the magnitude of the problem. In view of the research done e-waste management is a big grey area that needs detailed and more research carried out in Kenya.

The following areas need to be explored further:

i. There is need for research on the adoption and integration of EPR into national legislation and what impact it would have to the various players and actors in the e-waste scene.
ii. Detailed exploration on how various e-waste management strategies can be synergized with EPR and developed to aid in e-waste management in Kenya.
iii. Another interesting research would involve looking at the benefits of manufacturer involvement in end of life (EoL) management of their products as

opposed to development of functional recycle markets that are liberalized and open to competition from the existing recycling practices.

iv. Research on the general flows and quantities of e-waste in Kenya, the origin of the e-waste so as to determine the source of the e-waste if it is generated domestically or is it imported. This should be done with the view of identifying the gaps and loop holes that need to be addressed for effective management of e-waste.

v. Finally research on potential knowledge transfer in relation to e-waste management from Europe to Kenya this can be conducted with the aim of identifying what kind of knowledge exists in the developed countries and how could the knowledge be transferred to the developing countries grappling with the e-waste management. In line with knowledge transfer it would worthy to explore in details the possibility of transfer of the e-products along with the EoL fee from jurisdictions with the provisions to the jurisdictions not covered but are grappling with management of e-waste from the covered jurisdictions

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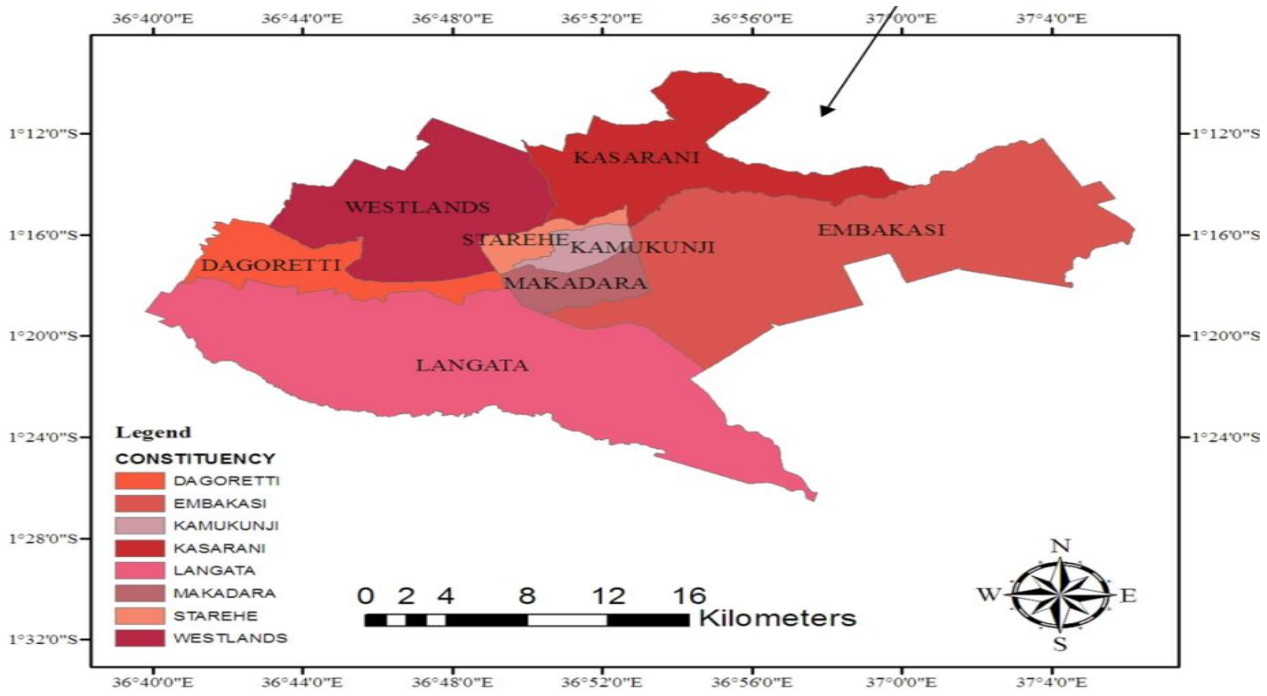
APPENDICES

Appendix 1: Map of Nairobi county of Kenya

The places circled in red indicate where primary data was collected from to be representative of urban areas of Kenya.



Appendix 2: Questionnaire for Individual Households

I am an MSC student at JKUAT doing a research on e-waste and therefore the answers you provide shall be treated with the confidence they deserve

Individual questionnaire on electronic waste management in Nairobi County, in Kenya.

The questionnaire will be used to determine the e waste management in Kenya.

Please take a few minutes of your time to choose the response which best describes your opinion in the following statements. Please consider all the e-waste equipment you have already used or currently under use, as you formulate your response. Your response will be considered confidential.

Tick appropriately where required.

Personal details

1. Questionnaire N0. _____
2. GPS longitude _____latitude_____
3. Name _____ Mobile/ Telephone Number_____
4. The respondent Age in years?

   Less than 19 [ ] 20 – 29 [ ] 30 – 39 [ ] 40 – 49 [ ] 50 – 59 [ ] over 60 [ ]

5. Gender of the respondent? Male [ ] Female [ ]

6. Educational level of the respondent?

   Primary [ ] Secondary Level [ ] College [ ]
   University [ ]

7. Residential area (sub location)……..
   (District)……

General Observations

1. a) Which of the following electronic equipment do you have? Computers[ ] Printers[ ] photocopier[ ] fixed lines[ ] phones[ ] calculators[ ] public address system[ ]radios[ ] TV set[ ] cameras[ ]watches[ ] refrigerators[ ] microwaves[ ] and electric heating appliances[?

   b) If, Yes list them_____

2. From where do you get the equipment?

E-waste collectors [ ] Retail shops [ ] E-waste recycler [ ] E-waste refurbisher [ ]

Dumping site [ ] Electronic shop [ ] others, _____

3. Where do you use these electronic equipment?

   Home [ ] Learning institutions [ ] Place of Work [ ] any other specify)
   ……

4. For how many years have you used these electronic equipment for the past 20 years?

   Less than5 [ ] 6 – 10 [ ] 11 – 15 [ ] 16 – 20 [ ] over 20 [ ]

5. How often do you use the electronic equipment?

   Occasionally [ ] Averagely [ ] Often [ ] Always [ ]

6. Approximately for how long do use the electronic equipment before discarding? (in years)

Less than 2 [ ] 3 - 4 [ ] 5 - 6 [ ] 7 - 8 [ ] 9 - 10 [ ] over 10 [ ]

7. a) Are there dumping sites in particular for disposing the electronic wastes?

Completely unavailable [ ] Unavailable [ ] Not sure [ ] Available [ ] completely available [ ]

b.) who is responsible for managing the dumping sites?

Community [ ] Council [ ] NGOs [ ] None [ ] Government [ ] Institutions [ ]

c.) What methods do you use to handle the electronic wastes?

Keeping in the house [ ] Burning [ ] Dustbin/ Rubbish pit [ ] Sale [ ] Giving to relatives [ ]

Other (specify)……

d.) If keeping in store approximately how much? (in kg)

Less than 10 [ ] 11-20 [ ] 21-30 [ ] 31-40 [ ] 41-50 [ ] 51-60 [ ] over 60 [ ]

e.) If keeping in store for what purpose? Repair broken equipment [ ] Sell them as parts [ ] Make new products [ ] Others, _____

f.) If thrown to the dust bin/ rubbish pit how the actual e-waste collected?

Pick-up of e-waste from door to door [ ] Have a common collection point [ ]

Pick –up from garbage disposal gardens [ ] Direct collection by municipal Lorries [ ]

Others _____

8. a) Are you aware of any laid down policies in Kenya that govern the handling of the electronic wastes?

   Completely unaware [ ] unaware [ ] averagely aware [ ] Aware [ ] completely aware [ ]

   b.) Do you think the policies are effective in the electronic waste handling?

   Very ineffective [ ] ineffective [ ] averagely effective [ ] Effective [ ] Very effective [ ]

   c.) Name the policies that govern your handling of the electronic wastes.

   ……
   ……

9. a.) Are you aware of the positive effects of e-waste?

   Completely unaware [ ] unaware [ ] averagely aware [ ] Aware [ ] completely aware [ ]

   b.) If aware list_____

   9. a) Are you aware of the negative effects of e-waste?

   Completely unaware [ ] unaware [ ] averagely aware [ ] Aware [ ] completely aware [ ]

   b.) If aware list_____

10. a.) Are there better ways through which the electronic wastes handling can be managed in Kenya? Very unconvinced [ ] unconvinced [ ] average convinced [ ] convinced [ ] Very unconvinced [ ]

11. b.) What are these ways that can improve the electronic wastes handling?

Appendix 3: Questionnaire for businesses

I am an MSC student at JKUAT doing a research on e-waste and therefore the answers you provide shall be treated with the confidence they deserve

Tradesmen/women e-Waste assessment questionnaire

The questionnaire will be used to determine the e waste management in Kenya.

Please take a few minutes of your time to choose the response which best describes your opinion in the following statements. Consider all the e-waste equipment you have already used or currently under use as you formulate your response. Your response will be considered confidential.

Tick appropriately where required.

Part I: General information

1. Questionnaire N0. _____
2. GPS longitude _____ latitude_____
3. Name of company _____ Telephone Number_____
4. Type of institution:

Government [ ] Private co. [ ] NGO [ ] International Informal business [ ] other …….

5. What is number of employees? _____
6. Interviewee name:_____

   Position:_____
7. Gender: Female [ ] Male [ ]

Part II: The e-waste management

1. a) Are you dealing with electronic equipment namely; computers[ ] Printers[ ] photocopier[]fixed lines[ ] mobile phones[ ] calculators[ ] public address system[ ] radios[ ] TV sets[ ]cameras[ ] watches[ ], refrigerators[ ], microwaves[ ] and electric heating appliances[ ]

b) If, Yes list them:

_____

2. What type of electronic equipment business are you doing? Importer Supplier [ ] Assembler Distributor [ ] Individual Repairer[] Collector Refurbisher [ ] Recycler Downstream vendor [ ]

   Final disposer vendor [ ] Other (Specify) ……

3. a.) How many years have you handled these electronic equipment for the past 20 years?

Less than 5 [ ] 6 – 10 [ ] 11 – 15 [ ] 16 – 20 [ ] over 20 [ ]

4. Do you have an e-waste training program?

Completely unavailable [ ] unavailable [ ] averagely available [ ] available [ ]

Completely available [ ]

5. What percentage of your imported or assembled equipment is second hand?

Less than 10% [ ] 10-20% [ ] 20-30% [ ] 30-40% [ ] 40-50% [ ] Over 50% [ ]

6. How do you distribute your electronic equipment?

Sell directly to customers [ ] Appointed distributors [ ] Sell directly to retail outlet chains [ ]

Sell to recyclers [ ] others, specify_____

7. How many retail outlets sell your electronic equipment in Nairobi/Nyamira?

Less than10 [ ] 11 – 20 [ ] 21 – 30 [ ] 31 – 40 [ ] 41 – 50 [ ] over 50 [ ]

8. What is in your own view the proportion of the second hand e- equipment in the Kenyan market?

Less than 10% [ ] 10 - 20% [ ] 20 - 30% [ ] 30 - 40% [ ] 40 - 50% [ ] Over 50% [ ]

9. Are you able to separate electronic waste from solid waste before disposal?

Completely unable [ ] Unable [ ] Not sure [ ] Able [ ] completely able [ ]

10. What methods do you use to handle the electronic wastes?

Keeping in the house [ ] Burning [ ] Dust bin/ Rubbish pit [ ] Sell [ ] other (specify)……

11. How is the actual e-waste collected?

Pick-up of e-waste from door to door [ ] Have a common collection point [ ]

Pick from garbage disposal gardens [ ] Send municipal collection Lorries [ ]

Others, specify_____

12. Under what financial arrangements do you collect e-waste?

Consumer pays for collection of e-waste [ ] Purchaser pays for the collection e-waste [ ] others _____

13. Are you aware of any modern technology of electronic waste handling?

Completely unaware [ ] Unaware [] Not sure [ ] Aware [ ] completely aware [ ]

14. a). In your own view, does Kenya have an infrastructure for hazardous waste disposal? Yes[] No[]

b).If yes how available is the infrastructure?

Completely unavailable [ ] unavailable [ ] averagely available [ ]

Available [ ] completely available [ ]

15. Who is responsible for managing the dumping sites in your area?

Community [ ] Council [ ] NGOs [ ] Nobody [ ] Government [ ] Institutions [ ]

16. a.) From where do you get the equipment?

E-waste collectors [ ] Hardware shops [ ] E-waste recycler [ ] E-waste refurbisher [ ]

Dumping site [ ] others, (specify) _____

b.) After collecting the e-waste, what do you do with it?

Dismantle and sell as parts [ ] Repair and sell as 2nd hand (recycle) [ ]

Deposit to a refurbishing firm [ ] others,

specify_____

17. How do you use the parts/fractions?

Repair broken equipment [ ] Sell them as parts [ ] Make new products [ ] others,

_____

18. Where do you dispose the material?

Dump sites [ ] Throw away with normal waste [ ] Open burning [ ] others,

specify_____

19. Have you/your workers undergone any training on e- waste collection and management?

None [ ] One [ ] A few [ ] Many [ ]

20. Are Mask and other protective gadgets available to your workers?

Completely unavailable [ ] Unavailable [ ] averagely available [ ]

Available [ ] completely available [ ]

21. a.) Are you aware of the positive effects of e-waste?

Completely unaware [ ] unaware [ ] averagely aware [ ] Aware [ ] completely aware [ ]

b.) If aware on average, how much money do you make per month from E-waste collection?

Less than 15000 [ ] 15100 – 30000 [ ] 30100 – 50000 [ ] 50,100 – 100000 [ ] Over 100,000 [ ]

22. What is in your own view the main obstacle to proper recycling of electric and electronic equipment in Kenya?

Costs [ ] Lack of infrastructure and/or policy within your company [ ]
Absence of recycling possibilities [ ] Lack of legislation [ ] other, specify

_____

23. Are there better ways through which the electronic wastes handling can be managed?

Very unconvinced [ ] unconvinced [ ] averagely convinced [ ] convinced [ ] Very convinced [ ]

24. What are these ways that can improve the electronic wastes handling?……

Appendix 4: Semi-structured questionnaire for policy and regulatory bodies on e–waste handling

I am an MSC student at JKUAT doing a research on e-waste and therefore the answers you provide shall be treated with the confidence they deserve.

The semi-structured interview questionnaire will be used to determine the e waste handling in Kenya Please take a few minutes of your time to give some highlights concerning your institution in regard to e-waste handling in Kenya.

Your response will be considered confidential.

Part I: General information

1. Questionnaire N0. _____
2. GPS longitude _____Latitude_____
3. Name of institution _____ Mobile/Telephone Number_____
4. Type of institution:

Government [ ] Private [ ] NGO [ ] International Informal business [ ] FBO [ ] other specify_____

5. For how long has the institution been in operation?

Less than 10 [ ] 10-20 [ ] 21-30 [ ] 31-40 [ ] 41-50 [ ] Above 51 [ ]

6. Interviewee's name:_____

   Position:_____

7. Gender: Female [ ] Male [ ]

Part II e-waste management

1. What is the mandate of your institution?
2. Describe the e-waste state in Kenya for the last 20 years
3. On average how many metric tons of e-waste are disposed per year for the last 20 years?
4. What is the geographical e-waste distribution in Kenya?
5. What is the general understanding of the process of managing e-waste?
6. What methods that are used in e-waste management?
7. Are there Modern material handling equipment for e-waste?
8. Who are the main players of e-waste in Kenya?
9. What are the negative and positive effects of e-waste to Kenyans?
10. What are some of the opportunities of e-waste?
11. What actions are being taken to benefit from the opportunities (if any) and minimize the negative effects (if any)?
12. In your view, does Kenya have an infrastructure for hazardous waste disposal?
13. Do you have e-waste management policy in the ministry/institution? If there is provide a copy for the policy
14. If no, why is there no e-waste policy and do you see a need for one?
15. Which Ministry/institution should be tasked with the responsibility of coming up with a national e-waste policy
16. What key issues should the national e-waste policy take into consideration?
17. Is there a training program on e-waste management in Kenya
18. What is your general view of e-waste management in Kenya?

Appendix 5: The Questionnaire for Institutions and Companies

Structured questionnaire for policy and regulatory bodies on e–waste handling

I am an MSC student at JKUAT doing a research on e-waste and therefore the answers you provide shall be treated with the confidence they deserve.

Name of the enumerator----------

The structured interview questionnaire will be used to determine the e waste handling in Kenya Please take a few minutes of your time to give some highlights concerning your institution in regard to e-waste handling.

Name of the respondent----------

Your response will be considered confidential.

Part I: General information

A. **Name of the institution/company**…….....
.....
……
……
……
……

B. contacts(Postal address/ e-mail, /telephone number)……
……
……
……..

C. GPS: latitude…….
Longitude……
…….

D. **Type of institution/company** (please tick appropriately below)

1. Government ministry ( ) 2. Parastatal ( ) 3.Local authority ( ) 4.Learninig institutions ( )

5. Non- governmental organizations ( ) 6. Public company ( ) 7.Private companies ( ) 8. Other ( )

E. what electronic equipment do you use?, tick appropriately

1 computers ( ) 2 mobile phones ( ) 3 fixed lines ( )

F. **What was the method(s) of acquiring those equipment (s)**? …. *tick appropriately below.*

1. Retail shop ( ) 2. Imports ( ) 3. Wholesalers ( ) 4 donations ( ) 5.others ( )

G. How many of these equipment do you have? …. *Indicate in the brackets below.*

1. Computers (……...) 2. Mobile phones (…….....) 3. Fixed lines (……)

H. **For how long have you used this equipment(s) below**? *Use the scale provided below to answer the questions.*

(1)-Less than 1 year. (2). 2- 4 years. (3). 5 -10 years. (4).10 – 20 years. (5). Over 20 year.

1. Computers (…….) 2. Mobile phones (……) 3. Fixed lines (……..…)

I. Of the equipment ticked above how many have become obsolete / out of use?

1. Computers (…….) 2. Mobile phones (……) 3. Fixed lines (.....)

J. **Of the equipment ticked above what was the reason for obsoleteness…** *Use the options provided below to answer the question.*

1. Wearing out 2. Malfunctioning/breaking down/obsolete 3. Change of policy 4 .others

1. Computers (….) 2. mobile phones (…) 3. Fixed lines (…)

K. **How did you dispose the obsolete equipment?** *Use the answers provided below to answer the question.* 1. Waste bins 2 .keeping in the store 3. Burning 4.selling 5. recycling

1. Computers (….) 2. mobile phones (…) 3. Fixed lines (……)

Part c

A. **In your own view does your institution/company have a policy of handling e-waste?**

1. Yes ( ) 2. No ( )

B. **If yes, is there an infrastructure for implementing this policy?**

1. Yes ( ) 2. No ( )

C. **How adequate is the infrastructure for e-waste handling?**

1. Completely adequate ( ) 2. Adequate ( ) 3.Averagely adequate ( ) 4.Least adequate ( )

5. Not adequate ( )

D. **What does the policy entail as far as e-waste handling is concerned?**

1 .equipment re-use ( ) 2. Disposal –landfills ( ) 3. Recycling ( ) 4. Others ( )

E. **Does your institution have an e–waste training program?**

1 .yes ( ) 2. No ( )

F. **If yes, who is involved in training?**

1. Internal staff ( ) 2. Employees from other companies ( ) 3. Students ( ) 4. Others ( )

Q. **Is there an accredited institutional body which monitors the training of your employees on e-waste management?**

1. yes ( ) 2. NO ( )

PUBLICATIONS

1. We were involved in a Sustainable Research and Innovation(SRI) Conference and we presented Environmental and health effects of e-waste which was held Wednesday 24th to Friday 26th April 2013, Conference Venue: AICAD, JKUAT.2. Then the presentation was published under: J. N. Omari1, U. N. Mutwiwa2 and J. T. Mailutha3 The current status and handling of E-waste in Kenya: A case study of Nairobi County was submitted to the School of Mechanical, Materials and Manufacturing Engineering for publication with their journal of Sustainable Research in Engineering (JSRE).It is in the process of publication**.**
2. The current status and handling of E-waste in Kenya: A case study of Nairobi County was submitted to the School of Mechanical, Materials and Manufacturing Engineering for publication with their journal of Sustainable Research in Engineering (JSRE).It was accepted and is on the process of publication**.**
3.