ASSESSING THE SUSTAINABILITY OF E-WASTE MANAGEMENT IN KISUMU CITY, KENYA

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any university or any other award

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DEDICATION

I dedicate this research work to my father Mr. Philip Okuna Amolo and mother Mrs. Margret Okuna who have instilled a culture of smart work and consistency in the quest for knowledge and expansion of opportunities for survival in the ever competitive life market.

ABSTRACT

The increased use of electronic gadgets has proportionately increased the accumulation of e-waste. In Kenya, a 200% rise was recorded in 2007 compared to 2005. E-waste is hazardous to the environment and health if not properly managed due to toxic substances contained in them. Currently, E waste in Kisumu is informally managed and it is not known whether the informal management of e-waste is sustainable. The purpose of this study was to evaluate e-waste management in Kisumu. The main objective of the study was to assess sustainability of e-waste management in Kisumu City. The specific objectives were: to assess the sources of e-waste; to assess the role of stakeholders in e-waste management; to establish management systems of 3R and to assess public awareness on sustainability of e-waste management. The research was carried out in Kisumu City using a cross-sectional study design. The sample size was 425 respondents out of a population of 148,494 households randomly sampled. Qualitative and quantitative data was collected through questionnaires, interviews, Focus Group Discussions and observation and subjected to descriptive analysis at a significance level of 0.05. Qualitative analysis involved thematic clustering and triangulation of results to other findings. The study concludes that the current e-waste management is not sustainable because: there is no monitoring of the volumes of e-waste generated making it difficult to plan for its disposal, there is a high turnover of e waste since 78% of the respondents purchased electronic equipment every 5 years without a corresponding mechanism for reducing, recycling and reusing, the current level of stakeholder awareness on e-waste management is not adequate, policy formulation and enforcement by relevant government ministries remains weak and investors and NGOs are unwilling to invest in this area due to expensive capital infrastructure and technology inadequacy. The study recommends that NEMA e-waste management guideline 2010 should be enforced to ensure proper reduce, reuse, recycling and disposal besides amendments to Public Health Act (1962), Urban Areas and Cities Act No.13 of 2011 (Cap. 265) to comply with the NEMA guideline. MIC should enforce their requirement for Extended Producer Responsibility on ICT Actors. The relevant ministries and the civil society need to create awareness of e-waste and its safe handling. NEMA and the County Government should offer incentives to interested investors. KEBS should train expertise in forensic audit of hazardous components included in electronic equipments and discourage importation of such substances.

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LIST OF ABBREVIATION AND ACRONYMS

CBOs	: Community Based Organizations
CCK	: Communications Commission of Kenya
CVI	: Content Validity Index
EMCA	: Environmental Management and Coordination Act
ICT	: Information Communication and Technology
KARA	: Kenya Alliance of Resident Associations
KEBS	: Kenya Bureau of Standards
KCC	: Kisumu City Council
KRA	: Kenya Revenue Authority
NEMA	: National Environmental Management Authority
NGOs	: Non-Governmental organizations
MENR	: Ministry of Environment and Natural Resources
MIC	: Ministry of Information and Communication
MLG	: Ministry of Local Government
MPHS	: Ministry of Public Health and Sanitation
OECD	: Organization for Economic Cooperation and Development
PCs	: Personal Computers
SANA	: Sustainable Aid in Africa
UNEP	: United Nations Environmental Programme

OPERATIONAL DEFINITION OF TERMS

Awareness: having adequate information on formal systems of e-waste management, opportunities and hazards to human health and environment

Incineration: A controlled and complete combustion process, in which the waste material is burned at a high temperature (900-1000^{o}C)

E-Waste: Electronic equipments that are considered to be hazardous and do not in their functional state serve any purpose to any intending user unless refurbished e.g. Large and Small household appliances, IT and telecommunications equipment, Medical devices, Toys, leisure and sports equipment, Light equipment, Electrical and electronic tools

Sustainable management: Is management that ensures reduction, recycling and reuse of E-waste streams in eco-efficient manner through stakeholder responsibility

Recycling: Is the processing of used materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, energy usage, and air and water pollution by reducing the need for "conventional" waste disposal

Re-use: A method of waste control constitutes direct second hand use or use after slight modifications to the original functioning equipment

Land-filling: the covering of waste materials with thick layer of soil in trenches made on flat surfaces

Stakeholders: Are all groups and individuals who have a stake, an interest, in the waste management system in a certain area

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CHAPTER ONE
INTRODUCTION

1.1 Background of the study

The growth in electronic equipment production and consumption has been exponential in the last two decades due to urbanization and the growing demand for consumer goods in different regions of the world (Babu *et al.*, 2007); eventually leading to increased volume of e-waste. Financial constraints on acquiring ICT materials in developing regions has led to consumption of second hand products (Nnorom & Odjango, (2007)) besides internal generation or illegal importation of used goods in an attempt to bridge the digital divide.

About 20 to 50 million tones of electronic waste ("e-waste") are generated worldwide every year, much of which has been transported to the developing nations (UNEP 2010). In 2007, Kenya, Morocco and Senegal discarded approximately 17,500 tones of IT e-waste (Hewlett-Packard 2009). South Africa generates 100,000 tons annually (Lombard 2004). In Kenya the total e-waste generated from computers, monitors and printers is about 3,000 tons per year (Mureithi *et al.,* 2008) and likely to increase dramatically as the importation and use of computers increases; a 200% rise was recorded in 2007 (Hewlett-Packard 2009). The e-waste concept came to light as far back as in the 1970s and 1980s following environmental degradation that resulted from hazardous waste imported into developing countries (Shinkuma & Huong, 2009). The Basel Convention on the control of trans-boundary movements of hazardous wastes and their disposal was instituted in 1992 to control the situation. Although "the Basel Convention does not regulate secondhand items and some e-waste scrap" (Shinkuma & Huong, 2009), it has played a role in banning exportation of obsolete products and engineering waste solutions.

E-waste contains toxic substances and creates serious risks to human health and the environment if not handled properly (Chatterjee, 2008; Li *et al.*, 2008). In the e-waste recycling regions, the improvement of disposal systems is the most cost-effective method to reach the objectives of solid-waste management (Brunner & Fellner, 2007) and calls for proper processing and management methods and enactment of timely regulatory and legislative policies. Current technologies are not particularly cost-effective in many developing countries; and many aspects

of recycling depend on informal recycling (Babu *et al.*, 2007). Public awareness of the health and environmental threat posed by e-waste is minimal due to failure to provide up-to-date information by the relevant authorities (Brunner & Fellner, 2007). To best protect public health and the environment, policy makers of all developed and developing nations must be willing to fundamentally redesign the approach to e-waste management (Babu *et al.*, 2007). The absence of a policy and legislative framework and a practical management system, means that much e-waste remains in storage or recycled/disposed of in an unsafe and unsustainable manner putting both the recycler and local population at risk (Hewlett-Packard, 2009). Extended Producer Responsibility (EPR) as a policy strategy was first proposed by Thomas Lindhqvist in 1988 for a shared responsibility among relevant stakeholders across the product life cycle (Lifset & Lindhqvist, (2002); Lindhqvist, 2000) and is currently being implemented by Nokia Ltd in Kenya as "a take-back strategy" (Nokia, 2010). National and local governments ensure effective EPR programmes by raising awareness of programme requirements and establishing mechanisms to help prevent free riding and anti-competitive behavior (OECD, 2001).

The first Medium Term Plan (2008-2012) of Vision 2030 stating the government's commitment to improve ICT infrastructure as a foundation for a knowledge economy further raises an alarm because to bridge the digital gap there will occur exponential importation of ICT and Telecommunication equipments which will eventually turn into e-waste but the existing legislative Acts and by-laws do not recognize e-waste in specific and the e-waste management systems are informal. Capacity constraints hindering the disposal of e-waste as well as the collection system and recycling infrastructure are the major challenges facing all the East Africa nations. In Kenya a huge quantity of e-waste is handled by the informal (jua kali) sector. In addition, many developing countries have been caught up in the web of global e-waste dumping (Waema & Muriuki, 2008). The major source of e-waste is the disposal of the hardware and electronic items from Government offices, public and private sectors, academic and research institutes and Household consumers (Chatterjee and Krishna, 2009). Many of these products can however be refurbished, reused, or recycled in an environmentally sound manner so that they are less harmful to the ecosystem and public health i.e. to reduce leaching, radiations and emission of toxic gases (William, 2010).

The generation of solid waste in Kisumu is on the increase due to the rising population and high rates of resource consumption while the handling capacity of the council has been exceeded (KARA, SANA & Ilishe Trust, 2007); the legal framework and the Municipal Council By-laws of 2008 on solid waste management, is held captive by inadequate capacity of the county council resulting in illegal dumping on road reserves (Obera & Oyier, 2002). The dumpsite at Kachok on the Kisumu-Ahero Road, 2 km from the town centre, receives unsorted solid waste mixed with toxic e-waste (Carl Bro Report, 2001; Ecoforum, 2001; World Bank, 1995). People from nearby informal settlements use the dumpsite as a source of income, oblivious of the harmful fumes from waste burning and methane fires in it. Only 17% of households in Kisumu have access to private collection and 47% by county council while the rest are just disposed off roadsides (KARA, SANA & Ilishe Trust, 2007).

In general the consumption of secondhand, cloned and refurbished electronic equipments has led to the generation of e-waste even though locally recording has not been done to track the quantities generated per source. On policy issues, Despite NEMA's development of e-waste management policy guidelines in 2010, the relevant ministries have not amended the necessary Acts and by-laws to comply with the policy guideline i.e. EMCA (1999); Articles 42; 60-70 of the new Constitution; Urban Areas and Cities Act No.13 of 2011 (Cap. 265) and the 2008 city by-laws and Public Health Act (1962) do not specifically address e-waste management since it's a recent phenomenon even though currently the council is considering drafting specific by-laws and also engage in public-private partnership. The inexistence of recycling facilities and the unwilling nature of NGOs and the private sector to cooperate with the City Authority in recycling of e-waste due to the huge capital and technology requirements has left the authorities in a limbo.

1.2 Statement of the Problem

The increased use of electronic gadgets has proportionately increased the accumulation of e-waste i.e. In Kenya, a 200% rise was recorded in 2007 compared to 2005 (Hewlett-Packard 2009). E-waste is hazardous to the environment and health due to toxic substances contained in them that can leach into the soil and underground water, produce dangerous radiations and toxic gases if not properly managed. E waste is Informally managed and it's not known whether the

informal management of e-waste is sustainable. There do not exist recorded information on the quantities of e-waste generated by various sources such as brand new, secondhand, cloned, and refurbished equipments. Despite NEMA's development of e-waste management policy guidelines in 2010, the relevant ministries have not amended the necessary Acts and by-laws to comply with the policy guideline i.e. EMCA (1999); Articles 42; 60-70 of the new Constitution; Urban Areas and Cities Act No.13 of 2011 (Cap. 265) and the 2008 city by-laws and Public Health Act (1962) do not specifically address e-waste management except for CCK requirement of license applicants to demonstrate their readiness to minimize the effects of their ICT infrastructure on environment. The Extended Producer Responsibility has not been expedited across stakeholders. The problem is further compounded by the limited consumer awareness on e-waste dangers and opportunities; incapacitated municipal council infrastructure; uninventorized waste flow from sources; informal recycling and the uncoordinated stakeholders' roles.

1.3 The Study Objective

To assess the sustainability of e-waste management in Kisumu City

1.3.1 Specific Objectives

1. To assess the sources of e-waste in Kisumu City
2. To assess awareness on sustainable e-waste management in Kisumu city
3. To assess the role of stakeholders on e-waste management in Kisumu city
4. To analyze the management systems of reduction, reuse and recycling on e-waste

1.3.2 Research Questions

1. What are the sources of e-waste in Kisumu city?
2. What is the level of awareness on sustainable e-waste management?
3. What are the stakeholders' roles on e-waste management?
4. How are the management systems of reduction, reuse and recycling of e-waste sustainable?

1.4 Significance of the Study

The study aimed to contribute valuable knowledge on sustainable e-waste management policy formulation for a healthy environment in general. It focused on sources of e-waste, public awareness, role of stakeholders and existing systems of e-waste management. At policy level, the Public Health Act (1962); Urban Areas and Cities Act No.13 of 2011 (cap. 265); EMCA (1999); Municipal Council by-laws 2008 and Articles 42; 60-70 of the new Constitution do not address e-waste in specific and generalizes it as solid waste while NEMA (2010) e-waste management policy guideline developed is not being enforced. Policy amendments in these areas will ensure formal handling of e-waste because every stakeholder will be held accountable after the ratification of the Acts. The study therefore endeavored to highlight e-waste sources that would aid in tracking e-waste flow by indicating the quantity of waste generated by each source, be it brand new, secondhand, cloned or refurbished products; mechanisms of creating public awareness on sustainable e-waste management; coordinate stakeholders in the management of e-waste in terms of policies and regulations and; establish appropriate formal systems of e-waste management practices that observe reduction, reuse, recycling through enforcement of Extended Producer Responsibility. Formal e-waste management would ensure recovery of valuable resources such as gold, silver and aluminum; employment creation both formal and informal; revenue generation to the local authorities through taxation of registered recyclers and refurbishers and improved health and environment. The study also provides a reference and vital information to the databank on sustainable e-waste management for other researchers and development agencies interested on the issue. This research provides an insight into the dynamics of e-waste management in Kisumu.

1.5 Scope of the Study

The study on sustainability of e-waste management was done in Kisumu city in Nyalenda A&B, Manyatta A&B, Milimani, Migosi, Industrial Area and CBD. Kisumu was chosen due to its urbanized population that uses electronic appliances on a daily basis which eventually results in e-waste accumulation. The research involved various stakeholders drawn from relevant government ministries, private sector and the household consumers. E-waste in this context constituted ICT and telecom equipments; office electronics; large and small household appliances; consumer equipments; toys, leisure's and sports equipments; lighting equipments; medical equipments; automatic dispensers; monitoring and control equipments and batteries.

CHAPTER TWO
LITERATURE REVIEW

2.0 Introduction

This chapter presents literature analysis from various authors on e-waste management: encompassing e-waste sources; public awareness; management systems and stakeholders role. Sustainable waste management aims to address issues of recovery, recycling and reuse of resources and the reduction of waste streams (UNEP, 2000). Integrated Sustainable Waste Management (ISWM) recognizes three important dimensions in waste management: (1) stakeholders, (2) waste system elements and (3) sustainability aspects.

2.1 Sources of e-waste

Globally e-waste has been escalating rapidly with the rise of the information society. E-waste equals 1% of solid waste on average in developed countries and is expected to grow to 2% by 2010 while in developing countries, e-waste range from 0.01% to 1% (Kleine & Unwin, (2009)). Life style in developing countries especially in India has changed considerably due to the advent of technology revolution on electronic gadgets and the existence of large consumer base. Europe and United States exports around 22% and 50-80% of their e-waste respectively illegally to developing nations (China and India) for disposal due to cheap labor, absence of law to prevent toxic import and the export practices are accepted legally in the country which exports the waste (http://www.ban.org). E-waste is both valuable as source of secondary raw material and toxic if discarded improperly (Hayford & Lynch, (2003)). E-waste in European society is generated from the purchase of more products as a result of higher living standards and technology advances; single-person households which tend to produce more waste than families and products designed to have short lifespan (Schluep *et al.,* 2008).

The potential levels of e-waste in South Africa are affected by importing new/refurbished or second-hand gadgets into the country and e-waste imports from other African countries for recycling (Lombard, 2004); South Africa also exports a substantial amount of recycled electronic waste in a refined or raw form to Europe and Asia. East Africa nations import cheap, low quality and short lifespan ICT products from China (Yoon & Jang, 2006). In Kenya the advance development of information technology, change of life style and the growing consumer demand

for newer electronic products have resulted in significant amounts of obsolete electronic devices (Yoon & Jang 2006). Difficulty in acquiring ICT materials in developing regions has led to consumption of second hand products (Kleine & Unwin, (2009); Hayford & Lynch, (2003)) with short lifespan e.g. 50% of Kenya's PC market is second hand; 60% of equipment given to beneficiaries is beyond refurbishing when it is donated and should be recycled (Schluep *et al.*, 2008). Nnorom & Odjango (2007) suggest that e-waste is "internally generated or imported illegally as used goods in an attempt to bridge the digital divide". Government offices, public and private sectors, academic and research institutes and Household consumers all generate e-waste (Chatterjee & Krishna, 2009). E-waste in Kenya consists of large and small household appliances, IT and telecommunications equipment, medical devices, toys, leisure and sports equipment, light equipment, electrical and electronic tools (Mureithi *et al.,* 2008).

The key driver to the rapid generation of e-waste in Kenya is policy failure particularly with respect to importation of used electronic equipment (Waema & Muriuki, 2008). The first Medium Term Plan (2008-2012) of Vision 2030 that requires government's commitment to migrate from analog to digital broadcast and improve ICT infrastructure if not well managed will lead to rapid e-waste generation. There have been incidents of electrical goods earmarked for transit ending up in the country due to corruption (Mureithi *et al.*, 2008) which eventually adds into the waste stream within short time span. There have also been incidents of deliberate mislabeling of containers to conceal the true identity of goods leading to substandard electronic products finding their way into the local market (Waema & Muriuki, 2008). Locally, the data on e-waste sources are poor and insufficient, limiting our understanding of the issues and therefore solutions (Hewlett-Packard, 2009).

2.2 Awareness on e-waste management

To realize tangible progress in e-waste management, public awareness on effects and e-waste management system is paramount. Waema & Muriuki (2008) recommended awareness creation and training programmes development and implementation at consumer level. Globally, the data on e-waste are poor and insufficient, limiting our understanding of the issues and therefore solutions (Hewlett-Packard 2009). Given the very limited data on amounts of e-waste collected and treated through "official" e-waste channels, it is clear that the recycling of significant

proportions of e-waste currently goes unreported in different parts of the world (Hewlett-Packard, 2009).

The lack of awareness that recycling is even possible and knowledge on existing recycling programs and locations are the main obstacles for consumers (Liu, 2009) and this shows why globally only 10% of people have recycled their old mobile phones while the rest are in stores at home. In the United States, increased awareness on e-waste potential dangers to human health and the environment has led to increased efforts to divert e-waste from landfill disposal (Brunner & Fellner, 2007). Awareness of the e-waste risks in European Union has led to calls for legislation of "Directive on Waste from Electrical and Electronic Equipment (WEEE Directive)" and "Directive on Restriction of the use of certain Hazardous Substances (RoHS) in electrical and electronic equipment", (OECD, 2001). In Korea despite enacting regulations such as "Waste Management Act" and "Act on the Promotion of Saving and Recycling of Resources" (Lifset & Lindhqvist (2002)); information on handling and disposal of e-waste remain limited, resulting into mixed solid waste disposed of in municipal landfill sites and incineration facilities.

E-waste is receiving a relatively high priority in South Africa at the moment (Lombard, 2004), and there are good management and monitoring systems governing waste streams. Some waste practitioners, such as Lombard (2004) see e-waste as an opportunity to significantly scale up local refurbishment processes and a way of developing effective recycling industry offering opportunity for socio-economic development. East Africa countries are aware of the e-waste implications and are signatories to multilateral environment agreements (Basel, Bamako conventions) but these agreements have so far had little impact on overcoming the problem at a national level (Waema & Muriuki, 2008).

In Kisumu awareness and information on dangers of e-waste has not been documented (Mang'eli, 2010) due to failure to provide up-to-date and accurate, environmental information to communities to enable them to effectively participate in decision making despite improvements in waste legislation (Ecroignard, 2005). Active engagement of communities can help engender local 'ownership' of schemes enhancing participation (Petts, 2001; Watson & Bulkeley, 2005a). To increase awareness of waste reduction and encourage changes in society, government needs

to carefully consider the appropriate forms of intervention like environmental activism and participatory engagement and media information dissemination i.e. moving beyond surface responses to the issues: small scale, local and intensive schemes with a high degree of community ownership in reduction, re-use, recycle and proper disposal (Waema & Muriuki, 2008). Consumers and policy makers think e-waste is a distant issue (Waema and Muriuki, 2008); hence there is need to sensitize the public on the negative effects of e-waste on health and environment (Liu 2009) and opportunities on recoverable valuable secondary materials and other social-economic gains (Waema & Muriuki, 2008).

2.3 Roles of stakeholders on e-waste management

Stakeholders are groups and individuals who have a stake, an interest, in the waste management system in an area (Streicher-porte *et al.,* 2005). Three groups are usually defined as having a stake in waste management: the community, public and private sectors (Wang & Chou, (2009)). To better understand the stakeholder responsibilities in this context it's wise to understand the underlying issues such as legislative and policy frameworks, administrative responsibility such as Extended Producer Responsibility, technical and financial support at global, regional, national and local areas.

In 2003 European Union implemented two directives i.e., Directive 2002/96/EC on WEEE and Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (Peralta & Fontanos, 2005). The directives enforce an extended producer responsibility system and encourage reuse, recycling and recovery, and minimizing the environmental impact of e-waste. In addition, EU uses the concept of QWERTY/EE (Quotes for environmentally Weighted Recyclability and Eco-Efficiency) to improve environmental performance of end-of-life products ((Streicher-porte *et al.,* 2005). Europe favors manufacturer-operated take-back systems (Dempsey *et al.,* 2010); however despite all legislative efforts in many developed countries these laws often lack effective implementation. In China, regulations that specifically deal with e-waste are in implementation e.g. the Management Measures for the Prevention of Pollution from Electronic Products regulation that aims at prohibiting the environmentally adverse processing of e-waste and reducing utilization of hazardous and toxic substances in electronic appliances (Shinkuma & Huong, (2009)); In respect to the local

government, they have entirely banned any form of e-waste imports into China from 2000. Similar legislation is active in other developed countries such as Japan, where the Specified Home Appliance Recycling (SHAR) Law holds electronics manufacturers responsible for recycling their products (OEDC, 2010). Currently, there is no federal level legislation in the USA, while state level action has recently gained momentum. State-operated take-back appears to be favored in Taiwan and China and some states in the USA (Shinkuma & Huong, 2009).

South Africa currently does not have any dedicated legislation dealing with e-waste and lacks cooperation between national and provincial government since both share the constitutional power over pollution control (http://ewasteguide.info). In the East Africa community governments discourage old imports and are working with NGOs to introduce recycling and a take back policy; are signatories to international conventions and protocols that tackle environmental issues (Basel and Bamako) (Wang & Chou, 2009). In Kenya Section 3(1) of Environmental Management and Coordination Act EMCA (1999) and Articles 42; 60-70 of the new Constitution entitles every person to a clean and healthy environment and to safeguard and enhance the environment (Waema and Muriuki, 2008). Kenya subscribes to the Basel Convention to avoid unwittingly becoming an importer of e-waste. Shinkuma & Huong (2009) found that there was no specific government policy on e-waste management except for CCK requirement of applicants to demonstrate their readiness to minimize the effects of their ICT infrastructure on environment, as a prerequisite for grant or renewal of license in ICT sector; But on further analysis its realized that NEMA had developed an e-waste management policy guideline in 2010 which entails collection, sorting, classification, transportation, recycling to disposal (remains dormant).

Some manufacturers for instance Sony Ericsson, Nokia, LG and associated suppliers and service providers are implementing take-back schemes (Waema and Muriuki, 2008). When the Safaricom scheme became operational (2007-2008), it only took back its own obsolete appliances and the scheme has stalled in recent years but is being revitalized (Shinkuma & Huong, 2009). In 2008 the National Environment Management Authority (NEMA) signed a memorandum of understanding with Computer for Schools Kenya (CFSK) which set up a recycling plant in Nairobi which is a good step towards e-waste reduction (Waema and Muriuki,

2008); but currently it's not working. This if properly implemented will generate opportunities such as employment for both the formal and informal workers involved in the recycling process, generate revenue to the government, ensure economic development through extraction of valuable metals such as gold and silver and reduction of toxic substances; and to a greater extent aid in urban poverty reduction.

The involvement of local communities in planning and implementation can play a range of roles (Moreno et al., 1999; Anschutz, 1996) which can lead to more responsible behavior, increased environmental awareness, and a higher willingness to pay among users of a waste management system thus empowering underprivileged groups in waste management system (Cunningham & Cunningham, (2002)). Actors like community-based organizations (CBOs), non-governmental organizations (NGOs), research institutes and universities should be strengthened to support communities and the informal sector by providing them with training, advocacy, research, technical or financial assistance (Moreno *et al*., 1999; Anschutz, 1996). Local governments can create room for local communities and the informal sector by changing legislation and recognizing them as candidates for service contracts (Cunningham & Cunningham, 2002). Besides this, the participation of communities and micro- and small-scale enterprises can generate income and employment in low-income urban areas and thus contribute to the alleviation of urban poverty (Lardinois, 1996). To involve all these groups and to address the constraints they face requires a change in the attitudes of governments (Moreno *et al*., 1999); and decisions about waste management options should take local resource constraints and concentrate on what is possible in the given context (Davoudi, 2000; Gandy, 1994). Consumers have responsibilities including Critical Awareness and Maintaining a Healthy and Sustainable Environment i.e. a responsibility to buy smart, use right, and manage well and dispose well (Shinkuma & Huong, 2009).

2.4 Systems of e-waste management

Key strategies for sustainability include radical improvements in eco-efficiency, eliminating waste and dematerialization (Gertsakis & Lewis, (2003); Tibbs, 1999). Rather than regarding ‘rubbish’ as a homogenous mass that should be buried, Schall (1992) argued that it was made up of different materials that should be treated differently i.e. reduced, reused, recycled, burnt and

buried. The concepts of waste management hierarchy of popularly 3R (reduce, reuse and recycle) is the basic requirement for sustainability in waste management (Smith & Scott, (2005); Gertsakis & Lewis (2003)). A study by Greenpeace in 2008 estimated that, 25% and 20% of the e-waste is recycled safely in Europe and USA respectively while China and India which have the biggest population in the world have 95% informal recycling sectors (Liu, 2009).

Today, land filling remains the most widely used waste disposal option (70% Solid Waste Management) across the European Union but recent changes to the landfill directive in Europe have restricted the types of waste that will be accepted at landfills i.e. landfill are required to have liners and leachate treatment systems. Incineration emissions legislation (Directive 200/76/EC) and the ever-present stigma attached to incineration plants have limited their introduction in most of Europe to industrial centres. However, locally, state-of-the-art facilities have gained public acceptance; and has provided heat recovery (Copenhagen) (Greenpeace, 2008). In Italy there is significant public concern over incineration as poorly managed incinerators have lead to smoke and ash deposits on surfaces of nearby habitations. Following reported health effects and public pressure, since 1995, dirty incineration technologies in the United States, Germany and Japan have been rapidly phased out but Incinerator manufacturers (US government) are pushing their deadly wares into Africa under the guise of "technology transfers", taking advantage of the less stringent health and environmental regulations in the region (Smith & Scott, 2005). The e-waste recycling and disposal methods in India, China and Pakistan pollute the environment as they do open burning.

In South Africa formal recyclers process approximately 20% while the rest is stored by the owner, recycled informally, added to the domestic waste stream or dumped illegally. There is no specific legislation to deal with e-waste in South Africa, although a National Environmental Management Waste Bill was passed in 2009 to deal with issues such as hazardous waste and to introduce measures such as extended producer responsibility (Chatterjee & Krishna, 2009). Nigeria has neither a well-established system for separation, storage, collection, transportation, and disposal of waste nor the effective enforcement of regulations relating to hazardous waste management (Liu, 2009). As a result electronic wastes are managed through various low-end

management alternatives such as disposal in open dumps, backyard recycling and disposal into surface water bodies.

Infrastructure of e-waste recycling is not well-established in Kenya (Smith & Scott, 2005). Due to high costs of recycling and lack of consumer incentives, only a very small fraction of e-waste are being refurbished and resold to consumers or recycled (Smith & Scott, 2005). E-waste collection activities by local governments are still limited because e-waste is commonly viewed as a potentially valuable resource by consumers but in recent years, take-back programs by cellular phone producers and retailers have begun (2007-2008) but have stalled in recent past (Nokia, 2010). The solid waste management scenario in Kisumu is a big challenge. A system of solid waste segregation at household level is lacking and subsequent waste collection rates are low. Several methods of waste disposal are widely used in Kisumu municipality: open dumping, open burning and incineration of medical waste; but the Incineration facilities are limited and where available, they are either broken down or improperly used (Obera & Oyier, 2002). Open dumping or unsanitary land filling are the dominant mode of disposal at Kachok dumpsite which is already full (Obera & Oyier, 2002; KARA, SANA & Ilishe Trust, 2007).

Besides the general advantages of the incineration of wastes such as the hygienic reduction in waste volume to be disposed of, the ability to handle both hazardous and non-hazardous wastes and the possibility to recover energy (Pirrone *et al.*, 2001), it also poses threats due to the release of toxic emissions (dioxins) (Tibbs, 1999) with negative environmental and health effects e.g. Immuno-toxicity, reproductive and developmental effects and cancer (Van Beukering *et al.*, 1999). While the burden of illness can be greater in socially disadvantaged communities (Pirrone *et al.*, 2001).

It is very important to identify both valuable materials and toxic substances in order to develop a cost-effective and environmentally sound recycling (Gertsakis & Lewis, (2003)) for the recovery of valuable materials such as ferrous, aluminum, and copper. Informal recycling of e-waste in developing nations is an environmental challenge due to research scarcity in areas of appropriate planning and infrastructural analysis on best recycling systems (Williams, 2006). Even though recycling approach has been the recommendation of many institutions and experts on waste

management (van de Kludert, 2000), in western countries it is economically non-viable due to rising cost of manpower, compelling them to find alternative destinations (developing nations) for disposal, where the labor cost is comparatively low and the environmental laws are not enforced strictly (Gao *et al.*, 2004; Mou *et al.*, 2004; Hanapi & Tang, 2006).

No waste management option can handle all wastes, except land filling (Costner, 1998); however, this would lead to a large loss of recoverable resources (Smith & Scott, 2005). It is therefore best to keep it as a last resort and send each waste streams to the option that allows the highest overall level of recovery possible with an acceptable level of safety and cost (Bontoux & Leone, 1997). The environmental risks from land filling are leaching of toxic metals (cadmium and lead) into soil and ground water and emission of gases (methane explosion, mercury) via the landfill gas combustion plant (Van de Kludert, 2000). According to Lombard (2004), unrefined e-waste dumped on landfills does not pose much of a health risk since registered landfills are reasonably protected to prevent leaching. Re-use as a method of waste control constitutes direct second hand use or use after slight modifications to the original functioning equipment (Waema and Muriuki, 2008), this helps in the conservation of raw materials and maximizes the utility of the equipments. Large companies should purchase the used equipments back from the customers and ensure proper treatment and disposal of e-waste by authorized processes (Gao *et al.*, 2004). Setting up a system where it's easy to take-back old technology has met resistance due to unwilling nature of big recyclers (Ecroignard, 2005).

2.5 Literature Gap

The literature reviewed analyzed the sources, management systems, stakeholders' role and awareness on e-waste and led to identification of numerous knowledge gaps. Shinkuma and Huong (2009) identified that there was no specific government policy on e-waste management. Stakeholder analysis, defining their roles and interests, as a prerequisite for setting up a new or improving an existing waste management system is a necessity (Wang & Chou, (2009)). There was no identified research in Kenya that had been done to analyze the possibility of formalizing the informal recycling which is hazardous to the environment and health and also leads to substantial loss of valuable materials. Consumers and policy makers felt e-waste is a distant issue yet e-waste has toxic materials with devastating health and environment problems (Liu, 2009). In

general the lack of dedicated e-waste legislation, informal recycling, uncoordinated stakeholders' roles, lack of awareness on e-waste hazards and lack of clear data on e-waste generated locally prompted the research. The research information was intended to enable formalization of recycling sector, employment creation, resource recovery and e-waste hazard reduction for improved health and environment.

2.6 Conceptual Framework

Sustainable Waste Management recognizes three important dimensions in waste management: (1) stakeholders, (2) waste system elements and (3) sustainability aspects. The conceptual framework shows the relationship of the objectives under study with the Variables for analysis: sources of e-waste (material nature; category of electronic appliance; acquisition influence factor; inventorization); stakeholder role (legislation and regulation; marketing and awareness; technology and skills transfer); systems of management (reduction (collection, sorting, classification, inventorization and transportation); reuse (repair, refurbish, donation, retake, resale); recycling (disassemble, classification, recyclers protection, recycling method/extraction of valuables, licensing recycling) and; disposal (methods, site conditions)) and; awareness creation (hazards, opportunities, disposal techniques)).

A stakeholder analysis, defining these roles is a prerequisite for setting up a new waste management system or for improving an existing one (Wang & Chou, (2009)). The Government formulates policies and regulations on sustainable e-waste management (Waema & Muriuki, 2008). Actors like CBOs, NGOs, research institutes and universities support communities and the informal sector by providing them with training, advocacy and research, technical or financial assistance (Moreno *et al*., 1999; Anschutz, 1996). Extended producer responsibility ensure tack-back strategy while the local communities (Moreno *et al*., 1999; Anschutz, 1996) can ensure more responsible behavior and increased environmental awareness thus empowering underprivileged groups in waste management system. Sustainable waste management addresses issues of reduction, reuse and recycling of waste streams in an environmentally sound and eco-efficient manner (UNEP, 2000); for recovery of materials, provision of employment in the informal sector, and reduction of toxic substances for improved health and environment (Lardinois, 1996). For sustainability to be achieved aspects such as: (i) policy and legislation, (ii) technology and skills and (iii) business and awareness must be observed.

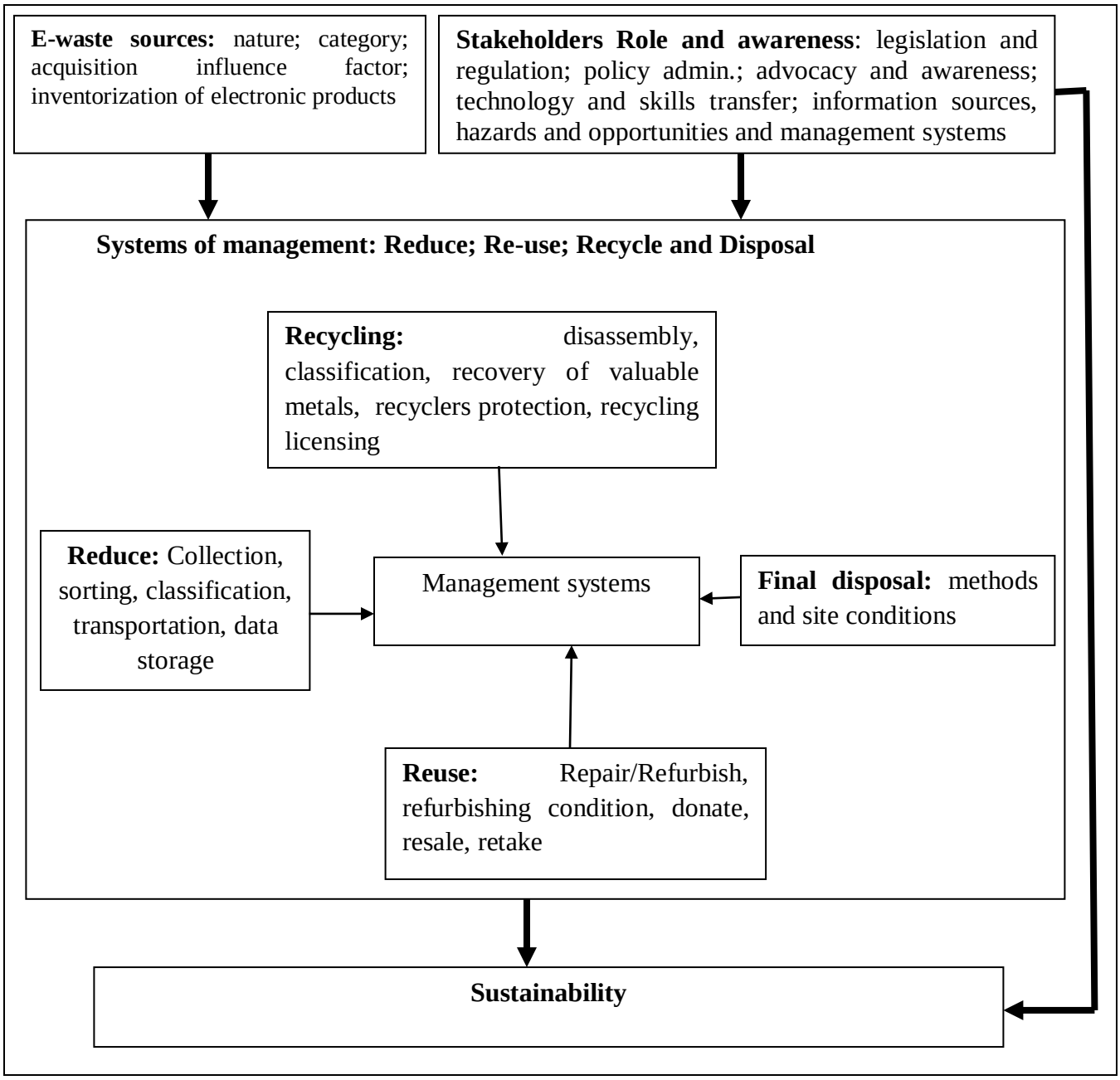

Fig. 1.0 Conceptual Framework

CHAPTER THREE
METHODOLOGY

3.0 Introduction

This chapter presents a description of the research design, study location, population, and sample, sampling techniques, research procedure, instruments, quality control, data analysis and ethical considerations.

3.1 Research Design

The study was conducted through descriptive cross- sectional survey design. The design involves numeric descriptions of some part of the population concerning the current status of the subjects in the study (Peil, 1995). This type of research attempts to describe possible behavior, attitudes, values and characteristics (Mugenda & Mugenda, 2003). This survey of part of a population and description of values and behaviors in their current status is the domain of descriptive survey which involved asking questions to respondents at one point in time on the management of e-waste. The study intended to establish the best management practices on e-waste for improved health and environment. In specifics it involved establishment of e-waste sources, stakeholder role analysis, public awareness and systems of reduction, reuse and recycling of e-waste. To achieve this, various questions were asked to the respondents probing on various attributes and opinions on e-waste management. The design was cost effective and ensured efficiency in short time data collection making it possible to identify attributes of a large population from a small sample.

3.2 Study Location

The study was carried out in Kisumu city, Kenya. Kisumu is a port city in western Kenya at 1,131 m (3,711 ft) above sea level; Area of 417 sq. km (157 sq. km. of water and 260 sq. km. of land), with a population of 148,494 households (Kenya Bureau of Statistics 2009). It is the third largest city in Kenya and the headquarters of Kisumu County. In Kisumu respondents were drawn from Nyalenda “A & B”, “Manyatta “A & B”, Kibuye (Low income areas); Industrial area, CBD, Milimani (High income areas); Tom Mboya and Migosi (Middle income areas) with a population size of 56,603 households (Kenya Bureau of Statistics 2009).

Fig 3.1 Map of Kenya showing location of Kisumu

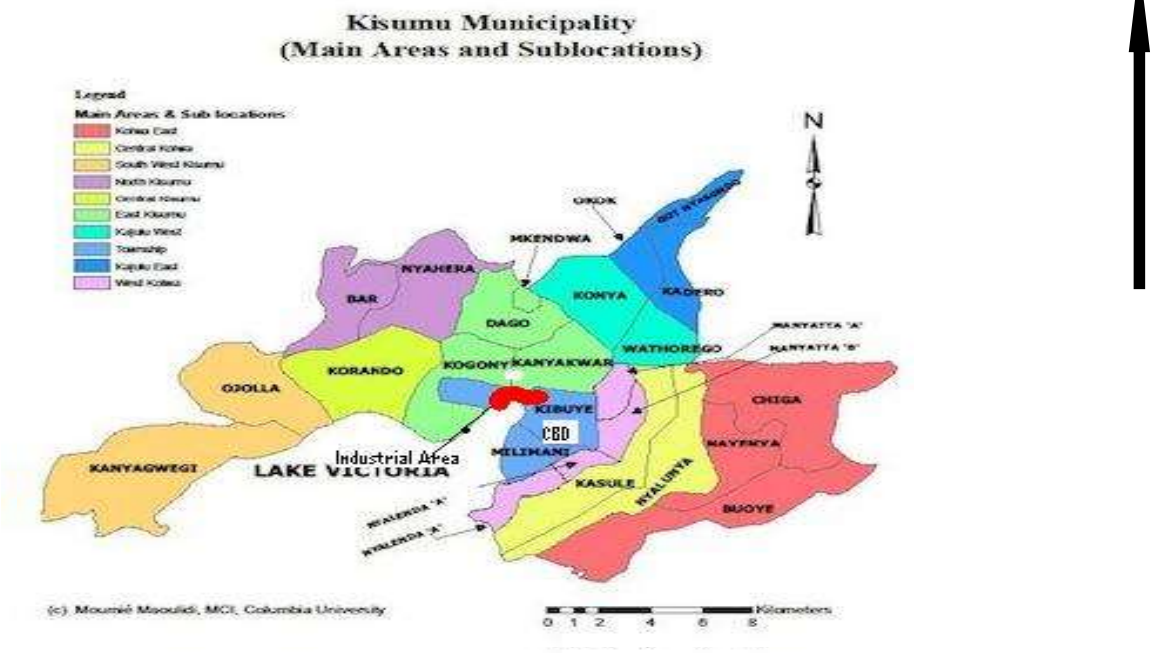

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Fig. 3.2 Map of study location/sites in Kisumu city

3.3 Population and Sampling

3.3.1 Target Population

Kisumu city consists of a population of 148,494 households (Kenya Bureau of Statistics, 2012) who use electronic equipments to meet their digital demands and these equipments eventually turn into e-waste. The city was selected because of the need to address the information gap that exists in the area concerning e-waste management. Analysis of the sources, stakeholder role, consumer awareness and barriers to existing systems of e-waste management was done. The

research involved respondents drawn from relevant government ministries(MIT,MH,MENR and Ministry of Finance), public and private sector and the household consumers to provide insight into e-waste management practices and prompted recommendations into better practices to ensure clean and healthy habitat. The respondents were drawn from CBD, Industrial Area, Milimani, Migosi, Kibuye, Nyalenda A&B and Manyatta A&B.

3.3.2 Sample size

The sample consisted of 425 household respondents selected from a population of approximately 148,494 households in Kisumu city through simple random sampling. The number 425 had been chosen to give a true representation of the population characteristics and also to cater for limited resources and time thus providing high probability of population characteristic generalization (Kothari, 2004). The sample was distributed as shown in Table 3.1 based on population ratio and production of e-waste per site. The stratified selection (sampling) of the study sites was informed by the heterogeneity of the respondents' characteristics such as living standards, quantity and type of e-waste produced and disposal mechanisms. The poor disposal of waste in informal settlements and high production of household e-waste in formal settlements, high production of ICT and Telecom and Office electronic waste in CBD and industrial Area prompted the inclusion of the above sites and this in researchers view provided substantial generalization ground and cross-social study of the municipality. The existence of Kachok dumpsite also provided suitable study site. Then for each site the respondents were proportionately distributed based on population ratio and then individual respondents randomly sampled per site to obtain the required characteristics.

The formula used to determine the sample size is as follows;

$n= (z^2.p.q.N)/ (e^2 (N-1) + z^2.p.q)$ (source: Kothari, 2004)

N= Population size == 394,684

n= Sample size == 425 Respondents

e= Acceptable error (the precision) ==0.05

z^2= Standard variable at a given confidence level ==1.96^2

p= sample proportion ==0.5; q= 1-p

This implies that; n= 425

Table 3.1: Sample Frame (Modified from Kenya Bureau of Statistics, 2009)

Area	No. of Household	**Sample Distribution**	% distribution of sample
Milimani	1,302	**20**	4.7
Tom mboya	3,420	**28**	**6.7**
Migosi	4,795	**34**	**8**
Kibuye	4,583	**34**	8
Industrial area	1,300	**60**	14.2
CBD	4,239	**83**	19.5
Manyatta A	12,525	**53**	12.6
Manyatta B	7,808	**36**	**8.5**
Nyalenda A	8,070	**37**	**8.8**
Nyalenda B	8,561	**38**	**8.9**
Total	**56,603**	**425**	**100**

3.3.3 Sampling Techniques

The study employed simple random and purposive sampling to select the sample. The household respondents were selected by simple random sampling while the key informants and Focus Groups were purposively selected. Random sampling ensures each member of the target population has an equal and independent chance of being included in the sample thus reducing sampling bias (Oso & Onen, 2009) while purposive sampling ensure the inclusion of phenomenon exhibiting typical and useful information only, besides saving time and funds (Kothari 2004). Three research assistants were involved in data collection from the respondents and respondents were household heads (consumer and office). Data was collected on both the working and obsolete electronic equipments.

3.4 Data Collection

3.4.1 Data collection tools

Questionnaires, observation, key informant interview and focus group discussion were used to collect primary data. Literature review was acquired through the internet, journals, magazines, policy and research papers and published books. Questionnaires were distributed to the 425 household respondents (households: 262 consumers, 13 repairers/refurbishers, 8 government and

142 private institutions). The selection of this tool was guided by the nature of data to be collected as well as the objectives of the study. The questionnaire was used since the study is concerned with variables that cannot be directly observed such as views, opinions, perceptions and feelings and values (Touliatos & Compton, 1988) and it caters for situations of time constraint when yet the population to be covered is large like for instance of this research (Oso & Onen, 2005). Key informant interview involved extraction of information from the government ministries (local authority, ministry of environment and natural resources, Kenya revenue authority and Kenya bureau of standards). This technique was preferred because it helped capture typical and useful information only besides saving time and funds (Oso & Onen, 2005). Four groups consisting of 10 household respondents each were subjected to focus group discussions for corroborative analysis. Focused information enables the researcher to use cases that have the required information with respect to the objectives of the study i.e. corroborative analysis of information and articulation of facts (Mugenda & Mugenda, 1999). Observation was conducted on the dumpsite at Kachok, incinerators in hospitals; repair/refurbishing conditions and methods of disposal by the research team to understand the actual conditions. This technique enables researcher to gain firsthand experience with information and to bridge the gap between what is said and what actually takes place (Oso & Onen, 2005).

3.4.2 Data collection Procedure

Qualitative and quantitative data was collected from a sample size of 425 respondents from the target population of 148, 494 households in April, 2013 using questionnaires, Key informant interview, observation check list and focus group discussion.

3.5 Data Analysis

Qualitative and quantitative data generated was subjected to descriptive statistical analysis. For quantitative data the responses were categorical in nature. Descriptive analysis methods used were frequency tests on opinions and behavior, percentages and cross tabulation to establish the relationship between the variables under investigation. Qualitative analysis involved thematic clustering of narrations of stakeholder roles and observed situation of e-waste management systems and then results used to triangulate the other findings. These statistics were useful for assessment of the dimensions of characteristics of variables under investigation (Mugenda &

Mugenda, 2003). Each objective had variables for analysis: sources of e-waste (material nature; category of electronic appliance; acquisition influence factor; inventorization); stakeholder role (legislation and regulation; marketing and awareness; technology and skills transfer); systems of management (reduction (collection, sorting, classification, inventorization and transportation); reuse (repair, refurbish, donation, retake, resale); recycling (disassemble, classification, recyclers protection, recycling method/extraction of valuables, licensing recycling) and; disposal (methods, site conditions)) and; awareness creation (hazards, opportunities, disposal techniques)). Analysis was done at a significance level of 0.05. Therefore the researcher left 5% chance of error to environmental factors and is 95% sure that the study sample is not biased. The results were presented in the form of percentages, bar-charts and cross tables.

3.6 Reliability and Validity of Instruments

Reliability is a measure of how consistent the results of a test are (Kombo & Tromp, 2006). The instruments were pre-tested amongst 10% of the respondents as a measure of reliability. The questionnaires were then revised for any corrections or alterations before final administration in the field. Peil (1995) says that pre-test sample should be similar to that of the survey. Validity is the extent to which research results can be accurately interpreted and generalized to other populations. It is the extent to which research instruments measure what they are intended to measure (Oso & Onen, 2008). To establish validity, the instruments were given to three experts to evaluate the relevance of each item in the instrument to the objective and rate each item on the scale of very relevant(4), relevant (3), somewhat relevant (2), and not relevant (1). Validity was determined using Content Validity Index (CVI). CVI= Items rated 3 or 4 by both judges divided by the total number of items in the questionnaire and is symbolized by n/N. The validity was adjusted to 0.87. Items with validity of at least 0.70 are accepted as valid in research (Kathuri & Pals, 1993). The researcher administered the instruments and this approach offered the researcher the opportunity to clarify to the respondents the difficult questions and to cross-check any misinterpretation.

3.7 Limitations

The major limitations of the study were financial and time constraints that forced the researcher to choose only 425 respondents for the study. If resources allowed the researcher could have

involved a third of the population for a more prudent generalization. The use of only 425 respondents might not lead to a comprehensive generalization of the findings to all the cities in Kenya but this was the most suitable technique to adopt since it sheds light into the problem under study.

3.8 Ethical considerations

E-waste management being a sensitive issue both to the public, Government and other stakeholders since it touches on public health and environmental sanitation required ethical considerations such as privacy and confidentiality, informed consent and researcher's responsibility. The researcher ensured anonymity of the respondents by assigning serial numbers not their actual names. The issue of privacy and confidentiality was maintained by ensuring that the data is only accessible to the researcher and applicable to the research purpose only. Respondent's participation was voluntary and the research purpose well clarified.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents results and discussion of the analysis. The study investigated the sustainability of e-waste management in Kisumu city. Inexistence of formal recycling system, limited public awareness, uncoordinated stakeholder roles implementation on policies and regulations besides undocumented waste flow record management necessitated the research. Qualitative and quantitative data generated was subjected to descriptive statistical analysis such as frequency tests, percentages and cross tabulation to establish the relationship between the variables under investigation. Qualitative analysis involved thematic clustering of narrations and results used to triangulate other findings.

4. 1 Potential Sources of E-waste

The first objective was to assess the potential sources of e-waste in Kisumu city. To achieve this objective, various issues were investigated and analyzed; ownership of electronic equipments, purchase rate of electronic equipments, nature of electronic equipments on acquisition, factors determining choice of electronic equipments, link between electronic type and brand on acquisition, link between nature of the product and factors determining electronic equipment acquisition. The links were established through cross tabulation.

4.1.1 Electronic equipment ownership

The data captured household, office, industrial and hospital. Obsolete Electronic equipments enter the waste stream from sources such as secondhand, cloned, refurbished and brand new products generated by public, private and household consumers. The electronic equipments were categorized as: ICT & telecom equipments, office equipments, large and small household equipments, consumer equipments, sports, leisure and toys equipments, medical equipments, lighting equipments, automatic dispensers, monitoring & control equipments and batteries. All the respondents indicated that they own electronic equipment with the ownership being highest on ICT & lighting equipments (48%) followed closely by house hold equipments at 28% as shown in Table 4.1. The change in design and equipment utility and evolving technology society has influenced the demand for new equipments to meet user satisfaction.

Table 4.1: Category of Electronic equipments and frequency of ownership

		Responses
		Percent
Type of electronic equipment	ICT & telecom equipment	24.0%
	Office equipment	3.0%
	Large household equipment	13.0%
	Small household equipment	15.0%
	Consumer equipment	5.0%
	Sports, leisure & toys equipment	5.0%
	Lighting equipment	24.0%
	Medical equipment	.3%
	Automatic dispensers	2.0%
	Monitoring& control equipment	2.7%
	Batteries	7.0%
Total		100.0%

Health facilities/Medical equipments remain very low (0.3%) due to the few number of hospitals besides their lack of proper equipment. The remaining electronic equipments constituted 23%. But this according to research still contributes substantial quantity of e-waste when the equipments become obsolete. Of worth notice is the 7% of batteries which was majorly generated by motor vehicles, sports, leisure & toys equipments and the ICT & Telecom equipments using batteries to operate. This implies that some of the electronic equipments are multiple e-waste generators and explains the massive danger they pose both to health and environment. Batteries contain lead and cadmium materials which leach to the soil and underground water.

The research findings are in concurrence with conclusions of Babu *et al.,* (2007) which states that the growth in electronic equipment production and consumption has been exponential in the last two decades due to urbanization and the growing demand for consumer goods, eventually leading to increased volume of e-waste. According to the analysis ICT & Telecom equipments and lighting equipments constitute 48% of all the electronic equipments owned by the respondents. This implies that a greater proportion of e-waste generated within the city is composed of ICT & Telecom equipments and lighting equipments compared with other individual categories. This is similar to a research by Kleine and Unwin (2009) who argued that

e-waste has been escalating rapidly with the rise of the information society. Mureithi *et al.*, (2008) found that in Kenya e-waste generated from computers, monitors and printers was likely to increase dramatically as the importation and use of computers increases; a 200% rise was recorded in 2007 in ICT and Telecommunication e-waste (Hewlett-Packard, 2009). Lighting equipments contain mercury which causes cancerous diseases while ICT materials have valuable materials such as gold, silver and copper which can be profitably recycled.

4.1.2 Purchase rate of electronic equipments

The growth rate of electronic equipments in the City within a time span of 5 years is high since 78% of the respondents purchase new electronic equipments. This is due to technology evolution and change in lifestyle that demands frequent change of the equipments. Since the electronic equipments will eventually turnover into e-waste it would thus require immediate response by the concerned authorities to ensure the situation is contained and health and the environment are safely protected.

The tendency amongst the respondents to purchase the electronic equipments is so high at the rate of 43% after a time lapse of 3months-1 year; 21% purchase rate after a time lapse of 2-3 years; 14% purchase rate after 4-5 years and 22% purchase rate after more than five years.

Table 4.2: Purchase rate of electronic equipments

		Percent
Valid	3months-1 year	43.0
	2-3 years	21.0
	4-5 years	14.0
	above 5 years	22.0
	Total	100.0

The findings are supported by Babu *et al.* (2007) who urgued that the growth in electronic equipment production and consumption has been exponential in the last two decades due to urbanization and the growing demand for consumer goods in different regions of the world eventually leading to increased volume of e-waste. Yoon and Jang (2006) indicated that in Kenya the advance development of information technology, change of life style and the growing

consumer demand for newer electronic products have resulted in significant amounts of obsolete electronic devices which is similar to the research findings.

4.1.3 Nature of Electronic equipment on acquisition

The nature of electronic equipments were classified as brand new, secondhand, cloned or refurbished. According to the findings high proportion (64%) of electronic equipments acquired are either refurbished, cloned or secondhand in nature with only 11% being brand new while the remaining 25% their nature at the time of acquisition could not be authenticated. This tends to explain why the growth of obsolete electronic equipment is high as most of the equipments are not brand new (short life span). The 25% respondents who indicated that they could not identify the nature of the equipments on acquisition further raises concern as this number could increase the percentage of non-branded equipments finding their way into the user enterprises and therefore turn obsolete quickly.

Table 4.3: Nature of electronic equipment on acquisition

		Responses
		Percent
Product nature	Brand new	11.0%
	Refurbished/repaired	17.0%
	Second hand	21.0%
	Cloned	26.0%
	Not aware	25.0%
Total		100.0%

The research findings are similar to that of Nnorom & Odjango (2007) which stated that e-waste is "internally generated or imported illegally as used goods in an attempt to bridge the digital divide" and supported by Yoon & Jang (2006) who found out that East Africa nations import cheap, low quality and short lifespan ICT products from China. Difficulty in acquiring ICT materials in developing regions has led to consumption of second hand products (Kleine & Unwin, (2009); Hayford & Lynch, (2003)) with short lifespan.

4.1.4 Factors determining choice of electronic equipments

For the consumer to acquire particular electronic equipment there must be a strong influencing factor. Some of the determinant factors influencing the choice of electronic equipment were identified as financial constraint, evolving technology, changing lifestyle, product durability and product donation. Table 4.4 presents results of the analysis.

Table 4.4: Factors determining choice of electronic equipments

		Responses
		Percent
Determinant factor on acquisition	Financial constraint	36.0%
	Evolving technology	25.0%
	Changing lifestyle	25.0%
	Durability	9.0%
	Donation	5.0%
Total		100.0%

Respondents indicated various factors influencing the choice of electronic equipment. On analysis it was found that 36% of the respondents' choice on electronic equipments was influenced by financial constraint while 50% were influenced by changing lifestyle and evolving technology. This shows that financial evolving technology and changing lifestyle due to urbanization has a greater impact on the quantity of e-waste generated and provides the basis for which the respondents would go for short lifespan equipment just to belong to the technology class. Yoon and Jang (2006) held a similar argument as they equally found out that in Kenya the advance development of information technology, change of life style and the growing consumer demand for newer electronic products have resulted in significant amounts of obsolete electronic devices.

Financial constraint limits respondents ability to buy brand new quality products which are always perceived to be expensive. Non-brand new electronic equipments acquired due to financial constraint have short life span thus increasing the e-waste turnover rate. Kleine and Unwin (2009) held a similar argument to the findings, that, difficulty in acquiring ICT materials in developing regions has led to consumption of second hand products with short lifespan. It is

also important to mention the fact that despite the challenges above 9% of the respondents still considered durability to be their driving force. The fact that 5% of the respondents have shown that the electronic equipments they acquired were donations either from friends, relatives or institutions further raises the question as to whether they were brand-new or not; and if not then it means they contribute towards the high growth of the e-waste. The findings are supported by Schluep *et al.* (2008) who indicated that 60% of equipment given to beneficiaries is beyond refurbishing when it is donated and should be recycled (Schluep *et al.*, 2008). Nnorom & Odjango (2007) similarly established that e-waste is "internally generated or imported illegally as used goods in an attempt to bridge the digital divide".

4.1.5 Link between Electronic type and condition on acquisition

From the analysis results presented in Table 4.5 it shows that medical equipments 32% and batteries 25% were brand new. The sensitivity of medical equipments and the quality standards requirement prompted the acquisition of brand new products in nature while for the batteries their cheap pricing and complement nature to the electronic products on purchase projects this. Office equipments were majorly cloned 31%. This is due to cheap pricing for such equipments. A record 26% and 21% of the respondents indicated that the ICT & telecom equipments they owned were cloned and second hand respectively due to financial constraint. The evolving technology of mobile phones and computers were identified to be essential to such a choice as the respondents needed to bridge the digital gap and remain relevant in the dynamic information society. This explains why most of the ICT & telecom equipments find their way into the waste stream in greater quantity. Lighting equipments followed the same trend as that of ICT & telecom at the rate of 26% and 21% for clone and secondhand respectively due to financial constraint. The high rate at which the respondents showed that they were not aware of the product nature on acquisition is a clear indication that the respondents could be easily duped into buying low quality and substandard products or second hand equipments which expire fast and adds into the waste stream. This would require sensitization by those in their distribution chain.

Table 4.5: Relationship between electronic category and product nature

		Product nature					
		Brand new	Refurbished/ repaired	Second hand	Cloned	Not aware	Total
Type of e-waste	ICT & telecom equipment	11.0%	17.0%	21.0%	26%	25.0%	100.0%
	Office equipment	15.0%	14.0%	10.0%	31.0%	30.0%	100.0%
	Large household equipment	20.0%	16.0%	19.0%	25.0%	20.0%	100.0%
	Small household equipment	15.0%	16.0%	21.0%	24.0%	24.0%	100.0%
	Consumer equipment	12.0%	21.0%	20.0%	26.0%	21.0%	100.0%
	Sports, leisure & toys equipment	14.0%	22.0%	21.0%	22.0%	21.0%	100.0%
	Lighting equipment	11.0%	17.0%	21.0%	26.0%	25.0%	100.0%
	Medical equipment	32.0%	15.0%	15.0%	23.0%	15.0%	100.0%
	Automatic dispensers	16.0%	27.0%	16.0%	25.0%	16.0%	100.0%
	Monitoring& control equipment	9.0%	37.0%	24.0%	18.0%	12.0%	100.0%
	Batteries	25.0%	15.0%	16.0%	25.0%	19.0%	100.0%

The findings are similar to those of other researchers who concluded that difficulty in acquiring ICT materials in developing regions has led to consumption of second hand products with short lifespan (Kleine & Unwin, (2009); Hayford & Lynch, (2003)). Yoon and Jang (2006) similarly concluded that in Kenya the advance development of information technology, change of life style and the growing consumer demand for newer electronic products have resulted in significant amounts of obsolete electronic devices.

4.1.6 Factors determining product nature on acquisition

Factors considered when acquiring an electronic product such as financial constraint, evolving technology, changing lifestyle, durability and donation were linked to the nature of electronic equipment acquired and results presented as shown in Table 4.6.

Table 4.6: Factor determining product nature on acquisition

		Determinant factor on acquisition					
		Financial constraint	Evolving technology	Changing lifestyle	Durability	Donation	Total
Product nature	Brand new	19.0%	28.0%	28.0%	21.0%	4.0%	100.0%
	Refurbished/ repaired	38.0%	24.0%	24.0%	6.0%	8.0%	100.0%
	Second hand	42.0%	24.0%	24.0%	5.0%	5.0%	100.0%
	Cloned	39.0%	25.0%	25.0%	7.0%	4.0%	100.0%
	Not aware	43.0%	24.0%	24.0%	4.0%	5.0%	100.0%

Evolving technology and changing lifestyle combined influenced to a great extent (48% and above) the nature of the electronic equipments acquired. This is attributed to the fact that there is growth in appetite for electronic products due to the growing information society and the need to bridge the digital divide. Financial constraint influenced 42% of the respondents on the choice for secondhand; 38% for refurbished equipments; 39% for cloned and 43% of the respondents who were not aware of the equipment nature on acquisition also attributed this to financial constraint which gives them very little choice exposure. Due to financial constraint only 19% could afford brand new electronic equipments. This can be linked to the fact that financial constraints and the ever changing technology squeeze respondents' purchasing power to fall for cheap products in order to bridge the digital divide. This is implies that improvement in living standard directly translates to more acquisition of electronic products a similarity to those of developed nation where improvement in living standards increases demands for more electronic products. Schluep et al. (2008) had a similarity in his findings that, e-waste in European society is generated from the purchase of more products as a result of higher living standards.

According to the findings the lower the price of an electronic product the higher the rate of its consumption that's why second hand, cloned and refurbished electronic product are highly consumed (38% and above) more than the brand new ones (19%). Respondents who considered durability a key factor for the acquisition of an electronic product chose brand new products (21%). Electronic equipments that were acquired through donation were majorly refurbished (8%) followed by second hand (5%) then cloned (4%) and brand new (4%) while the rest did not know the condition of the products at the time of acquisition. Of worth notice is the fact that a good number of respondents were not aware of the status of the electronic equipments they acquired as they could be used as soft spot for disposal of obsolete equipments.

The research findings are similar to those of other researchers as demonstrated in subsequent statement arguments. In Kenya the advance development of information technology, change of life style and the growing consumer demand for newer electronic products have resulted in significant amounts of obsolete electronic devices (Yoon & Jang 2006). Difficulty in acquiring ICT materials in developing regions has led to consumption of second hand products (Kleine & Unwin (2009); Hayford & Lynch (2003)) with short lifespan e.g. 50% of Kenya's PC market is second hand; 60% of equipment given to beneficiaries is beyond refurbishing when it is donated and should be recycled (Schluep et al. 2008). Nnorom & Odjango (2007) suggest that e-waste is "internally generated or imported illegally as used goods in an attempt to bridge the digital divide". Lombard (2004) indicated that the potential levels of e-waste in South Africa are affected by importing new/refurbished or second-hand electronics into the country and e-waste imports from other African countries for recycling (Lombard, 2004); while East Africa nations import cheap, low quality and short lifespan ICT products from China (Yoon & Jang 2006). Even though Waema and Muriuki (2008) argued that the key driver to the rapid generation of e-waste in Kenya is policy failure particularly with respect to importation of used electronic equipment, research finding contradicts because with lack of recycling facilities the existing laws have little to do

4.2 Awareness on sustainable E-waste management

The second objective was to assess the level of awareness on sustainable e-waste management. To achieve this objective the research focused on: consumer knowledge level on e-waste opportunities and hazards and sources of the information and relates this to the general respondent behavior on management practices, equipment choice and disposal mechanism through frequency tests and cross tabulation to determine variable relationships. It is very important to have adequate information on proper e-waste management mechanisms both on valuable materials and toxic substances in order to develop a cost-effective and environmentally sound recycling. Frequency analysis was done and results presented on tables.

4. 2.1 Awareness on E-waste hazards and opportunities

Household Respondent's awareness on risks and opportunities is average as shown in Table 4.7. About 55% of the respondents were aware of the environmental hazards; 52% were aware of health hazards; 45% were aware that e-waste needed special treatment before disposal; 60% were aware of recycling possibility and 48% were aware of the opportunities arising from properly managed e-waste. Despite e-waste being an emerging issue slightly above 50% of the respondents were aware of its risks; this in view of the research is an encouraging trend and with slight advocacy an informed society will be realized. The most identified hazards to the environment included heavy metals finding their way into the underground water thus destabilizing biodiversity. The fumes released into the atmosphere pollutes the air.

Table 4.7: Awareness on hazards and opportunities of e-waste

awareness level

		Percent		
		Yes	No	Total
E-waste risk & opportunity awareness	Environmental hazards	55.0%	45%	100%
	Health hazards	52.0%	48%	100%
	E-waste special treatment	45.0%	55%	100%
	E-waste recyclability	60.0%	40%	100%
	E-waste opportunities	48.0%	52%	100%

A record 48% of the respondents knew of the opportunities and mentioned some such as; employment creation, revenue generation for the government, and resource recovery besides environmental and health protection. Similar findings were made by waste practitioners, such as Lombard (2004) who saw e-waste as an opportunity to significantly scale up local refurbishment processes and a way of developing effective recycling industry offering opportunity for socio-economic development. The 60% knowledge on recycling possibility would make it easier for channeling of e-waste to recycling facility should one be established, but currently due to lack of a recycling plant, the respondents were left with little options and some opt to burn the waste or dispose into the dumpsites and road reserves. The findings contradicts Liu (2009) argument that lack of awareness that recycling is even possible and knowledge on existing recycling programs and locations are the main obstacles for consumers but it is rather the inefficiency of policy enforcement and lack of recycling infrastructure and technology.

Petts (2001), and Watson and Bulkeley (2005) cited that active engagement of communities can help engender local 'ownership' of schemes enhancing participation. Similarly Waema and Muriuki (2008) concurred with the fact that to increase awareness of waste reduction and encourage changes in society, government needs to carefully consider the appropriate forms of intervention i.e. moving beyond surface responses to the issues: small scale, local and intensive schemes with a high degree of community ownership in reduction, re-use, recycle and proper disposal. Consumers and policy makers think e-waste is a distant issue (Waema and Muriuki, 2008); hence there is need to sensitize the public on the negative effects and opportunities of e-waste (Liu, 2009).

4.2.2 Sources of Information on E-waste management

The respondents mentioned various sources that have contributed towards their knowledge exposure on how E-waste needs special management system distinct from the rest of solid waste. The main source of information on e-waste management mentioned by the respondents is print media at 25% followed by brochures attached with the product at purchase at 13% and then electronic media at 11%, 6% through public posters, 7% through mobilization while 3% through the internet. About 35% of the respondents did not have the information on e-waste. This means that electronic and print media could be used to disseminate the information on e-waste

management better since they reach a large majority at 36%. More advocacies and sensitization on this issue would probably improve the information sink in the respondents and reduce the 35% margin of those who do not have the information at all.

Table 4.8: Information sources on e-waste management

	Percent
print media	25.0
electronic media	11.0
internet	3.0
brochures	13.0
Public posters	6.0
Mobilization	7.0
None	35.0
Total	100.0

In United States increased awareness on e-waste potential dangers to human health and the environment has led to increased efforts to divert e-waste from landfill disposal (Brunner & Fellner, 2007). Awareness of the e-waste risks in European Union has led to calls for legislation of "Directive on Waste from Electrical and Electronic Equipment (WEEE Directive)" and "Directive on Restriction of the use of certain Hazardous Substances (RoHS) in electrical and electronic equipment", (OECD, 2001). In Korea despite enacting regulations (Lifset & Lindhqvist, (2002)), information on handling and disposal of e-waste remain limited resulting into mixed solid waste disposed of in municipal landfill sites.

4.2.3 Relationship between Awareness and Basic e-waste management practices

Record keeping on electronic products remains low (8%-10% in all cases) despite awareness on both dangers, opportunities and management practices. The respondents felt that the record was of no consequence as its use could not be obviously identified. This according to research would make it difficult to track the quantity of e-waste flow which usually informs of the capacity of a recycling facility to be established in an area. Respondents who were aware of environmental hazards and e-waste opportunities had a better developed culture of sorting waste (16%-19%) before disposal than those who were aware of health hazards, e-waste special treatment need and

recyclability. Respondents who were aware of e-waste recyclability (18%) were more willing to give their obsolete equipments for free than the lot that had knowledge on hazards (16%) and opportunities (12%). This can be transposed from the fact that those who were aware of e-waste opportunities believed the waste could still be recycled and the money gotten be used to finance the management instead of paying directly for their disposal while those who were aware of the hazards were more ready and willing to pay provided the disposal was effective.

Table 4.9: Relationship between awareness and basic management practices

		E-waste management practices							
		Sorting	Inventory	E-waste training	Ready market	Willingness to pay	Ready to give free	Disposal condition	Total
Awareness on E-waste	Environmental hazards	17.0%	9.0%	2.0%	20.0%	17.0%	16.0%	19.0%	100.0%
	Health hazards	16.0%	9.0%	2.0%	21.0%	18.0%	16.0%	18.0%	100.0%
	E-waste special treatment	14.0%	8.0%	2.0%	25.0%	21.0%	14.0%	16.0%	100.0%
	E-waste recyclability	15.0%	9.0%	2.0%	20.0%	15.0%	18.0%	21.0%	100.0%
	E-waste opportunities	19.0%	10.0%	2.0%	22.0%	16.0%	12.0%	19.0%	100.0%

On the proper disposal need above 16% of the respondents who had information on e-waste management exercised care. Under all categories of awareness the respondents had ready market for their e-waste products (20% and above). Even though awareness on the market readiness for the repaired or obsolete equipments remained high above 20%, the market remained informal and the sellers were less likely to get the actual market value of their equipments. Respondents who were aware of e-waste dangers (17%) and special treatment (21%) were more willing to pay for the proper disposal of the waste than their counterparts who were aware of e-waste recyclability (15%) and opportunities (16%).

The record keeping trend remains minimal (8%-10%) despite awareness on both hazards and opportunities and this similarity is found in Hewlett-Packard (2009) report which recognized that globally, the data on e-waste are poor and insufficient, limiting our understanding of the issues and therefore solutions. To realize tangible progress in e-waste management Waema and Muriuki (2008) advocated for public awareness on effects and e-waste management system at consumer level. At the same time they argue that knowledge without enforcement has less impact on e-waste management.

4.2.4 Link between Awareness and Disposal condition of obsolete equipments

Of those who were aware of Environmental hazards 54% disposed of obsolete electronic equipments in broken-unfixable condition; 28% in broken but fixable condition while 18% disposed them in a working condition. Those who were aware of health hazards 48% disposed obsolete electronic equipments in broken-unfixable condition; 27% in broken-fixable condition while 29% disposed them in working condition.

Table 4.10: Relationship between awareness and disposal condition

Awareness on e-waste disposal condition

		Disposal condition			
		Brocken-unfixable	Broken-fixable	Working condition	Total
Awareness on E-waste	Environmental hazards	54.0%	28.0%	18.0%	100%
	Health hazards	48.0%	27.0%	25.0%	100%
	E-waste special treatment	43.0%	30.0%	27.0%	100%
	E-waste recyclability	57.0%	24.0%	18.0%	100%
	E-waste opportunities	52.0%	35.0%	13.0%	100%

Those who were aware of the need for e-waste special treatment 43% disposed obsolete electronic equipments in broken-unfixable condition; 30% in broken-fixable condition while 27% disposed them in working condition. Those who were aware of e-waste recyclability 57%

disposed obsolete electronic equipments in broken-unfixable condition; 24% in broken-fixable condition while 18% disposed them in working condition. Those who were aware of e-waste opportunities 52% disposed obsolete electronic equipments in broken-unfixable condition; 35% in broken-fixable condition while 13% disposed them in working condition.

Based on the findings those who were aware of the e-waste recyclability and opportunities were less likely to dispose the waste even if they were broken and unfixable due to the commercial value attached to the equipments unlike their counterparts who knew the hazards and the need for special treatment of e-waste since this group only identified the waste as a danger. On the part of disposing obsolete equipments in a broken but fixable condition the respondents almost gave a universal disposal percentage (28%) irrespective of their knowledge on hazards and opportunities. Less than 25% of the respondents disposed their electronic equipments in working condition. This shows that over three quarters had strong commercial value attachment on their equipments in working conditions and therefore were more unwilling to dispose. To increase awareness of waste reduction and encourage changes in society, government needs to carefully consider the appropriate forms of intervention i.e. moving beyond surface responses to the issues: small scale, local and intensive schemes with a high degree of community ownership in reduction, re-use, recycle and proper disposal (Waema & Muriuki, 2008). Consumers and policy makers think e-waste is a distant issue, hence there is need to sensitize the public on the negative effects of e-waste on health and environment (Liu 2009).

4.2.5 Relationship between Awareness and methods of final disposal

Respondents aware of Environmental hazards had various ways of disposal such as: disposed of as mixed rubbish 4%; 30% kept in store; 6% burnt; 21% sold as second hand; 10% given to recyclers; 16% donated; 8% returned to seller for subsidy on new product while 5% disassembled for reuse of parts. The rest of the findings of Table 4.11 follow the same procedure as described above. The argument was that the toxic substances would pollute the environment and be detrimental to health. Respondents who were aware of e-waste opportunities (2%) refrained from burning e-waste more than the rest of the group due the fact that had commercial value attachments to the e-waste. Respondents who were aware of e-waste need for special treatment (2%) were less willing to sell them as second hand as they did not trust the receivers

with their final disposal as this could turn to be hazardous to the environment. Respondents who were aware of e-waste opportunities (4%) were less willing to give e-waste to recyclers as they believed they still contained valuable resources that could be extracted for commercial gains and for that they could not give them for free. There was no large discrepancy on the willingness of respondents to donate their e-waste. Respondents who were aware of e-waste opportunities (22%) were more willing to return the used equipments to the seller at a price than the rest of the group; this was a form of commercial satisfaction.

Table 4.11: Relationship between awareness and final disposal method

		Final disposal									Total
		Dispose of as mixed rubbish	Keep in store	Burn	Sell as second hand	Give to recycler	Donate	Return to seller at a price	Return to seller for subsidy on new product	Disassemble for reuse of parts	
Awareness on E-waste	Environmental hazards	4.0%	30.0%	6.0%	7.0%	10.0%	16.0%	14.0%	8.0%	5.0%	100%
	Health hazards	4.0%	30.0%	4.0%	6.0%	10.0%	17.0%	16.0%	11.0%	3.0%	100%
	E-waste special treatment	17.0%	30.0%	10.0%	2.0%	12.0%	11.0%	14.0%	1.0%	5.0%	100%
	E-waste recyclability	11.0%	26.0%	8.0%	7.0%	10.0%	11.0%	13.0%	7.0%	7.0%	100%
	E-waste opportunities	7.0%	30.0%	2.0%	4.0%	4.0%	14.0%	22.0%	10.0%	9.0%	100%

Respondents who were aware of the need for e-waste special treatment (1%) were less willing to return the obsolete electronic products to the seller for a subsidy for a new product as compared to the rest of the group as they were not assured weather the seller had developed mechanism of their disposal. Respondents who were aware of e-waste hazards and need for special treatment were less willing to disassemble the obsolete products for reuse of parts than those who knew of opportunities and recyclability because they feared the being exposed to the environmental and health hazards posed by toxic substances contained in the obsolete equipments. According to the findings, awareness on both the dangers and opportunities of E-waste has greater gravity on the

way respondents indicated they disposed of their end-of-life electronic equipments. Averagely 30% of the respondents were keeping the waste in store due to the perceived commercial value they still hold, 20% donate and 15% return to seller at a price as compared with other disposal methods which are below 8%. This is an indication that the respondents not only attach commercial value to the equipment but do not also want to contaminate the habitat thus they either store, sell at a price or donate the electronic equipments.

Active engagement of communities can help engender local 'ownership' of schemes enhancing participation (Petts, 2001; Watson & Bulkeley, 2005a). To increase awareness of waste reduction and encourage changes in society, government needs to carefully consider the appropriate forms of intervention i.e. moving beyond surface responses to the issues: small scale, local and intensive schemes with a high degree of community ownership in reduction, re-use, recycle and proper disposal (Waema & Muriuki, 2008). Public sensitization provides adequate information on the negative effects of e-waste on health and environment and opportunities on recoverable valuable secondary materials and other social-economic gains (Liu 2009).

4.3 Stakeholder role

The third objective was to assess the role of stakeholders on sustainable e-waste management. The analysis synthesized on various policies and regulations and policy considerations by the consumers on e-waste management: EMCA (1999); Articles 42; 60-70 of the new Constitution; NEMA strategic plan 2006-2010; Public Health Act (1962); ICT policy (2006); Urban Areas and Cities Act No.13 of 2011 (Cap. 265) and by-laws of 2008 on waste management. Stakeholders in the value chain were interviewed on the articulation of their roles encompassing policy and legislation and policy consideration by the consumers. The stakeholders interviewed included internet service providers, distributors, consumers, policy regulators and refurbishers/repairers. Qualitative analysis involved thematic clustering and triangulation of results to other findings and results represented in Table 4.12.

4. 3.1 Policy and legislative framework

Table 4.12 Stakeholder Role Analysis

Stakeholders	
Ministry of Environment	**Role:** create an enabling environment through policy, legal and regulatory reforms for environmental and natural resources management through Implementation of EMCA (1999) and Articles 42; 60-70 of the new Constitution. EMCA defines hazardous waste, pollutants and pollution/polluter pays policy. **Achievement:** Ministry/NEMA has ensured the establishment of Environmental department in all major institutions be it public, private or Non-governmental to track on reduce, reuse and proper disposal of wastes. **Challenge:** No specific policy and legislation on e-waste; lack of formal recycling infrastructure
NEMA	**Role:** NEMA strategic plan 2006-2010, key objectives: universal compliance and enforcement of environmental regulations; developing guidelines, standards and the prosecution of offenders failing to meet the provisions of EMCA; and coordination agencies and stakeholders. Formulates and regulates policy that governs recyclers, vendors and collectors in the e-waste sector. The strategic plan emphasizes the principle of polluter pays. **Achievement:** Developed e-waste management policy guidelines (2010) from collection to recycling to disposal and areas that concern standardization to trans-boundary movement of hazardous wastes. **Challenge:** Lack of enforcement.
Ministry of Health	**Role:** Implementation of Public Health Act (1962) on proper disposal of medical equipments. **Achievement:** Installation of incinerators. **Challenge:** Dilapidated incinerators in public hospitals. Public Health Act (1962) does not address e-waste management in specific.
Ministry of	**Role:** Implementation of ICT policy (2006): cognizant of e-waste and

ICT	states that "CCK should enforce their requirement for environmental management on ICT infrastructure by ICT Actors to ensure implementation of take-back strategy (Extended Producer Responsibility). **Achievement:** The Universal Licensing Framework implemented by the CCK from 2008 takes a step towards enforcing ICT policy (2006). **Challenge:** Stakeholders are uncoordinated in the execution and enforcement of the e-waste management.
Kisumu City Council	**Role:** Implementation of Urban Areas and Cities Act No.13 of 2011 (Cap. 265) and by-laws of 2008 on waste management which is in cognizance of Public Health Act (1962), Licensing recyclers and Providing incentives to investors **Achievement:** Recognition of e-waste problem **Challenge:** Lack of specific policies and by laws on e-waste management; inadequate financial and technological infrastructure. Problem underestimation.
Consumers	**Role:** Ownership in reduction, re-use, recycle and proper disposal **Achievement:** Re-use and reduction done. **Challenge:** Lack of policy and regulatory enforcement by the city council; lack of recycling infrastructure; inadequate information and awareness; lack of designated disposal sites. Little representation at policy formulation.
Investors and NGOs	**Role:** Awareness creation and capital investment **Achievement:** None **Challenge:** Unwilling nature of investors and NGOs to invest in this due to expensive capital infrastructure and technology inadequacy.
Producers, Distributers and ISPs	**Role:** Extended producer responsibility i.e. Tack back strategy **Achievement**: Nokia and Safaricom initiated tack back strategy in 2010 but this stalled after 1 year **Challenge:** Lack of cooperation from equipment holders due to poor mobilization.

At policy level, the Ministry of Environment and Natural Resources (MENR) – has a strategic plan (2006-2010) which is in line with the Basel and Bamako Conventions that control the trans-boundary movement of hazardous waste and inclusion of hazardous components in electronic equipments as a strategy for reduction of which Kenya is a signatory. Similarly Wang and Chou (2009) found that the government of Kenya discourage old imports and is a signatory to international conventions but the enforcement of the conventions remains weak nationally and locally (Waema and Muriuki, (2008)).

One of Ministry of Environment key function is the full implementation of the Environmental Management Coordination Act (EMCA, 1999) and Articles 42; 60-70 of the new Constitution which entitles every person to a clean and healthy environment. EMCA defines hazardous waste, pollutants and pollution. The strategic plan also emphasizes the principle of polluter pays. To achieve this objective, the Ministry's role is to create an enabling environment through policy, legal and regulatory reforms for environmental and natural resources management. From the NEMA strategic plan 2006-2010, with key objectives of ensuring universal compliance and enforcement of environmental regulations; developing guidelines, standards that govern recyclers, vendors and collectors in the e-waste sector and the prosecution of offenders failing to meet the provisions of EMCA (1999); and coordination of agencies and stakeholders by emphasizing on the principle of polluter pays, it is worth pointing out that the Ministry has taken an all-inclusive approach on waste management issues to address all aspects of waste management. The same view was held by Waema and Muriuki (2008) who emphasized that Section 3(1) of Environmental Management and Coordination Act (1999) entitles every person to a clean and healthy environment.

According to the findings enforcing compliance of environmental regulations and guidelines on e-waste within Kisumu city has been minimal since there is the feeling by city authority that the problem has not grown into an alarming state and more so the lack of technological knowhow and legislative by-laws regarding e-waste management. Waema and Muriuki (2008) held similar view that consumers and policy makers think e-waste is a distant issue, hence the need to sensitize the public on the negative effects of e-waste on health and environment and opportunities on proper management (Liu, 2009; Waema & Muriuki, 2008). Dempsey *et al.*

(2010) similarly found that despite all legislative efforts in many developed countries these laws often lack effective implementation and based on the study findings it would be prudent to strengthen the implementation capacity.

In the NEMA strategic plan 2006-2010, key objectives include universal compliance and enforcement of environmental regulations, developing guidelines and standards and the prosecution of offenders failing to meet the provisions of EMCA. Similarly, the strategic plan allows for the coordination of environmental matters amongst all lead agencies and other stakeholders. It also formulates and regulates policy that governs recyclers, downstream vendors and collectors in the e-waste sector. NEMA produced e-waste management policy guidelines in 2010 that govern e-waste management from collection to recycling to disposal and areas that concern standardization to trans-boundary movement of hazardous wastes but this has little impact at the local level since no enforcement is done to control the situation.

The problem is further compounded by the fact that Kenya Bureau of Standards (KEBS) has not adopted advance technology to guard against inclusion of hazardous components in electronic equipments besides corruption at the terminus that has enabled importation of second hand and low quality short life span electronic equipments. Currently Kenya Revenue Authority (KRA) has not developed an integrated revenue collection system on imported secondhand and low quality electronic equipments that can be used to establish a recycling infrastructure to manage the treatment of e-waste. Even though KRA is taking statistics on electronic equipments imported some equipments still find their way into the local market through dubious means at the shipment terminus. The findings are in support of Mureithi *et al.* (2008) argued that, there have been incidents of electrical goods earmarked for transit ending up in the country due to corruption besides incidents of deliberate mislabeling of containers to conceal the true identity of goods leading to substandard electronic products finding their way into the local market. In effort to reduce quantity of secondhand electronics KRA has allowed tax free importation of ICT & Telecom equipments as a means to encourage technology development in the country and acquisition of original brand new equipments to bridge the digital divide but this olive branch has not been extended to other types of electronic equipments which makes it difficult to find an

integrated solution to the entrance of substandard electronic equipments. This incentive by KRA would only be economically viable within a specified time span but not forever.

It is clear from the law that individuals and organizations whose activities generate e-waste have an obligation to dispose end-of life equipment in a manner that takes into account its hazardous components but lack of designated disposal locations by the municipal council jeopardizes the whole scenario. The law requires e-waste collectors and final disposers to register with NEMA and dispose of the waste at designated facilities. The Act empowers NEMA to apply in a court of law compelling any individual or organization to immediately stop the generation, handling, transportation, storage, or disposal of any waste where such activity presents an imminent and substantial danger to public health and the environment (NEMA, 2010; EMCA, 1999). In addition to MENR, which defines national policies, the Local Authorities implement waste management policies, while the Ministry of Public Health and Sanitation (MPHS) is concerned with health issues. The Urban Areas and Cities Act No.13 of 2011 (Cap. 265) bestows authority on the municipal authorities to deal with waste. In discharging this mandate the local authorities have to take cognizance of the Public Health Act. Under the Public Health Act (1962), it is the duty of every local authority to take all lawful, necessary and reasonably practical measures in maintaining its localities in a clean and sanitary condition.

Therefore, under the two Acts and subsequent by-laws of 2008, it is the responsibility of the Municipal council to manage waste in their respective jurisdictions. But because e-waste is a recent phenomenon the City Council of Kisumu has not articulated any specific by-law to address the issue and e-waste is treated just like any other solid waste even though currently the council is considering drafting specific by-laws to address the problem before it grows to unsustainable level based on the information provided by City council director of environment. The Public Health Act (1962) does not address e-waste management in specific but homogeneously address it under solid waste. According to Cunningham and Cunningham (2002) Local governments can create room for local communities and the informal sector by changing legislation and recognizing them as candidates for service contracts while Lardinois (1996) added that the participation of communities and micro- and small-scale enterprises can generate

income and employment in low-income urban areas and thus contribute to the alleviation of urban poverty.

The ICT policy promulgated in 2006 is cognizant of e-waste and states that "*As a prerequisite for grant or renewal of licenses, applicants must demonstrate their readiness to minimize the effects of their infrastructure on the environment. This should include provision of appropriate recycling/disposal facilities for waste that may contain toxic substances.*" The Universal Licensing Framework implemented by the CCK from 2008 which enforced EPR on dominant market holders according to ICT policy (2006) takes a step towards enforcing this statement. Generally e-waste management policy has not been integrated into the laws within various ministries and shows clearly how the policy makers (stakeholders) are uncoordinated in the execution and enforcement of the e-waste management guideline provided by NEMA. Waema and Muriuki (2008) argued that the key driver to the rapid generation of e-waste in Kenya is lack of policy enforcement particularly with respect to importation of used electronic equipment and this is in tandem with the research findings.

E-waste is an emerging challenge and all the relevant government ministries except MENR and MIT have not enacted specific e-waste management regulation and are currently using the general guideline on e-waste management from NEMA. Currently, there is no capacity to deal with e-waste. All the e-waste is dumped at Kachok dumpsite which posses' possible health risks and environmental pollution (Ozone layer depletion through Polychlorinated biphenyls (PCBs)). On holding a focus group discussion with the respondents from the surrounding immediate settlement revealed that the residents complained of the pollutant smoke emanating from the dumpsite on open burning. A site visit observation to the disposal site at Kachok which is full and overflowing confirmed open burning of e-waste materials. The mixing of the polluter liquids such as mercury and cadmium with underground water is possible as florescent bulbs with mercury components and used car battery litters could be spotted.

An interview with Ministry of Public Health officials and hospital management respondents indicated that only three hospitals (New Nyanza General Hospital, District Hospital and Aga Khan Hospital) had incinerators for managing medical equipments but only the one in Agha

Khan was in good condition while the rest were in deplorable conditions with no gas cleaners thus polluting air. This is true to the findings by Obera and Oyier (2002) that incineration facilities are limited and where available, they are either broken down or improperly used. Pirrone *et al.* (2001) noted that besides the general advantages of the incineration of wastes such as the hygienic reduction in waste volume to be disposed (Pirrone *et al.*, 2001); it also poses threats due to the release of toxic emissions (dioxins) into the air, water and land (Tibbs, 1999); causing negative environmental and health effects e.g. low sperm counts, Immuno-toxicity, reproductive and developmental effects and cancer (Van Beukering *et al.*, 1999); while the burden of illness can be greater in socially disadvantaged communities (Pirrone *et al.*, 2001).

The stakeholders also identified opportunities associated with properly managed e-waste such as recycling for resource recovery, job creation, revenue generation and technology transfer. E-waste management is facing challenge mainly because there is no funding and recycling technology is low. Some components of the discarded computers, mobile phones, TV sets and even radio sets are made of heavy metals such as mercury, cadmium and chromium which are highly hazardous especially if exposed to fire. The City Council of Kisumu confirmed that the current situation on e-waste management and policy formulation and enforcement remains weak, not to mention the unwilling nature of investors and NGOs to invest in this area due to expensive capital infrastructure and technology inadequacy . Similarity of the findings are argued by Gao *et al.* (2004); Mou et al. (2004) and; Hanapi & Tang (2006) that developing nations do not enforce strictly the environmental laws and therefore end up as alternative disposal destinations for the developed nations. According to Smith and Scott (2005) infrastructure of e-waste recycling is not well-established in Kenya due to high costs of recycling, thus only a very small fraction of e-waste are being refurbished and resold to consumers. Nokia (2010) found out that e-waste collection activities by local governments are still limited because e-waste is commonly viewed as a potentially valuable resource by consumers but in the study case its the lack of recycling infrastructure that limits proper e-waste management.

4.3.2 Policy considerations

Despite the KRAs lift on importation tariff on ICT & telecom equipments to encourage consumption of brand new equipments and also ensure information society, little has been reflected at the consumer level and surprisingly enough only 11% of the ICT & telecom equipments are brand new (Table 4.5) while the rest are either cloned, second hand or refurbished according to respondents. This was attributed to the fact that this category of equipments were evolving faster with inclusion of additional complex but necessary features. Since original brand new equipments are expensive consumers find it difficult to purchase them frequently, thus resorting to cheap ones to fulfill their digital demands. Respondents (ISP/Distributors/private) attributed lack of policy and regulatory enforcement by the municipal council as provided in the NEMA e-waste management guideline 2010 as an obstacle to proper management of e-waste.

The respondents further indicated that lack of recycling infrastructure, inadequate information and awareness, lack of designated disposal sites and the fact that waste was not being separated at the source are the other obstacles. Further, respondents indicated that there should be an established recycling infrastructure besides a policy of zero tolerance on waste in general, the country's youth be empowered and given the necessary skills for waste management, should be strict government regulations and awareness creation, and more research should be undertaken to provide alternatives to e-waste management. Respondents cited various organizations which they suggested should take an active role in the management of e-waste from importation to the point at which it needs to be discarded. The five most cited were the Government, through the MIC, MTI and MENR. Others are NEMA, KEBS, KCC and KRA. Respondents also cited the private sector (manufacturers and their downstream vendors) and civil society.

The respondents (ISP/Distributors/private/households) also felt less represented at the level of policy formulation and legislation enforcement process as it was not participatory driven. The involvement of local communities in planning and implementation can play a range of roles (Moreno *et al*., 1999; Anschutz, 1996): which can lead to more responsible behavior, increased environmental awareness, and a higher willingness to pay among users of a waste management system thus empowering underprivileged groups in waste management system (Cunningham &

Cunningham, (2002)). An interview with the service provider Safaricom Ltd in collaboration with Nokia Ltd revealed that they had initiated an Extended Producer Respossibility involving tacking-back old electronic equipments on purchase of new products at a subsidized price but this has not been effective enough as most of the people are reluctant to cooperate. Airtel and others had not initiated the same program but are considering engaging in the business. Waema and Muriuki (2008) similarly indicated that some manufacturers for instance Sony Ericsson, Nokia, LG and associated suppliers and service providers are implementing take-back schemes.

At the same time Shinkuma and Huong (2009) found that when the Safaricom scheme became operational, it only took back its own obsolete appliances. Gao *et al.* (2004) recommended that large companies should purchase the used equipments back from the customers and ensure proper treatment and disposal while Ecroignard (2005) noticed that setting up a system where it's easy to take-back old technology has met resistance due to unwilling nature of big recyclers. The municipal council of Kisumu recognized the complex nature of the waste and mentioned that the cost of establishing a recycling plant was too high and lack of technological knowhow in this area also undermine the development of e-waste management infrastructure. The municipal council is considering partnering with the private sector in order to provide a lasting solution to the growing hazard.

4.4 Systems of e-waste management in Kisumu city

The fourth objective was to assess the management systems of e-waste. E-waste management systems tend to address issues of reduction, reuse and recycling for resource recovery, job creation, revenue generation and health and environmental enhancement. Rather than regarding 'rubbish' as a homogenous mass that should be buried, it is made up of different materials that should be treated differently. To achieve this objective the following pertinent issues were analyzed: development of downstream market infrastructure; general observation of health and safety standards; possession period of electronic products; equipment status at disposal; market value of end-of-life equipment in relation to its original purchase price; final disposal method and basic management practices. Frequency analysis was done on the above variables and results presented on tables and charts.

4.4.1 Downstream market infrastructure

The resultant downstream market is not fully developed to address both economic opportunities and safety and environmental concerns raised by e-waste. Field research revealed that KCC does not have the capacity to extract all of the value from e-waste. There is no local e-waste recycling industry while refurbishing and repair are informal leading to loss of valuable resources and related socio-economic gains besides risks posed health and environment. The inexistence of recycling industries locally is different from the conditions of developed countries i.e. Greenpeace (2008) estimated that, 25% and 20% of the e-waste is recycled safely in Europe and USA respectively while China and India which have the biggest population in the world have 95% informal recycling sectors (Liu, 2009). Economically the e-waste sector is an area generating employment both formal and informal. It was noted that repairers are able to make an average of Ksh 2000 daily which is approximately 23 dollars a day. This is twenty three times more than the World Bank poverty benchmark of a dollar a day. But since the business is run informally the City council only charges Ksh 20 daily as operational charges and exempts them of the proprietor taxation which goes to the government thus losing revenue. Some waste practitioners, such as Lombard (2004) similarly see e-waste as an opportunity to significantly scale up local refurbishment processes and a way of developing effective recycling industry offering opportunity for socio-economic development. Similarly Lardinois (1996) concluded that sustainable waste management enables recovery of materials, provision of employment in the informal sector, and reduction of toxic substances for improved health and environmen.

Observations of health and safety standards on repairers

An observation on the health and safety standards of repairers/refurbishers revealed that disassembly was done without wearing protective gears such as gloves, masks and gumboots besides other dangers such as working unsafely with CRT monitors; obvious potential for eye damage, backaches and electric shocks; dangerous objects at the premises (sharp and heavy computer parts placed in the open). Many workers were in a relatively small shop and experienced congestion from dust and poor circulation of air generally. Pollution from burning plastic parts of the equipments and mercury and smells from laser printers that were believed to have a potentially negative health effect could be experienced; however, in some places, the premises appeared organized and clean.

Infrastructure of e-waste recycling is not well-established in Kenya (Smith & Scott, 2005). Due to high costs of recycling and lack of consumer incentives, only a very small fraction of e-waste are being refurbished and resold to consumers or recycled (Smith & Scott, 2005). Informal recycling of e-waste in developing nations is an environmental challenge due to research scarcity in areas of appropriate planning and infrastructural analysis on best recycling systems (Williams, 2006).

4.4.2 Period of use before disposal

The possession period of the electronic equipments before disposal was short as 41% of the respondents indicated that they only took 3 months-2 years before disposal; 31% possessed the equipments for 3-4 years while only 28% possessed the equipments for 5 years and above. At 72% turnover rate/disposal level in a span of 4 years is an indication of how technology evolution and changing lifestyle can contribute adversely to health and environment if not checked. At this rate the enactment of policies by responsible authorities and awareness creation amongst consumers besides active engagement of other stakeholders in the private sectors such as manufacturers and their downstream vendors for a take-back strategy (EPR) and private public partnership in the establishment of recycling system (plant) is the most amicable solution.

Figure 4.1: A Bar graph showing possession period of electronic products

A similarity is found in research by Yoon & Jang (2006) who identified that East Africa nations import cheap, low quality and short lifespan ICT products while in Kenya the advance development of information technology, change of life style and the growing consumer demand for newer electronic products have resulted in significant amounts of obsolete electronic devices. Difficulty in acquiring ICT materials in developing regions has led to consumption of second hand products (Kleine & Unwin, (2009); Hayford & Lynch, (2003)) with short lifespan as 50% of Kenya's PC market is second hand; 60% of equipment given to beneficiaries is beyond refurbishing when it is donated and should be recycled (Schluep *et al.*, 2008).

4.4.3 Equipment status at disposal

Of the respondents interviewed 57% discarded the electronic equipments in broken and unfixable condition while 24% discarded the equipments in broken but fixable condition and only 19% discarded the equipments in a working condition. Even though more than half of the respondents disposed obsolete electronic equipments were in broken and unfixable condition, this does not eliminate the existence of valuable materials like gold, copper and silver which are usually used in making the equipments finding their way into the waste stream. The broken but fixable equipments disposed which constitute 24% and the 19% of the electronic equipments disposed of in working condition is a clear waste of resource that would have been repaired to be in the normal working condition. It also leads to the depletion of raw materials that are used to make new equipments instead of recycling the existing ones.

Table 4.13: Equipment status at disposal

		Percent
Valid	Brocken-unfixable	57.0
	Broken-fixable	24.0
	Working condition	19.0
	Total	100.0

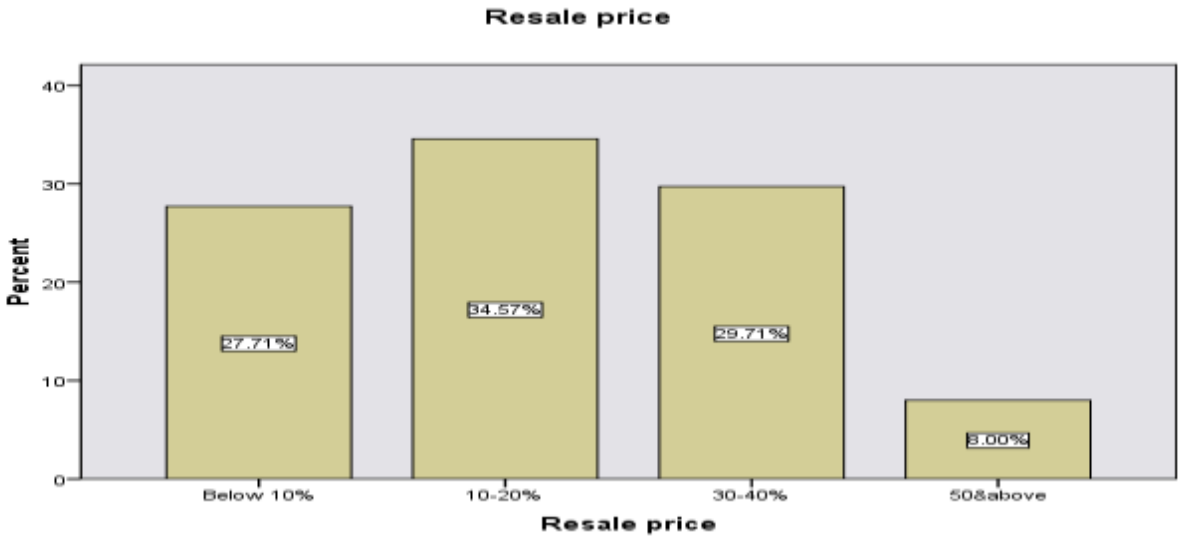
In the e-waste recycling regions, the improvement of disposal systems is the most cost-effective method to reach the objectives of solid-waste management (Brunner & Fellner, 2007) and calls for proper processing and management methods and enactment of timely regulatory and legislative policies which is lacking in Kisumu. Current technologies are not particularly cost-

effective in many developing countries (Kisumu inclusive) and many aspects of recycling depend on informal recycling that leave valuable resources to be disposed (Babu *et al.*, 2007), similar to the situation in Kisumu. According to Hewlett-Packard (2009) the data on e-waste sources are poor and insufficient, limiting our understanding of the issues and therefore solutions.

4.4.4 Market value of end-of-life equipment in relation to its original purchase price

The respondents were selling their end-of-life equipments at lower price than the original purchase price. Around 35% of the respondents were willing to sell their obsolete equipments at between 10-20% of the original price; 30% were willing to sell them at 30-40% of the original price; 28% were interested in selling the products at below 10% of the original price and only 8% were interested in selling the products at 50% and above. This gives a good impression of the willing nature of the respondents to resale their equipments at the end-of-life or when it does not serve the very purpose for which it was acquired but this does not eliminate the accumulation of the waste downstream (internal generation of waste). The minimum number of respondents indicating the willingness to resell the electronic products above 50% plus of the original price stems from the fact that most of the respondents recognized depreciative nature of electronic equipments over time.

Fig 4.2: Resale price of electronic product in comparison with initial price



E-waste is both valuable as source for secondary raw material and toxic if discarded improperly (Hayford & Lynch, (2003)). The findings are similar to those of Gertsakis & Lewis (2003) who argued that; it is very important to identify both valuable materials and toxic substances in order to develop a cost-effective and environmentally sound recycling for the recovery of valuable materials.

4.4.5 Final Disposal method

On the final disposal mechanism 29% of the respondents were keeping in store the e-waste; 15% disposed them as mixed solid waste while 21% were selling them as second hand after repair. Of great concern is that 7% of the respondents burn the e-waste which release toxic fumes that can cause cancerous related diseases and also interfere with the reproduction systems of organisms as per the information provided by the health specialists. Only 5% were taking back end-of-life equipments for subsidy on new products. The 15% of the respondents whose e-waste are disposed as mixed rubbish still finds its way into the disposal sites at Kachok which is already full and overflowing and most times they are burnt openly producing toxic gases risky to health. The 29% of the respondents keeping the e-waste in stores not only experience dust collection in the stores which cause respiratory problems but also occupy a lot of space that would have otherwise been used for other more creative economic activities. About 9% of the respondents indicated that they donated the equipments either to institutions, friends or relatives who in most instances use the equipments shortly before their breakdown.

Table 4.14: Final disposal method

	Percent
Dispose of as mixed rubbish	15.0
Keep in store	29.0
Burn	7.0
Sell as second hand	21.0
Give to recycler	8.0
Donate	9.0
Return to seller for subsidy on new product	5.0
Disassemble for reuse of parts	5.0
Total	100.0

The ability of the respondents to either give the recycler the equipment or subsidy on new product or disassembly of parts for reuse is exercised by 18% of all the respondents. This shows that the respondents are moderately informed on the issue of repair or retake and resale of obsolete equipments (reuse). The resale market is informal and most times exchanged below market price. This in view of research does not only erase genuine value of the obsolete products but also strips the government the revenue which would otherwise been collected. The burnt waste poses real threat due to the chemicals released in form of fumes such as mercury, cadmium and lithium which are toxic. The waste left by respondents at the refurbishers/repairers shop still finds its way into the waste stream.

The findings are similar to that of Liu (2009) who argued that globally only 10% of people have recycled their old mobile phones while the rest are in stores at home. Chatterjee and Krishna (2009) found that in South Africa formal recyclers process approximately 20% while the rest is stored by the owner, recycled informally, added to the domestic waste stream or dumped illegally; and in Nigeria Liu (2009) found that electronic wastes are managed through various low-end management alternatives such as disposal in open dumps, backyard recycling and disposal into surface water bodies. Due to high costs of recycling and lack of consumer incentives, only a very small fraction of e-waste are being refurbished and resold to consumers or recycled similar to findings by Smith & Scott (2005). Re-use as a method of waste control Waema and Muriuki (2008) argue can help in the conservation of raw materials and maximizes the utility of the equipments. Gao et. al. (2004) recommended that large companies should purchase the used equipments back from the customers and ensure proper treatment and disposal of e-waste by authorized processes and large companies like Nokia in collaboration with Safaricom had locally initiated such project but it stalled after 2 years due to lack of cooperation by the consumers. Yet setting up a system where it's easy to take-back old technology has met resistance due to unwilling nature of big recyclers (Ecroignard, 2005); but in the locality even the recycling facility does not exist.

4.4.6 Management practices

The results suggest that 17% of the respondents are doing household sorting which kills the spirit of waste stream reduction at consumer level. Only 11% of the respondents indicated that they keep record of the electronic equipments they dispose meaning most of the equipments are discarded into the waste stream without recording making it difficult to quantify e-waste generated within the City, thus it would be difficult in establishing the capacity of the recycling plant even if funds were availed for the same purpose. About 29% had ready market for the second hand electronic equipments but this was mostly done in an informal way which results into resale at lower value not commensurate with the actual product market price and the government also loses revenue in the course of black market transaction.

Among the respondents interviewed 19% were willing to pay for the disposal of e-waste they generate provided there was an elaborate method of collection and proper disposal. This implies that if proper advocacy is done then the funding for the recycling infrastructure development is not a great deal as some portion would be generated from the consumers. Only 23% were willing to give their e-waste for free while the remaining felt that there was value attachment to the e-waste and therefore the need for compensation either in the form of new product subsidy or refund on submission of obsolete electronic equipment.

Table 4.15: Basic E-waste management practices

E-waste management practices

		Responses
		Percent
E-waste management practices	Sorting	17.0%
	Inventory	11.0%
	Ready market	29.0%
	Willingness to pay	19.0%
	Ready to give free	23.0%
	E-waste training	2.0%
Total		100.0%

Only 2% of the respondents (households) had attended e-waste management training meaning the responsible authorities tasked with knowledge dissemination on e-waste management are doing very little to the public (consumer) in terms of awareness creation and this might be

attributed to the poor and uncoordinated execution of duties by the relevant agencies regarding e-waste management. The 2% of the sample 425 when extrapolated to the general population is equivalent to 2,970 people.

Rather than regarding 'rubbish' as a homogenous mass that should be buried, Schall (1992) argued that it was made up of different materials that should be treated differently. The concepts of waste management hierarchy of popularly 3R (reduce, reuse and recycle) is the basic requirement for sustainability in waste management (Smith & Scott, (2005); Gertsakis & Lewis, (2003)). Hewlett-Packard (2009) findings concurred that globally; the data on e-waste are poor and insufficient, limiting our understanding of the issues and therefore solutions and given the very limited data on amounts of e-waste collected and treated through "official" e-waste channels, it is clear that the recycling of significant proportions of e-waste currently goes unreported in different parts of the world. Waema and Muriuki (2008) emphasized that awareness and training programmes should be developed and implemented at consumer level. There is no specific structured collection mechanism for the e-waste and instead it's treated like other solid waste. Currently, there is no specialized equipment in the country for handling material fractions like copper, printed circuit boards (PCBs), CRT tubes and other hazardous fractions such as lead, mercury and lithium which make it impossible for recycling to be fully undertaken.

The findings are similar to that of Smith and Scott (2005) who argued that infrastructure of e-waste recycling is not well-established in Kenya due to high costs of recycling and lack of consumer incentives, thus only a very small fraction of e-waste are being refurbished and resold to consumers or recycled. A similar research by Liu (2009) in Nigeria indicated that lack of well-established system for separation, storage, collection, transportation, and disposal of waste has led to electronic wastes being managed through various low-end management alternatives such as disposal in open dumps, backyard recycling and disposal into surface water bodies. Nokia (2010) found out that e-waste collection activities by local governments in Kenya are still limited because e-waste is commonly viewed as a potentially valuable resource by consumers.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

This chapter presents the summary, conclusion and recommendations based on the major findings of the study.

5.1 Summary

The first objective of the study was to identify the potential sources of e-waste. According to the analysis ICT & Telecom equipments and lighting equipments constitute 48% of all the electronic equipments owned by the respondents. This implies that a greater proportion of e-waste generated within the city is composed of ICT & Telecom equipments and lighting equipments compared with other individual categories. The turnover of electronic equipments in the City is high since 78% of the respondents purchase electronic equipment within a time span of 5 years. At the end of life these electronic equipments turn into e-waste posing health and environmental risks. A high proportion (64%) of electronic equipments acquired are none brand new with only 11% being brand new, this tends to explain why the growth of obsolete electronic equipment is high as most of the equipments have short life span. Research indicates that evolving technology and changing lifestyle influenced the decision of 50% of the respondents to acquire electronic equipments followed by financial constraint (36%). Financial constraint contributed 40% on average to the acquisition of non-brand new electronic equipments which are cheaper.

The second objective was to assess public awareness on sustainable e-waste management. The findings were as follows: Despite e-waste being an emerging issue slightly above 50% of the respondents were aware of its risks and opportunities; this in view of the research is an encouraging trend and with slight advocacy an informed society will be realized. The main source of information on e-waste management was print and electronic media (36%), which makes it a better mode of information dissemination to reach the majority. Awareness has greater gravity on the way respondents managed their e-waste, for example, those who were aware of the e-waste recyclability and opportunities were less likely to dispose the waste due to the commercial value attached to the equipments unlike their counterparts who knew of the hazards and the need for special treatment of e-waste.

The third objective was to assess the role of stakeholders on e-waste management. Even though the government has promulgated various policies and regulations such as: EMCA (1999); Articles 42; 60-70 of the new Constitution; NEMA strategic plan 2006-2010; Public Health Act (1962); ICT policy (2006); Urban Areas and Cities Act No.13 of 2011 (Cap. 265) and by-laws of 2008 on waste management from sorting, collection, transportation to disposal, enforcement compliance is minimal due to the feeling that the problem is not yet alarming and more so, the lack of technological knowhow on handling e-waste. A part from NEMA strategic plan 2010 and ICT policy of 2006 of EPR which recognizes e-waste the rest of the policies do not specifically address e-waste. Generally E-waste management policy has not been integrated into the laws within various ministries and shows clearly how the policy makers are not included in the execution and enforcement of the e-waste management guideline provided by NEMA 2010. The Universal Licensing Framework implemented by the CCK from 2008 which enforced EPR on dominant market holders according to ICT policy (2006) takes a step towards enforcing this statement. Even though EPR was initiated by Safaricom Ltd in collaboration with Nokia Ltd it stalled due to reluctance on customers to cooperate. Generally the private sector (Investors) and the civil society (NGOs and CBOs) have been unwilling to invest in this area due to expensive capital infrastructure and technology inadequacy. It is clear from the law that individuals and organizations whose activities generate e-waste have an obligation to dispose end-of life equipment in a manner that takes into account its hazardous components but lack of designated disposal sites jeopardizes the whole scenario.

The fourth objective of the study was to establish management systems of reduction, reuse and recycling on e-waste. The findings were as follows: There is no formal e-waste recycling industry locally. On reduce, only 17% of the respondents are doing household sorting which kills the spirit of waste stream reduction at consumer level. Only 11% of the respondents keep record of the electronic equipments they dispose making it difficult to quantify e-waste generated, thus it would be difficult in establishing the capacity of the recycling plant even if funds were availed. There is no specific structured collection mechanism for the e-waste and instead it's treated like other solid waste. On Reuse, there is informal refurbishing and repair done but this leads to loss of valuable resources and related socio-economic gains besides risks posed to health and environment. The resale market is informal and most times exchanged below market price which

does not only erase genuine value of the obsolete products but also strips the government the revenue. Final disposal mechanisms on e-waste involved: keeping in store (29%); mixed solid waste (15%) while 7% were burnt. The mixed rubbish still finds its way into the disposal sites and most times they are burnt openly producing toxic gases. The waste kept by respondents in store still finds its way into the waste stream besides occupying the economic space. Incineration was done in three hospitals (New Nyanza General, District and Aga Khan Hospitals) but only the incinerator in Aga Khan was in good condition.

5.2 Conclusion

The study investigated sustainable management of e-waste in Kisumu city. The study concludes that: There is a high turnover of e waste since 78% of the respondents purchased electronic equipment every 5 years without a corresponding mechanism for reducing, recycling and reusing the e waste making e-waste management unsustainable. Such a scenario indicates that if nothing is done there will be an increasing accumulation of e-waste over time thus endangering the environment and its users. The study also concludes that the current management of e-waste is not sustainable because there is no monitoring of the volumes of e-waste generated making it difficult to plan for its disposal. The current level of stakeholder awareness on e waste management is not adequate to make e-waste management sustainable. The study concludes that the current situation on e-waste management and policy formulation and enforcement by relevant government ministries remains weak. The unwilling nature of investors and NGOs to invest in this area due to expensive capital infrastructure and technology inadequacy render the management of e-waste unsustainable. E-waste management therefore remains informal leading to resource wastage and minimal health and environmental safety observation, thus it remains unsustainable.

5.3 Recommendations

Arising from the conclusions the following recommendations are proposed:

At policy level; MENR through NEMA should enforce the e-waste management guideline 2010 to ensure proper sorting, collection, recording, reuse, reduce, recycling and disposal and the licensing of investors along this line. The MPHS should amend the Health Act (1962) to include e-waste management and comply with NEMA e-waste management guideline 2010. MIC through CCK should enforce their requirement for environmental management on ICT

infrastructure by ICT Actors to ensure implementation of take-back strategy (Extended Producer Responsibility). The County Government should amend Urban Areas and Cities Act No.13 of 2011 (Cap. 265) to incorporate e-waste management.

The relevant ministries and related stakeholders need to create awareness of e-waste and its safe handling i.e. dispose unusable equipment through sorting of waste at the source, organized collection and disposal system separately from solid waste by e-waste collectors. NEMA should set training standards for personnel handling e-waste to be enforced by the County Government. Awareness and training programmes for consumers and technicians handling e-waste should be developed and implemented after establishing a recycling facility/infrastructure.

MENR, NEMA and the County Government should encourage the growth and expansion of recycling capability in Kisumu through offering incentives to interested investors. Kisumu city council should endear interested investors to establish a formal e-waste recycling infrastructure. KRA should establish a mechanism to raise funds for e-waste management through charging a fee to the suppliers of old equipment or those who want to dispose large volumes of equipment in the city. KEBS should train expertise in forensic audit of hazardous components included in electronic equipments and discourage importation of such substances.

Consumers should be made aware and encouraged to buy brand new equipments to discourage acquisition of short lifespan equipments. County Government should establish disposal sites far from residential areas due to health concerns. MENR should encourage and acknowledge the role of civil society stakeholders in creating awareness and conducting research on e-waste.

5.4 Areas for further research

Further research will be necessary in the following areas:

1. Assess the rate of electronic equipment turnover
2. Establish mechanisms of awareness creation on e-waste management

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Appendix

Appendix I: Research tools

INFORMED CONSENT

Hello, my name is…….and I am a student at Maseno University. I am conducting a survey on E-waste management and would appreciate your participation in this survey. The information you provide will help the Researcher and other concerned parties in finding out information on sustainable E-waste management mechanisms. This questionnaire will take around 20 minutes to complete. You will remain anonymous. Please just answer as many questions as you can.

Key informant's (Stakeholder's) interview Questions

Name of institution……

1. In your view, how is e-waste situation in Kisumu?
2. What effect is e-waste having on your ministry/institution?

A. Sources of E-waste

1. What is the importation/acquisition trend of electronics?
2. What is the source of these electronic imports?
3. How do you describe these electronic imports? (Original, secondhand, cloned)
4. Is there a system of monitoring material flow?

B. Awareness on E-waste

5. How does the government consider e-waste? (Hazard, opportunity)
6. What are some of the opportunities of e-waste?
7. What are the negative effects of e-waste?
8. What actions are being taken to benefit from the opportunities (if any) and minimize the negative effects (if any)?
9. Do you have e-waste management policy in the ministry/institution?
10. If no, why is there no e-waste policy and do you see a need for one? If there is, get a copy
11. What is your general view of e-waste management in Kenya?
12. Should the quality of imported electronics be audited and regulated? If yes, by who? (NEMA/CCK/KEBS/Municipal council)
13. Which Ministry/institution should be tasked with the responsibility of coming up with a national e-waste policy.
14. What key issues should the national e-waste policy take into consideration?
15. Are there standards for electronic products imported?
16. What are the real scale and nature of environmental/health risks associated with e-waste?

C. Systems of management

17. What methods are used to manage e-waste? (State challenges/opportunities)
18. Does the council have adequate infrastructure for handling e-waste (collection, sorting, and disposal) (no. of tracks available/designated collection points/manpower protection)?
19. How is recycling done (informal/formal)? (Recyclers working conditions/awareness)
20. Are there alternative low-capital means to achieve reuse and recycling in an environmental safe way appropriate to the municipal?
21. How is Council planning for Sustainable Waste Management?
22. What are the prerequisites for licensing a recycler?
23. Are there incentives for recyclers in e-waste management?
24. Are there adequate skilled manpower for the handling of e-waste?
25. How is e-waste management financed?

26. Is there a fee for collection of waste?

D. Stakeholders' roles

27. Is the way e-waste currently collected convenient to you? (a) YES (b) NO
28. If no, what can be improved?
29. Have you and members of your organization undergone any training on E-waste collection and management? (a)YES (b) NO
30. What is your role in combating e-waste impacts?
31. What have you done to guarantee your activeness on e-waste management?
32. Are there specific legislations on e-waste management?
33. Is there finder's fees, to effect a shift from informal to the formal sector?
34. Are community members included in the management of e-waste? (To what capacity)
35. Is there strategy on extended producer responsibility, i.e. tack-back initiative?
36. Does the government ensure exclusion of hazardous products to ensure reduction?
37. What are the strategies to market recycled/refurbished products?
38. Are recyclers adequately protected?
39. Describe how the refurbishing or re-cycling business is organized.
40. What key expertise is needed in the refurbishing or recycling business?

Household Questionnaire

A. Sources of e-waste

1. Type of stakeholder (Please tick): (a) Importer (b) Supplier/distributor (c) Recycler/refurbishers (d) Consumer (e) Other (Specify) ……..
2. Use the table below to answer question 2. (1, 2, 3, 4)

2.1 Do you have any electronic equipment? (a) Yes (b) No

2.2 If yes in 2 (a) above tick the electronic equipment provided in the table below.

2.3 What was the nature of the electronic equipment? (Tick at most 3 most common)

2.4 What factors influenced the acquisition of the electronic gadget in 2 (c) above? (Tick at most 3 common)

Type of e-waste	**electronic equipment**	**Nature on acquisition**	**Factors influencing Equipment choice**
ICT and Telecommunications equipment	Mainframes, Printers, computers, Networking equipment, Scanners, Mobile phones, CD / DVDs / Floppy Disks, UPSs, Radio, TVs, Video cameras, Video recorders, Hi-fi recorders, Audio amplifiers and Musical instruments.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Office electronics	Photocopying equipment, Electrical and electronic typewriters, Pocket/desk calculators, Facsimile and Telephones.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution

Large Household Appliances	Refrigerators, Freezers, Washing machines, Cooking equipment, Microwaves, Electric heating appliances, Electric hot plates, Electric radiators, Electric fans, Air conditioner appliances, large appliances for heating beds, rooms and seating furniture.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Small Household Appliances	Vacuum cleaners, Carpet sweepers, Water dispensers, Toasters, Fryers, hair-cutters, hair drying, brushing teeth, shaving and massage; Electric knives, Clocks and sewing machines.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Consumer Equipment.	Wood and metal processing equipment, Tools for gardening activities, Sewing machines.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Toys, leisure and sports equipment	Electric trains or car racing sets, Hand-held video game, Video games, Computers for biking, diving, running, rowing.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Lighting	Fluorescent tubes, Compact fluorescent lamps, High intensity discharge lamps (pressure sodium lamps /metal halide lamps); Low pressure sodium lamps, Other lighting equipment except filament bulbs.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Medical equipment	Scanners, Operating equipments, Stethoscopes, Radiotherapy equipment, Cardiology, Dialysis, Pulmonary ventilators, Nuclear medicine equipment, Laboratory	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/

	equipment for in-vitro diagnosis, Analyzers, Freezers, Fertilization tests.		family/institution
Automatic dispensers	Automatic dispensers for hot drinks, cold bottles/ cans, solid products, money and other products.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Monitoring and control instruments	Smoke detectors, heating regulators, thermostats, Measuring appliances for household or laboratory equipment and other monitoring and control instruments used in industrial installations.	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution
Batteries	Lead Batteries, Nickel and Cadmium batteries	1. Brand new 2. Refurbished 3. Second hand 4. Cloned 5. Not aware 6. Any other……	a. Financial constraint b. Evolving technology c. Changing lifestyle d. Financial availability e. Cheap price f. Durability g. Donation from a friend/ family/institution

3. Where did you acquire your equipment from? (Tick 2 of the most common)?
(a) Retail outlet (b) General distributor (c) Leased (d) Formal 2nd hand market
(e) Informal 2nd hand market (f) others, specify_____
4. How often do you acquire electronic devices?
(a) months-1 year (b) 2-3 years (c) 4-5 years (d) above 5 years
5. How often do you repair your device?
(a) months-1 year (b) 2-3 years (c) 4-5 years (d) above 5 years

B. Awareness on e-waste

6. 1) Are you aware about the environmental hazards caused by discarded electronic equipment?
(a) YES (b) NO
6.2) If yes, then list the possible hazards……
7. Are you aware that some hazardous fractions in e-waste need a special treatment in order to be safely disposed of? (a) YES (b) NO
8. a) Are you aware of the health hazards of discarded electronic equipment? (a) Yes (b) No
b) If yes, then list the possible hazards……
9. a) Are you aware that some electronic parts may be profitably recycled? (a) YES (b) NO
b) If yes, have you ever recycled/repaired any of your electronics? (a) Yes (b) No
10. What are the opportunities derived from properly managed e-waste?
(a) Job creation (b) Improved health (c) Improved environment (d) Resource recovery (e) Source of revenue

11. Can you differentiate between original and secondhand/fake/refurbished product? (a) Yes (b) No
12. Have you undergone any training on E-waste disposal and management? (a) YES (b) NO
13. List five organizations that you think should take an active role in the management of e-waste from importation to the point at which they need to be discarded.
14. In your view, does Kisumu municipal council have infrastructure for hazardous waste disposal? (a) YES (b) NO

C. Systems of management

Reduction

15. Do you sort e-waste from other solid waste at household level?
16.1) Is there an organized system of e-waste collection in your residence? (a) Yes (b) No
16.2) If yes which organization does this?
(a) Government (b) Private (c) NGOs/CBOs (d) municipal council
17. Is there a fee for collection of e-waste? (a) Yes (b) No
18. Do you keep inventory of the e-waste? (a) Yes (b) No

Reuse

19. Do you recycle/refurbish your electronic for reuse? (a) Yes (b) No
20. What do you do with the recycled/refurbished electronic?
(a) Reuse (b) resale (c) donate (d) other, specify……..
21. Are there well known ready markets for recycled/refurbished electronics?
22. How do recyclers handle the e-waste during disassembly (what do you/they protect)?
(a) Gloves (b) Face masks (c) Overalls (d) Boots (shoes) (e) Others, specify _____

Recycling

23. What main products are produced from the refurbishment or recycling processes?
24. Would you be ready to pay for your discarded equipment to be collected and recycled?
(a) YES (b) NO
25. Would you be ready to give away your e-waste for free? (a) YES (b) NO
26. If yes, with what conditions? (Pick-up service, guarantee of proper disposal) Provide details
27. If No at what percentage of the initial cost?
(a) Below 10% (b) 10-20% (c) 30-40% (d) 50% and above

Disposal

30. What do you do with the electronic materials that are no longer useful?
(a) Dispose off with other rubbish (b) Keep in the store (c) Burn (d) Sell as 2nd hand equipment
(e) Give to a recycler (f) Donate to family/institutions/friends
(g) Return to the seller on a buy-back arrangement
(h) Give back at the store for a reduction on the price of new equipment
(i) Disassembled to reuse some parts (j) others, specify
31. For how long did you possess the equipment before you discarded (became obsolete)?
(a) 1 month-1 year (b) 1-2 years (c) 2-3 years (d) 3-4 years (e) 4-5 years (f) Over 5 years
32. In what condition was the equipment when you discarded it?
(a) Broken – unfixable (b) Broken – fixable (c) Working condition (d) Other, specify
33. Do you keep inventories of the equipment you discard/dispose? (a) YES (b) NO
34. What is your source of information on how to discard/dispose the equipment?

D. Stakeholder role

35. Is there any organization you are aware of that is working on e-waste management?
(a) Government (b) NGOs/CBOs (c) municipal council
(d) private sector (manufacturer, distributer, retailer)
36. What role do they play?
(a) Take back strategy (b) Formulating legislations and regulations (c) Sensitization/advocacy
(d) Developing incentives (e) Recycling (f) collection
37. How did you know of this organization?
(a) Local participation (b) Integration with government administrative activities
(c) At purchase point/terminal (d) Attached brochures
38. Do you think there is strong representation of community members' one-waste management?
39. On what capacity are community members involved?
(a) Collection/sorting (b) Disassembly (c) Sensitization (d) Recycling/refurbishment
40. Are you aware of any legislation to guide on e-waste management?
(a) NEMA rule (b) multilateral agreement (c) Environmental regulation (d) Municipal legislations
41. What to your point of view is the most important obstacles to proper recycling of electronic equipment in Kisumu? (***Rank starting with the most important***)
(a) Costs (b) Lacking infrastructure/policy (c) Absence of technical personnel
(d) Awareness inadequacy (e) other (specify)

Observation Checklist

1. What health and physical risks are workers exposed to from observation.
2. Is it obvious that the workers have undergone/use the following?
(a) Mask and other protective gadgets (b) Have undergone training on e-waste handling
(c) Others, specify _____
3. Describe the geographic setting of major e-waste treatment facilities and Sites.
4. Are the collection points, refurbishment, recovery or disposal sites located in or nearby populate areas? (a)YES (b) NO
5. If yes: Describe the socioeconomic set-up of the settlement, distance to e-waste treatment sites._____
6. What suggestions would you give for proper e-waste management based on this particular site as the researcher? _____
7. Check disposal system and notify any open risk or opportunity
8. Check for the working conditions of the recyclers
9. Check for the recycling tools used
10. Check for any organizations desk review on e-waste management

Appendix II: List of Key informants

The Deputy Director of Environmental Awareness and Public Participation- NEMA

The Director of Environment- Kisumu Municipal Council

The District Environmental officer- Kisumu Central District

The Western Regional Manager- Kenya Bureau of Standards