UNIVERSITY OF NAIROBI

SUSTAINABLE COMPUTER E-WASTE DISPOSAL MANAGEMENT

APPROACHES IN NAIROBI CITY COUNTY, KENYA

BY

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DECLARATION AND APPROVAL

DECLARATION

I declare that this Thesis is my original work and has not been submitted in whole or in part for examination, award of a degree or publication, except where clearly stated in reference or properly acknowledged in accordance with the University of Nairobi requirements.

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DEDICATION

This Thesis is dedicated to the Almighty God who has cared and sustained me all my life, inspired and led me to this level; to my wonderful daughters, Jane Wanjeri, Maureen Muthoni and Diana Wanjiku, without whose support, patience, prayers, and love, the completion of this study would not have been possible, I thank you; to my husband, Dr. John Maimba, for his well wishes in all that I dreamed to achieve, I thank you; to Timothy Chege-my son-in love, thank you for being part of my family; to my grand-daughter- Tiffany Waithera, you will always be in my thoughts; to my late dad, Ephraim Gachigua and late mom, Shelomith Gathoni, for instilling in me the virtues of hand work; to all other members of my family, I thank you for who you have been in my life; to all the environmentally conscious people, who believe in a cleaner, safer and better world for all to live in and those who believe in mutual love, respect and dignity, I salute you.

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ABSTRACT

Computer electronic waste (e-waste) is the swiftest growing solid waste stream in the world. It is a human health and environmental problem in the urban areas because of the hazardous nature of its contents. The enormous computer e-waste generated creates a major disposal management challenge especially in the low-income countries of the world. Information on how these countries are disposing of their computer e-waste is lacking. This study identified the computer e-waste disposal management approaches in Nairobi City County, examined the potential effects on human health and environment, assessed the level of public awareness on potential effects on human health of computer e-waste, and explored the possible planning, policy and regulatory interventions for sustainable computer e-waste disposal in the study area.

The study target population consisted of all computer users in Nairobi City County. The study examined 48 randomly sampled institutions consisting of 30 private companies, 9 universities, 7 purposively sampled research institutions and 4 government ministries. In addition, 9 purposively sampled e-waste policy and regulatory institutions and 3 disposal sites were covered. A total of 156 randomly sampled households consisting of 77 high income and 79 middle income were interviewed using semi-structured questionnaires. Low-income households were excluded from the study because they were found not to have computers. Secondary and primary data were gathered to inform the research. Documents were reviewed on studies conducted in different parts of the world on objectives of the study. This was followed by face to face interviews with the responsible officers in the sampled institutions, employees housed by the government and heads/adult representatives of the sampled households. Observations and photography were also used in gathering data. The data was analysed using Statistical Package for Social Sciences (SPSS) and presented using frequency distribution tables, cross tabulations, pie charts, graphs, and narratives. Modelling was also done to formulate a Zero Computer E-waste Management System for Nairobi City County.

The findings revealed that the disposal management approaches used by the public institutions include auction (75%), throwing away into county solid waste (CSW) stream (20%), and donation (5%). Private companies sell to e-waste collectors (50%), donate (47%) and lease out (3%). For households, it was mainly storage (45%), throw away into CSW stream (27%), donation (11%), sell as 2nd hand (9%), and sell to the recycling facility (8%). E-waste pickers/scavengers use urban mining (95%) and open-air burning (5%), while the yard shop operators purchase recycled metals and sell to local industries (80%) and export market (20%). Auctions, donations, sell as second hand, sell to e-waste collectors, leasing

out, refurbishment, reuse were found to have no direct negative effects on human health and environment. However, throwing away computer e-waste into CSW landfill had the following potential effects on human health and the environment. The literature reviewed indicated that mercury, cadmium, lead, zinc, brominated flame retardants (BFRs) pollute surface and underground water, soils and air. Broken plastics cause physical injuries, inhalation and ingestion of chemical components such as lead and mercury lead to poisoning. In recycling, the risks are from emission of hazardous heavy metals (e.g. mercury, lead, cadmium and plastics); inhalation of acid fumes, direct exposure through skin contact or ingestion of components. For urban mining, recovering and recycling of e-waste from dumping sites is risky because of limited use of safety gear. The level of public awareness on human health and environmental effects of computer e-waste disposal management approaches was low at 8.3% and12.5% respectively. All the approaches used except recycling by WEEE Centre were found to be unsustainable. The sub-sector lacks both institutional capacity and the expertise to sustainably manage computer e-waste.

From the modeling exercise, the study recommended the creation of a County E-waste Management Authority (CEMA) or a department created at the Communication Authority of Kenya or City County Office to implement a Zero Computer E-waste Policy (ZCEP) in the County. Others are introduction of a 2-level model of a computer e-waste disposal management system that will include: i) residential/commercial/neighbourhood Computer E-waste Drop Off Points (CEDOPs) and ii) a County Computer E-Waste Recycling Centre (CEREC) for Zero Computer E-waste in Nairobi. The CEDOPs should be spatially located in every residential/commercial/neighbourhood. The study also recommends the establishment of Ward Computer Literacy Centres (WCLCs) in all Wards to absorb some of the recycled products for Community Computer Literacy Capacity Building. Similar studies should be undertaken in all counties of Kenya to quantify and generate information to facilitate planning for and implementation of sustainable computer e-waste disposal management.

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LIST OF ABBREVIATIONS AND ACCRONYMS

ARF   Advanced Recycling Fee

BAN   Basel Action Network

Basel Convention   Control of Trans Boundary Movements of Hazardous Wastes
                             and their Disposal

BFR   Brominated Flame Retardants

CEMA   County E-waste Management Authority

CFSK   Computer for schools Kenya

CA   Communications Authority of Kenya

CEDPs   Computer E-waste Drop Off Points

CEM-REC   Computer E-Waste Recycling Centre

CoP   Conference of Parties

CRT   Cathode Ray Tube

CBD   Central Business District

CUE   Commission for University Education

DEEIPP   Department of Environmental Education, Information and Public
                             Participation

DEFRA   Department of Environment, Food and Rural Affairs

EA   Environmental Audit

EEE   Electric Electronic equipment

EIA   Environmental Impact Assessment

ELCI   Environment Liaison Centre International

EMCA   Environmental Management and Coordination Act

EM   Environmental Monitoring

EMPA   Swiss Federal Laboratories for Materials Testing and Research

EMS   Environmental Management System

EoL   End-of-Life

EoP   End-of-Pipe

EPR   Extended Producer Responsibility

E-waste	Electronic Waste
EU	European Union
GoK	Government of Kenya
HA	Household Appliances
ICT	Communications Technology
IT	Information Technology
ICT	Information Communication Technology
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
KALRO	Kenya Agricultural & Livestock Research Organization
KEBS	Kenya Bureau of Statistics
KENSIDOC	Kenya National Scientific Information and Documentation Centre
KICTANet	Kenya ICT Action Network.
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KIRDI	Kenya Industrial Research and Development Institute
KNBS	Kenya National Bureau of Statistics
KORECO	Korea Recycling Corporation
KRA	Kenya Revenue Authority
KIRDI	Kenya Industrial Research & Development Institute
KPA	Kenya Ports Authority
LCA	Life Cycle Assessment
MEA	Multilateral Environmental Agreements
MDGs	Millennium Development Goals
MENR	Ministry of Environment and Natural Resources
MoE	Ministry of Environment
CSW	County Solid Waste
MCA	Multi Criteria Analysis
MFA	Material Flow Analysis
MTP	Medium Term Plan

NACOSTI	National Commission for Science, Technology and Innovation
NCC	Nairobi City County
NCRC	National Crime Research Centre
NEMA	National Environment Management Authority
NGO	Non-Governmental Organizations
NMD	Nairobi Ministerial Declaration
NSE	Nairobi Securities Exchange
NST	National Science and Technology
OECD	Organization for Economic Co-operation and Development
OEMS	original Equipment Manufacturers
PC	Personal Computer
PAH	Pulmonary Arterial Hypertension
PPP	Public-Private-Partnerships
PPE	Personal Protective Equipment
R&D	Research and Development
RoHS	Restricting the Use of Hazardous Substances in Electrical and Electronic Equipment
TCLP	Toxicity Characteristic Leaching Procedure
SDGs	Sustainable Development Goals
SMEs	Small Medium Enterprises
SPSS	Statistical Package for Social Scientists
SSA	Sustainable Systems Approach
StEP	Solving the E-waste Problem
SWMS	Sustainable Waste Management Systems
UNCHE	United Nations Conference on Human Environment
UNCSD	United Conference on Sustainable Development
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
UNU	United Nations University
UNCHS	United Nations Commission on Human Settlements

UoN	University of Nairobi
URTI	Upper Respiratory Tract Infections
USA	United States of America
US EPA	United States Environment Protection Agency
USD	United States Dollar
US EPA	United States Environment Protection Agency
LCD	Liquid Crystal Display
WCED	World Commission on Environment and Development
WCLCs	Ward Computer Literacy Centres
WEEE	Waste Electrical and Electronic Equipment
WRA	Water Resources Authority
ZCEP	Zero Computer E-waste Policy

CHAPTER 1: INTRODUCTION

1.1   Background to the Study

The increasing volume of computer electronic waste (e-waste), considered as one of the challenges of the 21stcentury (UNEP, 2012), has become an important environmental and health consideration in urban planning and management in the recent years. Various factors have contributed to this increase. They include rapid technological innovations, changing consumer lifestyles and preferences, decreasing consumer costs, introduction of new products and product types, and faster obsolescence of the products(Khetriwal *et al*., 2009).There has also been massive shift to information and knowledge societies with a twist to electronic technologies as the kingpin of economic restructuring and reconstruction of social values (Babayemi *et al.,* 2009). Today, computer technologies are found in nearly all educational centres, training and research institutions, government offices and business places, and are fast spreading to residential areas. Various institutions, commercial establishments, private organizations and households increasingly use computers and related equipment for different purposes. Socially, used computer equipment has improved access to information technology by making low-priced computer equipment available.

The use of computer components and accessories has become a common feature for the public and private sector worldwide (Castells, 1994; Mansell *et al.,* 1998). This paradigm change with a focus on production, distribution and diffusion of computers and related electronic gadgets has caused a dual cluster of effects on spatial flows and processes. On the one hand, it has tremendously transformed social and economic lives in modern times towards a more networked, resource efficient and flexible modes of interaction (Postman, 1998; Priyadharshini *et al*., 2011). On the other hand, it has been a fundamental pipeline to degradation of life support systems upon which sustainability of the very aspirations for social and economic advances are anchored (WCED, 1987; World Resource Institute, 1996*et al*., 1996; MacMichael, 2004; More, 2015).

The concern with the environmental and human health implications of computers and related electronic gadgets is particularly acute in the urban areas of low-income countries such as Kenya, a scenario which has been shaped by multiple factors. These factors run the breadth of population dynamics, financial and technical resource

constraints (Bubba, 1991); inadequate, even intuitive basis for integration of environmental and health dimensions in planning and management of the urban built form (Clarke, 1992; Mbugua, 1992; UNHABITAT, 2009); World Resource Institute *et al.*, 1996); and normative individual and institutional decision making choices or actions that do not embrace the principles of sustainability in confronting threats to human health and environmental degradation (Ribeiro, 1992; Oosteveer, 2009) and data flows from the trans-border electronic equipment. The interest in computer electronic equipment also arises from the fact that they are products with high consumption levels and have short periods of substitution.

On the demographic front, the number of people who live in urban areas by 2025 is expected to exceed 5 billion, and most of this growth will occur in the developing countries of the world with both Asian and African countries becoming 54 percent urban (World Resource Institute *et al.*, 1996). The increase in urban population with growing income and complex lifestyles has become the subject of wasteful attitudes with undue regard to environmental scarcity (UNHABITAT, 1996). From the perspective of trade, the technological explosion has also opened windows of opportunity for trans-border entrepreneurship.

While re-use and recycling waste disposal management routes have been instrumental in providing employment to many people, especially in the informal urban areas, disposal remains the primary management approach for city authorities in the low-income countries of the world. Yadong *et al.,* (2006) adjudge that computer components and accessories are used by three principal groups in the market: - namely the Government (Government Ministries, Universities and Research institutions), businesses and households. These were the earliest users of IT products. In these contexts, the public institutions, private organizations, the business community and household are increasingly making use of computers and related equipment but, like for all other forms of county waste, most of the resultant electronic waste neither end up in the re-use and recycling waste management flows nor are they formally collected from these generation points and disposed of in the legal sites (Furrady, 1992; Odegi-Awuondo, 1994; World Resource Institute *et al.*, 1996; (JICA, 1998; Njeru, 2006; Oyake-Ombis, 2012). Consequently, computer e-waste has been considered as one of the fastest growing components of the urban solid waste stream, accounting for 8 percent of all county waste (Yadong *et al.*, 2006)

However, finding an alternative approach to sustainable management of this waste remains elusive to many urban authorities of low-income countries, including Kenya. Ironically, existing efforts mostly focus on authorizing domestic recycling systems and decreasing toxic content of processes. As Williams *et al*., (2008) have argued, current policies are only likely to alleviate but not provide solutions to the problem of the environmental effects of recycling of e-waste, mostly done in the informal parts of large cities. This inadequate current response strategy evokes the need for more empirical research as a basis for decision making towards a more sustainable future of the waste from computer components and accessories disposal management practices in the urban settings of low-income countries.

The study focused on waste from computer components and accessories disposal management approaches of personal computers (PCs) or desktops, cathode ray tubes (CRTs) display monitors, liquid crystal display (LCD) monitors and laptops, by public institutions, private organisations and households. The computer e-waste constitutes an essential fraction of information communication technology (ICT) related devices defined as category 3 by the European Waste Electrical and Electronic Equipment (WEEE) Directive (EU, 2003). The computer equipment has been selected because: first, the share of sold equipment is not constant: LCD monitors are currently replacing CRT display monitors, and the penetration of laptops is increasing. Second, the composition and weight of the three-computer equipment differ significantly, that is, a PC with a CRT display monitor weighs 27 Kg and contains lead, but Liquid Crystal Display (LCD) monitor weighs 4-5 Kg do not contain lead. While numerous older laptops used rechargeable nickel-cadmium (NiCa) batteries, which contain hazardous cadmium, the newer ones, weigh about 3 Kg, and rely on modern types of batteries (nickel-metal hydride and lithium ion), which are less hazardous compared to the cadmium-based batteries.

Today computer components and accessories account for a substantial amount of total ICT equipment in use. The Table below indicates the list of e-waste categories according to the EU WEEE directive. The computer equipment - the primary emphasis of this study, is included in the third category - the IT and communication equipment which is highlighted.

Table 1. 1: Categories of E-waste according to the EU WEEE Directive

S/No.	Category	Label
1.	Large household appliances	Large HH
2.	Small household appliances	Small HA
3.	IT and communications equipment	ICT
4.	Consumer equipment	CE
5.	Lighting equipment	Lighting
6.	Electrical and electronic tools (except stationary industrial tools)	E and E tools
7.	Toys, leisure and sports equipment	Toys
8.	Medical devices (With the exception of all implanted and infected products	Medical equipment
9.	Monitoring and control instruments	M & C
10.	Automatic dispensers	Dispensers

EU E-waste Categories. (Source: Widmer *et al.*, 2005)

1.2   Statement of the Research Problem

The heterogeneous and toxic composition of computer e-waste is considered as one of the highest problematic components of the solid waste streams in urban areas (Rousis, *et al.*, 2008). Thus, the computer e-waste disposal management approaches are an important environmental and human health concern in this era of rapid urbanization (Wong *et al.*, 2007; UNEP, 2005; Kang *et al.*, 2005). This is mainly the situation in the context of low-income countries where a variety of complex factors contrive to make e-waste management an elusive phenomenon. The low-income countries lack sustainable computer e-waste disposal management system to effectively manage the increasing volumes of computer e-waste.

The increase in urban population with growing income and complex lifestyles has become the subject of wasteful attitudes with undue regard to environmental scarcity (UNHABITAT, 1996). Rampant trans-boundary transmissions from high-income countries to low-income countries in Africa, (Puckett *et al.*, 2002; Puckett *et al.*, 2005; Schmidt, 2002; Schmidt, 2006; Sepúlveda, *et al.*, 2010); increase in domestic computer e-waste; decreasing consumer costs; saturation of global market for computers; shortening of lifespans (Mallawarachchi *et al.*, 2012) which has resulted in faster obsolescence of the products (Khetriwal *et al.*, 2009), rapid technological innovations; changing consumer lifestyles and preferences, and introduction of new products and product types. However, most users of computer components and accessories are also not aware of the potential negative effects to human health and the environment associated with the computers they use.

Other challenges to computer e-waste disposal management include: - poor implementation, monitoring and evaluation of environmental standards (Nyakang'o, 2015), high poverty levels (World Resource Institute *et al.*, 1996; Njeru, 2006); inadequate e-waste management infrastructure and technical capacities (UNEP, 2005; Oyake-Ombis, 2012; Nyakang'o, 2015). Recycling of computer e-waste is touted in a vast body of literature and environmental management discussions as a viable route to solutions to the problem of the burgeoning e-waste stream. Some studies, by EMPA for example, have indicated that e-wastes could be reused, refurbished, or recycled in an environmentally sound manner so that their end-of-life (EoL) status are less harmful to human health and the environment. Lee *et al.*, (2004) and Andreola *et al.*, (2005) have noted that certain valuable materials such as plastic or iron parts, copper-containing motors, copper bearing printed wiring boards, silver and gold contained in waste from computers make them worthy of recycling. However, the successful pursuit of recycling is still a distantly situated solid waste management option in low-income countries urban settings.

There are several fundamental scenarios that shape up the elusive character of sustainable routes to e-waste disposal management. First, recycling plastic is the most challenging component of electronic equipment (Bannerman, 2004) because it is difficult to make recycled plastic pure enough to be useful. Still, separating plastics in electronic equipment also remains a major challenge for many actors in the waste management domain. Second, the components of computer equipment are not often clearly labelled, thus, one is likely to have small amounts of incompatible plastic contaminate in any batch of material (Schmidt, 2006). Third, a major problem associated with poor computer e-waste disposal management includes risk to human health in terms of vulnerability to diseases such as cancer, neurological, respiratory disorders and birth defects (Davis, 2006).

Research findings by classical disposal management approach of computer e-waste remains the major management option for urban waste streams in Kenya, including computer e-waste (cf. Njeru, 2006; Oyake-Ombis, 2012) potential environmental and health implications of this approach has not been comprehensively addressed in the literature. Existing studies by scholars such as Odegi-Awuondo (1994), Njeru (2006) and Oyake-Ombis (2012) have been instrumental in highlighting the gravity of waste-induced human health and environmental impacts on the urban area. However, they have remained peripheral on the psycho-social and behavioural factors that grant this topic its public disdain perspective on urban ecosystems

planning and development. This is to the extent that environmental and human health dimensions are only hinted to in the introductory sections of these writings but not carried through to the scope of study objectives, and as centres of analysis and discussion.

The overtly, intuitive and wanton treatment of environmental and human health imperatives on the urban waste scene has the potential of excluding important hallmarks of its proper planning and management in relation to knowledge, attitudes and practices of the actors involved. For example, it is not yet clear how knowledgeable consumers and marketplace actors in electronic waste uphold the potential human health and environmental hazards presented by unsustainable disposal management approaches for this type of waste. It is against the backdrop of this unresolved discourse that this study was conceived to generate information on the same.

1.3 Research Questions

1.3.1 Main Research Question

How sustainable are the computer e-waste disposal management approaches in Nairobi City County?

1.3.2 Specific Research Questions

i) What are the computer e-waste disposal management approaches in Nairobi City County?

ii) What are the potential effects of computer e-waste disposal management approaches on human health and the environment in Nairobi City County?

iii) What is the level of public awareness of computer e-waste disposal management approaches on human health and the environment in Nairobi City County?

iv) What planning, policies and regulatory interventions can promote sustainable computer e-waste disposal management approaches in Nairobi City County?

1.4   Research Objectives

1.4.1   Overall Objective

To examine the sustainability of the computer e-waste disposal management approaches in Nairobi City County.

1.4.2   Specific Objectives

The specific objectives of the study were to:

i)   Identify the computer e-waste disposal management approaches in Nairobi City County.

ii)   Determine the potential effects on human health and the environment of the computer e-waste disposal management approaches in Nairobi City County.

iii)   Evaluate the level of public awareness of computer e-waste disposal management approaches effects on human health and the environment in Nairobi City County.

iv)   Establish planning, policies and regulatory interventions for sustainable computer e-waste disposal management approaches in Nairobi City County.

1.5   Justification and Significance of the Study

This study will add to the body of knowledge on how to make urban development through urban planning more sustainable. It seeks to identify the current computer e-waste disposal management practices; the factors that influence the choice of these disposal management approaches; the potential effects of computer e-waste disposal management approaches on human health and the environment of the urban landscape; the level of public awareness of computer e-waste disposal management approaches on effects on human health and environment; and the potential planning, policies and regulatory interventions for reshaping sustainable computer e-waste disposal management approaches towards an environmentally sound and human health responsive approach.

This evidence base is essential as a source of reference for planning and implementation of computer e-waste disposal management approaches in urban settings, ultimately saving the country from the impacts of inappropriate disposal management practices of the computer e-

waste. The results are equally useful as recourse to evidence-based public education and awareness creation and advocacy for changes on the levels of risks of waste from computer components and accessories on human health and the environment and can constitute to the foundation for investment in sustainable disposal management of computer e-waste in Nairobi, and other urban areas in Kenya. The research will provide a practical solution for improving computer e-waste disposal management approaches not only in Nairobi City County but also provide a reference to other County Solid Waste (CSW) disposal management approaches. This study will also benefit other researchers wishing to do similar studies since it would provide the background information which would be used for improving their research. Finally, the recommendations made in this study will provide potential bearings for further research in sustainable computer e-waste disposal management.

1.6   Scope and Limitations of the Study

The field setting for this study was the City County of Nairobi. This City was selected owing to its pre-eminent position as the largest and most urban ecosystem in Kenya, headquarters of most central Government administration offices, and the hub of educational, training and business activities in the country (Hake, 1977). Thus viewed, it is the largest consumer of ICT equipment, including computer components and accessories. By virtue of this characteristic, Nairobi City, is the County, in Kenya that is most prone to environmental and human health challenges associated with the computer e-waste disposal management approaches in the country. While restricting the site of the study to Nairobi City County limits generalization of findings to other urban contexts in the country, the results point to critical insights that underpin decision-making in urban and regional planning processes across spatial scenarios.

The study has focused on computer e-waste; the set of waste from computer components and accessories such as desktop computers with cathode ray tubes (CRTs) display monitors, liquid crystal display (LCD) monitors or flat screen monitors and laptops – selected due to the presence of hazardous elements in their constitution. The data used in the study were obtained from public institutions (line Government Ministries and Research Institutes) public and private universities, private companies, middle-level and upper-level households. The underlying assumption for this choice of data sources was that these are the major users of computer technologies, thus most prone to generation of computer e-waste and resultant environmental and human health dimensions of its disposal management approaches at end-of-life. Data was also collected from the disposal sites within Nairobi City County (WEEE Centre and Yard-

shops) because they are the recipients of the computer e-waste. Although this is a credible conceptual scope and strategy for mapping out most of the useful data, some degree of attention to other computer components and accessories such as keyboards, pieces of a mouse, wire cables and removable disks as well as other data sources may still introduce critical bearings on the results.

Computer components and accessories is only one component of the larger urban electronic waste stream in Nairobi City. While it is an outstanding concern about waste disposal management in urban settings, care should be taken in an attempt to generalise the result findings of this study for the management of all types of electronic waste in the urban solid waste stream. Also, the focus of the analysis was on computer e-waste disposal management approaches in relation to the sustainability of human health and the urban environment. Thus, while this is a useful aspect of waste disposal management, precaution is still necessary in the event of attempting to extrapolate the results to other approaches and perspectives on waste disposal management.

Still, the methodological scope was limited to surveys of major users of computer technologies and key actors in computer e-waste disposal management, interviews with key informants, review of secondary data and observations of disposal sites. In this light, there is need of being careful about interpretations of additional insights likely to accrue from such ethnographic methods as focus group discussions. Finally, the analysis was done within the ambit of sustainable waste management theoretical framework. Care should, therefore, be taken in attempting to mirror the results against the backdrop of alternative theoretical underpinnings of waste management studies.

1.7   Outline of the Thesis

This chapter of the thesis ends with a glossary of key concepts and operational terms used in the study. Chapter 2 provides a review of the literature relevant to the study topic. It begins by highlighting the various computer e-waste disposal management approaches and the potential effects on human health and environment that have featured in the recent empirical studies; the level of public awareness of effects on human health and environmental degradation of the urban area; and insights on urban planning, policies and regulatory interventions on sustainable computer e-waste disposal management approaches within Nairobi City County. Finally, the need to pursue a comprehensive theoretical approach that explicitly articulates human health and environmental dimensions in analyzing computer e-waste disposal management

approaches is the second issue addressed in this chapter. Springing from this argument, a sustainable computer e-waste disposal management approach is proposed towards the development of a theoretical framework. This is an important part of the contribution of this thesis towards the computer e-waste disposal management approaches to research, urban planning and development policies continuum.

Chapter 3 describes the data used, their sources and methodological decisions employed to answer the research questions. Besides describing the urban planning and development ecosystem characteristics of the field setting for the research, chapter 3 explains how the concepts embedded in the research questions have been operationalized on the basis of the conceptual framework developed in chapter 2. It goes also into research design details, including methods of data collection and analysis as well as validity and reliability considerations.

The empirical results component of the thesis are described and discussed in chapters 4, 5, 6 and 7. Each of these chapters focus on the four specific objectives of the study in that order: computer e-waste disposal management approaches; potential effects on human health and environment of computer e-waste disposal management approaches; public awareness and attitudes about computer e-waste disposal management approaches on urban environmental and human health performance and the possible related mitigation measures; and urban planning policies and regulatory interventions for a sustainable and environmentally sound and human health responsive computer e-waste disposal management approaches in Nairobi City County. Central to the discussion sections of these empirical chapters is the degree to which the study results mirror the propositions of a sustainable waste disposal management framework and presenting a critical evaluation of how these results compare or contrast with insights from the literature reviewed in chapter 2.

Chapter 8 presents a summary of the research results, the conclusion drawn and recommendations. In sum, chapter 8 reflects on the research process accomplished, the utility of the analytical framework proposed and used, and the relevance of results to urban planning and development policy-practice nexus from a human health and environmental management perspective.

1.8 Definitions of Operational Terms

End-of-Life

This refers to the end of the useful life of computer components and accessories in a particular environment. The computer may then be passed onto the second-hand market.

End-of-Pipe

Finding solutions to a problem, causes and effects at the final stage of its cycle. In the case of urban computer e-waste, it means focusing on e-waste disposal management approaches rather than a sustainable disposal management system that would lead to zero computer e-waste.

E-waste

Any electrically powered product that is no longer valuable to the current owner for its original intended purpose.

Computer e-waste disposal management approaches

The sum activities, practices and decision-making structures relating to shifting of an item that has become undesirable to its user (herein, computer e-waste) from its current location to a different destination, through the processes that follow.

Computer e-waste

A set of electronic components and accessories that constitute or are applied to use of computer technologies that have attained their end-of-life.

Cathode ray tube (CRT)

The technology used in traditional computer display monitors.

Liquid crystal display (LCD)

The technology used in flat screen monitors.

Environmental aspects

Based on the view of development, environment interactions in urban settings, environmental aspects of computer e-waste disposal management approaches herein refer to the norms,

behaviour characteristics, practices and institutional arrangements deliberately tailored to ensuring that this relationship does not subject the natural resource base to extreme loss or value degradation.

Health aspects

Constitute parameters embedded in the computer e-waste disposal management approaches that focus on the quality of life or the state of being associated with such practices.

County solid waste stream

Waste generated by households, private companies, institutions, and other consumers and disposed of in the county solid waste disposal sites.

Toxic

Any material able to cause injury or death, especially by chemical means.

Extended producer responsibility

The extended producer responsibility (EPR) is an environmental protection policy that makes the manufacturer responsible for the complete lifecycle of the product, specifically for take back, recycle and final disposal of the product.

Refurbish

Upgrading computer equipment either internally or externally to bring it to a usable condition.

Re-use

 Second-hand use of computer components and accessories as it was originally intended.

Repair

Servicing unusable computer equipment to working condition.

Recycle

All processes that close the material flow loops and bring the material back into a usable or marketable state for use other than landfill disposal or incineration or to extract useful materials for re-use.

Sustainability

Quality of not doing harm to human health and the environment or depleting natural resources but supporting long-term ecological balance.

Zero computer e-waste

Means designing and managing disposal management system to avoid and eliminate the waste from computer components and accessories and to conserve and recover all resources from urban solid waste streams.

CHAPTER 2: LITERATURE REVIEW

2.1   Introduction

Chapter two provides the literature review on the subject of study, the theoretical standpoints that underpin the research and the conceptual framework. The contents of the chapter reflect the analysis of material on the broader e-waste disposal management domain, particularly waste from computer components and accessories disposal management approaches concerning human health and the environment aspects of urban planning and development.

The chapter is split into five interrelated parts. Part 2.1 provides the definition, description and composition of e-waste. The section that follows is the most expansive component of this chapter, and it is divided into four sections that reflects the structure of the objective and specific objectives of the study. Section 2.2 sets the scene by describing the existing types of approaches to computer e-waste disposal management then extends to a synthesis of the literature on the disposal management approaches. Section 2.3 deals with the potential effects on human health and environment of the computer e-waste disposal management approaches on the urban planning and development. Section 2.4 deals with the knowledge on public awareness and attitudes about impacts on human health and environment including the literature that points to the implications of the level of public awareness and attitudes for computer e-waste disposal management approaches in urban settings.

In section 2.5, an exploration of urban planning, policies and regulatory interventions for sustainable computer e-waste disposal management approaches in decreasing the potential negative effects on human health and environmental impacts in the urban area is ventured into. All the relevant material reviewed in this section is drawn from experiences of urban areas of countries across different economic, social and spatial contexts, also highlighting the cases specific to Nairobi City for which related literature exist.

The sustainable systems approach theory upon which the study was based is covered in section 2.6. Finally, part three elaborates the theoretical perspectives on connections between computer e-waste-disposal management approaches and environmental and human aspects of urban planning and development practices. The constructs evolved from the theoretical perceptions are, eventually, used as bases of the resultant conceptual framework developed for the study.

2.1.1 Definition and Composition of E-waste

Definition of electronic waste

According to the literature reviewed there is luck of existing standard definition for electronic waste (e-waste). It is composed of different types of waste electrical and electronic equipment (WEEE) such as computers, office electronic equipment, entertainment device electronics, mobile phones, television sets, and refrigerators. It includes waste from computer components and accessories (computer e-waste) that have ceased to be of any value to their present owners. The waste from desktop computers with cathode ray tubes (CRTs) display monitors, liquid crystal display monitors and laptops is considered in this study. The e-waste definitions as reported in reviewed literature are explained in the section that follows.

The European Waste Electrical and Electronic Equipment (WEEE) Directive (European Parliament, 2003; 2012) described electronic equipment including its composition at the time of disposal as e-waste. According to Basel Action Network, waste from computer e-waste is described as a varying and rising of electronic products such as huge household products (e.g. air conditioners, refrigerators, cell phones, consumer electronics, computers and personal stereos) which are disposed of by the users (Puckett *et al*., 2002). Besides, Solving the E-waste Problem (Step), defined e-waste as all types of electrical and electronic equipment (EEE) that were disposed of by the consumer as waste that has attained its end of use.

Further, Porter, (2002) defined e-waste as and an electronic product that uses an electric power supply, has attained its end-of-life and has ceased to be of any value for its present owner. His description indicated that the end-of-life of a product is the juncture when the product ceases to satisfy the original buyer. However, this definition did not take into consideration electronic products that had achieved the EoL for their original buyer but were, however, of value to second or third-hand buyers. Just because the product is of zero-use to its current owner, did not mean that was valueless to another person. Therefore, *'present user'* instead of *'original buyer'* was a correct position of ownership. Balakrishnan *et al*., (2007) defines e-waste as any equipment that is relies on electric currents or electromagnetic fields to work properly, including equipment for generation, transfer and measurement of current. In Kenya, NEMA defines e-waste also referred to as WEEE resulting from EEE including components and accessories.

Composition of Computer Electronic Waste

The composition of waste from computer components and accessories varies from the type and age at EoL (Gaidajis *et al*., 2010). It is made of numerous metals (e.g. Fe, Cu, Al and joined to, coated or mixed with plastics). In addition, Balakrishnan *et al*., (2007), noted that desktop computers with cathode ray tubes (CRTs) display monitors contained potentially hazardous elements and also heavy metals that include arsenic, barium, chromium, cadmium, mercury, lead, selenium and beryllium within their composition. These may present potential threat to human health and the environment if not handled properly or discarded in an environmentally unsafe way. Yadong *et al*., (2006) adjudged that the individual computers (PCs) formed the fastest growing fraction only next to computers with CRT display monitors in the urban solid waste stream. The PCs also contain largest volume of printed wiring boards (PWBs) amongst electronic products. Besides, PWBs contained different types of heavy metals and BFRs that has potential risks to human health through bioaccumulation (build up in humans). They also negatively impact on the environment because they are nondegradable. Some have wide-ranging environmental pollutants, with high amounts of toxins that negatively impact on the atmosphere and water sources at close vicinity to cities. These elements can also be released onto recyclers' clothes, thus transferring dust in the household and resulting in direct exposure to human health. Phosphorus coatings of the CRT components, such as funnel glass and batteries, polychlorinated biphenyls (PWB) capacitors have high lead content, and parts of mercury and the computer e-waste may adversely pollute the environment if disposed of in an unsound manner. Due to hazardous content of lead, the disposal management of computer e-waste, therefore, requires special treatment to minimise the potential impacts on both the human health and the environment.

According to Gao *et al*., (2004); Xuefeng *et al*., (2005); Mou, (2004); and Hanapi *et al*., (2006) waste from computer components and accessories also comprises precious components composed of glass, plastics and metals which constitutes 95% of the total weight of computer. Besides, it is also composed of useful metals such as gold, silver, copper, palladium and tantalum and other unrecoverable secondary products for saving energy and reducing gas emissions from greenhouses. Recovering and reusing these materials conserves natural resources, create economic value and prevents potential pollution from extraction of new materials and metals. Substantial amount of fortune is discarded of in waste from computers that could be utilised by low-income countries or be used to improve the computer e-waste

reprocessing technologies. The world needs urban mining to provide the virgin materials required for the digital era. '*Solving the E-Waste Problem'* (StEP) initiative, reports that 7,500 tons of silver and 320 tons of gold with a combined value of $21 billion dollars are required for manufacturing of electronic products every year thus making urban mining a lucrative business.

The increasing demand and high value materials for second hand computers in low-income countries like Kenya, makes computer e-waste attractive to the '*jua kali'* (informal) sector recyclers. Chawla *et al*., (2012) reports that the reprocessing of waste from computer components and accessories demands high cost, high-level technology and capacity building for the operation. The authors argued that most of the people in the informal sector in low-income countries of the world lacked this expensive technology to handle the e-waste. Williams *et al*., (2008) concludes that potential negative impacts to human health and the environment still occurs while extracting precious materials, even when all the toxic components are removed or reprocessed.

The United Nations Environment Programme reports that the production of electronic goods especially the computers equipment, high resource-demanding activity and the potential negative environmental impact due to the extraction (referred to as ecological baggage), exceed the manufacture of other household materials by far. A study by Kuehr, (2003) adjudges that assembling computer equipment including the monitor requires 22 Kg of chemicals, 240 Kg of fossil fuels and 1.5 tonnes of water.

Ruchi, *et al*., (2017) concluded that there are several tools such as life cycle assessment (LCA), extended producer responsibility (EPR), multicriteria analysis (MCA) and material flow analysis (MFA) that can be used to improve [computer] e-waste disposal management approaches especially in developing countries. The writers adjudged, that though the tools can be used to complement one another, no exact one can be used to solve the computer e-waste issue.

Thus, the e-waste disposal management approaches are an important environmental and human health concern in this era of rapid urbanization (Wong *et al*., 2007; UNEP, 2005; Kang *et al*., 2005). This is mainly the situation in the context of low-income countries where a variety of complex factors contrive to make e-waste disposal management an elusive phenomenon. These factors range from trans-boundary transmissions from high-income countries (Puckett *et al*., 2002; Puckett *et al*., 2005; Schmidt, 2002; Schmidt, 2006; Sepúlveda, *et al*., 2010), obsolete or

poor implementation, monitoring and evaluation of environmental standards (Nyakang'o, 2015), high poverty levels (World Resource Institute *et al*., 1996; Njeru, 2006); inadequate e-waste disposal management infrastructure and technical capacities (UNEP, 2005; Oyake-Ombis, 2012; Nyakang'o, 2015). Recycling of computer e-waste is touted in a vast body of literature and environmental management discussions as a viable route to solutions to the problem of the growing e-waste stream. Some studies, by EMPA, for example, have indicated that e-wastes could be reused, refurbished, or recycled in an environmentally sound manner so that their end-of-life (EoL) status are less harmful to human health and the environment. Lee *et al*., (2004) and Andreola *et al*., (2005) have noted that certain valuable materials such as plastic or iron parts, copper-containing motors, copper bearing printed wiring boards, silver and gold contained in waste from computers make them worthy of recycling. However, the successful pursuit of recycling is still a distantly situated solid waste disposal management option in low-income countries urban settings.

There are several fundamental scenarios that shape up the elusive character of sustainable routes to computer e-waste disposal management. First, recycling plastic is the most challenging component of electronic equipment (Bannerman, 2004) because it is difficult to make recycled plastic pure enough to be useful. Still, separating plastics in electronic equipment also remains a major challenge for many actors in the waste disposal management domain. Second, the components and accessories of computer equipment are not often clearly labelled, thus, one is likely to have small amounts of incompatible plastic contaminate in any batch of material (Schmidt, 2006). Third, a major problem associated with poor computer e-waste disposal management includes risk to human health in terms of vulnerability to diseases such as cancer, neurological, respiratory disorders and birth defects (Davis, 2006).

Despite tacit evidence acknowledging that classical disposal management approach of computer e-waste remains the major option for urban waste streams in Kenya, (cf. Njeru, 2006; Oyake-Ombis, 2012; Odegi-Awuondo (1994),), potential environmental and human health implications of this approach has not been comprehensively addressed in the literature. However, the authors have remained peripheral on the psycho-social and behavioural factors that grant this topic its public disdain perspective on urban ecosystems planning and development. This is to the extent that environmental and human health dimensions are only hinted to in the introductory sections of these writings but not carried through to the scope of study objectives, and as centres of analysis and discussion.

2.2 Computer E-waste Disposal Management Approaches

One of the objectives of sustainable computer e-waste disposal management is to enhance the quality of the human health and the environment of the urban populace. According to (Tietenberg, *et, al*., 2010) high disposable incomes, many years in school (and hence access to information), gender and household size plays a significant role in increased demand for improved environmental goods and services. The writers expound on access to information, regarding the costs and benefits of improved quality of health and environment, the need for a clean environment, and the number of people in a household playing an essential role in the willingness to pay for the collection of the computer e-waste for enhanced disposal management.

As the volume of computer e-waste increase, the concern for their healthy and environmentally sound disposal methods comes to the fore. According to Kalana, (2010), the industrial sector usually adheres to e-waste disposal management practices but the same poses serious problem at the household level. The household mostly stores the obsolete computers for a while for perceived value, either for emotional or physical connection before it is discarded of.

Even in public sector and private businesses, studies by Kalana, (2010) and Oteng-Ababio, (2012) found that the computer components and accessories is normally stored in the premises awaiting instructions for their disposal from elsewhere. Apart from the potential effects on human health and degradation of the environmental and associated consequences, disposal of waste from computers has liabilities related to what the product is made of and what it is composed of. For example, public institutions are exposed to the risk of unwanted data exposure if private client data or private information was not properly removed from hard drives when disposing of computer e-waste. Likewise, software license intrusion may result when institutions discards technology. Failure to remove data from hard drives before disposal, any software found on the computer equipment could be retrieved and utilized or sold off, thereby infringing on the software companies' licensing agreements.

Hossain, (2010) noted that more computer components and accessories are shipped to low-income countries such as Kenya, without testing for functionality (Obisanjo *et al*., 2007), where it is disassembled in poor environment, harming the residents, polluting soils, atmosphere and water sources. Although most of these countries have established environmental management statutes and related regulations, their treatment capacity for e-waste remains low. Thus, the

consignments are generally re-labelled and re-directed as charity provided computer components and accessories to clear them at the customs and deliver it to the buyers who are readily waiting for their arrival at a low-income country.

While exportation of second-hand computer components and accessories is legal in many low-income countries, it is banned in the international and regional treaties and also in the legislations of many nations. The Basel Action Network, (BAN), the Silicon Valley Toxics Coalition, Toxics Link and others reveal that only computer reprocessing practices in Africa, India and China and are toxic to the environment.

The priority on extension of lifespan of computer components and accessories is recommended as a computer e-waste disposal management approach. Williams, (2003) and Hischier *et al*., (2005) observed that encouraging the market for used computers is one of the important and sensible way to do this. Hence, when the computer components and accessories became obsolete, users have three main choices for their equipment: namely store it, throw into the County Solid Waste (CSW) stream or pass it on to a second user. (Williams, 2003) noted that there is increased reuse of computers and at the same time, institutions hardly installed used computer equipment and that most of the re-used equipment is thus reused and finally disposed of by small companies and households who had bought them through auctions. He estimated that 40% of the computer components and accessories are re-used by small companies and 60% by households.

According to Kalana, (2010), the computer e-waste disposal management is often practiced by the institutions, and private businesses, but it is at the household level where the waste from computer components and accessories is of great concern. However, Williams *et al*., (2008) and Arora, (2008) noted that usually the acquisition of new products is led by the desire to purchase brand-new software rather than repair and not due to breakage of the equipment and at the same time Williams *et al*., (2008) reported that it is because of the declining lifespan of all computer components and accessories.

In Kenya, disposal management practices for waste from computer components and accessories vary depending on the user. Once computers attain the end-of-life, they are stored at homes or offices, sold as second-hand, donated to schools, friends or neighbours who could otherwise not afford the cost of a new such product (Mureithi *et al*., (2008). The writers note that few consumers took their used computer components and accessories for reprocessing or

disassemble for reuse. The study further noted that with 1,210.4 tonnes discarded of in the secondary market and an estimated 1,640 tonnes of new computer components and accessories entering into the market each year, the outflow to refurbishing market were lower compared to the new acquisitions. This clearly indicates that it was possible that a substantial amount of waste computer components and accessories were stored by consumers who had limited level of awareness about the risks of improper disposal management practices of computer e-waste especially if it is broken down.

According to Lis *et al*., (1993), increasing public demands for environmental transparency has increased the cost of traditional disposal or treatment methods and sitting new landfills have over time become exceedingly challenging and expensive. Also, potential burden for computer e-waste discharges has increased with the formulation and increased uptake of the cradle- to-grave solid waste legislation. The legislation requires the generators of computer e-waste to take responsibility for the management of its disposal.

Lack of proper infrastructure, lack of or weak regulatory enforcement, unclear legislation, low pressure from outside in the form of environmental NGOs or justice groups, lack of sufficient information, lack of waste minimisation audit reports and lack of financial resources have been highlighted in a vast body of literature as the foundation stones that have to be addressed for a successful e-waste disposal management system (Fagbohun, 2011; Satvir, 2016).

2.3 Potential Effects of Computer E-Waste Disposal Management Approaches on Human Health and Environment

The volume of e-waste generated is currently estimated to be 20-25 million tonnes globally per year (UNEP, 2009) and that the computer e-waste generation mainly occurs in high-income countries of the world such as Eastern Europe, United States of America, Japan and Australia (Pérez-Belis *et al*., 2014). In the perspective of low-income countries, such as Kenya, the challenges are due to the importation of waste from computer components and accessories in the form of obsolete, relatively non-environmentally friendly equipment disposed of from high-income countries (NEMA, 2010) to the high-income countries (Hicks et al., 2005) cited in Robinson, 2009; Arora, 2008; and Babayemi *et al*.,2009, and computer components and accessories constitute a significant proportion of this kind of waste (Kuehr *et al*., 2009; Schluep *et al*., 2009; (Horne *et al*., 2006).

Kalana (2010) remarked that one of the causes for dumping the computer e-waste in low-income countries by the high-income countries is because recycling computer equipment in the high-income nations of the world such as the USA costs an average of USD 20 per kg, and the cost of the same in low-income countries is ten-fold much less (USD 2 per kg on average). According to UNEP, (2009), the annual rate of increase of total e-waste generated in Kenya alone is about 20%. This statistic is set to be on the rise upon implementation of the proposed Laptop Project in public primary schools in Kenya.

Computer e-waste is made of complex components some of them containing toxic materials that have potential to negatively impact on human health and the environment (Borthakur *et al*., 2013) arising from the improper disposal management approaches used (NEMA, 2010). This type of waste is associated with a broad human health issues in the form of bioaccumulation in humans and environment, owing to their non-biodegradable characteristics compounded by the volume and chemical composition of the e-waste. This challenge is aggravated due the low-income countries lack of infrastructure for disposal management of toxic waste contained in the waste from computer components and accessories and are economically challenged (Shamim, *et al*., 2015). These problems mostly occur in urban areas where use of electronic equipment such as computer components and accessories are high, with increased levels found in the atmosphere and the water bodies close to urban areas or released from manufacturing industries. When these hazardous materials are disposed of into the landfills or incinerated, they affect human health due to their toxic content. Direct exposure to the toxic elements of the computer e-waste can increase via inhalation, ingestion, and skin contact (Grant *et al*., 2013). In addition, occupational exposure of waste from computer components and accessories and with polluted soils, air, dust, water and food sources may negatively impact on human health.

Informal computer e-waste recycling, practice by the e-waste pickers/scavengers include the dismantling of end-of-life computer components and accessories to extract precious metals with crude techniques with very low technology to reduce exposure or protection (Nartey, 2016; Pradhan *et al*., 2014). Besides, formal computer e-waste recycling facilities such as the WEEE Centre, utilise BAT and best environment practices to extract materials from obsolete computer components and accessories, while protecting workers and the environment from adverse health effects and environmental degradation. Furthermore, elevated risks of cancer

and developmental and neurological disorders (Kalana, 2010; Bhutta, 2011; Rao, 2014) can be caused by exposure to environmental pollutants.

In the context of Nairobi City County (Njoroge, 2007) has reported the leaching of hazardous chemicals into the soil and the Nairobi River flowing from the Dandora dumpsite. According to the United Nations Environmental Programme (UNEP, 2010) report, the current estimates of e-waste generated in Kenya is 11,400 million tonnes annually out of which 2,500 tonnes are generated from computers and 500 tonnes from printers. Njoroge, (2007) established a close link between environmental pollution and public health issues from 328 children between the ages of 2 and 18 years living in the vicinity of the Dandora dumpsite.   In the process of waste, sorting exposed both children and adults involved in the e-waste recycling are exposed to toxins emitted from open burning and leaching of components from the e-waste.

Urban mining is increasingly being used in developed countries because the raw material resources are slowly and surely being exhausted. Computer e-waste holds valuable metals and minerals than in the ores extracted from mines (Zeng, 2018). Appropriate computer e-waste disposal management approaches can reduce effectively reduce adverse effects on human health and the environment including the demand for conflict minerals being experience in some low-income countries such as Congo.

Gaidajis *et al*., (2010) reports that chemical constituent of computer e-waste varies with age and type of the electronic equipment disposed of, predominantly metal alloys such as Aluminium (Al), Copper (Cu) and Iron (Fe). Further, Balakrishnan *et al*., (2007) has also noted that computer e-waste contains several hazardous elements in their composition and several heavy metals (e.g. barium, chromium, cadmium, lead, beryllium, mercury, selenium, arsenic and silver) occurring in the CRT display monitors. These are hazardous and have potential risks on health of the populace and cause environmental degradation if disposed of in an environmentally unsound manner. Poor computer e-waste disposal management approaches (storage, collection and disposal) have been cited in some documents. These risks are as presented in Table 2.1.

Table 2.1: Human Health and Environmental Hazards related to Computer E-Waste Disposal Management Approaches

E-waste component	Processing	Potential human health risks	Potential environmental risks
Printed circuit boards[1]	De-soldering of boards, removal of chips	Tin and lead inhalation, the possibility of inhalation of brominated dioxin, beryllium, cadmium and mercury	Air pollution by the same substances
Cathode ray tubes (CRTs)	Removal of copper, breaking, dumping	Silicosis; cuts from glass, inhalation or contact with phosphor	Contamination of ground water by the toxic phosphor
Chips and other gold-plated components	Chemical stripping	• Acid contact with eyes, skin resulting in permanent injury • Inhalation of acid fumes resulting in respiratory irritation problems	Acidification of water sources
Motherboards, dismantled printed circuit boards	Burning of circuit boards	The intoxication of dumping sites surrounding residents, workers in dumping sites from lead, beryllium and tin	Contamination of surroundings and groundwater
Steel, copper and precious metal	Recovery of steel, copper through the furnace	Exposure to dioxins and heavy metals	Contamination of air by dioxins and heavy metals
Plastic components	Shredding, melting, low-temperature	Exposure to hydrocarbon, brominated dioxin and PAH	Contamination of air by brominated dioxins, heavy metals and hydrocarbons

Source: Deng *et al.*, 2006 and Wath *et al.*, 2011.

Zeng *et al.*, (2016) notes that recovery and reprocessing of computer e-waste can reduce potential effects on human health and degradation of the urban environment. Precious materials (gold, platinum, silver, palladium, steel including glass and plastic) can be recycled and reused in industry.

According to Heacock *et al.*, (2015) recycling using the BAT and best environmental practices is a widely acceptable disposal management approach since it prevents contamination of the environment and risk to human health; decrease in greenhouse gases (GHGs) emissions which causes climate change; minimises the use of raw materials and conserves energy in comparison with use of virgin materials as indicated in Table 2.2. According to Eygen *et al.*, (2016) reprocessing of and laptops and PCs saves 87% and 80% of natural resources respectively.

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[1]Circuit boards contain most of the heavy metals and also the highest precious metal values. The concentration of metals in an average computer may be more than twice that found in ores.

Table 2.2: Recycled Material Energy Savings over Raw Materials

Raw materials	Energy savings (%)
Aluminium	95
Copper	85
Iron and Steel	74
Lead	65
Zinc	60
Plastics	80

Source: Cui, *et al.*, 2003

The electronic sector consumed 44% of mined copper, 50% of tin,14% of platinum group metals, 9% of gold and 30% of silver in 2014 (Golev *et al*., 2016). Despite all the potential negative effects related to the improper disposal of computer e-waste, public awareness levels among populations tend to be overly low. According to Ritu *et al*., (2013) and Saritha *et al*., (2015) consumers lacked knowledge on disposal management approaches and did not know the types of human health risks associated with their improper disposal. The latter reported that 95% of respondents in the City of Visakhapatnam, India, were unaware about computer e-waste and its related risks. Further, a survey by Shah *et al*., (2014) on public awareness regarding e-waste hazards showed that only 35% of respondents knew about any specifically related environmental risks.

Yadong *et al*., (2006) adjudged that personal computer (PCs) constitute the second largest and fastest growing component after the desktop computers with CRT display monitors in the e-waste stream. Phosphorus coatings of the CRT components, such as funnel glass and batteries, polychlorinated biphenyls (PWB) capacitors have high lead content and mercury-containing parts of the computer equipment and may adversely pollute the environment if disposed of in an unsound manner.

Although not commonly known, waste from computer equipment has toxic substances such as lead, lead oxide and cadmium in CRT display monitors; mercury in the LCD monitors; and cadmium in computer batteries. Computers also has printed circuit boards that are harmful due to their lead content, brominates flame retardants (5-10 % by weight), and antimony oxide as a flame retardant. Williams (2003) reported that CRT monitors exceeded toxicity characteristic leaching procedure (TCLP) provide limitations for zinc leachate, thus qualifying it as harmful waste. The toxicity arises when monitors weather in landfills, thereby discharging these hazardous elements into the water sources and soil and the atmosphere. Long-term exposure to these toxic components has potential to damage the reproductive and endocrine systems, the kidney and bones, and the nervous system. Some of these components are carcinogenic, and

they have long-term effects on the environment, when improperly discarded of (landfilled) with domestic waste, can pollute the soil, air and water (Moeller, 2005).

Williams, (2003) projected that in future, the world shipment of LCDs would surpass that of CRT display monitors. The writer noted that despite the preference of LCDs for their efficient use of space and power saving, they also have substantial amounts of mercury (4-12 mg/unit), which could be leached from improperly discarded of systems. Besides, Williams (2003) reported that the manufacturing of an LCD monitor requires 266 kg of fossil fuels, a figure that surpasses that needed for the manufacturing of CRT display monitor of 240 Kg of fossil fuels. Table 2.3 and Table 2.4 provide a summary of the toxic components of desktop and laptop computer equipment by their weight respectively.

Table 2.3: Hazardous Waste Components in Desktop Computer (Average Weight of 27.2 Kg)

Description	Content % of total weight	Weight of material
Toxic Components		
Plastic	22.99	7.24 kg
Lead	6.2988	1.98 kg
Mercury	0.022	0.693 gm
Arsenic	0.0013	0.4095 gm
Chromium	0.0063	1.98 gm
Beryllium	0.0157	4.92 gm
Barium	0.0315	9.92 gm
Cadmium	0.0094	2.961 gm
Non-Toxic Components		
Aluminum	14.1723	3.86 kg
Iron	20.4712	5.58 kg
Copper	6.9287	1.91 kg
Gold	0.0016	<0.1 kg
Silver	0.0189	<0.1 kg

Source: http://svtc.igc.org/hightech_prod/desktop.html

Table 2.4:Hazardous Waste Components in Laptop Computer with Average Weight of 2.85 Kg

Description	Content % of the total weight	Weight of material (Kg)
Toxic Components		
Battery/Transformer/Capacitors	9.58	0.273
Plastic parts	26.66	0.760
PCB	15.8	0.450
Glass	134.4	0.382
Non-Toxic Component		
Metals	34.49	0.983

Source: AEA Technology (WEEE & Hazardous waste Part 2) for DEFRA

Table 2.5: Precious Metals and where they are found inside the Computer Equipment

Metals	Location in the Computer Equipment						
	Printed circuit boards	Computer chips	Keyboard membranes	Hard drives	Connectors/ fingers	CPU	Wiring & cables
Gold	v	v	-	-	v	-	-
Silver	v	v	v	-	v	-	-
Platinum	v	-	-	v	-	-	-
Palladium	v		-	v	-	-	-
Copper	v	v	-	-	-	v	v
Nickel	v	-	-	-	-	-	-
Tantalum	v	-	-	-	-	-	-
Cobalt	-	-	-	v	-	-	-
Aluminum	v	v	-	v	-	v	-
Tin	v	v	-	-	-	-	-
Zinc	v	-	-	-	-	-	-
Neodymium	-	-	-	v	-	-	-

Source: Researcher, 2018

Open burning of the computer e-waste can have severe repercussions for those nearby. When plastic components are burned, dioxins fumes from toxic elements (e.g. mercury, cadmium) are released into the atmosphere causing respiratory complications and food poisoning through food chains. Chemical leachates pollute both the surface and groundwater sources.

Herat *et al*., (2012) observes that the greatest amount of e-waste generated in high-income nations end up in countries with low-income and lack structures for environmentally-sound disposal management (ESM) of computer e-waste resulting in adverse human health and environmental impacts of toxins.

Recycling of computer e-waste causes challenges as it is often practiced by the informal sector, using crude and rudimentary tools with no respect to human health and the environment. The usage of chemical leaching techniques to extract valuable materials from computer e-waste involves either the use of acid which when released causes both air and soil pollution (Yang *et al*., 2011; Lee *et al*., 2009). According to Shamim *et al*., (2015) an economical means for supporting the development of recycled computer e-waste product market need to be established to reduce the potential negative effect on human health and the environment by the computer e-waste disposal management approaches. Recycling involves the extraction of precious materials from the computer e-waste some of which are highlighted in Table 2.5.

Computer components and accessories, when broken down, can affect respondents directly or indirectly from exposure of the computer components and accessories. The direct exposure can occur through inhalation of chemicals, ingestion or skin contact. Many of the chemicals found in the waste from computer components and accessories may readily leach into the soils and surface and groundwater sources, find their way into the food, blown away by the wind and transported into the air. Heavy metals such as mercury get their way to human through the food chain. Consumption of such food (e.g. fish) is therefore not safe and can be poisonous to humans.

Donating to friends and relatives, selling as second hand to the recycling facility and refurbishing used computer components and accessories extends its end-of-life and hence removed from the e-waste disposal management system for a long period (Kalana, 2010).

The research aims to identify the computer e-waste disposal management approaches; the potential effects on human health and environment of the computer e-waste disposal management approaches; the level of public awareness on human health and the environmental effects of computer e-waste disposal management approaches; and planning, policies and regulatory interventions for sustainable computer e-waste disposal management approaches in Nairobi City County.

2.4 Level of Public Awareness on Environmental and Human Health and aspects of Computer E-waste

Increasing public education awareness and participation in decision making are the critical components as in computer e-waste disposal management in addition to policies and legislation. According to Saxena *et al.*, (2014), public awareness and understanding of human health and environmental issues provide justification for dedication and meaningful action towards environmentally sound and sustainable development. Public awareness includes awareness on deteriorating human health risks and environmental conditions and raises their consciousness to the dangers they may be exposed to. Public knowledge and attitudes about a product's environmental friendliness can also affect the bottom–line for use and ultimate management of its end-of-life cycle destination (Seadon, 1999; Fikrom *et al.*, 2016). Waste from computer components and accessories is an outcome of human activities and therefore the need for all stakeholders to have the correct understanding of its disposal management issues, without which the success of any conceived waste disposal management plan becomes impossible. This enhances the understanding of disposal management attitudes, improves

decision transparency, and accessibility to information as stipulated by Marshall *et al.*, (2013). This is also an area that has attracted a growing and diverse attention for empirical studies in the recent years (Martin *et al.*, 2014). Lack of public awareness and education, low technical capacity to deal with computer e-waste have been identified as some of the common barriers towards computer e-waste disposal management approaches. In particular, studies by scholars such as Kalana, (2010) have established that many people do not know the potential adverse impacts to the human health of the increasing use of computer components and accessories, especially when they get into the urban solid waste stream at the end-of-life. Besides, lack of interest in the environmental issues may create a tendency for stakeholders not to participate in decision-making processes (Bolaane, 2006) and hence non-committal to computer e-waste matters. Eventually, this results in stakeholders that have very low awareness of, or interest for their potential effect on human health and the environment (Poswa, 2001).

According to Bolaane, (2006); Mrayyan *et al.*, (2006); Milea, (2009); O'Connell, (2011), social incentives can be a significant motivator to behaviour change for effective computer e-waste disposal management and many researchers have considered it as an effective intervention in low-income countries. The media involvement, through campaigns and use of advertisement can play a significant role in increasing public awareness and participation (Mosler *et al.*, 2008). Further, several scholars have quoted monetary incentives as essential tools in behavioural change towards computer e-waste disposal management.

As examples of countries such as Malaysia have shown (Suja *et al.*, 2014), for institutions and businesses to perform well in e-waste disposal management, the existence of internal environmental management systems is crucial. From an environmental management systems perspective, these may take the form of practices such as written environmental sustainability policy, the reflection of e-waste minimisation in the quality assurance statements of the organisation, the existence of waste disposal management teams, and statements of explicit goals to be achieved should be formulated based on specified benchmarks.

Several factors influence the disposal management practices adopted for computer e-waste depending on the user or actor involved. Nsengimana *et al.*, (2011) have reported that public institutions wait for other public institutions responsible for disposal of the e-waste to decide on their behalf. The writers further state that computer e-waste is disposed of due to many factors such as upgrading technology or broken or unsuitability of old technologies to cater for the current requirements. UNEP, (2009; and Nsengimana *et al.*, (2011) underscore that people

involved in refurbishing normally use government assets' public auctions as pathways for disposing of computers at end-of-life. Nsengimana *et al.*, (2011) and Chawla *et al.*, (2012) have also reported that some individuals and households use this avenue to purchase low cost used computers and that there were always large quantities of remaining unserviceable computer equipment at the end of the auction which was disposed of to the landfill. In Kenya, disposal by public institutions is highly influenced by the specific disposal procedures and guidelines as provided for in the public procurement and disposal act (GoK, 2005; 2015) as stipulated by Lewa (2012).

The literature reviewed indicates that people are not aware that exposure to waste from computer can have potential negative effects on health and the environment (Nartey, 2016; Pradhan, 2014). Hence the respondents, therefore, fail to know how and where to discard of the computer e-waste. The study consequently set to examine the level of public awareness on human health and the environment of computer e-waste disposal management in the Nairobi City County because there was no data available on the same.

2.5 Planning, Policies and Regulatory Interventions Context for Sustainable Computer E-waste Disposal Management Approaches

Supportive management plans, policies, regulatory and institutional frameworks are a necessary precondition for successful waste disposal management in urban areas, including practices relating to disposal management of computers. From a sustainability perspective, for policies, legislation and development planning tools as well as institutional arrangements to adequately support e-waste disposal management practices considering both health and environmental aspects of an urban ecosystem, they need to mirror the totality for sustainability (social, economic and environmental) scope.

Thus, an analysis of the treatment of human health and environmental considerations in the evolution and current scope and content of the policy, regulatory and institutional regimes become an essential beginning point for discerning weak points and windows of opportunity for promoting healthy and environmentally sound practices in the disposal management of computer e-waste in urban settings. Ongondo *et al.*, (2011) present an analysis of e-waste disposal management approaches in several countries and regions around the globe. The writers conclude that the rate of starting legislation on e-waste is increasingly growing in the globe while it is non-existent in some cases.

Switzerland was the first country in the world to develop and implement a formal e-waste management system for the collection, transportation, recycling/treatment and disposal of e-waste (Wäger *et al*., 2011). The system was based on the extended producer responsibility (EPR) model, where manufacturers are responsible for the disposal of e-waste in environmentally sound manner.

The WEEE management regulation (2001) in Sweden ensure appropriate treatment of WEEE (Sasaki, 2004) through take-back of computer e-waste to retailers in exchange for new ones (old-for new or new-for-old rule). The households drop of their e-waste at municipal collection points, while institutional and private businesses pay for treatment of their computer e-waste.

According to US Environmental Protection Agency (EPA), US recycling systems vary according to the individual state perspectives. However, more than 20 states have enforced legislation to manage [computer] e-waste, most of which are based on an EPR policy (Silveira *et al*., 2010).

Under the Japanese regulation (2001), consumers have the responsibility to liaise with the retailers and pay a to '*recycling fee*' and a '*transportation fee*' ensure collection of their computer e-waste. 'The retailers have also the responsibility to transfer the e-waste to the producers at given collection points (Chung *et al*., 2008).

In Korea, there are three main actors in collection of computer e-waste namely: Ministry of Environment (MoE), the Korea Recycling Corporation (KORECO) and the manufacturers. The MoE ensures that the manufacturers pay advance deposits to cover recycling costs while KORECO manages the administration of the recycling and the unreturned deposits.

China and low-income countries (including Kenya) lack a computer e-waste disposal management system; lack effective enforcement of existing regulations and also specific regulations relating to computer e-waste disposal management (Nnorom *et al*., 2008 The countries also lack best available technologies and state-of-the-art recycling facilities for formal recycling of computer e-waste. As a result, computer e-waste disposal is managed through various low-end management alternatives such as disposal in open dumps, backyard recycling and disposal into surface water bodies (Osibanjo *et al*., 2007).

Considering that international deliberations and partnerships have been central in framing the agenda for environmental management policy discourse and actions across spatial settings

(LeBel, 2012; Suja *et al*., 2014; More, 2015), the section begins by presenting a synthesis of the attention to e-waste disposal management approaches and policy discussions in the global arena. After that, the types, provisions and policy, legal and institutional challenges for computer e-waste disposal management approaches in relation to the promotion of a healthy and environmentally sound urban planning and management in Kenya is reviewed.

2.5.2 Global initiatives for Computer E-waste Disposal Management

E-waste constitutes a significant global human health and environmental issue, negatively impacting vulnerable groups (Frazzoli *et al*., 2010). Against this background, appropriate policies for enhancing e-waste disposal management practices have been at the centre of new international human health and environmental management and discussions, agreements and instruments. However, the issues that suffuse on these trajectories of common action are neither unique nor expressly particular to e-waste disposal management specific systems. Instead, they reflect a contingent web of value judgments rooted in intense global environmental management discussions of the early 1970s and continue to engulf countries till today (Lis *et al*., 1993; Mol, 2010; Nyakang'o, 2015). The Stockholm Conference on Environment and Human Development (UN, 1972), made some propositions that have had a profound bearing on waste disposal management policies, plans and programmes on environmental sustainability at national and county levels.

The World Commission on Environment and Development

The Report of the World Commission on Environment and Development (WCED, 1987) on our common future, provides an important pointer to the future initiatives. The report called on world countries to quickly address the problems associated with waste generation while making an invitation for adoption of sustainable development concept. UNEP has been influential in the role state governments may play in formulating policy directions to drive effective and efficient e-waste computer disposal management system from a sustainable development imperative. The WCED focusses on the '*3E*' principle that balances the values of the Environment, Equity, and Economy. Since the WCED, the economic development theories have put more emphasis on the quality of life, the role of technology and innovation, and environmentally friendly production. This implies that economic development may not necessarily be an extension of economic growth, but it opposes activities, traditionally regarded as growth that have negative impacts to human health and the environment. While economies of scale in production may promote growth, they are not sufficient for sustained growth and

may have opposite effects on sustainable development in case of in the case of waste management.

The United Nations in Sustainable Development Conference, 2012

The United Nations in Sustainable Development (Rio+20) Conference on the green economy agenda provides developing countries with important national policy space to devise their paths, while discussing with developed countries on the willingness to take on responsibilities for a sustainable global future. UNEP, (2010) describes the green economy as the outcome of an improved human health while substantially decreasing environmental degradation resulting in an economy that is low in carbon, efficient in resource and in social inclusiveness (UN, 2011). In the context of this study, therefore, is the green economy which can create jobs, reduce the effects of climate change by lowering greenhouse gasses (GHGs) emissions, and through sound environmentally computer e-waste disposal management approaches.

According to Robinson *et al*., (1998); Saxena *et al*., (2014); UNEP, (2009); and Kiddee *et al*., (2013), low institutional capacity, lack of education and awareness, inadequate technologies, inadequate of institutional structure, inadequate or absence of policies, regulatory frameworks and are some of the main factors that have stood as barriers to full realisation of sustainable waste disposal management systems in the cities of low-income countries particularly in Africa. While the search for adequate mechanisms to solve the challenge posed by computer e-waste has acquired a solid grounding in intellectual discussions and empirical studies, efforts to formulate national policies and programmes specific to the phenomenon are only starting to emerge on the scene.

Initially, the problem was perceived as that only requiring technological fixing (Jain, 1984; Mol, 2010; Guerrero *et al*., 2013). Over time, it became apparent that environmental problems that result from indiscriminate disposal of the e-waste are much more complicated, hence require multiple solutions and elasticity that take social, economic and environmental considerations for the users of computers. The past two decades have made tremendous milestones in the international debates and formulation of collaborative initiatives on planning, policies, legislation and institutional frameworks relevant to responsible computer e-waste disposal management approaches.

The Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal

Basel Convention (UNEP, 2006) is the supreme international Multilateral Environmental Agreement (MEA) on hazardous and other [computer] wastes (UNEP, 2004). The Convention aims at promoting reduced volume and toxicity of generated waste as well as encouraging environmentally sound waste disposal management within low-income countries. In the late 1980s, the computer e-waste disposal management became very expensive in the high-income countries, resulting in stricter environmental regulation. To counter this, the high-income countries resorted to dumping hazardous waste in the low-income countries (Yap, 2006). The [computer [e-waste was recognized as toxic and hazardous in 1998 and required prior permission from countries of import and even transit regardless of whether they were signatories or not to the Convention (Asante-Duah *et al.*, 1992). In September, 2010, the Convention had 178 signatories but countries such as the USA had not ratified the Convention (Basel Convention, n.d). The Convention, established in 1998, legally bans disposal of hazardous waste from high-income to low-income countries. Article 4 of the Convention allows Parties to exercise their right in prohibiting the importation of toxic wastes for disposal; exportation of the same wastes to the Parties that have prohibited the importation of such wastes; and prohibition of the exportation of hazardous wastes if the State of importation does not approve in writing to certain importation, in the case that State of importation has not prohibited the import of such wastes.

The Convention in section 12, further directs the Parties to adopt a protocol that determines liability rules and procedures that applies to transboundary damage of the toxic waste.

The Basel Action Network

The Basel Action Network (BAN, 1992), amendment imposed stringent measures on trade in toxic waste and disposal management in Africa (Tutu, n.d.). Though this adjustment prevented exportation to low-income countries, it fails to prevent [computer] e-waste trade for reprocessing purpose as provision of raw materials to the low-income nations. A huge amount of imported hazardous wastes, into low-income countries, are non-recyclable. However, the Basel Action Network, (BAN, 2005) though morally binding, is yet to come into force by parties to the Convention, due to non-ratification by a majority (e.g. Haiti, Afghanistan and the United States of America) that are signatories to the Basel Convention, which came into force in 1992 and had 172 Parties including Kenya. The non-compliance to the international e-waste

disposal management policies by some countries has posed a significant challenge in the prevention of transboundary movement of toxic waste to low-income countries such as Kenya.

European Union Waste, Electrical and Electronic Equipment, 2012

The European Union (EU) Directive (2012/19/EU, 2012) is the most influential and popular requiring its domestication into Member States national laws for compliance and enforcement (Article 4). The Directive aims to sustain, prevent and enhance the quality of human health and the environment including prudent use of natural resources and reducing the total e-waste into the landfill. Besides, it called for considerable change in current developmental patterns, manufacture, utilization, behaviour. The Directive also demanded the reduction of wasteful use of natural resources and decrease in pollution to achieve sustainable development in related human health and environmental performance. The Directive, further, encourages the producer to collect products from consumers, disassemble the products, and reuse or recycle as many parts as possible. The Directive provides that all new EEE, including computer e-waste, be marked with specific data to allow for proper disposal by the user at end-of-life. Further, the recycling facilities should have access to the data to enable them efficiently reprocess the new products.

Electrical and Electronic Equipment Directive, 2011

The Electrical and Electronic Equipment (2011/65/EC, 2011) is the European Union (EU) legislation that controls the use of toxic materials in Electrical and Electronic Equipment (EEE). It provides for substitution of heavy substances (e.g. cadmium, mercury, lead, hexavalent chromium, flame retardants (e.g. polybrominated biphenyls (PBB) or polybrominated diphenyl and ethers (PBDE) by harmless alternatives. Table 2.6 indicates the permissible levels of the six substances in the manufacture of EEE such as computer components and accessories.

Table 2.6: Substances Limited for use in Electrical and Electronic Equipment

Substance	Maximum limit % by weight
Lead (Pb)	0.1
Hexavalent Chromium (CrVI)	0.1
Cadmium (Cd)	0.01
Polybrominated Biphenyl (PBB)	0.1
Mercury (Hg)	0.1
Polybrominated Diphenyl Ether (BDE) flame retardants	0.1

Source: Researcher, 2018

The legislation aims to create collection schemes that require end-users to return their used e-waste free of charge at the end-of-life. The aim of the schemes is to increase the reprocessing and/or re-use of such materials.

Extended Producer Responsibility

Extended Producer Responsibility (EPR) is an environmental policy that holds manufacturers liable for assembly and delivery of goods and also towards the disposal management of their commodities (Lifset, 1993; Sachs, 2006). It is widely used as a new paradigm by both high and low-income nations, to manage the increasing challenges of computer e-waste (Bandyopadhyay, 2010). The EPR aims to encourage reduction of impact of the product to the environment at end-of-life by making the producers internalise the cost of their commodities at the end-of-life. This would influence the design of commodities that can be reprocessed and less toxic and ensure stability in financial sustainability in managing a recycling system for use after the end-of-life (Mayers *et al*., 2013). In normal situations, the responsibility of computer e-waste disposal management is the concern of the county government and, therefore, financed by taxpayers. However, the EPR transfers the burden of computer e-waste disposal management to the producers, and away from the county government.

The EPR policy is based on the '*Polluter-Pays-Principle*' which identifies and transfers responsibilities to stakeholders involved mainly the producers. Besides, the EPR policy approach also provides inducements to the manufacturers to include computer e-waste disposal management expenses at the design stage (OECD, 2005) thus making economic sense by reducing disposal management costs. For example, commodities made with less harmful materials have reduced processing costs for toxic components after their end-of-life. These two reasons make adoption of EPR for computer e-waste disposal management (OECD, 2005) feasible. Lifset *et al*., (2008) identify the following three key policy instruments for implementing the EPR:- i) economical, ii) administrative, and iii) informative. The EPR implementation requires external support due to the cross-border issues.
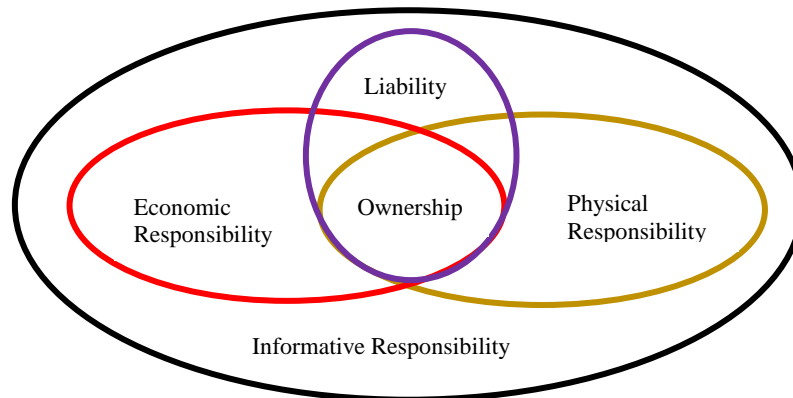
Figure 2.1: Examples of EPR-based Policy Instruments
Source: Lindhqvist, 2000

According to Lindhqvist, (2000) and Tojo (2004), the manufacturer's responsibilities (Figure 2.1), are defined as:- i) *Financial responsibility* (producer responsibility for collection costs, reuse and/or recycling and disposal management of the product); ii) *Liability responsibility* (for compensation of environmental degradation) often determined by legislation; iii) *Informative responsibility*(provision of information on effects of the manufactured products by the manufacturer; iv) *Physical responsibility* (Responsibility on ownership and impacts of the products by manufacturer throughout its life cycle); and v) *Ownership responsibility* (manufacturer ownership and responsibility over its impact to the environment).

Table 2.7: EPR-based Policy Instruments

Type of instrument	Mechanism
Economic	Product taxes and subsidies; advance disposal fee systems; deposit-refund systems; upstream combined tax and subsidies; tradable recycling credits.
Informative	Reporting to authorities on labeling of products and components; consultation with county government on disposal management system; information provided to users on producer responsibility and separation at source; information provided to recyclers on composition and elements used in products.
Administrative	Collection and take-back of disposed of products; landfill restrictions; attainment of collection, reuse and recycling targets; use of best available technologies and environmental practices; achievement of minimum material content for recycling requirements; product standard.

Source: Tojo, 2004

The EPR approach mandates all stakeholders to accomplish the requirements through legislation while the individuals are responsible for the voluntary actions. The current Kenya scenario is based on the voluntary action by companies due to lack of a regulation

encompassing EPR. According to Carisma (2009), the EPR policy gives producers and policy-makers an opportunity to choose the specific instruments adaptable to the existing market and local conditions in performing their responsibilities. Computer e-waste is a nascent subject and it is a concern to both national governments and non-governmental organisations such as Greenpeace and Solving the E-waste Problem (StEP) that is delegated by United Nations to deal with challenges of e-waste. All these schemes often concentrate on the promotion of the 3-Rs principle and the EPR policy. According to the hierarchy in computer e-waste disposal management, the 3-Rs is the principal terms used for Reduce, Reuse and Recycle.

2.5.2   *Regional Initiatives*

Bamako Convention

In the context of African countries, the Bamako Convention (1991) placed a complete ban on the importation of hazardous waste within Africa. This Convention was drafted by high-income countries in reaction to observation that low-income countries became the dumping fields for hazardous waste from the high-income countries under the endorsement of Basel Convention. High-income countries snubbed the initiative and are indirectly promoting the dumping of hazardous computer e-waste in the low-income countries (BAN, 2007). For instance, under the Basel Convention, used computer equipment that is functioning and intended for re-use is not considered to be e-waste, regardless of whether it is hazardous or not (Terada, 2012; Puckett *et al.*, 2005).Unlike the Basel Convention, the Bamako Convention has a better preventive framework towards the trans-boundary trade relating to computer e-waste (Donald, 1992). Further, the Convention does not exempt certain hazardous wastes such as radioactive materials but permits the cross-border movement of toxic wastes produced in Africa subject to strict regulatory controls. This is, therefore, a significant setback towards sustainability of computer e-waste disposal management as this readily permits movement of the e-waste within African countries such as Kenya. Though Kenya is a Party to the Basel Convention and a signatory to the Bamako Convention, in 2003, it is yet to ratify the Bamako Convention.

Durban Declaration

The Durban Declaration (2008) on e-waste disposal management in Africa is based on the apportioning experiences from South Africa, Kenya, Senegal, Morocco and Uganda. The Declaration stipulates the development of a specific roadmap and importance of optimising the life cycle of e-waste; intensifying public awareness on potential impact of waste from

electronic equipment on the human health and the environment and electronic waste disposal management approaches; socio-economic opportunities available in processing waste from computer components and accessories; public perception on sustainability solutions of e-waste problems; national, regional and international partnerships among companies, governmental, non-governmental organisations and academic institutions in dealing with the e-waste disposal management, and existing gaps on access to EEE resulting in a digital divide.

Nairobi Ministerial Declaration

The Nairobi Ministerial Declaration (UNEP, 2006) is concerned by the risk to human health and the environment resulting from trans-boundary movement of electronic waste to low-income countries and lack of capacity on the best available environmental practices for disposal management for e-waste. The Declaration identified laxity in enforcement of existing legislations in the low-income countries; seeks to revitalise the need to cooperate; and provide innovative solutions to bridge the developmental gap. It has also adopted the activities towards the best environmental disposal management practices of e-waste (CoP9-Basel Convention) concentrating on the requirements of the low-income nations and nations with economies in transition. The statement from this Declaration is hinged to the Basel and Bamako Convention and hence the movement of waste from computer components and accessories from high-income to low-income countries and within African countries continues.

The Pan African Forum on E-waste, Nairobi

The Pan African Forum (UNEP *et al*., 2012) underscore the green economy prospects in e-waste segment. The Forum calls to action on priority to mend best environmental practices disposal management of computer e-waste in Africa. Further, it calls for execution and enforcement of both the Basel and Bamako Conventions; development of national disposal management systems to enhance collection, transportation, storage, reprocessing and disposal of e-waste; establishment of institutional frameworks and multi-stakeholder (UN, NGOs, Private Companies, e.t.c) involvement; recognition of safe and sustainable e-recycling for provision of opportunities for green jobs and thus reduce poverty; and public awareness creation campaigns on potential effects of human health and environmental degradation of the urban area due to use of unsound e-waste disposal management approaches.

The forum underscores the need to formalise the informal recycling and recovery activities by using international recycling standards. It also calls for the importers, producers, re-sellers and

other dealers of computer e-waste to organise for collection, transportation, recycling and extraction of valuable metals from computer e-waste and stipulates the use of EPR in the environmentally sound disposal management of the e-waste.

2.5.3   Kenya Initiatives

Since Rio de Janeiro Conference on Environment and Development (UNCED, 1992), the country has initiated several policy guidelines that take cognisance of sustainable development principles and incorporated them in the country's development plans and programmes. This includes the Sessional Paper No. 6 of 1999 on Environment and Development, the National Environment Action Plan (NEAP) of 1994;the Constitution of Kenya (GoK, 2010); the Kenya Vision 2030 (GoK, 2008); the Environmental Management and Coordination Act (GoK, 1999; 2015) - the principal statute for environmental management in Kenya, and its subsidiary Waste Management Regulations (GoK, 2006); and the E-waste Management Regulations (GoK, 2016); the Water Act (GoK, 2016); the Public Procurements and Disposal Act (GoK, 2005; 2015) and its subsidiary Public Procurement and Disposal Regulations (2006); Science, Technology and Innovation Act (2013); and the Integrated Solid Waste Management Plan for the Nairobi City County (2010-2020) (UNEP, 2010). As provided for under Environmental Management and Coordination Act (GoK, 1999), the Government has also established the National Environmental Management Authority (NEMA) that formulates the national environment research agenda which informs policy decisions and planning processes on emerging environmental concerns and how they impact on the quality of both social and economic lives.

The Integrated Solid Waste Management Plan for Nairobi

The management plan (UNEP, 2010) aims to minimize e-waste by advocating for the 4-Rs principle (reduce, reuse, recover, recycle) where possible; monitor its disposal management approaches especially the computer e-waste; and (annually) review the plan. The management plan is meant to improve co-operation between public-private-partnerships in contributing towards sustainable recycling of the [computer] e-waste. It promotes and protects human health and environmental degradation of the urban area and establishment of sustainable environmentally sound disposal management systems. However, management plan recognises the need for the formulation of legislation on e-waste; lack of relevant technologies and knowledge to address e-waste; and lack of a national policy on handling of hazardous wastes,

such a waste from computer components and accessories, as the significant gaps. The plan should provide for computer e-waste disposal management using the best available technologies. The plan is, however, guided by the polluter-pays-principle, public participation and sustainability.

However, huge volumes of computer e-waste continuously grow in the urban solid waste stream resulting in the persistence of many environmental problems in Kenya despite the wake of this myriad policy, legal and institutional milestones in the country frameworks. EMCA (GoK, 1999), raises the possibility that the fundamentals of an efficient and effective computer e-waste disposal management system cannot be attained without institutional framework, technical capacity and administrative support towards efficiency, public awareness and attitudes change. These are yet to be adequately addressed to the degree they can cause a radical transformation in the management of fast emerging components in the urban solid waste stream such waste from computers.

Against the backdrop of this scarcity, the remaining section concentrates on highlighting the various management plans, policies, regulatory and institutional frameworks in Kenya regarding the promotion of healthy and environmentally sound computer e-waste disposal management practices in urban settings such as Nairobi.

Policy Frameworks and Computer E-waste Disposal Management in Kenya

Constitution of Kenya 2010

The Constitution was promulgated in 2010. It has provided for the centrality of environmentally sensitive structures and values of governance. At the outset, the Constitution reflects this aspiration for environmental management as an essential engine of the sustainability prism in the Preamble in which the people of Kenya pledge to respect the environment, their inheritance and determination to sustain it for the benefit for the generations to come.

Some articles in the constitution specifically indicate government's position regarding the benefits of the Kenyan people. Article 42 stipulates the right to a clean and healthy environment for every citizen including the right for environmental protection for the benefit of current and generations to come through legislation specifically those envisaged in Article 69; and commitments regarding the fulfillment of the environment under Article 70.

Likewise, Article 70 (2a), provides for the right to compensate victims who have been violated of their rights to a clean and healthy environment. Furthermore, Article 72commits Parliament to enact legislation to actualize the provisions relating to the environment. The Constitution therefore lays the foundation for inculcating policies, plans, regulations and programmes necessary to drive sustainable e-waste disposal management systems in the county. Article 69 commits the state to be in charge of the sustainable management of the environment. Under this Article, the state is expected to ensure sustainable exploitation, utilisation, management and conservation of the environment and natural resources and to ensure equitability in sharing of the increasing benefits.

In Article 69 (d), the state is required to promote public participation in the management, prevention and conservation. However, in some occasions, public participation has been viewed as an administrative procedure (Kimani, 2010) and hence lack of information on environmental degradation(Amechi, 2009). Further, Article 70 ensures that environmental rights are enforced. It requires peoples' right to a clean and healthy environment are recognised and protected. Besides, it provides for application to the court for redress in addition to any other legal solutions that are available in related to the same matter (Article 42) when the citizens are denied, violated, infringed or threatened. In response to this, the court may give guidelines it considers appropriate. Article 70 (2) (a) provides for protection, halt or continuation of any act or omission to contribute to environmental risks. Part (b) of the Article commits the public officers to address protection, actions that may cause risks to the environment; and provides for compensation for the right to clean and healthy environment to victims of violation.

Under the Article 70 (3) an applicant does not need to show that loss or suffered injury to any person has occurred. With these requirements, the state commits to ensure all citizens can apply to the court for redress of environmental matters, whether affected directly or indirectly.

Kenya subscribes to 16 international environmental treaties whose aim is to protect the environment. Article 2 (6) requires that the treaties or conventions ratified by Kenya will form part of the law. The Constitution provisions ensure that environmental conservation approaches for both local and international laws are implemented and guaranteed. Further, the Constitution gives the national government as the overall manager of the environment and natural resources and establishment of a sustainable disposal management system. However, the county government, has the responsibility to implement particular national policies on natural

resources and environmental conservation relevant within their jurisdiction. The constitution of Kenya, therefore, plays a significant role in environmental management by acknowledging the environmental sustainability, and this will ensure conservation of the environment.

The Kenya Vision 2030

This is the overall blueprint for development (2008-2030) and based on three pillars of economic, social and political. The waste disposal management is under the environmental and the social pillars. However, the components specific to computer e-waste disposal management systems are missing, the Kenya Vision 2030 proposes protection of the environment relevant to sustainable e-waste disposal management at both the county and national government. This includes prevention of pollution and waste disposal management through environmental conservation; implementing economic incentives; and advocating for public-private-partnerships (PPPs). The Government of Kenya recognises the critical role played by public participation in democratic governance (GoK, 2008)) sustainable development.

Sessional Paper No.6 of 1999 on Environment and Development

The paper addresses broad issues and challenges concerning environment and has provided a basis for the development of many sector-specific and multi-sectoral policies, legislation and creation of institutional frameworks for governance of the environment in Kenya. Further, it has been an instrumental tool of reference in the environmental issues in the formulation of national blueprints for development planning and programmes.

The paper is the springboard for the development of legal frameworks as well as enactment of EMCA of 1999 and establishment of NEMA. The Authority supervises and coordinates all issues related to the environment. EMCA provides for formulation of laws to compel private polluters to make disclosures of the volume of the computer e-waste they release into the environment and guarantee public access to this information.

In societies that have been successful in waste disposal management minimisation practices such as the USA and Eastern Europe (Kiddee *et al.*, 2013), environmental and special interest groups have taken full advantage of this provision and enhanced public awareness on corporate environmental prowess.

Substantial incentive for business ventures has resulted in more resources devoted towards waste reduction due to threats of big fines and jail sentences. For example, disposal permit notations resulting in huge millions of monetary fines and jail terms have been widely recognised as important, significant drivers of waste minimisation efforts in countries such as USA, Canada and Sweden (LeBel, 2012; Kiddee *et al*., 2013; Barletta *et al*., 2016.

Thus, this regulatory Authority (NEMA) is expected to design and support such programmes as to promote environmentally sound and healthy e-waste disposal management and to influence the attitudes of people to adopt sound environmental practices for e-waste disposal management in their life patterns. The institutions' competence and capability for e-waste minimisation strategies: the kind of management and supervision practices espoused by these policies and regulations need to be flexible to accommodate the dynamics and emerging challenges associated with e-waste management concerning new technological options and responding to new regulatory requirements (UNEP, 2009; 2010). Research and development (R&D) are also necessary towards reducing the inefficiencies inherent in the administration of regulations and enforcement of compliance. Thus, questions regarding the powers conferred to NEMA as the overall regulatory agency and the conditions that might prevent the institution from driving adequate computer e-waste disposal management approaches in the country are important issues for research.

National Environment Policy

The Ministry of Environment and Natural Resources (MENR) has developed the national environment policy (GoK, 2014). The policy underscores the principle of sustainability in development. Besides, the policy underscores the principle of public participation and lays the basis for a harmonization and all-inclusive (e.g. Government agencies, county governments, the private sector and civil society and communities) approach on use of environmental resources, inherent planning, implementation and decision-making processes. The policy takes recognition of the potential effects on human health and environment as components of analysis for all projects under the environmental impact assessment and audit (EIA). Further, it enhances the safety services for occupational health. Besides, it provides for the use of monetary incentives to manage [computer] e-waste disposal and encourages creation of amenities and incentives for cleaner production, waste salvage, re-use and recycle.

In this regard, the policy promises to marshal diverse perspectives and synergies towards enabling an effective and efficient waste disposal management system that embraces the right to a human health and environmentally sound habitat. However, the policy provides for benefit of extraordinary power and legitimacy of control over societal processes. The policy is also the authoritative document for recourse and valuation of previous and imminent government actions on related issues of environment, a verdict that can be extrapolated to the analysis of the utility of the policy to current e-waste disposal management practices in Kenya. The policy recognises information as the basis of sustainability and is crucial to effective planning and decision-making and commits the government to support research and development initiatives for purposes of knowledge transfer of technologies for sustainable environmental disposal management. Nevertheless, the fact that the MENR has also developed E-waste Management Guidelines (2010) not only attests to the commitment by the government in driving the agenda of reducing the flow of [computer] e-waste to the environment but is as well a symbol of its belief in the change likely to occur in the event the environment policy is operationalized.

National ICT Policy, 2006

Full liberalisation of information communication technology took place in 2004 when the Ministry of Information and Communication Technology (ICT) policy (MoICT, 2016) and the accompanying regulations to implement the policy were developed. The Policy contains a clause on e-waste which necessities dealers to demonstrate the relevant reprocessing and disposal management infrastructure for [computer] e-waste as part of the requirements to minimise the effects of their ICT infrastructure on human health and the environment, as a condition to grant or renewal the communications license in the ICT sector (Tocho, *et al.*, 2013). The Communications Authority of Kenya has incorporated this requirement into its legislation and this ensures accountability in conservation and protection of the environment from the hazardous effects of computer e-waste generators. However, these provisions are inadequate and mainly cover the licensing and frequency distribution. The pre-export verification of conformity programme by Kenya Bureau of Standards is inadequate to address the complexity of the end-of-life disposal management of waste from computer components and accessories especially the potential harm of unsafe and substandard products entering into the country.

E-Waste Management Guidelines, 2010

The guidelines provide a framework for the formulation of policies and regulations with the participation of main stakeholders in the sustainable disposal management of computer e-waste in Kenya. The Guidelines (MENR, 2010) aims to protect the environment from computer e-waste; creation of a foundation for a policy and regulatory framework on e-waste disposal management; and increased public awareness on sustainable disposal management of e-waste in Kenya. In this regard, the Guidelines provide mechanisms for the waste from computer components and accessories disposal management and its potential effects on human health and the environment. However, despite the development of these guidelines, there is still limited documentation on how institutions and households dispose of their computer e-waste and how much users of computers know about the impacts of the e-waste on human health and the environment. Further, the guidelines have lack well implemented and clear policies, thus giving a loophole in the computer e-waste disposal management in Kenya. This is contrary to the practices in other countries particularly the high-income ones in the European Community (EU), where the Member States undertake to recovery, minimum collection, reuse and processing targets as specified in various directives(Lindhqvist, 2000). Besides, consumers' perceptions of options for sustainable disposal management of computer e-waste are not documented. However, the guidelines advocate for the use of extended producer responsibility (EPR) as a strategy for making the manufacturers responsible for the entire life cycle of the product and for taking back of the products from the market and its proper disposal.

Kenya Health Policy

The Kenya Health Policy, 2014-2030 (MoH, 2014) aims at giving guidelines to guarantee enhancement of human health in Kenya as mandated by the Constitution of Kenya (GoK, 2010), the country's long-term development agenda and the Vision 2030. The policy provides for the prevention of the rights and fundamental freedoms of right to human health. Policy objective 5 stipulates the promotion of a clean environment, enhancement and prevention of potential harm on environment and human health such as waste from computer components and accessories. The policy defines the roles of various stakeholders in the sector in the delivery of the human health agenda, the institutional frameworks under the devolved system of government and the significant roles of two levels of government.

The Medium-Term Plan 2013-2017 (MoDP, 2013) stipulates the need for the review of the policy for purposes of harmonisation with sectoral policies, legislation, regulations. This would result in the strengthening of the relevant institutions in human health and environmental regimes. This, therefore, calls for reviews of the human health and environmental policies and legislation that govern waste from computer components and accessories in order to address their disposal management. There is also need to maintain open government policy by the state actors to continuously inform the public on any new developments in these sectors.

Regulatory Frameworks and Computer E-waste Disposal Management in Kenya

Environmental Management and Coordination Act (Amendment) 2014

The Act is the supreme statute for environmental governance in Kenya. It established the National Environment Management Authority (NEMA) for the overall coordination and enforcement of environmental laws in Kenya. The Environmental Management and Coordination Act (EMCA) have developed several subsidiary regulations relevant to e-waste disposal management from a human health and environmental sustainability perspective. Under Section 147, the Act empowers the Cabinet Secretary for environment at the recommendation of NEMA to gazette regulations for the implementation of the Act. They include the Water Quality Regulations, 2006; the Environmental Impact Assessment, the Audit Regulations, 2003 for environmental monitoring and assessment; the Occupational Health and Safety Regulations, 2006; the Waste Management Regulations, 2006; the Air Quality Standards Regulations, 2007; and the E-Waste Regulations, 2016. However, analyses of the utility of these regulations concerning e-waste disposal management in the country are still scanty, almost absent in the literature. Their relationship to e-waste disposal management is highlighted as follows.

Table 2.8: EMCA Subsidiary Legislations and their Relationship to E-waste Disposal Management Approaches

Regulation (Year)	Description
Environmental Impact Assessment and Audit (2003)	Provides rules and procedures for licensing, carrying out and reporting of impact assessment and audit (GoK, 2003).
Waste Management (2006)	Provides rules, procedure and criteria for managing different types of waste (GoK, 2006).
Water Quality2 (2006)	Provides for protection of water quality through pollution by gasses, liquid or solids (GoK, 2007).
Controlled Substances (2007)	Provides definition, classification, licensing and permit, disposal, monitoring on manufacture, packaging, import and export of controlled substances (GoK, 2007).
Hazardous Substances (2007)	Provides guidelines for disposal of all unused, obsolete or expired chemicals in an environmentally sound manner (GoK, 2007).
Air Quality (2009)	Provides for prevention of pollution of air through direct or indirect acts (GoK, 2009).

Environmental Management and Coordination Act (Water Quality) Regulations, 2006

The Water Quality Regulations was developed under section 147 of the Act. However, there is a conflict between these regulations and the water rules developed by WRMA- being the lead agency that is in charge of all issues related to water management (GoK, 2002). Under Section 4 (2), the regulations prohibit pollution of any water resource by liquid, solid or gaseous substance. The regulations outline the quality standards and monitoring for water sources; monitoring procedure for environment pollution and effluent flow into public sewers. While the regulations do not explicitly provide for computer e-waste, it is implied, since computer e-waste is a component of the solid part of the county solid waste stream (CSW). However, the regulation does not provide for pollution of water by toxic chemicals leaching into the water sources.

Environmental Management and Coordination Act (Impact Assessment and Audit) Regulations, 2003

The environmental monitoring (EM) and environmental auditing (EA) are management tools for continuous environmental improvement in organisations. The tools are used for post-environmental impact assessment activities by providing guidelines for licensing, carrying out and reporting impact and assessment of the environment. They provide regulatory

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[2] They conflict with the water rules developed by WRMA being the lead agency that is in charge of all issues related to water management

requirements, clean-up of pollution, potential and current levels of environmental hazards and risks and address the emerging environmental concerns.

Section VII 58 and 68 provides for impact, assessment and audit of the environment respectively and a participatory approach. The regulations provide for detailed conduction of the EIA and EA for new developments that may have potentially significant on the human health and environment as stipulated in the second schedule of EMCA. The objective of the EIA system is to include environmental issues in planning, decision-making and implementation of activities. Thus, it establishes critical conditions for pollution prevention in new developments by ensuring that harmful processes are substituted with cleaner, less polluting technologies at the planning stage. The EIA system has become an important element of pollution management in Kenya. Clause 58 (10) in the regulations, provides a maximum jail sentence of three years and a maximum fine of five million Kenya shillings or both for submitting false or misleading EIA or EA reports.

Despite the EIA being a tool for management, it is often not carefully integrated into planning and decision-making process. The EIA is carried out after planners and decision makers begin advocating for a particular proposal and it then only serves largely to suggest mitigations for a project already selected (Abracosa, 1987 and Hirji, 1990). An issue related to the integration problem is that EIA does not ensure that projects with significant adverse effects will be stopped. In many contexts, EIA does not ensure that projects with significant adverse effects will be stopped and officials often promote environmentally damaging projects if the economic benefits outweigh their negative environmental impacts.

Environmental Management and Coordination Act (Waste Management) Regulations of 2006

These regulations apply to all categories of waste [computer e-waste] including hazardous and toxic wastes such as the one contained in the computer components and accessories. The regulations provide procedure for disposal management of all types of waste. Section 1 (2) provides for collection, segregation and disposal of waste as provided in the regulations. Further, Section 5(1) provides for segregation of waste through separation of toxic waste from non-toxic waste and eventual disposal in facilities provided by the county government. Section 6(1) provides for reduction of waste through adoption of the cleaner production technologies. Besides, the regulations provide collection of e-waste by NEMA certified waste collectors.

However, the regulations luck specific mention of e-waste, but it can be argued that it is addressed under hazardous waste.

Environmental Management and Coordination Act (Air Quality Standards) Regulations of 2007

The quality of air has declined and increased reported cases of Upper Respiratory Tract Infections (URTI) has been reported over the years. The Economic Survey (2014) reports that out of 47 million cases of morbidity17 million cases were attributed to respiratory diseases. Some causes of air pollution include waste disposal approaches such as burning of computer components and accessories at the end-of-life. Part 5 (1) of the regulations stipulates that no person shall act directly or indirectly cause air pollution. Section 12 (1) reports that the Minister will consult the Authority and declare controlled areas where ambient air quality standards are likely to be exceeded, or other situation that may cause significant negative impact on human health, environment. Section 21 (4) provides for a fine on convention not exceeding one hundred thousand or imprisonment for a term not exceeding three years for any person, who fails to comply with these provisions. Further Section 29 (1) requires occupier or operator of premises to ensure that exposure of indoor air pollutants does not exceed the exposure limits as stipulated in the factories and other places of work. According to the regulations, the owner or occupier of a controlled facility, workers will be informed and trained on the potential hazards of any hazardous substance to which they are exposed and the safety precautions to be taken to thwart protect their health. However, the regulations fail to explicitly mention computer e-waste but it is implied because its disposal has potential to pollute the air if not handled in an environmentally sound manner. The adoption of best environmental practices in [computer] e-waste is encouraged in the regulations.

Environmental Management and Coordination Act (E-Waste) Regulations of 2016

The E-Waste Regulations (2016) which are yet to be gazette, provide that those who introduce e-waste such as waste from computer components and accessories into the country bear the cost of their reprocessing or refurbishing at end-of-life to prevent human health and environmental instead of leaving the burden to the public. The regulations require the importers to state the quantity of e-waste imported by commodity type. This would allow tracking of all the amounts of e-waste likely to be generated by NEMA.

Section 11, provides for segregation of [computer] e-waste from other forms of waste and delivery of the same to licenced refurbishers, collection centres or recyclers and compliance with Regulation 8 of the EMCA (Waste Management) Regulations of 2016 on the mode of transport used. It provides for application of the relevant licenses in a recommended form and payment of the relevant fee from NEMA. Section 16 (1) prohibits for importation of desktop with cathode ray tubes (CRTs) display monitors into the country and approval for the importation of computer components and accessories for donations from the relevant Authority.

Section 17 (1) prohibits e-waste to be discarded through open burning in non-defined areas, by burial at a dump site and that CRTs be treated in an environmental sound manner [Section 17 (2)]; prevents valuable materials with acids and other harmful waste from printed wire boards not to be leached in an uncontrolled manner; disposal e-waste to be disposed of only in the collection centres and/or in the licenced recycling facilities. Violators of this provision are penalised by the regulations and such a person are liable, on conviction, to a fine not exceeding one hundred thousand shillings or to imprisonment for a term not exceeding six months or to both. Section 18, stipulates that the handlers of computer e-waste shall practice principles and standards of environmentally sound disposal management of e-waste. These regulations are very clear that individual manufacturers will be held responsible for the e-waste disposal in an environmentally sound manner. Despite the regulation providing for the 3Rs, these are not always taken into consideration in waste disposal mangement.

Public Procurement and Asset Disposal Act, 2005 [2015]

The public institutions employ various disposal management approaches as stipulated in the Procurement and Disposal Act (GoK, 2005). The Act stipulates the disposal approaches through sale by open tender, public auction, dumping or burying, trade-in, transfer to another public entity, destruction, and disposal to civil servants. However, the Act failed to reference disposal management of hazardous or e-waste components and accessories. The Act has since been reviewed and replaced with the current Public Procurement and Asset Disposal Act (GoK, 2015). The current Act has taken into consideration the e-waste disposal management and stipulates that NEMA is consulted on the identification of certified e-waste collectors for purposes of disposal management of computer e-waste. There is, therefore, need to integrate sustainable procurement for goods, services, works and utilities in a way that the public

institutions achieve value for money, generating benefits not only for the organization, but also to society and the economy while minimising damage to the environment. (DEFRA, 2006).

Science, Technology and Innovation Act, 2013

The Act has no reference to e-waste or waste disposal management of computers but provides for the establishment of a Schedule on Earth and Space Sciences at the National Commission for Science, Technology and Innovation (NACOSTI) to deal with all issues of the environment. The Schedule has seen the development of institutional e-waste and environmental sustainability management policy. By the time of this study, NACOSTI being a public entity, was using the Public Procurement and Disposal Act, (GoK, 2005) which did not have any reference on waste or e-waste disposal management.

Scientific, technology and innovation research and development (R&D) are central to sustainable disposal management. The high-quality information generated from research on environment and monitoring improves the country's data-base for decision- making on environmental matters. The Kenya National Scientific Information and Documentation Centre (KENSIDOC)was established in 1983 to elaborate and implement the national scientific and technological information, promote, harmonise and effectively co-coordinate information services through a national network of information resource centres. The Centre is based at NACOSTI.

Public Health Act (Amended) 2012

Section 116 and 117 of this Act provide that Local Authorities be responsible for maintaining cleanliness and preventing risks to human health and the environment. Further, Section (126A) expects the county to make by-laws that facilities for drainage and sewer. Part 126 (Rules under Part) provides for the relevant Minister to make rules, confer powers and impose duties related to enforcement on local authorities, magistrates, owners. Section (129) grants the County's responsibility to prevent any pollution dangerous to drinking water sources and the prosecution of polluters.

Water Act, 2016

The water resources sector operates under the Water Act (2016) was an amendment of Water Act of 2002. It addresses the two levels of government and their functions and responsibility.

The Act establishes the Water Resources Authority (WRA) originally, Water Resources Management Authority (WRMA). The Act provides the guiding principle and regulatory mechanism for sustainable use of water. Like EMCA, the Act makes it an offence to pollute any water resources. Section 19 supports national monitoring and information systems on water resources. According to the National Water Quality Management Strategy (2012-2016), this includes monitoring industrial effluents and other point sources of pollution. Section 34 makes it mandatory to obtain a permit before release of a pollutant into any water resource. Permit details are provided under the Water Rules.

Water Resources Management Rules, 2007

The Water Resources Management Rules (GoK, 2007) aims at having all water resources, both surface and groundwater, in good quality status. Part V stipulates that effluents must be treated to permissible standards before discharge. Failure to achieve these standards attract a fine or imprisonment for 3 months or both. While these fines and sanctions are necessary for reducing pollution, their basis and sufficiency in remediating the polluted resource is not provided.

The Water Resources Management Authority undertakes pollution surveys to identify pollution sources with a view to planning pollution control programs to protect the quality of water resources. However, lack of flow meters at both the abstraction and effluent discharge points attracts a penalty of ten percent charged on the full amount of water used.

Physical Planning Act 1996 (Revised 2012)

Part III section 7 provides for the establishment and composition of physical planning liaison committees with the relevant Directors of planning being the Secretary to the various committees at the national, regional and local level. One of the functions of the liaison committees as indicated in Section 7 (d) is to determine development applications relating to location of dumping sites (e.g. Dandora) or sewerage treatment which may have risks to human health and degradation to the urban environment. Section 14 provides for legal protection of the members of the liaison committees for decisions made or omitted in the exercise of the functions conferred under this Act. Section 15 provides for appeals against the decisions of the liaison committees within 60 days. Part IV Section 16 of the Act, provides for the development of a regional physical development plan with reference to any Government land, trust land or private land within the area of authority of the County for the purpose of improving the land and providing for the proper physical development of such land, and securing suitable provision

for […] open spaces, or other purposes such as dumping sites and landfills. The regional physical development plan also defines the area to which the plan relates. In consultation with the local authority whose area is affected by the plan, the director presents the plan for approval by the relevant Cabinet Secretary. The plan is then published in the Gazette, by the Director of planning with or without modification. In addition, Part V section 36 provides for an environmental impact assessment report for proposed locations of dumping sites. or any other development that may have negative effects on human health and the environment. The act cascades activities of the National Director of physical planning to the regional and then the local level of the government which are currently not provided for in the Constitution. The physical planning Act is, therefore, important in the location and siting of disposal management sites including disposal for toxic components such as waste from computer components and accessories. There is, therefore, need for the review of the physical planning Act to cater for the current governance structures in the county government.

Urban Area and Cities Act, 2011(Revised 2012)

Part V Section (d) subsection provides for the preparation of environmental management plans; provision of physical and social infrastructure; overall delivery of services such as provision of water, health, telecommunications and solid waste management; and the preparation of a geographic information system (GIS) for a city. Section (e) provides for the promotion of development of informal commercial activities in a sustainable manner. Besides, subsection (1) provides for an integrated urban/city development plan that will guide and inform all planning development and decisions and ensure comprehensive inclusion of all functions. Section (3) provides for the initiation, by the County Government, of an urban planning process for every settlement with a population of at least two thousand (2,000) residents. Section 40 subsection (f) provides for a spatial development framework which includes the provision of basic guidelines for land use management system (such as spatial location for drop of points for the computer e-waste at the residential/commercial/neighbourhoods) for the city. Annual review of integrated development plan is also provided for in Section 42.

In the First Schedule, classification cities by provision of services indicate that a city should not have a population of at least 500,000. The planning and development control of such a city should include: Water and Sanitation, Storm Drainage, heath facilities, refuse collection, solid waste management air pollution among others.

The Second schedule provides for resident participation in its affairs (such as computer e-waste disposal mangement), and shall for that purpose (a) create appropriate conditions for participation.

County Government Act, 2012

The statute mandates County Governments to carry out the planning function at the county level. Section 104 (2) provides the Act provides for the integration of economic, physical, social, environmental and spatial planning. Part 4 of this section provides for citizen participation in all the planning processes. Section 110 provides for County spatial plans. Part (1) provides for a ten-year county Geospatial Information System (GIS) based database system spatial plan for each county, was a component of the county integrated development plan. The plan provides for spatial illustration of the socio-economic development programme; clear statements on link between the spatial plan and the regional, and national plans; and clear explanations on the anticipated sustainable development outcomes of the spatial plan. The spatial plans also provide where public and private land development and infrastructure investment should take place; and the desired or undesired utilization of space in a particular area.

In response to this Act, Part 2 of the Fourth Schedule of the Constitution of Kenya, clearly commits the County Governments to be responsible for; trash removal, refuse dumps and solid waste disposal such as waste from computer components and accessories.

In 2007, the By-laws on solid waste management were developed under the Local Government Act (Cap 265) to specifically regulate and manage solid waste generated within its precinct. Article 4(7) of the By-laws, stipulates that the resident of any dwelling or trade premises within the boundary the City Council (currently County) shall be responsible for the waste arising from the premises as per its guidelines, either individually or under the scheme of arrangement as stipulated in these By-laws. This provision provides a platform for urban solid waste management within its jurisdiction. The By-law, however, refers to solid waste management specifically but not to e-waste and this may create challenges if not reviewed to specifically cater for the handling of e-waste mainly from computer components and accessories. Article 8(4), of the By-laws, commits every resident of premises where any toxic waste is generated to make relevant arrangements, including the segregation of such waste from other non-toxic to the satisfaction of the Council. Despite the provision, the County Government has limited

capacity for enforcement, labour and knowledge of waste from computer components and accessories and hence the challenge of its disposal management.

Despite the aforementioned legislation and regulations, the Constitution recommends that additional legislation would be required to operationalize the relevant provisions adequately. It is also noted that despite the development of the national e-waste management guidelines and e-waste regulations, the City County of Nairobi is yet to domesticate the same in its management of [computer] e-waste.

Institutional Arrangements and Computer E-Waste Disposal Management in Kenya

The critical agencies established by the existing statutes for environmental management in Kenya applicable to computer e-waste disposal management are primarily the National Environmental Management Authority (NEMA). However, the ICT sector like any other sector is regulated by various state agencies which are arraigned with varying mandates in relation to computer e-waste disposal management. The regulators and their primary roles are highlighted in the following section.

The Kenya Bureau of Standards (KEBS) was established by the Standards Act cap 496 of 1974 to facilitate trade. KEBS prepares standards, testing and quality management of products such as computer components and accessories as well as verification of conformity prior export. However, the institution faces challenges of lack of capacity and infrastructure for safe disposal of hazardous goods although it should be upon the importer to bear the disposition. The Agency is in charge of pre-export verification of products. The Kenya Revenue Authority (KRA), Kenya Ports Authority (KPA), and KEBS are in charge of the import verification at the point of entry. Further, KEBS in liaison with relevant government agencies in charge of development of e-product standards, while National Environment Management Authority (NEMA) consults relevant lead agencies and stakeholders to develop e-waste regulations and e-waste disposal management.

The Communication Authority of Kenya (CA) in liaison with KEBS is responsible for development of standards for the ICT sector. Besides, KEBS is in charge of testing, quality management and the pre-export verification of conformity to standards. However, in the absence of national standards, the agency regulates the goods entering the country through use of international standards. The Communication Authority of Kenya (CA) conducts approval of type of telecommunication equipment in Kenya, but its mandate is limited to equipment that

can connect directly to or inter-work with public telecommunication network to send process or receive information. Also, the institution plays significant role in corporate communications, facilitating email, fax, video conferencing and more. It educates consumers as pertains to the communications sector; collaborates with industry and NEMA on best practices and issues of the environment respectively. To minimize the harmful effects of waste from ICT related equipment which includes computer components and accessories, this institution carries out awareness amongst stakeholders; requires putting in place licensees for safe disposal of products used in the industry; providing inputs in development of policies, legislation and regulations related to e-waste; collaborating with agencies such as NEMA; and promoting collaboration and sharing of infrastructure.

NEMA is cognizant of the potential negative impacts on human health and environment of waste from computer components and accessories. Heavy metals like mercury; contamination of soils and water bodies; non-biodegradable components, pollution of air on burning affect the environment negatively. Metals like mercury can negatively affect humans through the food chain and access to harmful components by minors hence the approach taken to minimise its risks. The Authority also is expected to manage the waste as per the Act and affiliated regulations which take into consideration measures that must be taken in handling hazardous materials in e-waste. E-waste disposal management approaches present a grave matter of concern considering the rapid uptake of ICT services and products. It is therefore prudent that support of the environmental sustainability initiatives is solicited through engagement with Ministry of Environment and Natural Resources, Ministry of Water and Irrigation, Ministry of Health and the Communication Authority of Kenya.

The Water Resource Management Authority (WRMA), established in 2003, through the enactment of the Water Act (GoK, 2016) and the National Commission for Science, Technology and Innovation (NACOSTI), established in 2013 through enactment of Science, Technology and Innovation Act (2013) are other state agencies relevant to computer e-waste disposal management.

Safe disposal management of the unwanted hazardous products is the major challenge facing KEBS since both the national and county governments lack the necessary infrastructure to discard them of although the law stipulates that the importer of computer e-waste meets the disposal management cost. KEBS also faces the challenges of the regulation on donations, especially the computer equipment.

Of particular interest here is NEMA which has the mandate of implementing all policies relating to the environment. One of the objectives stipulated in its Strategic Plan (2009-2012) (NEMA, 2009), is the compliance and enforcement of environmental regulations, development of guidelines and standards and the prosecution of offenders who fail to meet the provisions of EMCA, disposal of toxic wastes and backed by a number of penalties.

Nairobi City County

Disposal management site

Dandora Dump Site Disposal Management

The Dandora City County dumping site, which receives most of the County's solid waste, is approximately eight kilometres from Nairobi City centre. It is surrounded by a low-income residential area which exposes the slum residents to human health and environmental degradation risks from toxic components. This disposal site occupies valuable land near the City of Nairobi. It constitutes to source of human health and environmental risks. A study by Quaghebeur *et al.,* 2013; Hermann *et al*., 2014) indicates that such dumping sites are also regarded as a valuable repository of materials and energy. During recent decades, efforts have been made to deal with the environmental implications of waste disposal sites and the exploitation of valuable materials contained within them in the context of urban mining. Waste without proper management poses threat to the people's health (William *et al*., 2013; Ying *et al*., 2012; Lebersorger *et al*., 2011). The solid waste from the site is mainly referred to as garbage which consists of all daily items, including the waste from computer components and accessories, used and intend to throw away (U.S EPA, 2012). Though acting as the formal waste disposal site, the Dandora disposal site is uncontrolled. The environment is, therefore. not protected from toxic components. Controlled landfills are built in suitable geological areas away from faults, wetlands, flood plains or other restricted areas and 0.5 metres compacted clay soil lining the bottom and sides of the landfill. The aim is to protect both the groundwater and the underlying soil from leachates. The leachate collection and removal systems are removed from the landfill for treatment and disposal. These practices help reduce odour, control insects, and rodents, and protect human health. The landfills once closed are frequently monitored to protect against the release of hazardous constituents to the environment.

On the other hand, the solid waste (including computer e-waste) from the dumping site can be utilized for the production of energy through incineration. According to Lipp (2007), Denmark,

Germany and the UK (Martin, 2007) are the leading countries using this technology with their policies contributing to their success (Mitchel, 2004). Incineration is used as the best technology towards production of renewable energy in Europe (Connor, 2003) particularly in Scotland and UK. This technology also relieves pressure on land, which in urban areas can constitute a big saving. However, the county government will need to weigh the advantages and disadvantages of use of incinerators carefully considering this as an alternative. Deep-well injection is a technique where liquid wastes are injected through a well into an impervious rock formation that keeps the waste isolated from groundwater and surface water. Other methods of underground burial are also used to dispose hazardous industrial waste such toxic components from waste from computer components and accessories. According to the Environment Protection Agency (EPA, 2003), a landfill should be located at least 500 meters from an urban residential or commercial area or features such, rivers, wetlands, flood plain, highway, critical habitat areas, water supply, wells and airports. EPA also indicates that a buffer zone of at least 500 metres width should be provided and maintained around the landfill. However, suitability of siting of landfill increases with increase in width of the buffer zone.

Waste Electrical Electronic Equipment Centre

The Computer for Schools Kenya (CFSK) established the Waste Electrical and Electronic Equipment (WEEE) Centre in 2007, with the objective to handle electronic waste especially from the computer equipment. It was reported that the Centre collected, refurbished and redistributed used computer equipment to Kenyan schools through the CFSK programme. The Centre donated 50,000 computer equipment mainly desktop with LCD monitors to approximately 2500 institutions (primary schools, secondary schools, community centres) and sold those that were in demand by the public for re-use at a subsidised rate. The Centre scraps the category of computers that are still functional but are of very low specifications that even the members of the public were not interested. The Centre also provides opportunities for learning institutions; corporate organizations; small and medium enterprises (SMEs); government institutions and individuals to dispose of their computer e-waste in an environmentally sound manner. The Centre was set up at a cost of Kshs. 3.8 million, at the Kenya Youth Service facility at Ruaraka, but has since moved to a more expansive land donated by the Government at Embakasi, Nairobi. It has branches in Kakamega, Kisumu, Machakos, Mombasa, Meru, Nakuru and Nyeri.

The Centre uses mechanical ways of dismantling the computer equipment where the technicians disassemble and separate the fractions according to the type of materials. Other parts undergo further processing by use of machinery, e.g. plastics and CRT glass. Recycling of different fractions is carried out in different specialised factories both in Kenya and Europe. At the Centre, valuable components such as precious materials (e.g. gold, platinum, silver, palladium, tantalum, copper, aluminum, cobalt, tin, neodymium and zinc) are extracted from computer components and accessories, while the hazardous components (e.g. lead, polychlorinated biphenyls (PCBs), phosphorus, dioxins, brominated flame retardants, beryllium, chromium, cadmium, radioactive isotopes, lithium, and mercury are exported to the European countries for treatment and final disposal. Handling of computer e-waste with inadequate safety gear and using inappropriate methods is a sure human health hazard due to some toxic elements that they contain.

The Centre provides adequate safety clothing gear and uses environmentally sound methods of dismantling of the computer s. The Centre also has good working relations with some of the original equipment manufacturers (OEMs) and has service level agreements to dispose of e-waste on their behalf. However, it is not yet clear how the activities of the Centre connect with or foster e-waste disposal management practices.

Informal Disposal Management Sites

Temporary Disposal Management Sites

E-waste pickers are the principal actors in reclaiming waste for the recycling industry. Many authors attest to this portion of the society in the poor countries of the world that eke a livelihood out of waste picking or scavenging and trading activities (Bernache, 2003; Ahmed *et al*., 2004; Wilson *et al*., 2006). Across the word, they operate as individuals in low-income countries, mainly at the waste dumping sites such as Dandora. They collect, sort waste and then sell reclaimed waste through intermediaries, referred to as '*yard shop operators'* by Oyake-Ombis (2012), to the recycling industry. The e-waste pickers see plastics, metals glass where others see trash. They are able to sort and bundle different types of waste (including computer e-waste) by color, weight, and sell it to the recycling industry. However, the e-waste pickers are hardly recognised for the crucial role they play in creating value from the computer e-waste generated by others. Their effort leads to environmental sustainability by reducing greenhouse gas emissions and stimulates the economy by packaging and supplying raw materials to the

manufacturing industries. Globally, the e-waste pickers have been recognized and urban cities have begun to integrate them into the solid waste disposal management.

Brazil has integrated e-waste pickers/scavengers through their cooperatives, into urban solid waste management systems. The country has also developed and adopted a National Waste Policy which recognises the contributions of e-waste pickers and providing a legal framework to enable cooperatives of e-waste pickers to contract as service providers.

A national decree in Colombia mandated the cities across the country to develop solid waste management schemes that contract organisations of e-waste pickers to collect, transport and sort recyclable waste. E-waste pickers cooperative in Pune, India, has been supported to receive contracts for waste collection from households. Likewise, in Johannesburg, South Africa, e-waste pickers' cooperative has leveraged public and private partnerships to create a community recycling programmes.

According to ITU (2014), most of the waste from computer components and accessories are recycled or reused by formal or informal sectors depending on the recycling capacities of the county where it is generated. If it is properly managed, economic opportunities can be created to meet the need for reconditioning of the equipment and recovery of raw materials. Most of the high-income countries consider computer e-waste disposal management as a tool and opportunity for sustainable development.

In Kenya, the e-waste pickers usually operate informally and are often arrested by the City '*askaris*' but are, however, able to earn a livelihood from the e-waste. The traders, the yard shop operators, who are driven by the source of livelihood, however, provide an important linkage between the pickers, the recycling facilities and local industries.

2.6   Theoretical Underpinnings

According to Leedy *et al.,* (2005), a theory is an organised body of ideas and values which aim to support a specific occurrence. Theories, therefore, describe '*How'* and '*Why'* something functions the way it does (Johnson *et al*., 2007). Anfara *et al*., (2006) defines a theoretical framework similar to empirical or quasi-empirical of physical processes and social which exist at various levels applied to the understanding of the phenomena. Theories, therefore, provide widespread predictions of actual occurrences. Computer e-waste disposal management mainly deals with human health and the environment and economic aspects.

2.6.1 Waste Disposal Management Theories

There are six relevant theories related to computer e-waste disposal management. However, these theories are not explicit about special types of waste, but they can be applied to computer e-waste disposal management. The theories are expounded in the session that follows.

Theory of Waste Management

The waste management theory (WMT) is centered on the hope that waste disposal management is to stop waste from causing risks to human health and the environmental degradation of the urban area. The waste management theory stipulates the conservation of resources, averting waste creation and encompasses the aim of transforming waste into non-waste (Pongrácz, 2002; Phillip *et al.*, 2002). The WMT, thus, provides a response to conceptual uncertainty by explaining waste, theories and provides guidelines for identifying the waste disposal management approaches; provides a basis for knowledge on how and when to pick and amalgamate waste management disposal approaches; predicts the effects of the utilization of the waste disposal management options and helps in the legislation. In this regard, the best definition of computer e-waste becomes essential in constructing a sustainable plan for e-waste disposal management.

However, there may be a conflict with the goals of waste prevention when this definition is used because existence of something cannot be prevented from arising. When disposed of material is assigned the label of '*waste*', it will be treated as such; despite the need for waste prevention. The inherent philosophical implication of such definitions is, however, unable to facilitate a sustainable computer e-waste disposal management system. Therefore, there is need to use a new definition for waste and waste disposal management which can explain why waste is generated and which can offer genuine solution for the problem. While waste disposal management emphasis on the use of the 3-Rs (Reduce, Reuse and Recycle) principle and aims at extracting and maximizing benefits from commodities and reducing quantity of waste generated, it is however, not always implemented.

Urban System Theory

Human activities in cities often require imports of various resources and transform raw materials, energy, water into the built environment, air and water pollution including generation of waste (e.g. computer e-waste). According to Marsh (1864) human development has played

a destructive role to the environment over the years. He adjudged that humans should respect the laws of nature and act as collaborators of nature, because man and nature shape each other.

The concept of urban systems theory which was conceived by Wolman (1965) is crucial in developing sustainable cities. Since then comprehensive studies have been undertaken across the world (Kennedy, *et al.*, 2010). Both theoretical and empirical studies on urban systems suggest that urban and environmental systems are interdependent and environmental processes must be considered as drivers of the urban change (Alberti, 1999). It can be deduced that urban systems, therefore, cannot be sustainable if more resources are required than it can produce and generates more waste than it can absorb.

Planning Theory

According to Campbell *et al.*, (2003), planning is intervention with an intention to alter the existing course of events. The timing and legitimacy of the planned intervention, therefore, becomes central to planning theory- it is the why and what situations should planners intervene in. The current urban disposal management system practice is centered on short-term effects and end-of-pipe of socio-economic activities. Thus, current waste management programmes focus on disposal of the waste generated, instead of examining the sources of its generation and the entire end-of-life of the waste. It is natural, ineffective and inefficient to support sustainability within the urban systems. However, several potential opportunities exist (e.g. material flows), to reduce waste generation including the negative impacts on human health and environmental degradation of the urban area.

Involvement of City Planners in computer e-waste disposal management is not only on the built environment with emphasis to sitting waste management facilities (Hostovsky, 2000; Lober, 1995; Farhan *et al.*, 2006) but also to safeguard the environment as evidenced in the establishment of NEMA. The City Planner's role is to embrace the sustainability of waste disposal mangement. This is in line with the findings of UN-HABITAT (2009), which stipulate that economic, social, and environmental dimensions, are the goals of sustainable urban planning. Despite the involvement of the City Planners, computer e-waste disposal mangement continues to be a challenge to the County Government since its generation and management is not a priority to the county government managers.

Zero Waste Theory

Zero waste theory considers waste such as computer components and accessories as a resource for the manufacture of another new product. The theory involves the reduction of waste and emphasizes on the continuous reuse of waste, and hence the sustainability of waste disposal management. Applying this theory to computer e-waste disposal management, therefore, requires a holistic approach for sustainable consumption and recovery of resources from the waste from computer components and accessories. Application of a zero e-waste scenario would lead to recycling 100% of the e-waste or recovery of all the resources from urban solid waste streams without any negative impact on human health and the environment. The theory thus shifts the waste disposal management hierarchy from the 3-Rs (reduce, reuse, recycle) to 7-Rs (reduce, reuse, redesign, recycle, repair, remanufacture, resell) and eventual zero-waste landfill (El-Haggar, 2007; McDonough *et al.*, 2002; Jessen, 2003; Palmer, 2005). However, implementation of the zero-waste disposal management plan eliminates waste disposal from urban areas, water sources, air pollution and hence prevent potential risks to human health and the environment.

While 100% recycling of computer e-waste would be difficult to achieve for low-income countries, such as Kenya, a holistic computer e-waste disposal management plan can make it possible if the plan is implemented effectively. If the computers can also be designed with 100% recyclable materials then 100% recycling can also be achievable. It can be argued whether recycling is a more sustainable approach as compared to energy recovery or not, but considering the long-term sustainable development practice, recycling is desirable because it protects natural resources from depletion for future generation. Therefore, by achieving a 100% recycling of all county e-waste, further depletion of natural resource would be drastically reduced in future. Implementation of zero e-waste policy, however, will also require the engagement of public private partnerships and collaboration with countries with recycling facilities in the high-income countries.

Sustainable Development Theory

The World Commission on Environment and Development (WCED) defined sustainability in 1987 as development that meets the requirements of the present without compromising the ability to meet the needs of generations to come. The Commission also noted that there was an increase of potential threats to human health and the environment which impacted negatively

on the global economy. The Report of the Commission defines sustainability as an intricate system composed of social factors, environmental and economic factors and that a change in one factor is likely to trigger unpredictable changes in the other factors.

The sustainable development theory, can, therefore, prevent the creation of social inequalities, avoid negative effects on human health and the environment and therefore support an efficient and effective economic base. Attaining participative democracy in decision-making is also fundamental in achieving sustainability.
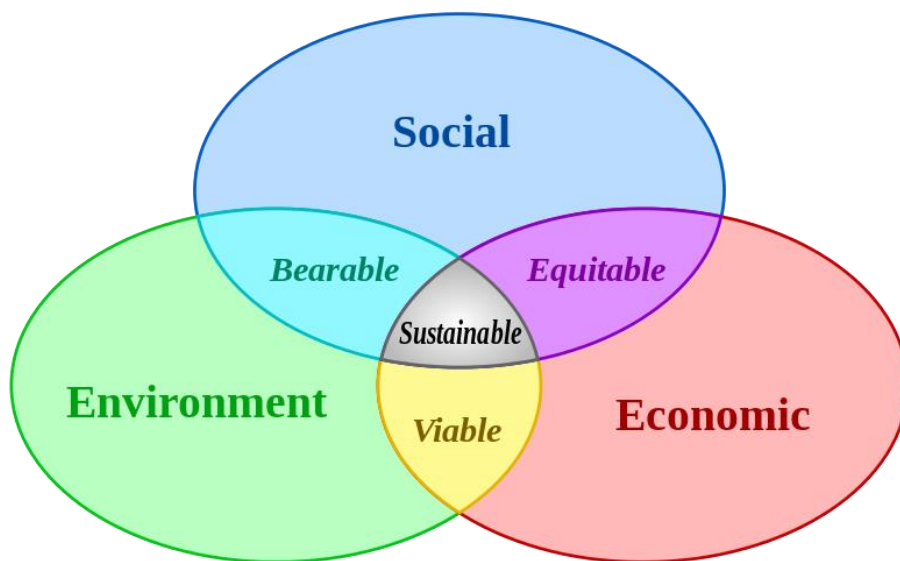
Figure 2.2: Tenets of Sustainability
 Source: Adams, 2006
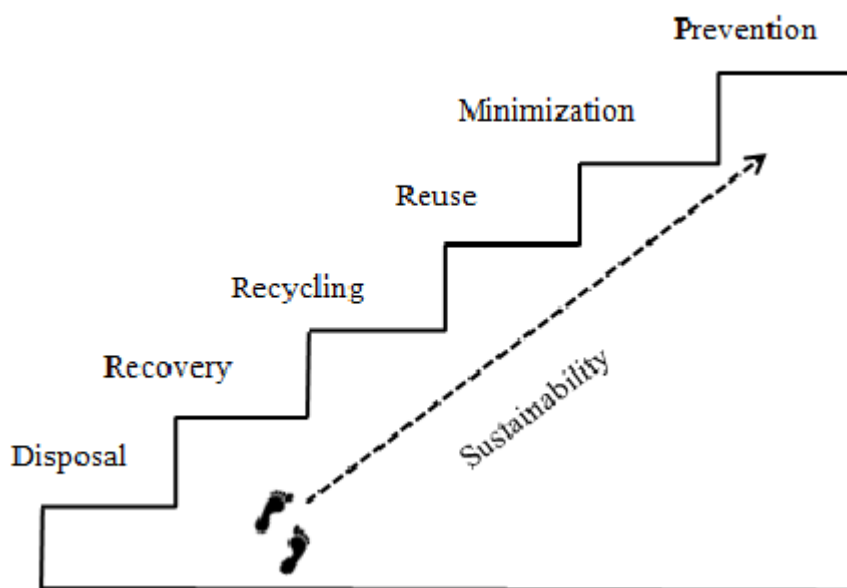
Figure 2.3: Sustainability of waste management
Source: Sasitharan *et al*., 2012

Sustainability development often makes transformation difficult, since it often translates into stable management systems. Unsustainable consumption such as the computer components and accessories and production patterns, of the resultant waste, that have evolved in time is the main challenge to sustainable development. Sustainable development theory, therefore, takes into consideration the balancing act between consumption of computers and production of the resultant waste.

The Systems Approach Theory

The sustainable systems approach theory (SSAT) has recently become an important analytical pathway in the search for solutions to numerous challenges facing societies today. Before delving into the utility of the SSAT it is important to present the evolution and epistemologies that underlie systems thinking so that the connection between this philosophical standpoint and contemporary approaches to successful waste disposal management can be accorded their appropriate contextual. The status this philosophy enjoys in human health and environmental analyses hinges on its promise to bring together various inter-related components embedded in the norms and practices that grant contemporary waste management strategies their structure and form. The output of the systems approach indicates that there is a problem - impacts to human health and the environment. There is therefore need to consider mitigations that would bring about the sustainability of the system. It should however be noted that while systems approach thinking is concerned with how inputs translate into outputs after undergoing through processes (Waltner-Toews *et al*., 2008), these translations are long-term (Meadows, 2008). According to Coffey *et, al*., (2010) efficiency, and reliability of waste disposal management systems in high-income countries has taken decades to evolve to the almost ideal status they are in. (Wilson (2007), therefore describes the impracticality of current expectations for low-income countries [computer e-] waste management systems. This section presents the sustainable systems approach theory (SSAT) that is underpinning this study.

2.6.2 Applying the Systems Approach Theory to Sustainability of Computer E-Waste Disposal Management

In extrapolating this diversity to computer e-waste disposal management, the theoretical framework for this study is indicated in Figure 2.1. The components of computer e-waste disposal management can be regarded as mirroring an open system structure which comprises

inputs, processes and outcomes. The inputs are conceivable as arising from various categories of actors operating at the social, economic and environmental domains of sustainability hallmarks. At the process level, the sum of these contributions can be directed at various facets of the e-waste disposal management activities. They include a set of activities that occur at mutually inter-locking phases such as storage, collection, transportation, separation, disposal and transfer to alternative users. Depending on the decision and/or care taken during each of these activities, the e-waste materials can become or fail to become part of the urban waste stream.

The outcome of these activities eventually determines the volume and character of the e-waste that ultimately gets to the natural surface of the urban area, thereby spelling out the quality of human health and environmental outlook of the urban area. The ultimate human health and environmental characteristics can be either positive or negative. This explains the use of the mathematical symbol ± before each of the possible operational measures of impacts on human health, environmental and economic factors at the end of the theoretical framework.

Central to this framework is the proposition, drawn from the sustainability thinking, which holds that the computer e-waste disposal management activities and inputs from the diverse actors involved can be viewed as single entities that are important in their own right, but cannot stand alone if they are to substantially bear on the processes and outcomes (Thyberg *et al*., 2015). This is because management of any county solid waste is a complex web of tasks that have critical implications for the quality of the urban surface environment over time (Pérez-Belis *et al*., 2014; Thyberg *et al*, 2015).

Underscoring this proposition presupposes that an important starting point for application of the sustainable systems approach theory for solid waste management proposed by Thyberg *et al*., 2015. is to look for the drivers in relation to the question of reducing exposure of the populace to health risks and environmental degradation consequences. This is a view akin to what has been the kingpin of concern with all types of waste management and pollution reduction throughout the history of environmental justice across the world (Wilson, 2007; Dunlap *et al*., 2014; Boyd *et al*., 2015)

Central to consideration of drivers of computer e-waste disposal management approaches evokes the thought of roles played by macro-level governance regime elements, reflected in theory as the enabling environment, and constitutes the policy provisions, legal requirements,

institutional mandates, R&D parameters and education and awareness creation conditions. While there are contingent aspects that can be considered influential under R&D, of particular interest to this study unravelling the degree to which human health and environmental considerations are embedded in the minds of the actors involved. It is this awareness and consciousness that can be expected to trigger computer e-waste disposal management approaches and actions, including the thought of reimaging environmental management and human health sustainability policies, legislation and institutional frameworks in the country towards the reduction of damages to the urban landscape.

Once the computer e-waste goes through the process of disposal management, it has an option of being disposed of into the dumping site (Dandora), being taken to the recycling facility (WEEE Centre), the temporary disposal sites (yard-shops) or recycled by the e-waste pickers. Apart from the computer e-waste disposed of at the WEEE Centre, all the other available disposal mangement options are not sustainable because they have potential negative effects to human health and the environment. The system approach is only then sustainable when the parts of computer e-waste disposed of is recovered and reused, incinerated, recycled and valuable components mined. The establishment of cooperatives for e-waste pickers/scavengers would also result in better computer e-waste disposal management. The use of systems approach towards sustainable computer e-waste disposal management is illustrated in the theoretical framework in Figure 2.4.
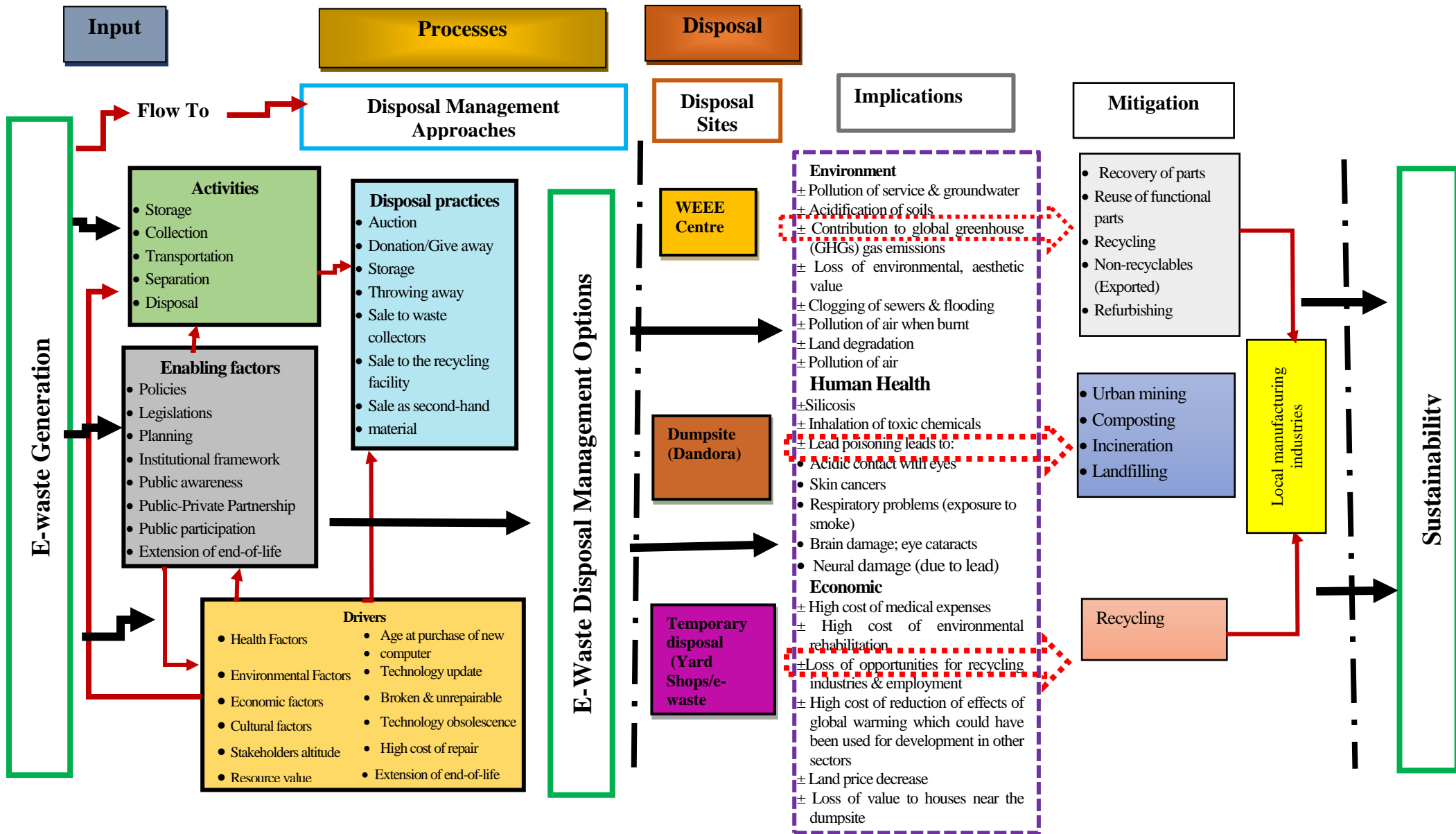
Figure 2.4: Theoretical Framework for Computer E-waste Disposal Management Approaches
Source: Researcher, 2018

2.7   Chapter Summary

The literature review on the four research objectives namely; to identify Computer e-waste disposal management approaches; to determine the potential effects of the Computer e-waste disposal management approaches on human health and environment; to evaluate the level of public awareness of Computer e-waste disposal management approaches on human health and the environment; and to establish planning, policy and regulatory interventions for sustainable Computer e-waste disposal management approaches in the Nairobi City County was considered and discussed in details. Literature reviewed indicate that computer e-waste disposal management approaches at the households present the highest level of challenge because storage of obsolete waste from computer components and accessories is for a while for perceived value, emotional or physical attachment before it is disposed of. The public sector and private businesses stored the computer e-waste in the premises awaiting instructions for their disposal, mostly through public auctions, from elsewhere.

The literature review also indicates that waste from computers contains components that are valuable (e.g. Aluminium, Copper, gold, and Iron) and others such as heavy metals (e.g. lead, mercury, cadmium) that are hazardous and have potential effects to human health and the environment. Several scholars have stipulated that public awareness enhances the understanding of computer e-waste disposal management attitudes, improves decision transparency, and accessibility to information. Lack of public awareness and education, low technical capacity to deal with computer e-waste has also been identified as some of the common barriers towards computer e-waste disposal management approaches. However, media involvement, through campaigns and use of advertisement has been reported to play a significant role in increasing public awareness and participation. Switzerland has been cited as the first country in the world to develop a formal e-waste disposal management system. The system was based on the extended producer responsibility model where the manufacturers take responsibility for disposal management of the computer e-waste. The review also stipulates that low-income countries (e.g. Kenya) lack a computer e-waste disposal management system, lack specific legislations on e-waste and an effective enforcement of the existing regulations. Systems approach towards sustainable computer e-waste disposal management approaches was used for the theoretical framework of this study.

From the literature review, it was observed that the planning and policy development and response mechanisms to the phenomenon of waste from computer components and accessories

disposal management are still peripheral to the critical thresh-hold needed to reduce the human health and environmental atrocities related to the mounting volumes of computer e-waste in the urban area in Kenya. These unmet needs beg for attention to empirical studies to unravel the prospects for sustainable computer e-waste disposal management approaches in cities such as Nairobi with a view to setting the roadmap for detailed planning, policy and regulatory practices in an era of unrelenting advances in the use of computer-based technologies.

While the circumstances, types and computer e-waste disposal management approaches are different in the high-income countries, the regulations and disposal management in Europe and Japan provide a good example of dealing with the growing problems. Europe and Japan though having similar regulations, have different approaches to e-waste disposal management, with one emphasizing on environmental legislations and the other, technological advancement. Past experiences in the low-income countries related to [computer] e-waste waste policies reveal that legislation should serve multiple and broader societal goals. It should also clearly define the roles, responsibilities and definitions of waste included under the ambit of the legislation in order to minimise administrative burden and confusion. Crucial and useful in the implementations is the separation of basic legal framework from operational standards. Dealing with computer e-waste disposal management is a long-term process involving cooperation between different stakeholders and technological advancements for better handling of e-waste and minimisation by better designing of computers. Even in high-income countries in EU and Japan which have had long experience in e-waste disposal management, potential exists for future improvements in collection and handling. However, existing good practices from high-income countries provide valuable lessons and insights for low-income countries to effectively manage e-waste in terms of good practices that can be adopted and considered in formulating or reviewing existing e-waste legislation in the country.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

Chapter three starts with a description of the study area, research design and methods of data collection analysis, interpretation and presentation of the research results. The methods and procedures described in this chapter are detailed and hence not provided for in the specific chapters namely 4, 5, 6 and 7 respond to the four research questions. Finally, the ethical considerations of scientific studies adhered to are documented.

3.2 Profile of the Study Area

This research was carried out in Nairobi City County, which is one of the 47 Counties in Kenya. Nairobi has grown across frontiers of urbanization beginning in 1899 as a single depot of the '*Kenya-Uganda Railway'* from Mombasa on the Coast to Kisumu on Lake Victoria. The city grew into British East Africa's business and commercial hub and became the capital of Kenya in 1907 (Mitullah 2003; Rakodi 1997; GoK, 2008). It covers an area of about 696 km^2 (KNBS, 2010). It is located 495 kms from Mombasa and 338 kms from Kisumu. Nairobi lies at latitude of 10 17'S and longitude 360 48'E on the East African plateau with an altitude ranging from below 1675 metres in the Central Business District (CBD) to 1905 metres above sea level at the north-western wing (Figure 3.1).

Over time, Nairobi, has gained a prominent character as the most urban area in Kenya with a population size of approximately 4.556 million (worldpopulationreview.com) in 2019 from 3.138 million in the last census (CBS, 2009). The City has grown into the centre of economic activities, including local and international exchange of goods and services; social functions such as provision of health, housing, information, education, training and research services; political administration; and more recently, environmental governance of the world due to presence of United Nations Environment. By this prominence, Nairobi enjoys urban and regional planning and development activities compared to the other 46 Counties of Kenya. Nairobi has become an outstanding host to several large public institutions, private companies, and multilateral/bi-lateral organisations.

Due to its elevation, average of 1500 metres and 1900 metres in the East and West respectively, and its closeness to the equator, there is little variation between the seasons with average rainfall

of 925 mm of rain per year, mainly falling from March to May and from October to December each year when it is often cloudy and damp, but rainfall is seldom very heavy.

The tropical nature of climate in Nairobi County is displayed as a moderated equatorial climate of the highlands, with rainfall and temperatures being affected by the altitude. The annual average temperature is 19 °C and rainfall is 800 mm and 1000 mm in the East and West respectively (Nakamura, 1967). In addition, the duration of sunshine ranges from 4 to 9 hours per day, with high moisture (over 80%) in the morning and lower (below 40 %) in the afternoon (Makokha *et al*., 2010).

Geology

According to Schackleton (1945) and cited by Saggers (1991), the geology of the Nairobi area is mainly volcanic rocks. The youngest tertiary rocks are Limuru trachytes and the Kerichwa Valley tuffs which are underlain by Olesayeiti volcanic phonolites followed by Ngong volcanic. The volcanic rocks comprise of OlDonyo Narok agglomerates, Nairobi trachytes, Nairobi phonolites, Kandizi phonolites, Mbagathi phonolitic trachytes which are underlain by Athi tuffs and lake beds with chert band. It is assumed that the phonolites are underlying the Nairobi trachytes. According to Mulwa *et al*., (2005), these tertiary volcanic rocks overly folded Precambrian basement system rocks of the Mozambique Belt occurring at a greater depth. Cooling of the differing lithologies influences the distribution of ground water in the study area.

Drainage

The Nairobi River basin is composed of three major rivers namely: he Nairobi, Ngong and Mathare rivers whose catchments are found within the Kikuyu and Limuru Hills. The major pollutants in the drainage system include organic, solid waste and heavy metals within the basin, which may have potential risks to both human health and the environment.

Vegetation

Nairobi at one time had a reputation as a healthy place to live in and was called the *'Green City in the Sun*'. Its landscape was characterized by natural forests, labyrinthine riverine ecosystems, and wetlands. Nairobi has retained a number of green spaces within and close to the city. Some of the existing green spaces include: the Nairobi National Park; Karura Forest (1, 063 ha); the Nairobi Arboretum (25 ha); and Nairobi City Park (69 ha). These green spaces

provide residents with shady recreation areas and visitors with a glimpse of Kenya's renowned wildlife and characteristic vegetation. The spaces also maintain biodiversity, reduce air pollution and act as minor water catchments within the City County. Although these green spaces have been protected, urbanisation, construction of roads and other city infrastructure has led to the loss of forests and other natural areas, such as mixed rangeland and bushlands.

Pollution

Atmospheric pollution by vehicles, industries, emissions from use of charcoal and firewood, open burning of waste has been the main sources of air pollution including emission of greenhouse gases. Charcoal burning, a very prevalent energy source in the city, emits methane (CH_4) and carbon monoxide (CO) and sends tiny particulates into the air. Several factors affect the county's water sources, ranging from poor disposal management of waste including computer e-waste and environmental degradation of the urban space.

Population and Population dynamics

The growing population in the Nairobi County is one of the causes of overwhelming environmental challenges. Urbanisation, high birth rates, poor city planning constitutes to both water and air pollution causing negative effects on human health and the environment. according to the population policy for sustainable development report (CBS, 2004). It is advisable to stabilize the fertility rate for purposes of achieving the millennium development goals (MDGs) and a high quality of life that is sustainable with available resources (Sessional paper 3 of 2012).

Settlements patterns

Much of Nairobi's urban impression is unplanned settlement driven by rapid population growth and urban poverty, among other things. Sprawling informal settlements hamper the County's delivery of social services and negatively impact on human health of the residents. Informal settlements in the City County date back to 1960s, when European settlers appropriated large tracts of land displacing the local African population from their resettlement. By 1993, informal settlements housed about 55% of the city's population (Matrix Development Consultants, 1993) and the City's population was said to be living in unplanned settlements. The poorest (60%) of Nairobi residents live mostly in informal settlements (ITC, 2004) where they face hardships due to lack of proper housing and public

services and where they are vulnerable to environmental challenges. The upmarket residential areas include Muthaiga, Kileshwa among others.

Housing

As the Nairobi City County population grows, it continues to face the challenge of planning for sustainable urban development that provides adequate housing and services at the same time as it protects air, water quality and the natural environment within its boundaries.
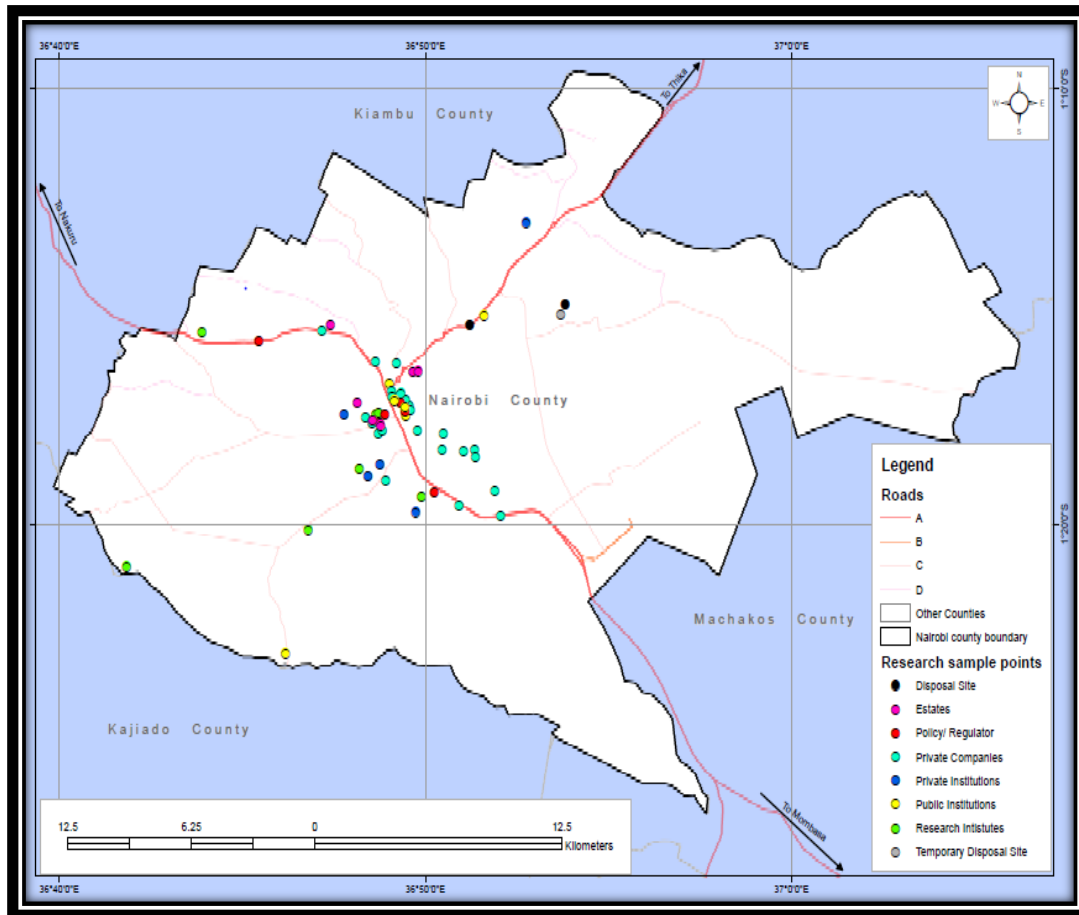
Figure 3. 1: Location of sampling Areas in Nairobi City County, Kenya

The concentration of the institutions, universities and business/offices at the central business district makes it essential to address the generation of waste from computer components and accessories to prevent their negative impacts to human health and environmental degradation of the urban area.

3.3 Study Design and Methods

The descriptive research design approach as stipulated by Dell (2003) was used because it allowed researcher to profile the population by collecting exact information and in-depth study of the problem within a limited time scale (Bell, 1999). Sample rather than the entire population was used to obtain information (Kerlinger, 1983; 1993). The samples had a spatial distribution and the sampling sites were geographically distributed.

To address the research questions, it was necessary to first underscore the reality that urban waste disposal management policy is a constellation of social values, economic aspirations and ideological positions that have historically constituted the fabrics of environmental sustainability (Moore, 2015). This includes built-up ecosystems and human health aspirations in various urban ecological settings (Hammal *et al*., 2005).

In line with theories of scientific mode of acquiring knowledge (Henslin, 2001; Grimes *et al*., 2002) underscoring the complex nature of the subject matter in turn, meant that the embedded diverse perspectives had to be reflected in the structure and composition of the data required, choice of sources, and the logic of the methods of collection and analysis.

The study used cross-sectional survey design using a combination of qualitative approaches. Against the backdrop of this dictum, the methodological approach for the study was a mix of phenomenological and positivist traditions in the social sciences. This include a study approach consisting of both quantitative and qualitative data collection, analysis, interpretation and presentation of findings were pursued (Charmaz, 2006). Rather than singly rely on aggregate measures, this dual strategy was adopted on the strength of its promise to unveil a systemic view of reality, in the sense that human health and environmental perceptions of actors involved in waste disposal management, whether at the upstream-generation waste flows stratum or at the policy and regulatory domains are linked in a circular way, with potentials to influence the outcome decisions, behavior and practices.

As described in the sections that follow in this chapter, the conception of variables, data collection and the instruments used, the analysis, interpretation and presentation of findings was done in ways that sought to map out most of the data from field settings and library sources and their bearings on the interface between human health, environmental factors and computer e-waste disposal management approaches.

3.3.1 Data Required and their Sources

Both the qualitative and quantitative data drawn from primary and secondary sources were used. This standpoint is in harmony with the philosophy of Miles *et al.*, (1984), Brandy *et al.*, (2007), Palinkas *et al.*, (2015) that qualitative research methods are necessary supplements to surveys because they are capable of identifying causal mechanisms, dealing with complex local networks and sorting out the temporal dimension of events. The data required was obtained across operations level of computer e-waste disposal management through to the national and local level decision making arms of environment and human health regimes. The details on the data required and their source is covered in the sections that follow.

Households

The data on computer e-waste generation was obtained from the households at the lowest downstream waste flows in residential areas of Nairobi. Specifically, a survey was conducted among the respondents occupying Government owned houses because they are well organised with high, medium and lower levels represented. However, from the pilot study, it was observed that the lower cadre of government officers do not own computer components and accessories and therefore was left out of the study. The data was, therefore, randomly collected from respondents living in the medium and high-level government houses.

Planning, Policies, Regulatory and Research Institutions

Information from this target population was collected from government research institutions, private universities, government ministries and agencies that relate to policy, regulatory and urban planning domains of environment and human health continuum. This information related to these domains was important in unveiling the computer e-waste disposal management drivers, computer e-waste disposal management governance systems as presented in chapter 4, 5, 6 and 7. The information collected included levels of public awareness of the staff of these institutions on the impact of computer e-waste on human health and the environmental degradation of the urban area, the disposal management approaches, regulatory pressures and

degree of environmental compliance, enforcement of the existing legislation, policies, economic and cultural factors. The interviews were done with the executive staff.

3.3.2   Target Population

The target population for this study was in five categories: i) public and private universities, ii) private companies, iii) government houses, iv) formal and informal disposal sites within the Nairobi City County and v) the Central Government Administration Ministries, and State Departments charged with the responsibility of environment and human health management within the City County, including policy and legal requirements development and enforcement of related regulations.

The sources of this information include: interviews with institutional environmental offices, compliance and enforcement offices, environmental specialists both at the regulatory (NEMA, CA, WRMA), and government agencies and policy development organs of the Government (Ministry of Water, Environment and Natural Resources (by then), Ministry of Health, research institutions and universities (Public and private), and Nairobi City County, (Department of Environment). Private companies (Listed at Nairobi Securities Exchange) were included in this study.

The internal organisational setting is an important aspect in enabling an efficient institution computer e-waste disposal management. The settings of such is determined by the presence or absence of environmental management systems, training programmes, mainstreaming of environmental issues, environmental budgets, recognition awards including incentives and the organisational structure. The main information was collected from the executive offices while others were collected from records and documents of the respective institutions.

3.3.3   Sample Frame

Like the target population, the sample frame for this research was diverse in categories. The first was a list of all public and private universities within the City County of Nairobi as indicated in Table 3.1. The second was a list of private companies as listed in the Nairobi Securities Exchange (NSE) directory, third was a list of households (Government houses) in the category that use and dispose of waste from computer components and accessories located within Nairobi City County; and the fourth was the formal and informal disposal sites within the Nairobi City County with a focus on the Nairobi City County Government; and the last tier of the sample frame for the study was a list of all the line Government Ministries, State

Departments and Government Agencies (Parastatals) charged with the responsibility of health and environment management.

Out of a total of 18 Government Ministries (GoK, 2013), 7 Ministries and State Departments where the Ministries had more than one State departments were randomly sampled. These include the Ministries of Interior and Coordination of National Government; Ministry of Education, State Department of Science and Technology; Ministry of Foreign Affairs and International Trade; Ministry of Transport and Infrastructure, Department of Transport Services; Ministry of Information, Communication and Technology; Ministry of Agriculture, Livestock and Fisheries, State Department of Agriculture. Likewise, 3 public Universities were randomly samples from a total of 5 located in Nairobi City County namely: University of Nairobi- (UoN); Technical University of Kenya (TUK) and Multimedia University of Kenya. UoN was randomly sampled as the oldest public university as opposed to Kenyatta University (KU). Between Catholic University and Strathmore University, the later was randomly chosen since both of them share the same faith. Others include United States International University and KCA University and Riara University.

The research institutions that were sampled in Nairobi were categorized in terms of their mandates e.g Gene bank, Industrial, Animal, Medical, Agricultural, Intellectual Property Right, Policy, Wildlife, Law and Forestry. From this category, the following research institutions were identified and sampled: Genetic Resources Research Centre (GRRC); Kenya Industrial Research and Development Institute (KIRDI); Institute of Primate Research (IPR); Kenya Medical Research Institute (KEMRI); Kenya Agricultural and Livestock Research Organization (KARLO); Kenya Intellectual Property Institute (KIPI); Kenya Institute for Public Policy Research and Analysis (KIPPRA); Kenya Wildlife Service (KWS); Forestry Research Institute (KEFRI); and National Crime Research Centre (NCRC).

The samples for the policies related to computer e-waste disposal management in this research were collected from the Ministry of Environment, Water and Natural Resources (MEWNR); Ministry of Health; and Ministry of Science and Technology. Samples were also collected from institutions related to regulations such as the Nairobi City County (NCC); Water Resources Management Authority (WRMA); National Environment Management authority (NEMA); Communication Commission Authority (CA); Kenya Bureau of Standards (KEBS); and Kenya Revenue authority (KRA- Custom department).

The study identified the companies listed at the Nairobi Securities Exchange for the study of computer disposal management approaches by the private companies. At the time of collection of data for this research, there were 67 companies listed in the Exchange. The companies were categorized into the following groups for purpose of sampling: Agricultural; Automobiles & Accessories; Banking; Commercial & Services; Construction & Allied; Energy & Petroleum; Insurance; Investment; Investment services; Manufacturing & Allied; Telecommunication & Technology; Growth and Enterprise Market Segment. Random sampling of the 67 companies using the above-mentioned criteria yielded 30 as recommended by Mugenda, (2003).

High-level grade (Muguga Green, Ashoka, Shanbrook, and Mihuti Court among others; Medium-level grade (Upper Hill and Nairobi West among others) government households were considered for sampling in this study. The number of houses which were sampled in each level was randomly done. However, the respondents living in low-level government houses did not own computers and, therefore, were not considered in this study.

3.3.4 Sampling Technique

A number of steps were undertaken in the sampling of the five categories of the target population. Using the Government classification of households (respondents living in Government houses) as high, middle and low-level residential areas of Nairobi City County. In the class of the public institutions, the focus was on Government Ministries, Research Institutes, and Universities (both private and public). The respondents living in the low-class Government residential houses did not have computers at home and therefore excluded from the study.

Based on the recommendation by scholars such as Bell (1993) and Mugenda (2003) that one-third is a reasonable representation of the target population, a sample size of 30% was drawn from each of the following: -Universities, Private companies and household clusters. Purposive sampling was carried out for some cases [such as Ministry of Science and Technology (MoST), Ministry in charge of Information Communication Technology (MoICT), Ministry of Health (MoH), Ministry of Environment and Natural Resources (MENR)], that had the required information related to the subject of the study (Creswell, 2005). Sampling for the Research Institutes [Genetic Resources Research Centre (GRC), Kenya Medical Research Institute (KEMRI), Kenya Industrial Research Development Institute (KIRDI), Kenya Forestry Research Institute (KEFRI), Institute of Primate Research (IPR), National Crime Research Centre (NCRC), Kenya Industrial Property Institute (KIPI),

Kenya Institute for Public Policy Research and Analysis (KIPPRA), and Water Resource Management Research Institute (KEWI)] was carried out taking into considerations the different mandates such as research on animal, crime, human, policy, intellectual property, forestry, industry and water. The official waste disposal management site for the county solid waste stream at Dandora, the WEEE Centre and temporary waste disposal stations, called '*yard-shops*' in the terminology of Oyake-Ombis (2012, 2015) located within the proximities of the formal dumping site (Dandora) was also included in the study. In cases where anomalies such as wrong numbering of samples were encountered, follow-up field visits and phone calls were made for clarifications.

3.3.5 Data Collection

Since a large part of this study was field-based, much of the methods of data collection process entailed face-to-face interviews with respondents in their natural settings. A variety of research tools were used to aid in the collection of information from various sources. In all the data collection scenarios, an introductory note was prepared (Appendix A) to aid in setting the scenes and ensuring that details relating to ethical requirements and intent of the study were provided to the target respondents before their participation in the exercise. Semi-structured questionnaires were designed for respondents from institutions (Public and private universities, public research institutes, and Government Ministries (Appendix B), and households (Appendix C). Interview schedule for e-waste pickers/scavengers and Yard Shop operators (Appendix D) and observation guide for formal/informal disposal sites (Appendix E) were used. Interview schedules were also prepared for use on occasions of gathering data from key informants as well as policy-making and regulatory agencies (Appendix F); Observation guide on environmental management systems (Appendix G); relevant documents for the analysis of computer e-waste disposal management approaches (Appendix H); Research Permit from NACOSTI (Appendix I); and letter from University of Nairobi requesting researcher to collect data (Appendix J).

3.3.6 Sampling and Sample size

Simple random sampling was the basic sampling method that was used for data collection. The major value of the simple random sample was that an equal chance of each member of the population was chosen and hence collection of a representative sample of the population was guaranteed.

Table 3.1: Sample size

Sampling frame	Population Category	Population Size (N₁ for Nairobi only)	Sample size (n₁=30% of N₁)
Universities	Public& private	20	9
Government	Ministries	18	7
	Research Institutions	11	9
Companies	Private	67	30
Households (Government Estates)	High-income	264	79
	Middle-income	257	77
Policy Makers/ Regulators	Ministries & Regulators	6	6
Disposal sites	Dandora	1	1
	Yard-shops	3	3
	E-waste pickers / Scavengers	3	3

Finally, towards obtaining data needed for the third objective of the study; mapping out existing weaknesses in and potential directions for change in policies and management approaches for the computer-based e-waste disposal, two document review guides were used: the first (Appendix G) was prepared for use in examining internal quality management, statements of the institutions included in the study for highlighting issues relating to environmental sustainability, with a focus on waste from computer components and accessories disposal management within their premises; and the second (Appendix H) for content analysis of treatment of computer e-waste disposal management from a human health and environmental perspective in the national and Nairobi County Government human health and environmental policies, plans and regulatory frameworks.

3.3.7   *Validity and Reliability Measures*

Central to empirical studies are issues of validity: - the extent to which the instruments used precisely measure the phenomenon to which they are tailored (Mugenda, 2003; Kombo *et al*., 2006) and reliability: - the degree to which the results of the study remain consistent or produce similar data after repeated trials. Most of the data used in this study was quantitative and qualitative in nature. The validity was, therefore, ensured by undertaking a pre-test of the instruments that were likely not to be accurate in the face of changes in the study context or response to investigative patterns of face-to-face interactions between the researcher and respondents in the field settings. Thus, pilot studies deemed necessary for the components wherein questionnaires were to be used. This step was used to identify and correct ambiguities and inappropriate contents of the study tools prior to the actual data collection exercise.

The utility of pre-testing for improving objectivity in scientific studies has been underscored in several books on research in the social sciences that only a pertinent mention can herein be made (Bell, 1993; Kothari, 2004; Barasa *et al*., 2008). To paraphrase Bell, the purpose of piloting was to get the bugs out of the instruments to carry out pilot analysis to determine whether the wording and format of questions would present any challenges in the main data analysis.

In this research, the pre-test of the questionnaire's administration process was conducted within Nairobi City County in one constituent college of the University of Nairobi; one chartered private university; one research institute; two government ministries; two large-scale businesses; and six households (three in each one high-class and middle-class residential area). The candidates for response in the pre-test exercise were not included in those ultimately selected for provision of data during the actual study.

On the reliability front, the strategy used was to design the contents of the tools by considering other scholars research instruments similar to this study. The research instruments were also reviewed by experts (two supervisors) in this field in such a way that the questions raised are complementary to each other within the same instrument, and that this thread of complementarity of questions is carried out throughout engagements between the researcher and respondents across tiers of data sources. Multiple data collectors were involved to reduce bias in the sampling. The research also employed simple random sampling approach in selection of samples. This approach made it possible to determine points of agreement and deviations in perspectives on various attributes that warranted realignment of emphasis during the collection of data and precautions in the analysis and interpretation of results. In the event extreme anomalies such as significant but missing data or overtly outlier responses were detected during analysis, clarifications were sought out through follow-up field visits and phone calls.

3.3.8   *Data Analysis and Interpretation*

Three distinct but mutually interactive steps were involved in the process of data analysis, interpretation and presentation of findings. First, all the primary data were first subjected to screening and cleaning. Second, responses contained in the filled-out questionnaires were coded and entered into computer vide statistical package for social sciences (SPSS) windows version 20 for analysis. The required statistical values were thereafter run and results summarised in the form of frequency distribution tables and graphs. Like in the data collection

process, the analysis of qualitative responses was in resonance with the propositions of grounded theory of qualitative studies; not approaching the data with preconceived ideas about what respondents might have to say or what possible themes might emerge (Glaser *et al.*, 1967; Merton, 1987; Miles *et al.*, 1994; Patton, 2002; Weiss, 2004). The intention of this exercise was to establish common themes, propositions and concepts related to human health and environmental perspectives on computer electronic waste disposal management as mirrored in the views and perceptions of the respondents themselves. As depicted in the four chapters that follow, the sum quantitative and qualitative results were consolidated and the resultant interpretations and discussions presented in a triangulated pattern of converging and diverging human health and environmental waste disposal management scenarios.

3.3.9 Ethical Considerations

Before visiting the sites selected for the study, written consent was obtained from the office of Chairman, Department of Urban and Regional Planning (DURP), in the School of the Built Environment, University of Nairobi (Appendix J). Further, a research permit was obtained from the National Commission for Science, Technology and Innovation (Appendix I). During the data collection exercise, the aim of the study would first be explained to the respondents, in the course of that they would be requested to provide their most sincerely considered as accurate responses to the study questions. The respondents were not required to give personal identities like their names or contact details, either verbally or in writing.

The assurance was further granted to the respondents relating the utmost confidentiality attached to the study that their personal details would not be disclosed in the study process, and they were guaranteed that no personal victimization due to the data provided would arise. In addition, respondents were granted the liberty to pull out of the data collection sessions in the event they deemed appropriate. However, none of the respondents opted to pull out of the process. In a further bid to win their cooperation and rapor, they were also promised that copies of the resultant thesis would be disseminated to their respective affiliate institutions, Nairobi City County Government Offices including KENSIDOC at NACOSTI and National Library for public-wide use and reference for development of policies, plans and programmes on urban and regional development.

CHAPTER 4: COMPUTER E-WASTE DISPOSAL MANAGEMENT APPROACHES

4.1 Introduction

Chapter four provides the results on the first specific objective of the research which sought to determine the computer e-waste disposal management approaches in Nairobi City County, Kenya. Owing to the diversity of the tools used and questions raised in the field setting, this chapter starts with an explanation of the methods used in obtaining the responses specific to this study attribute. It provides definitions, measures and indicators used in the analysis of the disposal management approaches and provides an overview of the statistical tools and methods used in summarising and presenting the findings. The findings are described in the second part, and a summary of the results from the analysis relating to the scope of the chapter are given.

4.2 Results

The distribution of the different categories of samples is as indicated in Table 4.1 below.

Table 4.1: Distribution of Institutions, Disposal Sites and Households

Data source	Type of sample	Frequency	Per cent
Institutions	Universities (Public & Private)	9	18.8
	Government Ministries	2	4.1
	Research institutions	7	14.6
	Private companies	30	62.5
	Total	**48**	**100**
Policy and regulatory domains	Policy-making	3	50
	Regulatory	3	50
	Total	**6**	**100**
Households	High level	77	49.6
	Middle level	79	50.4
	Total	**156**	**100**
Disposal sites	Official County disposal site (Dandora)	1	12.5
	Temporary collection sites (Yard-shops)	3	37.5
	Official recycling facility (WEEE Centre))	1	12.5
	Total	**8**	**100**

4.2.1 Characteristics of Respondents in Computer E-Waste Disposal Management

The institutions, households and landfill setting, as well as individuals from whom primary data was collected, exhibited a variety of characteristics. As Figure 4.1 depicts, most of the respondents (89.6%) at the institutional level were males and only 10.4% were females. In the

contrary, the majority of the respondents encountered upon visits to households were females (60.3%).
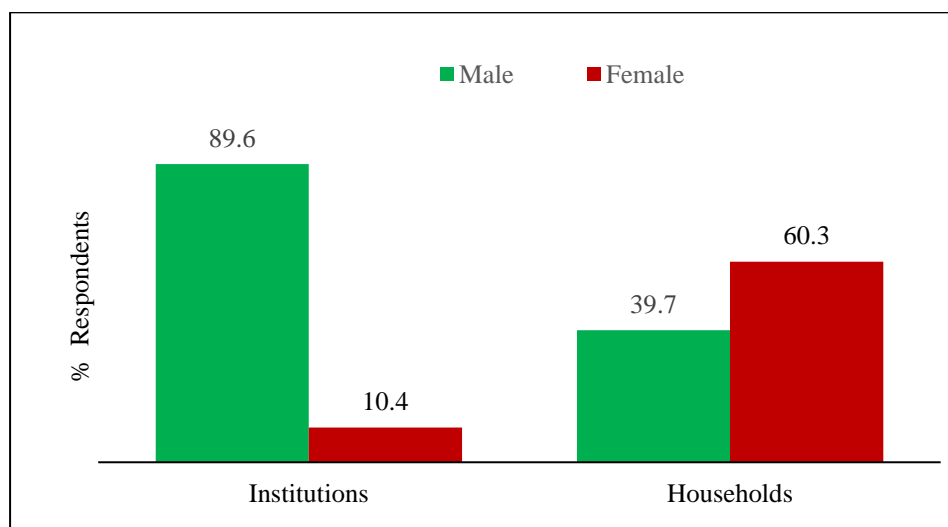

Figure 4.1: Sex of Respondent

Table 4.1 shows the distribution of respondents according to the duration they had worked in their respective working place affiliations, and for those drawn from the households, the period they had lived in the residential area.

Table 4.2: Distribution of Respondents by Familiarity with Field Setting

Familiarity with Field Setting	Frequency	Per cent
Duration worked in the institution		
No response	1	2.1
Less than 12 months	2	4.2
1-3 years	25	52.1
More than 3 years	20	41.7
Total	**48**	**100.0**
Duration of residence		
Can't remember	5	3.2
Less than 12 months	3	1.9
1-3 year	26	16.7
More than 3 years	122	78.2
Total	**156**	**100.0**

As Table 4.2 depicts, the majority of respondents had lived or served in their respective field settings for at least 12 months. Those who had been in those settings for less than 12 months were very few; 4.2% from institutions and 1.9% from households. Still, respondents from the landfills as well as policy and regulatory institutions reported that they had been in those places for at least two years. Table 4.3 shows that respondents from the households varied remarkably in their levels of education, with a vast majority reporting that 64.7% had attained university

level schooling and another 21.8% had tertiary schooling. Only 13.5% had secondary and primary schooling combined. To determine the capability levels of households for computer technology use, and management of the computer e-waste, three parameters were used: educational attainment, availability of a computer within the household and average monthly income of the household. The responses were as presented in Table 4.3.

Table 4.3: Education, Computer Ownership Characteristics of Respondents from Households

	Frequency	Per cent
Education of Respondents from Households		
University	101	64.7
Tertiary	34	21.8
Secondary	19	12.2
Primary	2	1.3
Total	**156**	**100.0**
Currently have a computer in the house		
Yes	102	65.4
No	54	34.6
Total	**156**	**100.0**

This raises the possibility that a large number of respondents (86.5%) of the households had been exposed to learning conditions in which computer applications is essential, even mandatory. This possibility was further reflected in the fact that another large size (65.4%) had computers in their houses at the time of the study compared to only 34.6% who responded to the contrary.

Table 4.4: Percent of Households Owning Computer Components and Accessories by Level of Education

Education of respondents from households	Frequency	Per cent	Per cent with computer
University	101	64.7	83.3
Tertiary	34	21.8	11.1
Secondary	19	12.2	5.6
Primary	2	1.3	-
Total	**156**	**100.0**	**100.0**

As indicated in Table 4.4, the study established that a household's level of education significantly affects computer ownership. Those households with respondents in the highest levels of education (64.7%) had the highest percentage of computer ownership (83.3%).

4.2.2   *Types of Computers Available for Use by Different Actors*

As a further proxy pointer to the risk of e-waste disposal management approaches, the types of computers found within offices of institutions, business premises and households were

examined in the study. To this end, respondents from institutions were asked to rate on a Liker-type scale of (1-most common, 2-second common, and 3-least common) desktop computers with CRT display (traditional monitors), desktop computers with LCD (flat screen) monitors and laptops. The result of those who responded is summarised in Figure 4.2.
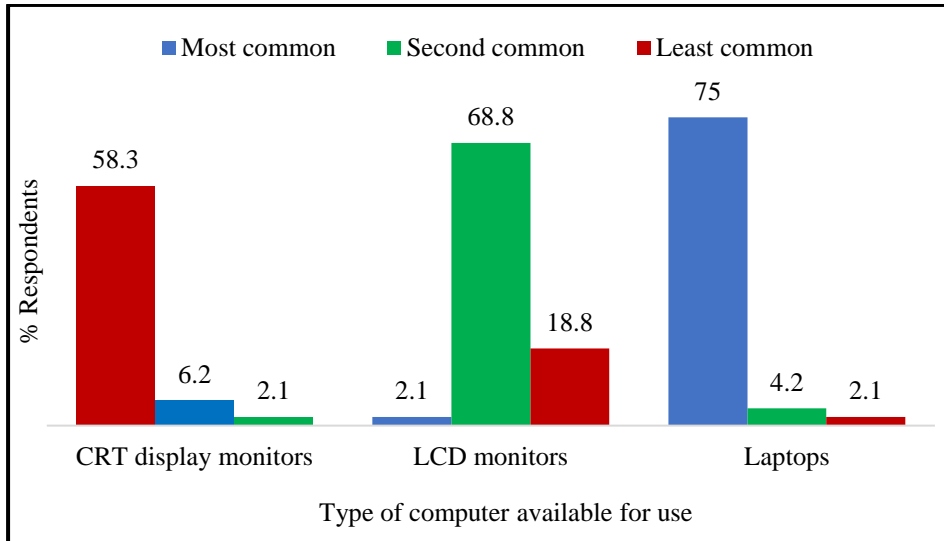
Figure 4.2: Use Rating for Types of Computers Available in Institutions

From the ratings of use provided in the responses (Figure 4.2), desktop computers with CRT display monitors were found to be the least commonly used while desktop computers with LCD (flat screen) monitors were found to be the second commonly used. The rating corresponding to laptops indicates that these types of computers were more likely to be used for current office purposes and also in the field.

The structure of responses depicted in Figure 4.2 was equally reflected in the responses to the question which sought to enlist the average type of computers purchased in the institution per year. The answers to the question of this attribute were as presented in Figure 4.3.
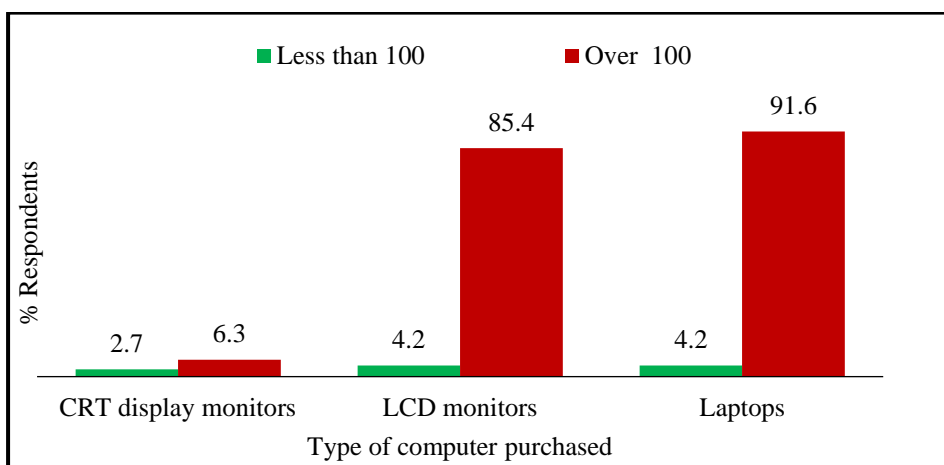
Figure 4.3: Average Type of Computers Purchased in Institution per Year

Figure 4.3 shows that most institutions and businesses prefer the use of desktop computers with LCD monitors (85.4%) or laptops (91.6%) to desktop computers with the traditional CRT display monitors (6.3%). At the time of the study, the type of computers in the households was reported to the magnitude presented in Figure 4.4.
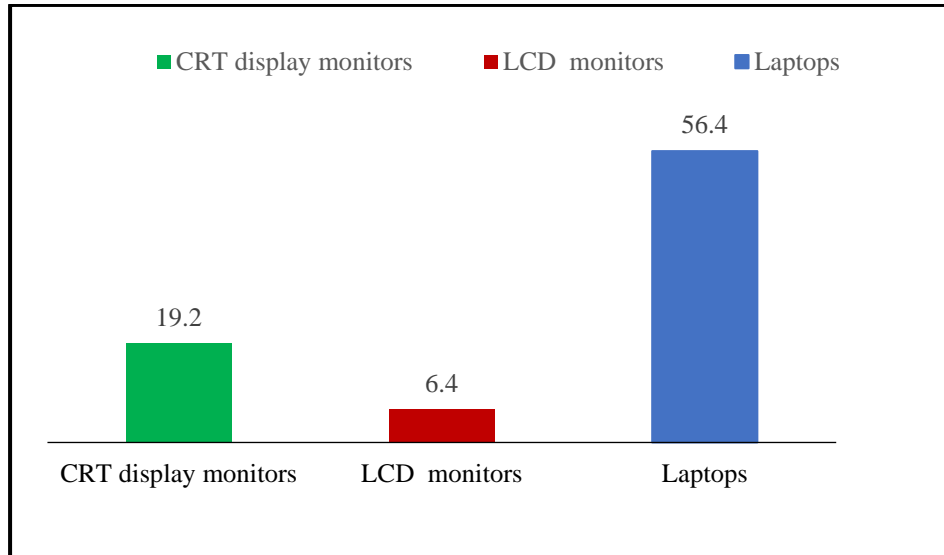

Figure 4.4: Type of Computers in the Household at the Time of the Study

Of those who responded to the question on this attribute (Figure 4.4), most of them (56.4%) said that there was at least one laptop in the house. Another 19.2% reported that there was a desktop computer with a CRT display monitor in the house. Those who reported that they had a desktop with LCD monitor were very few (6.4%).

4.2.3   Sources of Computer E-waste from Institutions

An important beginning point for effective disposal of computer e-waste is the question of where equipment users obtain them from. To this end, respondents from institutions and private companies were asked where they get their computer components and accessories. The responses to this question were as presented in Table 4.5.

Table 4.5: **Common Sources of Computer Components and Accessories for Institutions**

Source	Frequency	Percent
No response	2	4.2
Direct import of international brand	1	2.1
International brand retail outlets	43	89.6
Local assembler with no own brand / refurbished	1	2.1
Other sources	1	2.1
Total	**48**	**100.0**

As Table 4.5 indicates, nearly 90% of the institutions and private companies that participated in the study bought computer components and accessories from international brand retail outlets. Other sources for institutions with relatively less favour were the direct import of international brand (2.1%) and local assembler with no own brand/refurbishes (2.1%).

Similarly, as Figure 4.5 shows, most of the respondents from households (70%) reported that the computer in their house had been purchased. Those who reported having acquired the computer by way of donation were only 3% while a significant number of respondents (27%) indicated other sources they did not disclose as the source of the computer in their household, a scenario which raises the possibility that for households in Nairobi, ownership through purchase and donations is not the only option for attaining ownership of a computer.
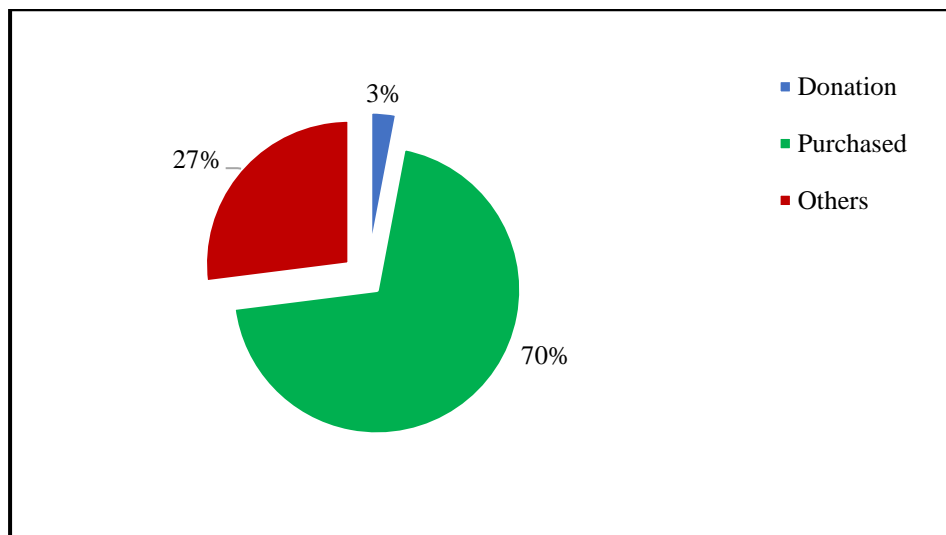
Figure 4.5: Source of Computers Present in the Households

Residents were further asked about the condition the computer used within their household was in at the time it was received. Of the 114 who responded to this question, only 4% said that the computer was '*second-hand but in usable condition*. An overwhelming majority (96%) of all households reported that the computer they had was *'new'* at the time they received it (Figure 4.6).
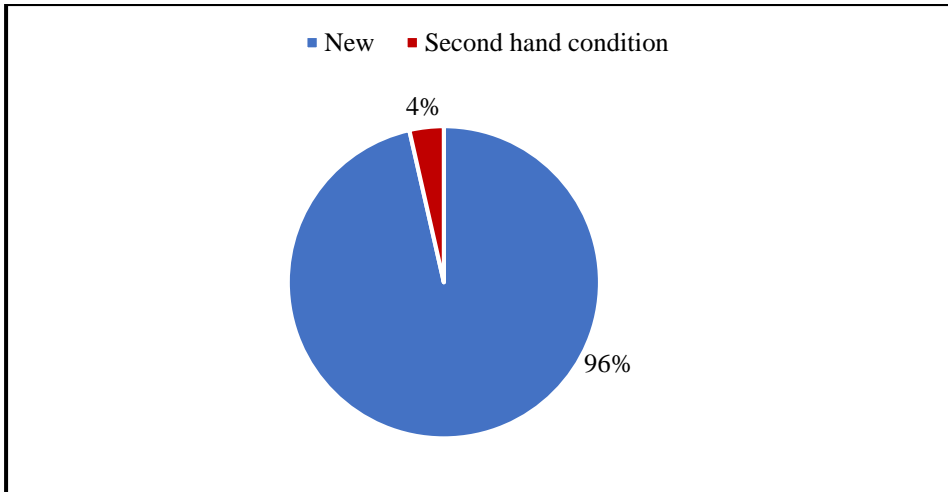
Figure 4.6: Condition of Computer Currently in the Household at the Time of Receipt

4.2.4 Management Systems for Computer Disposal

Environmental management literature has solidly established that record keeping is an essential step towards instilling a culture of precautionary measures for sustainable future regarding environmental management systems. This study examined institutions and business entities for keeping inventories of their waste from computer components and accessories. The results of those who responded to this question were as presented in Figure 4.7.
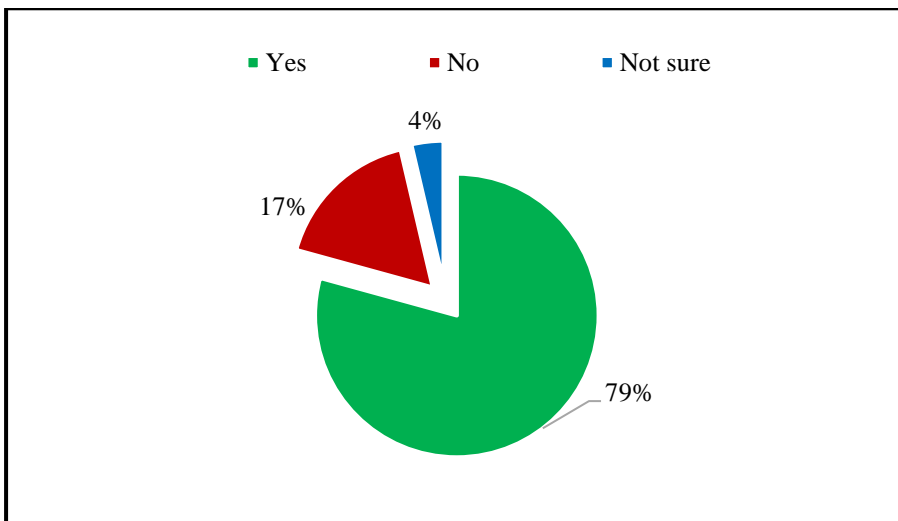
Figure 4.7: Institutions that Keep Inventory of Computer Components and Accessories

Further, Figure 4.7 shows that a high proportion of institutions and private companies in Nairobi City County (79%) have embraced the mantra of inventory maintenance, although a significant proportion in the category of '*no*' and '*not sure*' combined (21%) had not subscribed to this practice.

In particular, the study sought to unravel the extent to which institutions and businesses keep records relating to computer components and accessories purchased and disposed of. The result from those who responded to these questions were as presented in Figure 4.8.
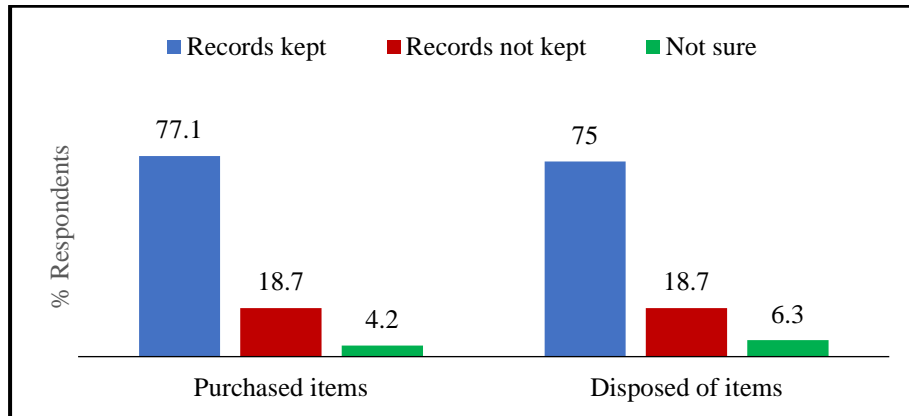

Figure 4.8: Responses on Records Keeping for Purchased and Disposed of Computer Components and Accessories by Institutions

As Figure 4.8 shows, the responses to the question of records keeping in respect of both purchased and disposed of computer components and accessories were in harmony with those on inventory keeping for computer equipment in general.

Another aspect of the precautionary step towards effective disposal of computer e-waste about human health and environmental sustainability of the urban area examined in the study were considerations of the warranty period associated with a computer component and accessory at the time of purchase. To this extent, the corresponding responses of those who responded were as presented in Figure 4.9.
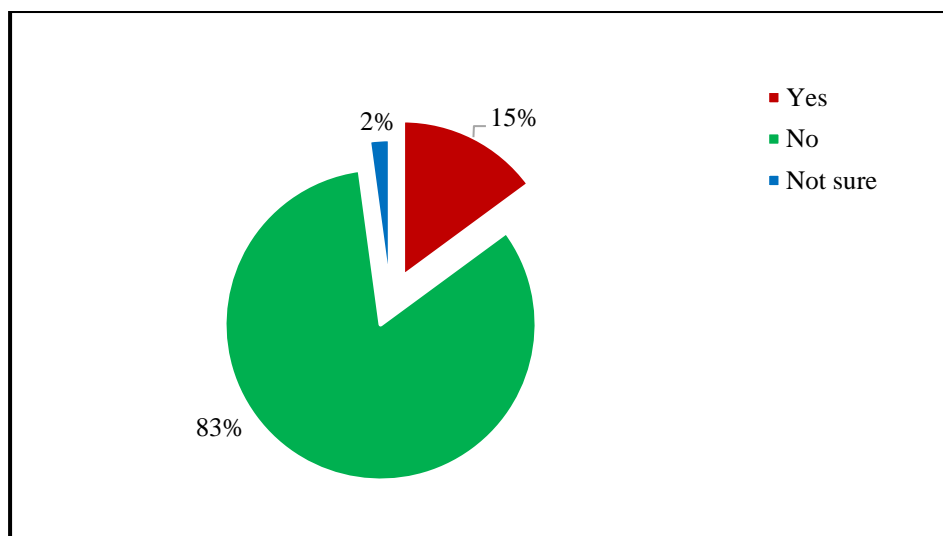
Figure 4.9: Institutions Consider Warranty Period when Purchasing Computers

Figure 4.9 shows that only 15% of the respondents from the institutions responded in the affirmative to the question on warranty period consideration upon purchase of computer components and accessories. On the contrary, a large size of respondents (83%) divulged that this was not the practice by their institutions and 2% of the respondents were not sure.

Out of the 7 who responded in the affirmative to the question on the matter, their responses to the question which sought to map out human health and environmental aspects as the underlying springboards for the consideration of warranty period were examined. The responses enlisted were as summarised in Table 4.6.

Table 4.6: Reasons for Institutions Warranty Considerations on Purchases

Reasons	Frequency	Per cent
Maintenance and replacement cost	4	57.14
No response	3	42.86
Environmental /Human health aspects	0	0
Total	**7**	**100**

As Table 4.6 indicates, the analysis revealed that none of them reported environmental nor human health implications of the purchases in their value attachments to warranty periods. Economic cost was the most outstanding underlying value attachment considerations presented in the responses.

More particularly, three response options were provided against a question in the questionnaires which sought to enlist the views of respondents about what would be the responsibility of computer technology users in the disposal management of waste computer components and accessories.

These options were postponing the purchase of new components and accessories when those in use are still in a position to serve; pay for waste disposal levies during the purchases, and engage in the separation of computer e-waste from the solid waste (CSW), and channel them to recycling plants. The magnitude of endorsement of these options in the filled-out questionnaires was as indicated in Figure 4.10.
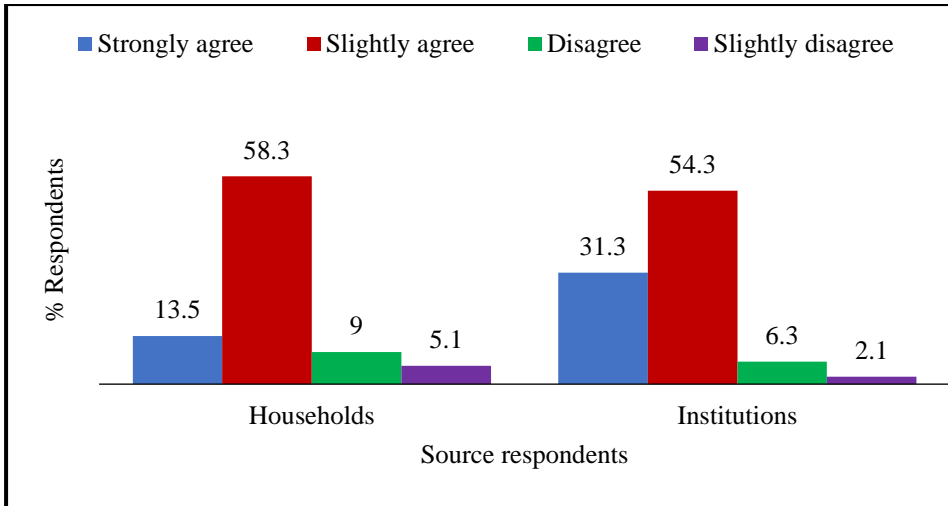
Figure 4.10: User Responsibility Preferences for Computer E-Waste Disposal Management Approaches

The findings summarised in Figure 4.10 show that an overwhelming majority of respondents from households (71.8%) and institutions (85.6%) were in favour of having computer technology users engage in separation and transmission to e-waste recycling facilities. However, few respondents from households (14.1%) and institutions (8.4%) were willing to delay the purchase of new computers before the ones under use entirely become redundant or incur disposal service levies charged on the cost of purchase of new computers.

4.2.5 Computer E-Waste Disposal Management Approaches Options

Respondents from the public institutions and private companies were asked to state the computer disposal management practiced by the institutions (n=18) and private companies (n=30) they worked for. The result of their responses is indicated in Figure 4.11).
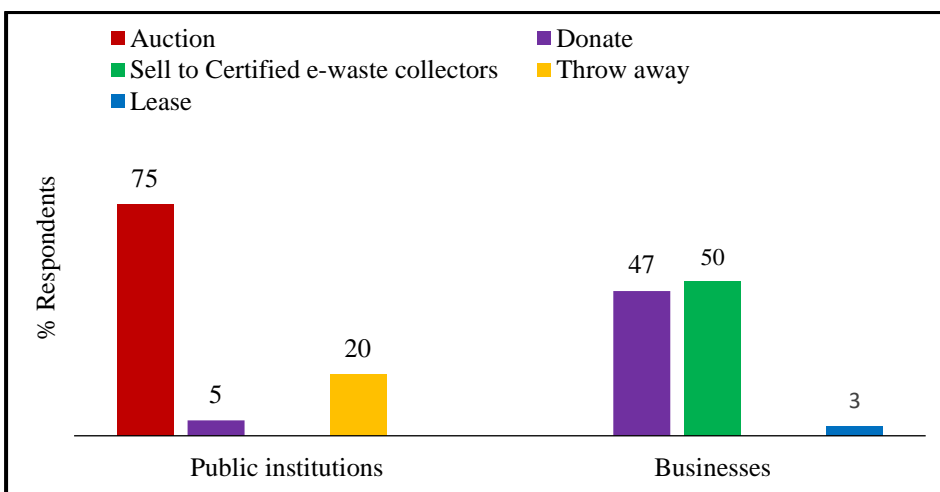
Figure 4.11: Computer E-Waste Disposal Management Approaches Employed by Institutions and Businesses

Figure 4.11 indicates that auction is the main computer e-waste disposal management approach employed by public institutions (75%) while donations to staff and selling to certified NEMA e-waste collectors are the approaches practiced by the private companies (47 % and 50% respectively).

Household occupants were asked about the approach they had employed for the disposal of computer components and accessories no longer deemed useful to them. An examination of cases (n=147) in which respondents indicated they had at least had any of the three types of computer waste (desktops with CRT display monitors, desktops with LCD monitors or laptops) revealed the responses presented in Figure 4.12.
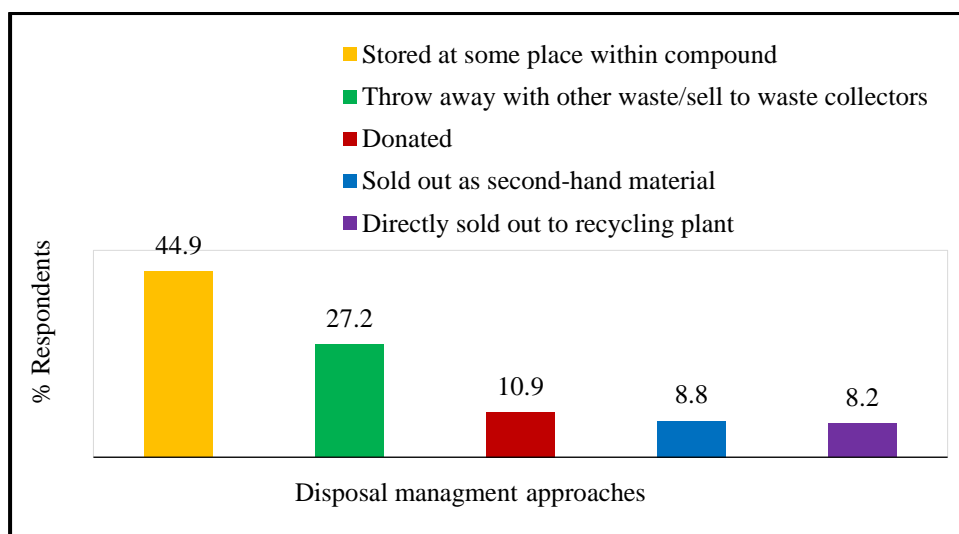
Figure 4.12: Computer E-Waste Disposal Management Approaches Employed by Households

As Figure 4.12 indicates that storing computer e-waste within residential compounds was the common practice among households, as reported by nearly half of the respondents (44.9%); or throwing it away with other waste by self or selling out to waste collectors (27.2%). Different modes of disposal not mainly practiced was donation (10.9%), direct sale to recycling plants (8.2%) or selling out as second-hand material (8.8%). Nonetheless, the responses from households indicated that disposal through open air burning or organising for transportation to the official county landfill had been practiced as a disposal option.

Asked what they do with waste from computer components and accessories that are functioning, one of the key informants of the WEEE Centre said that those that meet learning institutions standard specifications are donated to schools through the Computers for Schools Kenya (CFSK) programme and; those that are in demand by the public for re-use are sold to

them. Further, the category that is still functional but is of very low specifications that even the members of the public are not interested, is scraped.

Photo 4.1: WEEE Centre - A Private Recycling Facility in Kenya

Observation from a visit to the dumping site (Dandora) indicates the absence of e-waste despite it being in existence for the last 20 years, and also the country's fastest-growing waste component of the CSW stream. Asked what type of e-waste components that e-waste pickers or scavengers operating at Dandora dumping site collect, one of the respondents had this to say: "*We collect valuable metals such aluminium and copper, batteries and plastics but burn the plastics and batteries*". The computer e-waste they collect is usually sold to the yard shop operators (also living within close proximity to the dump site) who clean, sort and package in bulk ready for the recycling facility. The activities by the yard shop operators are attributed to limited opportunities for generation of income especially for the youth from the informal settlements where there is a high prevalence of poverty in the City. This is postulated by the findings of Mitullah *et al*., (2003). The yard-shops operators usually trade in metal, plastic and paper.

4.2.6 Drivers of Computer E-waste Disposal Management Approaches

In this study, the factors that stimulate the desire to dispose of waste from computer components and accessories were assessed in relation to two parameters: i) the type of technology application favoured; ii) attainment of the equipment's end-of-life (EoL) cycle. On the technology front, respondents from institutions were asked about the average age of computers purchased in their respective institutions. The results of those who responded in the affirmative to this question is as presented in Figure 4.13.
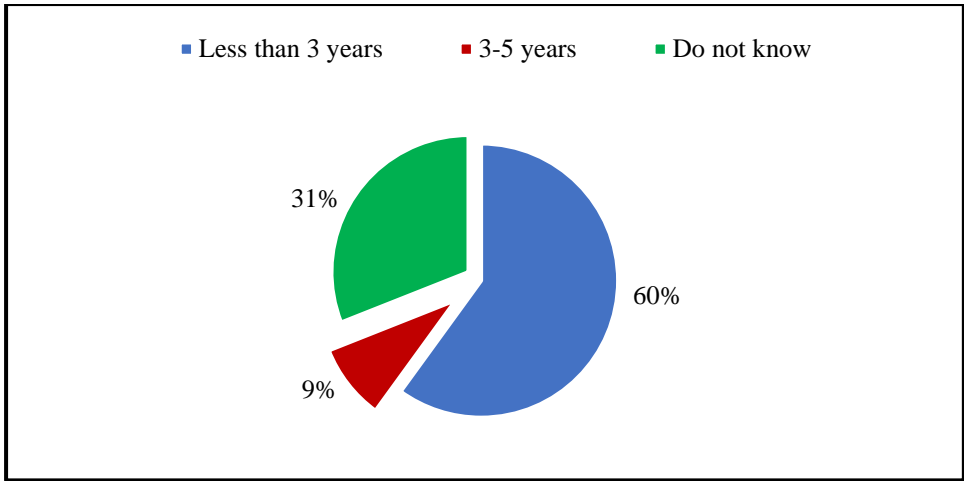
Figure 4.13: Average Age of Purchased Computer Components and Accessories by Institutions

As depicted in Figure 4.13, the majority of respondents (60%) reported that the average age of computers purchased in their institutions was less than 3 years. Another 9% of the respondents responded that it is between 3 and 5 years. Some 31% of respondents did not have answers about the appropriate average age of computers purchased by their institutions.

On a similar attribute, respondents from households who reported that the computers they had in the house were '*new*' at the time of purchase were asked to state the average time taken before they replaced the equipment. The results of those who responded to this question is represented against each category of computers in Figure 4.14.
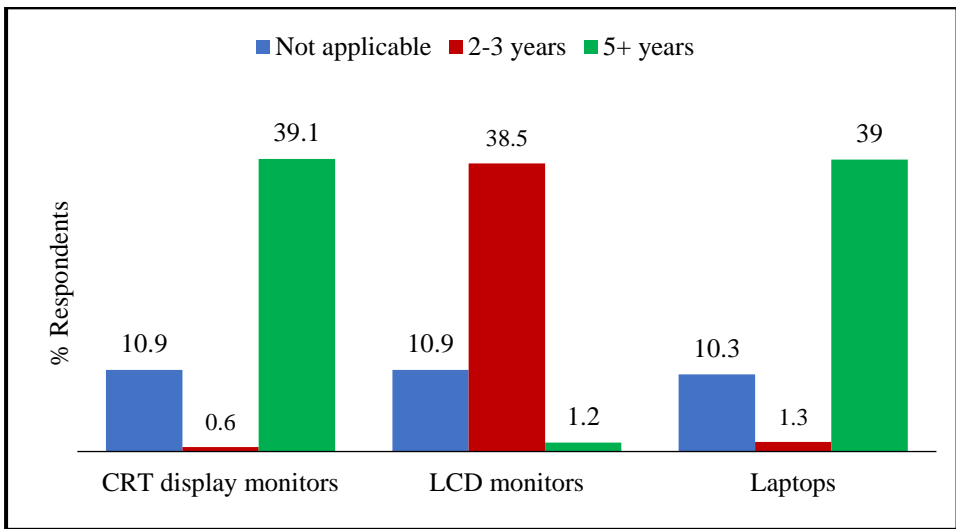
Figure 4.14: Duration Newly Acquired Computer used in Household before Replacement

Both Figure 4.13 and Figure 4.14 attest to the likelihood that age at purchase and duration is a crucial driver of decision for disposal of computer e-waste by many users of computers. Over 10% of respondents (Figure 4.14) indicated '*Not applicable*' which means that they have never replaced their computers. On the technology end, respondents were provided with a set of

options for which a decision to dispose of computers would be based within their respective institutions. These conditions were: when broken down and not repairable; when broken down but repairable; and when in excellent condition, functioning, but technologically out of date. To these effects, their responses were as presented in Figure 4.15.
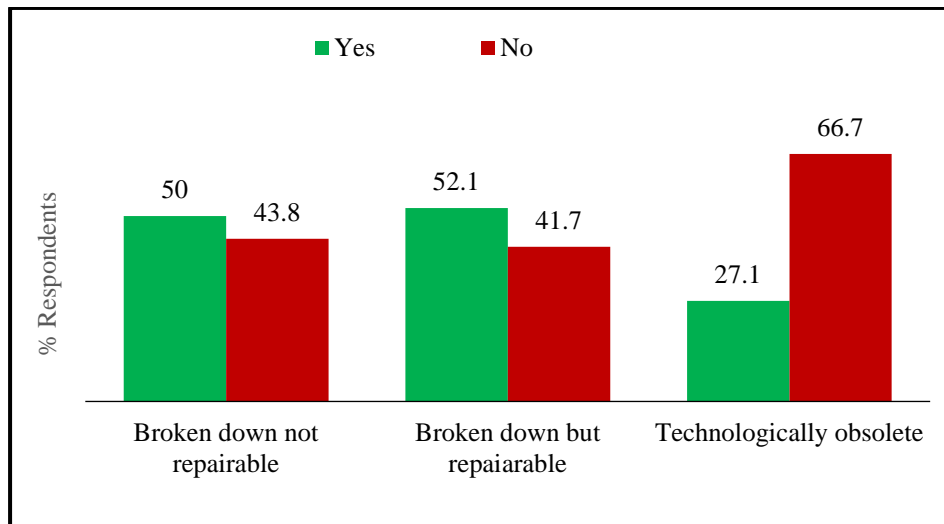
Figure 4.15: Conditions that Trigger Decision to Dispose of Computer E-Waste in Institutions

The Figure 4.15 indicates that nearly half of the respondents reported that breaking down of computer components and accessories was a common cause for disposal, albeit in a repairable state. However, the corresponding statistic for technologically obsolete consideration as disposal driver was much higher (66.7%). To further assess technological transition as a determinant of decision for the disposal, households were asked about the type of computers they had discarded from the house over the period dating past five years. They were also granted the liberty to indicate if they '*can't remember exactly*' the underlying reason for the disposal decision. The result of those who responded to this question is as presented in Figure 4.16.
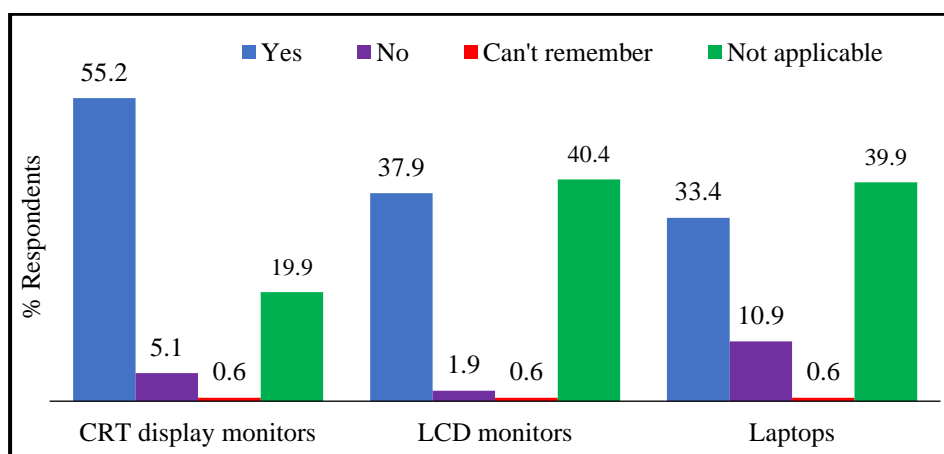
Figure 4.16: Types of Computers Discarded from Households over the Past Five Years

From Figure 4.16, the number of households in which computers had been discarded was highest for the desktop with CRT display monitor (55.2%), followed by the desktop with LCD monitor (37.9%), and least for the laptops (33.4%). Although with a much smaller magnitude, households which reported that they had not disposed of laptops over the past five years before the time of the study was highest relative to the statistic corresponding to disposal histories of the desktop with CRT or LCD monitors (5.1% and 1.9% respectively). Some respondents who indicated '*Not applicable*' has not discarded their computers for more than 5 years.

Photo 4.2:Cathode Ray Tube Display Monitors Stored in one of the Public Institutions

When the filled-out questionnaires from the households were examined for responses to the question which sought to enlist the major reason for the reported disposal, the results were as presented in Figure 4.17 (with '*no response*' or '*not applicable*' cases excluded from the analysis, n=58).
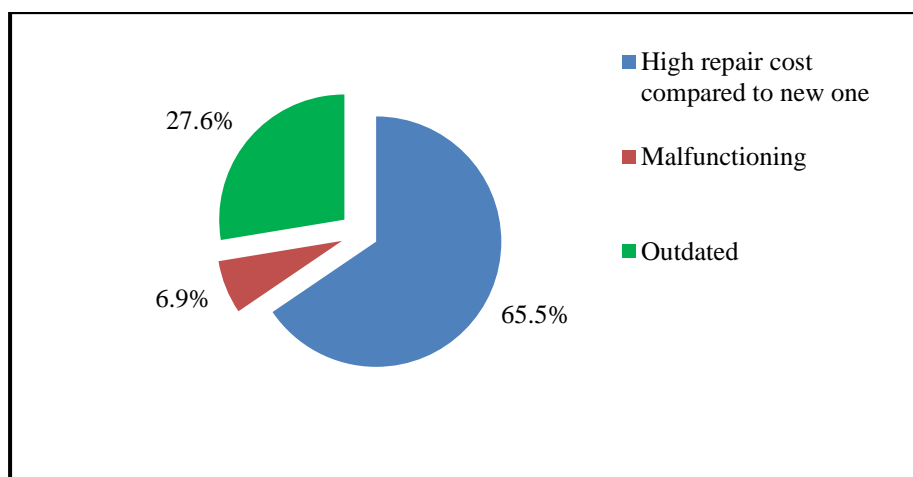
Figure 4.17: Major Reasons used for Computer Discarded from Households

4.3. Discussions

4.3.1 General Socio-Economic and Demographic

The study established that majority of respondents at the institutions/private companies were males (89.6 %) while those at the households were females (60.3 %). This picture is congruent with the gender disparity in participation in productive economies characteristic of Kenya where males are dominant in the key economic sectors in the urban settings (UN, 1995; UNDP, 1995).

As indicated in Table 4.2, 41.7% and 78.2% of respondents at the institutions and households respectively had been in their current field settings for more than 3 years and at least 2 years for those from the landfills, policy and regulatory agencies. In the light of these reported duration of interaction of respondents with the field settings, a strong sense of familiarity with computer e-waste disposal management approaches in their settings was expected to be reflected in their responses, thereby enhancing the likelihood of reliability in the responses received against questions raised in relation to disposal management practices for waste from computer components and accessories.

The results also revealed as indicated in Table 4.3 that majority (98.7%) of the respondents had attained education levels of secondary and above. This is a pointer to the possibility that the responses from households were obtained from people capable of exuding high intellectual sensibilities necessary to articulate the real scenarios on the subject of computer e-waste disposal management approaches in their residential settings, thus enhancing prospects for drawing objectively verifiable judgments from the responses.

Storage of computer e-waste especially with old technologies, such as CRT display monitors in the households, may impact negatively on human health and the environment. This is particularly if at the end-of-life they are improperly disposed of.

4.3.2 Computer E-waste Disposal Management Approaches in Institutions

The study established that all types of computers are being used at the institutions and private companies. The most purchased computers are the laptops and the desktop computer with LCD monitors, while the desktop with CRT display monitors is still being used at the institutions. It is evident that (Fig. 4.2) the desktop computers with CRT display monitors are being phased out and are fast being replaced by the desktop computers with LCD monitors.

There was evidence of many CRT display monitors in the institutions possibly awaiting disposal through the process advocated by the Public Procurement and Asset Disposal Act, (2015). This is a situation that compares well with the findings of Nsengimana *et al*., (2011); Kalana (2010) and Oteng-Ababio, (2012).

The study also found that the laptops are increasingly being used at the institutions. This is a clear indication that the institutions are utilising the laptops because they can be used both in the office and in the field. It is possible that a sizeable waste from computer components and accessories was still stored or held back by respondents who had limited awareness about the potential risks involved in the unsound disposal management approaches of the e-waste. The study also observed that respondents discard the laptops, personal computers with LCD monitors and CRT monitors in the ascending order.

The main driver to disposal management of computer components and accessories at the public institutions and private companies are technological obsolesce (Figure 4.15) at 66.7%. The technologies of which the computers were considered have played a significant role in making daily activities comfortable and smooth. The high rate of computer equipment disposal may be due to an update of technologies, malfunctioning or incompatibility of old computer systems - a situation that is affirmed by Nsengimana *et al*., (2011) or shipment of near-end-of-life computer components and accessories from the high to low-income countries such as Kenya in line with the postulates of Hossain, (2010) and Osibanjo *et al*., (2007). By opting to purchase/use the computer with LCD monitors, the amount of computer e-waste that is generated by the use of the computers with CRT display monitors is drastically reduced.

Warranties ensure that institutions/private companies get maximum performance and efficiency from equipment. The fact that the respondents identified maintenance and repairs for considerations of warranty period as opposed to human health and environment is a clear indication that they do not consider health and environmental impacts in the institution serious or they do not even know the seriousness of computer e-waste itself.

Although mandated by the government, records management has been unevenly implemented. Proper keeping of inventory and records of the waste from computer components and accessories is a significant way to reduce the resultant e-waste. The study observed that the institutions and private companies keep records of their purchases and disposals of computer components and accessories. This ensures that approval to purchase computer components and

accessories are made before any purchase is made. The study established that there was harmony between the computer components and accessories of purchased and the resultant computer e-waste disposed of. Despite the excellent record keeping of the institutions and private companies, the computer e-waste is often stored in the offices until directions to dispose of are given (Kalana, 2010, Oteng-Ababio, 2010).

The study observed that the institutions and private companies have put in place effective inventory control systems that ensure that computer components and accessories purchased or disposed of are accounted for. This eventually ensures that purchases are on a need-basis and that only the quantity needed for a specific period of time is purchased. This, therefore, controls the computer e-waste that would otherwise end up in the e-waste disposal management system chain.

The study also established that e-waste produced by the private sector is properly collected by NEMA licensed e-waste collectors while only a few numbers of e-waste collectors collect e-waste from public institutions. Individual households have no organized way of the collection of the computer e-waste disposed of. One private university lease computer components and accessories and uses them for three years and the vendor takes them back after the three years. The average age of purchased computers in the institutions was less than 3 years.

4.3.3 Computer E-waste Disposal Management Approaches in Households

Majority of the household respondents reported having computer equipment in their households. This was a clear indication that computer components and accessories have penetrated the modern way of life (Toxic Link, 2001) and that people are using technology for their daily activities. Laptops and desktop computers with LCD monitors are becoming increasingly preferred, especially when compared with desktop computers with the CRT display monitors. The study found that the desktop computers with CRT display monitors are used at a higher rate than those with LCD monitors at the household level possibly because they are cheaper and long-lasting and that the laptops are highly utilised at the household level because they are lighter and portable.

The study established that e-waste generators at the households do not know where and how to dispose of computer e-waste safely and in an environmentally sound manner and hence the storage in the premises and replacement frequency of the same after 5 years before it is resold or otherwise disposed of (Williams, 2005). At the time of the study, most of the households had

more desktop computers with CRT display monitors (19.2%); mainly stored in the premises (44.9%) - main mode of disposal management- (Figure 4.12,) because they had broken down and not repairable. The respondents (96%) also reported that they mainly purchased new computers (Figúre 4.6) because of high repair costs compared to new ones (Figure 4.17) and only a few (4%) were purchased as second hand material (Figure 4.6).It is also possible that household respondents purchase the computer components and accessories sold by the public institutions through auction as stipulated in the Public Procurement and Asset Disposal Act (2015). This compares well with the research findings by Nsengimana *et al*., (2011) and Chawla *et al*., (2012) who reported that some of the households use this avenue to purchase low cost used computers, a situation that compares well with Figure 4.6.

It was observed that households are unwilling to dispose of their computer e-waste but store it in the house possibly because they spent a lot of money and still think that it holds some value and can even be reused. They, therefore, wait for waste collectors to purchase the computer e-waste from them - a situation that is confirmed by Kalana, (2010),Oteng-Ababio, (2012), and Carisma, (2010).The results of the study on type of computers discarded from households over the past five years clearly indicate that the respondents had stored more desktop computers with CRT display monitors than the LCD and the laptops at home, a situation that is resonated by KICTANet (2008) and this resulted in more computer e-waste discarded from the desktop with CRT display monitors at the end-of-life.

Similarly, the results of wide-ranging literature have demonstrated that most respondents in the households store their unused or broken-down computer e-waste for a while before it is resold, donated or otherwise disposed of (Williams, 2005; Kalana, 2010) for perceived value, either physical or emotional attachment. This compares well with observations by Williams (2003) and Hieschier *et al*., (2005) who advocated the encouragement of a market for used computer equipment since this would extend the end-of-life of the computer. The hazardous components such as lead and mercury from computers especially from the computer with CRT display monitors may impact negatively on human health of the populace and environmental degradation of the urban space if not discarded in an environmentally sound manner (Kalana, 2010). The continued purchase of few computers with LCD monitors and laptops by the respondents from households would effectually result in reduced e-waste from computer components and accessories and hence less impact to human health and degradation of the urban area.

It is expected that the households which keep the old technologies like the desktop computer with CRT display monitors may be susceptible to impacts of health and urban area environmental degradation if at the end-of-life they are improperly disposed of. This compares well with the findings of Kalana (2010); Khurrum (2011); Njoroge (2007); and UN (2012) whose findings expounded on exposure to environmental toxins which is likely to occur resulting in elevated risks of cancer and developmental and neurological disorders. Balakrishnan *et al*., (2007) found that the hazardous components of the CRT display monitors would threaten the human health and the environment if not properly disposed of in an environmentally sound manner.

The fact that huge mountains of computer e-waste was still stored at the premises should be of great concern because if not disposed of in an environmentally sound manner, it can be a risk to human health and can cause environmental degradation of the urban area due to its toxic composition and increasing volume. This is in line with the research findings of the e-waste disposal management practices of households in Meleka, in Malaysia (Tiep *et al*., (2015). This also compares well with Sookman *et al*., (2005) who reported that this behavioural aspect is also found in other countries. This also mirrors the study by Kalana (2010) which indicates that it is at the household level that [computer] e-waste disposal management approaches impose a major problem.

The study established that the first preference for respondents at the household level to dispose of computer e-waste is by storing within their premises (Figure 4.12). If selling out to recycling plants, donating and selling out as second-hand material are grouped and considered as reuse and recycling, then respondents (27.9%) also preferred reuse and recycle as opposed to 27.2% who threw away the e-waste with other wastes. The option on selling to the recycling plant helps in dismantling the computer in an environmentally sound manner hence reducing the risks to health and environmental degradation of the urban area because there is no efficient take-back scheme for consumers in Kenya. Although 8.8% of the respondents sell their old equipment as second-hand equipment and donate the items (10.9%), there is a possibility that over 98% of the equipment is broken down and thus can be considered as computer e-waste. It is also possible to conclude that over 90% of the equipment is broken down beyond any repair. This parallels with the findings of William *et al*., (2008).

The study observed that one of the recycling facilities in Kenya, the WEEE Centre, makes donations of computer components and accessories to schools through the Computer for

Schools Kenya (CFSK). Those for reuse by public demand are resold to them, and those that are not functional are scrapped. Since the WEEE Centre cannot recycle the components that are hazardous, they are packaged and exported to the European countries such as Germany, Belgium, Netherlands and Finland (Respondent, WEEE Centre) for disposal management. The disposal to these countries with the best available technologies or best environmental mangement practices are through memorandum of understanding between the WEEE Centre and the countries.

4.3.4   Computer E-waste Disposal Management Approaches by Disposal Sites

Informal recycling is a growing computer e-waste disposal management challenge especially in low-income countries of the world and particularly in Africa. This has been necessitated by the need for high demand for second-hand computers and selling the same to the e-waste pickers or scavengers and the yard shop operators. This computer e-waste disposal management is associated with serious potential effects on human health and degradation of the urban area, but it is also due to lack of formal recycling facilities.

Asked how much the Centre recycles, one of the respondents from the formal recycling facility reported that: *"The WEEE Centre recycles only approximately 10% of computers that are donated locally, leaving a huge amount (90%) of the locally disposed of e-waste through the informal sector. Eighty per cent (80%) of all donations from Europe are refurbished and donated to needy schools through the Computer for Schools Kenya Programme."*

The informal sector is dominated by poor urban people who eke a living from the daily collection of the computer e-waste among other wastes. These people have no protective equipment. Child labour is the norm, and basic tools are used to dismantle the computer e-waste. These e-waste pickers or scavengers also collect and extract metals mainly copper wires, through the open burning of the cables without any regard to their health and the environmental degradation of the urban area. The valuable recycled materials are sold to the yard shop operators by weight. When the plastics are burned, they release brominated flame retardants (BFRs) which have the potential to be transformed into brominated dioxins. These are toxic and carcinogenic and has potential effects on human health and the environment.

4.3.5 *Drivers of Computer E-waste Disposal Management Approaches in Institutions*

The study established that technological obsolesce and attainment of end-of-life are crucial drivers of decision for disposal of computer e-waste by many users of computers but it was more prominent in institutions. It was also observed that the computer components and accessories are changed as often as the technology changes. This mirrors with the findings of William *et al*., (2008) and Arora (2008) who reported that the purchase of new computers is driven by the desire to purchase new software rather than repair of broken-down equipment. This has been necessitated by decreasing life-span of computers (William *et al.,* 2008) and the fact that every business needs to invest in the new technology to compete. However, the corresponding statistics for technologically obsolete consideration as disposal driver was much higher (66.7%).

As shown in Figure 4.14, nearly half of the respondents reported that breaking down and unrepairable state of computer components and accessories was a common driver towards the disposal management of computers. This corresponds to Williams *et al.,* (2008) that most of the respondents store their used broken-down e-waste for years before it is resold or otherwise disposed of (Williams, 2005). On the other hand, the government and private institutions prefer to shift to new technologies by purchasing desktop computers with LCD monitors for their efficient use of space and power saving, a situation that compares well with that of Williams (2003) findings.

The Public Procurement and Assets Disposal Act (2015) stipulates how the public institutions should dispose of the computer e-waste. This is demonstrated by Nsengimana *et al*., (2011) on the assessment of e-waste status and trends in Rwanda and the management of e-waste. The writers reported that the public institutions stored their waste in the basements or offices and waited for the relevant government institution in charge of disposing of the e-waste to come and decide on their behalf. The bureaucratic process of the procurement and disposal management of government assets has created a burden of the computer e-waste stockpiles at the institutions.

Most of the computers sold through auction end up being purchased by the informal sector (e-waste pickers/scavengers and the yard shop operators) who dismantle them with no regard to risks to human health or the environment.

4.3.6 Drivers of Computer E-waste Disposal Management Approaches in Households

Nearly half of the respondents in the households reported that breaking down and unrepairable state of computer components and accessories was a common driver towards their disposal management. The results also indicate that it was expensive to purchase new computer components and accessories and hence disposal was only when they break down rather than to update to new technologies. Age at the purchase of a '*new*' computer was reported to be a crucial factor on the decision to dispose of computer e-waste by many respondents. They reported that the average time before the replacement of the '*new*' computer was 5 years for a computer with CRT display monitors and the laptops and 2-3 years for the desktop computer with LCD monitors (Figure 4.14). This is the main reason why there is domination of desktop computers with CRT display monitor at the household level.

The study found that the main reason for used e-waste computer components and accessories disposal from the households was higher repair cost compared to new ones, malfunctioning and outdated in the decreasing order. This is a clear indication that respondents rarely took their broken-down computer components and accessories for repair works because it is easier and cheaper to purchase a new product than repair old equipment. The respondents are also propelled by the desire to update to the newer generation of technology than it is to upgrade outdated computers.

The fact that storage was used instead of reuse is an important factor. This was a clear indication that there was lack of awareness on where to dispose of the computer e-waste. It is possible that lack of proper disposal management approaches has also contributed to the storage of excess stock of computer e-waste in the households. This was a good comparison with KICTANET (2008) that consumers stored the waste from computer components and accessories at the homes or offices, sold it out as second-hand material, donated, or gave to neighbours who could not otherwise afford the cost of a new one. The fact that the respondents donated, sold out as second-hand material and directly to recycling plant is a good approach as donation and recycling would extend the lifespan of the computer components and accessories as postulated by Williams (2003) and Hischier *et al.*, (2005) and Bhutta *et al.*, (2011).

4.3.7 Sustainability of the Different Types of Computer E-Waste Disposal Management Approaches

The study observed that (Table 5.4) that all the computer e-waste disposal management approaches practiced by the different actors, except that of the WEEE Centre, have potential effects on the human health and the environment and hence they are unsustainable. According to Herat (2007) and Wath *et al.*, (2010), the increasing volumes of computers, rapid technology obsolescence and lack of end-of-life disposal management options, lack of capacity, legislations, commitments and socio-economic issues, have resulted in the unsustainable disposal management of the waste from computer components and accessories.

4.3.8   Altitude and Behavior on Computer E-Waste as a Resource

Cultural practices were identified as a crucial driver to disposal management of waste from computer components and accessories. Households were found to be unwilling to dispose of their computer e-waste instead they preferred to store it in the house possibly because they spent a lot of money and still thought that it held some value and could even be reused. They, therefore, wait for waste collectors to purchase it from them - a situation that is confirmed by Kalana (2010), Oteng-Ababio (2012), and Carisma (2010). The results of the study on types of computers discarded from households over the past five years indicated that the respondents had stored more desktop computer with CRT display monitors than the LCD and the laptops at home, a situation that is resonated by KICTANet (2008) and this resulted in more e-waste discarded from the desktop with CRT display monitors at the end-of-life. The hazardous components such as lead and mercury from computers especially from the desktop computers with CRT display monitors may impact negatively to human health of the populace and environmental degradation of the urban area if not discarded in an environmentally sound manner (Kalana, 2010).

4.3.9   Education and Computer Ownership and Implications for Sustainable Disposal Management Approaches

The study established that the households with respondents in the highest level of education category had the highest percentage of computer ownership (Table 4.4). Given the reported level of education of the majority of respondents at the household level, a sense of disposal management of computer e-waste was expected to be reflected in the responses received against the questions raised concerning disposal management of waste from computer components and accessories. However, this was not the case, and it would, therefore, be

concluded that the respondents did not know the effects of the computer e-waste on their health and the environment of the urban area. Table 4.4 further indicates that most of the respondents with a university level of education had the highest ownership of computer components and accessories.

Pritchett *et al*., (2001) adjudge that household ownership of physical assets is highly correlated with household expenditure. Although it would be expected that the respondents with a university education level, and with high household income, would have a high computer ownership, the study also failed to establish the correlation between, education, age and ownership of computer components and accessories because the respondents failed to give reliable responses to the question on age and household incomes. The study also found that the lower-income respondents are less likely to own computers.

4.5 Chapter Summary

The institutions store their computer e-waste in the offices until directives are given to dispose it of mainly through public auctions. The private companies dispose of their computer e-waste to NEMA certified e-waste collectors while others dispose of their e-waste to vendors through leasing. Storage on the premises (49.9%) and cultural practices were identified as the major computer e-waste disposal management approach by households. The households are unwilling to dispose of their computer e-waste because they do not know how and where to dispose of it and mainly store their unused or broken-down computers for a while before they are resold, donated or thrown away with other County solid wastes.

The computer e-waste disposal management approaches in the informal sites is recycling using rudimentary tools and open burning without any regard to effects on human health and environmental degradation of the urban area. The study observed that all respondents disposed of computers with CRT display monitors, computers with LCD monitors and Laptops in that order of preference and hence the old technologies are being replaced by new technologies.

The main drivers of the computer e-waste disposal management approaches at the institutions, and private companies are technological obsolescence. Breaking down and unrepairable state of the computers was found to be the main drivers towards computer e-waste disposal management approaches in households.

Sale of computer e-waste through auctions by public auctions present a risk to human health and the environment. The e-waste pickers/scavengers dismantle the computer e-waste using rudimentary tools with no respect to human health the environment. The fact that huge volumes of computer-e-waste are still stored in the premises should be a great concern because it is a potential threat to human health and the environment if is disposed of in an environmentally unsound manner. It is also not clear how the certified e-waste collectors and lease vendours dispose of the computer e-waste.

The systems approach used in this study results in the computer e-waste being disposed of in the dumping site, temporary disposal site and also by e-waste pickers through urban mining. Once disposed of in the dumping site, the waste collectors mine the valuable components and sell to the yard shop operators at the vicinity of the dumping site or sell to the local industries. The best practice is possibly to organize for the establishment of e-waste pickers cooperatives so that they can be able to improve their business and access loans from banks. The cooperatives can also do business with the government by allowing them to manage the drop off points. There would also be creation of jobs for the e-waste pickers at the recycling facility coordinated by the Nairobi City County. When the computer e-waste is deposited in the dumpsite, temporary disposal site (e-waste pickers/yard-shops operators) sustainable disposal of the computer e-waste will be through recovery of parts, reuse of functional parts, recycling, urban mining, composting, incineration (production of energy) and landfilling. To maximise on benefits of recycling, the computer e-waste pickers need to organize themselves into cooperatives to be able to upgrade their livelihoods.

CHAPTER 5: POTENTIAL EFFECTS OF COMPUTER E-WASTE DISPOSAL MANAGEMENT APPROACHES ON HUMAN HEALTH AND ENVIRONMENT

5.1 Introduction

This section presents the findings on the second objective of the study: which was *'to determine the potential effects of computer e-waste disposal management approaches on human health and environment in Nairobi City County'*. These issues have been highlighted in so far as they emerged from the views presented by respondents from the solid waste management policy domains in Kenya in relationship to current human health and environmental effects of the computer e-waste disposal management approaches in the County. To further determine if views and concerns raised by key decision-makers are harmonious with responses from the lower cadre, the views as filled out in questionnaires are also presented.

The chapter is divided into three sections. First, an account of the relevant data required and the methods followed for this specific study objective. The second part that covers the results is more elaborated section of the chapter. The section examines the different pointers towards potential human health and environmental effects of computer e-waste disposal management approaches identified for public institutions, private companies, households and the disposal sites. Finally, a reflection on the sustainability framework for e-waste management is delved into with a view to pointing out critical areas for attention about human health and environmental effects of computer e-waste disposal management approaches in Nairobi City County.

The collection of data for this section was both qualitative and quantitative from primary and secondary sources. The secondary data was collected from the literature review on articles related to the field of human health and environmental effects of the computer e-waste disposal management approaches and publications such as reports. Primary data was collected using a structured questionnaire which was administered to the public institutions, private companies through to households in government residential areas of Nairobi. The survey had questions related to personal information, main e-waste disposal management approaches, level of awareness about the potential effects of computer e-waste on human health and environment, policy, regulations and interventions. The respondents were randomly and purposively sampled.

5.2 Results

The study set out to identify and consider the pointers toward potential effects of computer e-waste disposal management approaches on human health and the environment. These are discussed in the section that follows.

Table 5.1: Summary of computer E-Waste Disposal Management Approaches Used by different Actors

Disposal management approaches	Public institutions	Private companies / institutions	Households	WEEE Centre	Yard-shops / Scavengers
Public auctions	√	-	-	-	-
Donation	√	√	√	√	-
Storage	√	-	√	-	-
Throwing away with other CSW	√	-	√	-	-
Recycling	-	-	-	√	√
Leasing	-	√	-		-
Urban mining	-	-	-	-	√
Selling as second-hand materials	-	-	√	-	-
Selling to recycling facility	-	-	√	-	-
Selling to certified e-waste collectors	-	√	-	-	-
Open air burning	-	-	-	-	√

Table 5.2: Percentage of Computer E-waste Disposal Management Approaches Practiced by Different Actors

Actors	Disposal management approaches	% of disposal management approaches
Public Institutions	Storage	100 ($\approx$ 2-3 years)
	Auction	75
	Throw away	20
	Donate	5
Private Companies or institutions	Donate	47
	Sell to e-waste collectors	50
	Lease out	3
	Storage	44.9

Households	Sell as second-hand materials	8.8
	Sell to the recycling facility	8.2
	Throw away	27.2
	Donate	10.9
WEEE Centre	Donate to schools	5 (Received from Europe)
	Recycle	10 (Received locally)
Yard-shops	Purchase recycled metals	80 (Sold to local industries)
		20 (Exported)
E-waste pickers / Scavengers	Open air burning	95 (Sold to local industries)
	Urban mining	5 (Exported)

5.2.1 Potential effects of Computer E-waste Disposal Management Approaches on Human Health and the Environment

The study observed that respondents practice different types and percentage of computer disposal management approaches from the public institutions, private companies, households and those living at close vicinity of the dumping sites. These types of computer e-waste disposal management approaches and their effects on human health and the environment are discussed in details in the section that follows.

Donations of computer e-waste

The study noted that the Public Procurement and Disposal Act, (GoK, 2005), Public Procurement and Asset Disposal Act (GoK, 2015); and Public Procurement Regulations, (GoK, 2006) provide for donations to public institutions such as polytechnics, technical colleges among others. Households also preferred waste from computer components and accessories disposal management approach through donations to friends and relatives. These computer donations are of poor quality given that some have broken down, some are un-serviceable, obsolete and too old to be used. This computer e-waste disposal management approach provides computers to those who would not otherwise afford the cost of a new such device and also extends the end-of-life of the computer thus delaying its disposal in the landfill. However, this type of disposal management approach has potential effects on human health and environmental degradation of the urban area if the poor quality, broken down, unserviceable and obsolete and too old to use computer components and accessories are not handled in an environmentally sound manner.

Storage of Computer E-Waste

If the waste from computer components and accessories is not dismantled, storage in itself does not have any potential effects on human health and the environment of the urban area. The

study observed that public institutions store their computer components and accessories for about 2-3 years before the Government agency in charge of disposal provides directives on their behalf. The storage of computer e-waste has potentially adverse effects on the human health and the environment only if it is broken-down/opened up and not handled in an environmentally sound manner.

The public procurement and asset disposal act and its associated regulations hamper the immediate disposal of computer e-waste from public institutions. The delay, usually during storage - between 2-3 years is caused by the provision in the act that requires directives for disposal of the computer e-waste by another public body. However, the public auctions avail for purchase computer e-waste mainly to the informal recyclers (e-waste pickerse=e-waste pickers/scavengers and the yard-shops operators) who usually dismantle them using rudimentary tools without any regard to the human health or the environment. This makes the e-waste auction disposal approach by public institutions one of the riskiest as far as human health and the environment are concerned. However, most of the frameworks in the high-income countries (U.K, Australia, New Zealand) provide for the disposal of assets by the institutions that generate the waste.

The households have a culture of storing their old or broken-down computer e-waste for more than five (5) years in their premises for perceived value, either physical or emotional attachment before disposal (Williams, 2005; Hieschier, 2005). This is in line with the research findings of the e-waste disposal management practices of households in Meleka, in Malaysia (Tiep *et al*., 2012, 2015; Sookman *et al*., 2005). While this type of disposal management approach may not in itself have potential effects on human health and the environment, if not broken down, it keeps away computer components and accessories from the recycling facility a process that provides employment and secondary materials for the local industry.

Throwing Away Computer E-Waste together with County Solid Waste

The study established that there were more old desktop computers with CRT display monitors still being stored on premises at the households. The same respondents in the households indicated that they throw away the computer e-waste together with other county solid wastes (CSWs). This is also practiced by the Shah community in Malaysia as reported by Kalana (2010).

CRT display monitors contain a mixture of several potentially hazardous components such as copper, aluminum, and several heavy metals such as barium, cadmium, mercury, iron and lead, a situation that has similarly been reported in various literature such as Gaidajis *et al*., (2010) and in e-waste recycling activities in China (Balakrishnan *et al*., 2007). Once the CRT is thrown away with other CSW it is crushed, broken-down, weathers and leaks into the landfill, releasing mercury, cadmium, lead, copper, brominated flame retardants, antimony oxide, Zinc leachate and polychlorinated biphenyls (PCBs) into the environment while plastics containing brominated flame retardants (BFRs), polybrominated diphenyl ethers (PBDEs) leach into the soil and groundwater.

The lead can also contaminate clothes of the workers mining valuable materials from the landfill and this has a potential negative effect on both their human health. When mixed with acid waters in the landfill, the lead ions dissolve from the broken glass of the CRTs. This is in line with the findings of Yandong *et al*., (2006) and Williams, (2003) who reported that when CRT display monitors are permitted to weather in landfills, they release mercury, cadmium, lead, brominated flame retardants (BFRs), antimony oxide, Zinc leachate into the soil and water sources. These toxic materials expose toxins to humans thus elevating health risks such as cancer, developmental and neurological disorders as reported by Kalana, (2010) and Khurrum, (2011). Likewise, if allowed to weather in the landfill, the LCD monitors and the laptops may release mercury and Ni-Cd ions respectively, into the water sources and soils and cause pollution of the air and food poisoning through the food chains and also negatively impact on the environment.

Direct exposure to broken-down computer components and accessories has potential to affect the skin through contact, inhalation, and ingestion of chemical elements. This may lead to mercury and lead poisoning. Besides, the toxic components from computer components and accessories can remain in the environment for a long time where it continues to increase in concentration for as long as the e-waste continues to be degenerated thus causing environmental degradation of the urban area.

Recycling of Computer E-Waste

The increasing amount of computer e-waste has occasioned two major problems: a shortage of mineral resources for sustaining the electronic industry and potential environmental pollution and human health risks. Recycling of computer e-waste is a disposal management approach practiced in the urban areas mainly by the urban poor represented by the e-waste pickerse-e-

waste pickers or scavengers living at or near the dumpsite (Dandora) and the yard shop operators (traders) operating at the vicinity of the dumpsite. Recycling is mainly practiced in the extraction of valuable computer components and accessories. It is significant in economic, environmental, and human health aspects. This disposal management approach reduces the cost of disposal of the computer e-waste; creates employment opportunities for skilled and unskilled workers; reduces demand for the manufacturing of computers from raw materials; reduces energy used for mining of raw material; reduces cost of human health care by improving sanitary conditions in urban areas; and reduces clogging of drains; pollution of air and water sources. According to Hossain, (2010), computer components and accessories were shipped to low-income countries such as Kenya, without testing for functionality (Osibanjo *et al*., 2007) as '*computers for charity'* to pass through the customs. These computer components and accessories are recycled often using crude tools to dismantle them and extract the valuable elements such as gold, copper, silver and platinum among others (Table 5.3).

Table 5.3: Substances Restricted for Use in Electrical and Electronic Equipment (ROHS Directive 2011/ 6 5 / E U-Regulations 2013)

Substance	Maximum concentration values (MCVs) (%)
Lead (Pb)	0.1
Cadmium (Cd)	0.01
Mercury (Hg)	0.1
Hexavalent Chromium (CrVI)	0.1
Polybrominated Biphenyl (PBB)	0.1
Polybrominated Diphenyl Ether (BDE) flame retardants	0.1
Polybrominated Diphenyl Ether (BDE) flame retardants	0.1
Butyl benzyl phthalate (BBP)	0.1
Dibutyl phthalate (DBP)	0.1
Bis (2-ethylhexyl)	0.1
Diisobutyl phthalate (DIBP)	0.1

Extraction of these valuable metals leads to the release of toxic components such as lead, plastics, mercury and cadmium among others which have widespread inhalation-related illnesses to humans and also degrade the environment of the urban area. This signifies that central to their disposal management approaches are connections with the recycling actors a situation that is meted with a lot of challenges especially to cities of low-income countries (Chawla *et al*., 2012). However, Williams *et al*., (2008) and SVTC, (1999) underscore that

even with all toxic components removed, the computer e-waste recyclers have high levels of toxic chemicals in their blood.

If improperly carried out, recycling emits hazardous heavy metals such as lead, mercury and cadmium. Chemical stripping of chips and gold-plated components have effects on the eye and skin resulting in permanent injury and inhalation of acid fumes resulting in respiratory irritation problems (Hilleman, 2006); and death defects (Davis, 2006); contamination of the air by dioxins and heavy metals; soil pollution from lead, antimony trioxide, mercury, arsenic, cadmium, selenium, polybrominated flame retardants, cobalt and chromium. Removal of precious metals from the circuit board using acids degrades the environment when dumped on the ground or and pollute water sources when dumped into water sources. According to Deng *et al.*, (2006) and Wath *et al.*, (2011) shredding of plastics may cause physical injuries and melting it at low temperatures may expose humans to hydrocarbons, brominated dioxin and Pulmonary Arterial Hypertension (PAH). The same components may contaminate air by dioxins, heavy metals and hydrocarbons.

Urban Mining

Recovering and recycling waste from computer components and accessories from disposal sites can also reduce the burden on raw material extraction from the mining industry. This would reduce the over-reliance on virgin materials which in some countries such as Congo DRC has fueled wars. According to Meskers, (2009), 300 million new computers utilised 150,000 tons copper, 9100 tons cobalt, Li-ion batteries (for laptops), 300 tons silver, 66 tons gold and 24 tons palladium produced worldwide was consumed in manufacturing of new computers and laptops in 2008. Urban mining can, therefore, reduce total global demand for production of metals from raw materials. Thus, reducing greenhouse gases (GHGs) as evidenced by King *et al.*, (2013) and Heacock *et al.*, (2016) directly contribute to climate change and result in adverse impact on human health and causes environmental degradation. This activity, practiced by the e-waste pickers or scavengers, also reduces consumption of energy because, for most elements, reprocessing consumes less power than producing new items from raw materials (Gutberlet, 2015). This has been confirmed by Cui et al., (2003) and Eygen *et al.*, (2016).

Leasing of Computer E-Waste

One of the private universities practice this disposal management approach. It is a powerful tool to maintain a desired period by enabling predictable spending patterns; introducing best

environmental practices and technologies for computer e-waste disposal management; and relieving corporations of the burden of safely in disposing of the used computers. In this case, the vendors retain ownership throughout the lease period. The mode of disposal management approach can also eliminate upfront costs and does not have any effects on human health and the environment. This is because the computer components and accessories are not dismantled before they are taken back by the vendors. However, the private university should make a follow up on how the computer e-waste is disposed of and recommend disposal by NEMA certified e-waste collectors only.

Selling Computer E-Waste to Certified E-Waste Collectors

NEMA licensed e-waste collectors are engaged by private companies to collect their computer e-waste. This is an acceptable mode of computer e-waste disposal management approach because there is no contact of the individuals at the private companies either through contact with the broken-down or obsolete materials from computer e-waste. There is, therefore, no potential human health or environment effects from this type of disposal management approach. However, it is important to make a follow-up on where the collectors dispose of the computer e-waste.

Selling Computer E-Waste as Second-Hand Materials

Some households were found to sell their computer components and accessories as second-hand material. This mirrors the findings of Kalana, (2010) on the Shah Community in Malaysia. Williams, (2003) and Hieschier *et al*., (2005) advocate the encouragement of a market for used computer equipment since this would extend the end-of-life. Use of this disposal management approach extends the computer end-of-life and ensures that the computer equipment is accessible to those who are not able to purchase new technologies at a cheaper price. As long as the computer components and accessories being sold as second-hand material are not broken-down, its contents do not have potential risk to human health and the adverse environmental effects of the urban area.

Open Air Burning of Computer E-Waste

The process of recycling through the open-air burning of computer motherboards, dismantling of printed circuit boards and cables to extract valuable materials at the vicinity of dumping sites, exposes workers and residents within proximity to the dumping site to toxic chemicals such as lead, beryllium and tin. These compounds also contaminate the surroundings, surface and

ground water sources. The removal of computer chips and de-soldering of the printed circuit boards result in inhalation of tin and lead, brominated dioxin, cadmium and mercury and also causes air emissions of the same substances (Deng *et al*., 2006; Wath *et al*., 2011). The writers report that recovery of steel, copper and precious metals may expose the humans and may impact on human health as a result of exposure to dioxins and heavy metals. The inhalation of toxic fumes on burning plastics may also cause asthma, skin diseases, eye irritation and in other cases long-term incurable diseases. The same chemicals have the potential to accumulate in soil, water and food. High temperatures create a high concentration of metals in fly ash and high toxic fallout negatively impact on workers, their families and the urban environment.

A summary of the different actors in the computer e-waste disposal management, the disposal management approaches they practice, and the sustainability of the disposal management approach used and how the potential effect to human health and the environment can be mitigated is indicated in Table 5.4.

Table 5.4: Summary of Actors, Disposal Management Approaches Practiced and their Sustainability

Actors	Disposal management approaches	% of disposal management approach	Tenets of Sustainability			Sustainability (NS=Not sustainable S=Sustainable)	Remarks	Mitigation
			Environ-ment	Social (Health)	Economic			
Public Institutions	Storage	100 (≈ 2-3 years)	-	-	-	-	Awaiting decision to be made to dispose of	Computer e-waste should not be stored in the offices for more than one financial year.
	Auction	75	x	x	√	Not Sustainable (NS)	- The Public Procurement and Asset Disposal Act (2015) stipulates the use of NEMA certified waste collectors, but it is not clear how the collectors dispose of the e-waste. - The e-waste ends up in the hands of pickers/scavengers who dismantle them with no regards to human health & environment	- The Act should be reviewed to remove disposal of computer e-waste through public auctions - Act should also provide for establishment of County computer e-waste management system - It should also provide for implementation of a zero e-waste policy - All computer e-waste should be taken to the county computer e-waste recycling centre
	Throw away	20	x	x	x	NS	E-waste ends up in the landfill polluting soils,	

							air, surface & groundwater, physical injuries.	(CEREC) for further processing.
	Donate	5	√	√	√	NS	Donations to technical institutions for capacity building extends the EoL of the computer, and later ends up being disposed of in an unsound environmental manner.	
Private Companies/ institutions	Donate	47	√	√	√		Donations to staff extend EoL, but after use, the e-waste is either broken down or unserviceable and finally stored in premises.	The computer e-waste should be taken to the Recycling Centre for processing and recycling at the EoL
	Sell to e-waste collectors	50	√	√	√	NS	It is not clear how the collectors dispose of the e-waste.	The private companies and institutions should take their computer e-waste directly to CEREC.
	Lease out	3	√	√	√	NS	Leasing out may not have any effects on human health and the environment, but it is also not clear where the e-waste is disposed of	

						once the vendors collect it.	
Households	Storage	44.9	√	√	x	NS	There are no effects on human health and the environment as far as it is not dismantled. However, this approach fails to provide the e-waste or recycling.	The computer e-waste should at the EoL be taken to the Residential/commercial neighbourhood computer Waste Drop Off Points (CEDOPs) for onward transmission to the Recycling Centre for further processing and recycling.
	Sell as second-hand material	8.8	√	√	√	NS	There are no potential effects on human health and environment, but it is not clear what the second-hand material buyers do with the e-waste after purchase.	
	Sell to a recycling facility	8.2	√	√	√	NS	Recycling emits hazardous heavy metals (Pb, Hg, Cd, etc.); respiratory irritation or inhalation of acid fumes, permanent injury, direct exposure through skin contact or ingestion of components.	

	Throw away together with CSW	27.2				NS	Weathering of CRTs in the dumping site releases toxic chemicals (Hg, Cd, Pb, BFRs, Zn etc.) that has the potential to pollute surface & underground waters, soils and, air. Broken plastics cause physical injuries and Inhalation/ingestion of chemical components may lead to Hg & Pb poisoning.	Computer e-waste should be segregated from the county solid waste and be taken to the CEREC for further processing and recycling.
	Donate to friends or to relatives	10.9	√	√	x	NS	Donations to friends/relatives extend EoL, but after use, the e-waste is either broken down and unserviceable and finally stored in premises.	The computer e-waste should at the EoL be taken to the Residential/commercial neighbourhood computer Waste Drop Off Points (CEDOPs) for onward transmission to the Recycling Centre for further processing and recycling
WEEE Centre	Refurbish and donate to schools	5 (Received from Europe)	√	√	x	NS	Refurbishing & donations to schools extend the EoL of the	This is a private E-waste Recycling Centre. The Facility collects computer

Stakeholder	Activity	Quantity					Effects	Recommendation
							computer, but finally, it ends up being disposed of in an unsound environmental manner.	e-waste, refurbish and recycle through a memorandum of understanding. The byproducts from computer e-waste recycling is sold to the manufacturing industries. The non-recyclable computer e-waste is exported to developed countries for proper recycling.
	Recycle	10 (Received locally)	√	√	√		There are little or no potential effects on human health and the environment. The Facility uses the BAT, staff use protective gear, and exports the e-waste that it cannot recycle.	
Yard shops **E-waste pickers / Scavengers**	Purchase recycled metals	80 (Sold to local industries) 20 (Exported)	x	x	x	NS	The packaging of extracted valuable minerals is carried out by the Yard shop operators. They, however, do it with no protective gear and thus are not prone to potential effects on their health and the environment.	These stakeholders should be trained and utilised in the Residential/commercial drop off points and the County Computer E-Waste Recycling Centre. The byproducts from computer e-waste recycling should then be sold to the manufacturing industries.
	Open air burning	95 (Sold to local industries)	x	x	x	NS	Burning of PVC (polyvinyl chloride) forms dioxins (toxic); high temperatures	

|		5 (Exported)					concentrate metals in fly ash; and toxic fallout affects workers, their families & urban environment.	
	Urban mining						Recovering and recycling e-waste from dumping sites can reduce the burden on the mining industry; reduce global demand of metals from raw materials – thus decreasing GHG emissions and climate change, and reduce conflicts (e.g. in DRC) from mining virgin materials.	
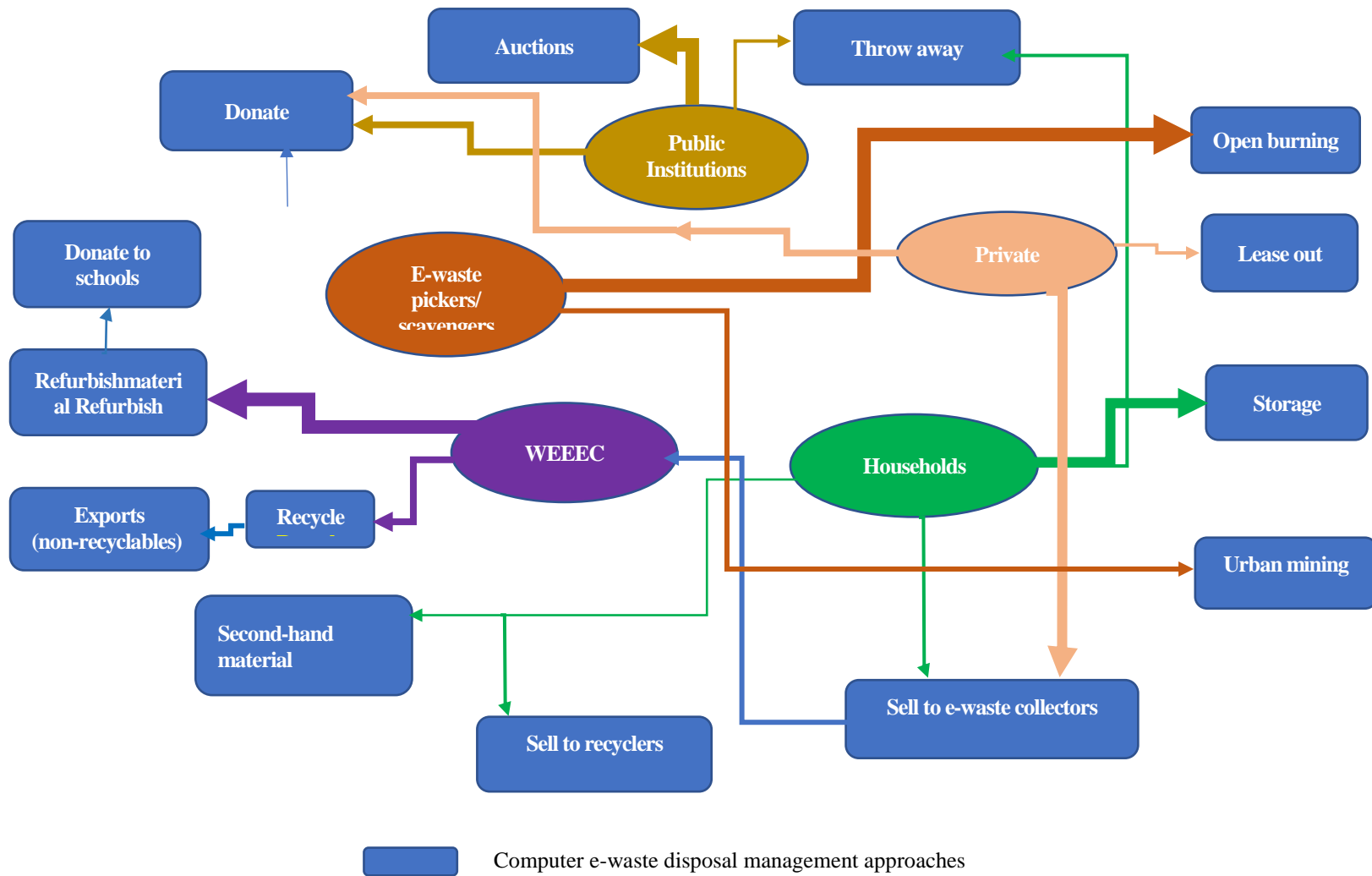
Figure 5.1: Computer E-waste Disposal Management Approaches Model

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5.3 Discussions

5.3.1 *Proposed Sustainable computer e-waste disposal management*

As Figure 5.2 indicates, all the computer e-waste from all the public and private sector would be taken to the county computer e-waste recycling centre (CEREC) where it will be processed and recycled in an environmentally sound manner and hence zero computer e-waste. The household computer e-waste will be dropped off at spatially located and strategic points most frequented by people (e.g. Supermarkets, petrol stations e.t.c), residential/commercial neighbourhood computer e-waste drop off points (CEDOPs) from where it is picked and taken to the CEREC. The computer e-waste at the recycling centre is prepared for reuse, refurbished, recycled for proper disposal to achieve zero waste being landfilled. Further, ward computer literacy centres (WCLCs) will be established in all wards to absorb the spin-offs from the recycling facility for purposes of community computer literacy capacity building. The sustainable computer e-waste disposal management system will provide social and financial benefits such as job creation and training opportunities to the County residents. The County Computer E-waste Disposal Management Authority (CEDMA) will implement a zero e-waste policy.

Evaluation of [computer] e-waste disposal management system in high-income countries such as U.S.A, U.K, and Switzerland indicates that there are no standards for spatial distribution of residential/commercial neighbourhood computer e-waste drop off points (CEDOPs). Kenya has also not developed standards for spatial distribution of the [computer] e-waste drop of points.

The County computer e-waste recycling centre (CEREC) will provide the raw materials (e,g. metals such as gold, copper, tantalum, palladium, rare earth metals, aluminium, silver, plastic (PP, ABS, PC, PS) to the computer/allied manufacturing industry. These metals are in short supply but crucial in the development of technologies to the computer manufacturing industries. Some of the non-recyclable from computer components and accessories (e.g. lead glass funnel) will be exported to the developed countries which have advanced technologies for recycling. The manufactured computer components and accessories are then sold to the public institutions, private companies and the households thus completing the sustainability cycle. The county government will partner with the private sector to run the County computer e-waste disposal management system.

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Computer e-waste disposal management system should be sustainably geared towards zero landfills (7-Rs) by i) **R**educe by setting up systems that require producers to take back the e-waste; use of less toxic or non-toxic alternatives; ii) **R**euse computer e-waste; iii) **R**edesign computer components and accessories for sustainability and takeback. The design should be durable, repairable, reusable, disassembled and fully recyclable, and encouragement of leasing rather than sell to customers; iv) **R**epair to retain value and usefulness by refurbishing and thus using parts to repair and maintain them in use; v) **R**ecycle the e-waste safely, efficiently and locally; vi) **R**emanufacture by changing manufacturing designs that are recyclable friendly and adjusted towards Zero computer e-waste/zero landfill; and vii) **R**esell the refurbished, and redesigned computer components and accessories.

5.4   Chapter Summary

The study established that the different types of computer e-waste disposal management approaches used in Nairobi City County are not sustainable. Most of them have potential to impact negatively on human health and environmental degradation of the urban area. The computer e-waste disposal management system will have no disposal sites, temporary disposal sites or e-waste pickers. All the actors in the system will be disposing of the computer e-waste to the designated areas.

A two-level model of a computer e-waste disposal management system is proposed that will include: i) Residential/Commercial/neighbourhood Computer E-waste Drop Off Points (CEDOPs) and ii) a County Computer E-Waste Recycling Centre (CEREC) where Computer e-waste will be processed, refurbished, prepared for reuse and recycled in an environmentally sound manner using the best available technologies and best environmental practices. The drop of points will be strategically located in conspicuous, easily accessible locations within residential / commercial / neighbourhood. The spatial location of the points will depend on the volume of computer e-waste in any given residential/commercial neighbourhood.

In addition, Ward Computer Literacy Centres (WCLCs) will be established in all Wards to utilize the spin-offs from CEREC for community computer literacy capacity building. A County Computer Disposal Management Authority (CEDMA) will also be established to implement a zero e-waste policy for Nairobi City County. A sustainable computer e-waste disposal management model. is proposed as indicated in Figure 5.3
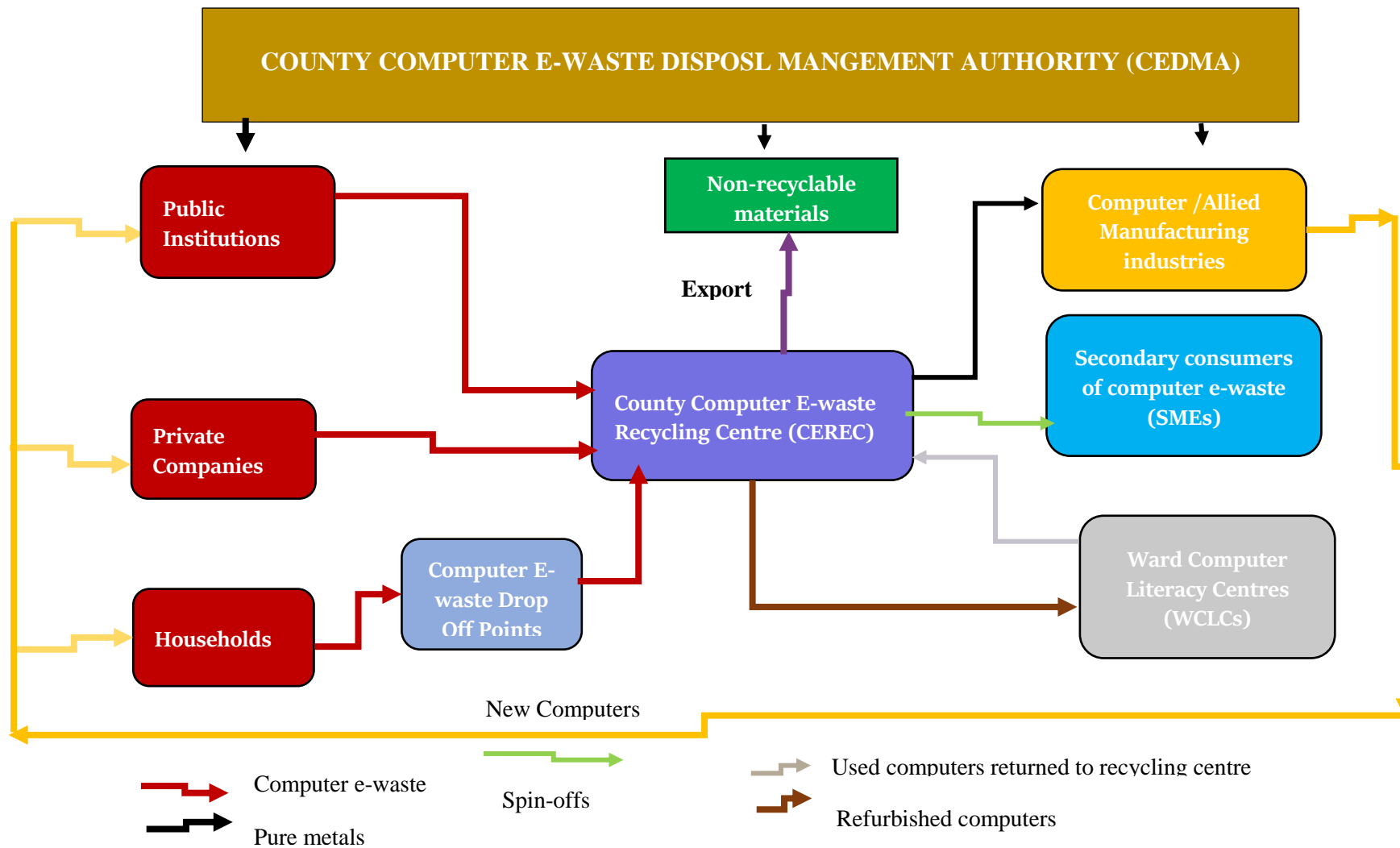
Figure 5.3: Proposed Sustainable Computer E-Waste Disposal Management Model
Source: Researcher's formulation

The public institutions and private companies (businesses) will dispose of the computer e-waste at the CEREC and the households will drop off the computer e-waste at the CEDOPs strategically placed in areas mostly frequented by people (e.g. supermarkets or commercial centres, petrol stations e.t.c.). The county government will partner with the private sector through public-private-partnerships to run the computer e-waste disposal management system. The computer e-waste will be collected in clearly labelled containers and lorries. The latter will take the computer e-waste to CEREC for recycling and processing.

The CEREC will provide the raw materials for the computer manufacturing industry and the new computer components and accessories once manufactured will then be sold to the public institutions, private companies and households. Any non-recyclable byproduct of the CEREC which the County cannot recycle will be exported to the developed countries which can recycle or dispose of using the BAT and best environmental practices.

CHAPTER 6: LEVEL OF PUBLIC AWARENESS ON POTENTIAL EFFECTS OF COMPUTER E-WASTE DISPOSAL MANAGEMENT APPROACHES ON HUMAN HEALTH AND THE ENVIRONMENT

6.1   Introduction

Chapter six presents the findings of analysis on responses to research question on *"the level of public awareness of computer e-waste disposal management approaches on human health and environment".* Like in the case of the computer e-waste disposal management approaches presented in chapter four, the responses to this attribute were garnered from multiple respondents drawn from households, private companies through to institutions in computer e-waste handling and environmental management and governance domains in Nairobi City County.

Aspects on public awareness canvassed through a wide range of analytical themes such as knowledge about composition of computer components and accessories with respect to effects on environmental sustainability and human health standards; options for reducing harmful effects of computer e-waste flows to the urban environment; and prospects for human health damages and reduction of environmental degradation of the urban area by computer e-waste compared to other types of waste and perspectives on responsibilities of actors in the waste disposal management regime in the City County. The preferences for various media outlets for purposes of enhancing public awareness and inculcating favorable attitudes regarding environmentally sound and human health responsive computer e-waste disposal management approaches are also covered. The findings on each of these dimensions are hereafter described.

6.2   Results

Overall, majority of the private companies were found to engage the NEMA certified e-waste collectors to collect and manage their computer e-waste. The institutions were found to keep their computer e-waste for 2 to 3 years before engaging the auctioneers in managing their computer e-waste majority of the household respondents kept their computer e-waste in their houses for about 5 years before they donated, gave away or sold to the waste collectors or recycling facility. Some respondents in the households have never disposed of their computer e-waste and hence stored in the premises. The study established that the institutions, private

companies and households lacked knowledge on the negative impacts of the computer e-waste they held to their health and the environment if not disposed of in an environmentally sound manner. The specific findings are covered in the sections that follow.

6.2.1 *Perceptions about Gravity of Computer E-waste Disposal Management Approaches in the Urban Environment*

Respondents from institutions were assessed on the extent to which they considered waste from computer components and accessories as part of waste flows from their respective institutions to the urban environment. As Figure 6.1 shows, an overwhelming majority (94%) responded in the affirmative. Only 3 respondents (6%) thought otherwise.
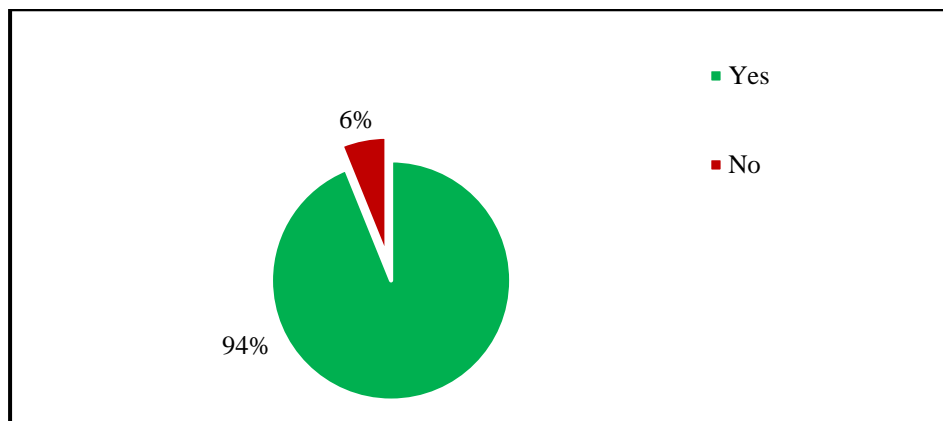
Figure 6.1: Consideration of Used Computer Components and Accessories within Institutions as Waste

From Figure 6.2, out of the 44 respondents (91.7%) who responded in the affirmative, only a small proportion (25%) rated the gravity of concern with the computer e-waste flows to the environment from their respective institutions as '*very serious*'. 39% of the respondents felt that the problem was only '*slightly serious*' Some category of '*can't tell*' (5%) in Figure 6.2 (n=44) was found to be somewhat indecisive on the level of seriousness about this matter.
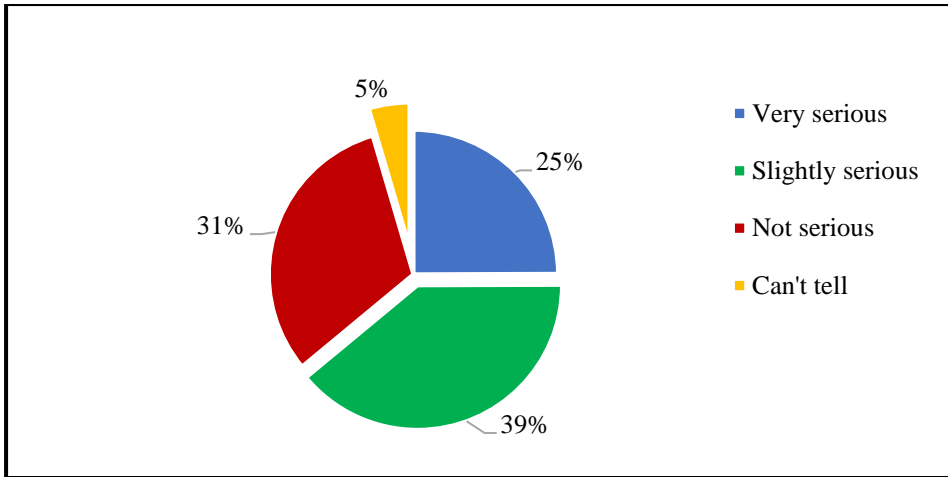
Figure 6.2: Degree of Seriousness Rating of Computer E-Waste Problem

On the same attribute, these respondents were asked to advance reasons for considering the problem of computer e-waste in the urban environment as serious. In the context of this study, the responses received were examined for the content of environmental and/or human health concerns. As Figure 6.3 shows, only 14% and 9% mentioned environmental and human health considerations respectively. A vast majority (77%) in the category of '*other*' in Figure 6.3 on the explanations advanced were outside the bounds of environmental or human health considerations. This clearly indicates that most of the respondents do not know that computer e-waste have potential to negatively impact on human health and environmental degradation of the urban area if not disposed of in an environmentally sound manner.
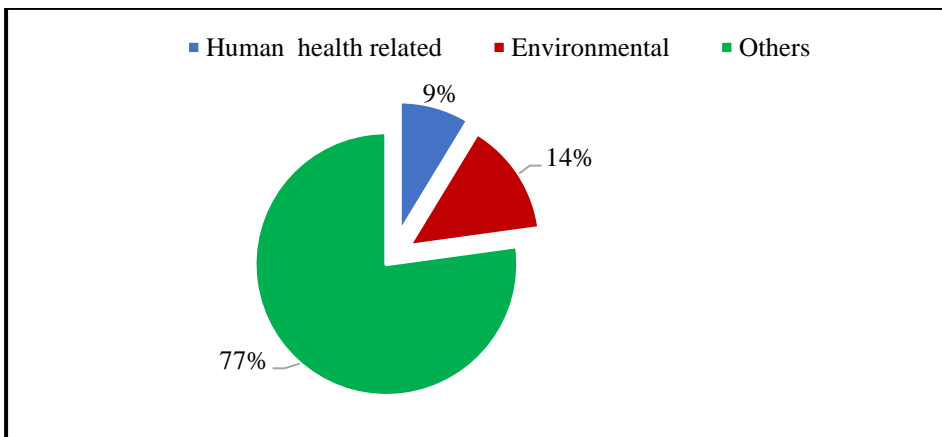

Figure 6. 3: Reasons for Considering Computer E-Waste as Serious

6.2.2 Public Awareness about Potential effects on Human Health and Environment of Computer E-waste Disposal Management

Respondents were probed on the level to which they agreed with the axiom that *'Some computer components and accessories contain harmful chemicals'* to determine the degree of

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public awareness about harmful environmental and human health impacts of computer e-waste. Their responses were as presented in Figure 6.4 (n=48).
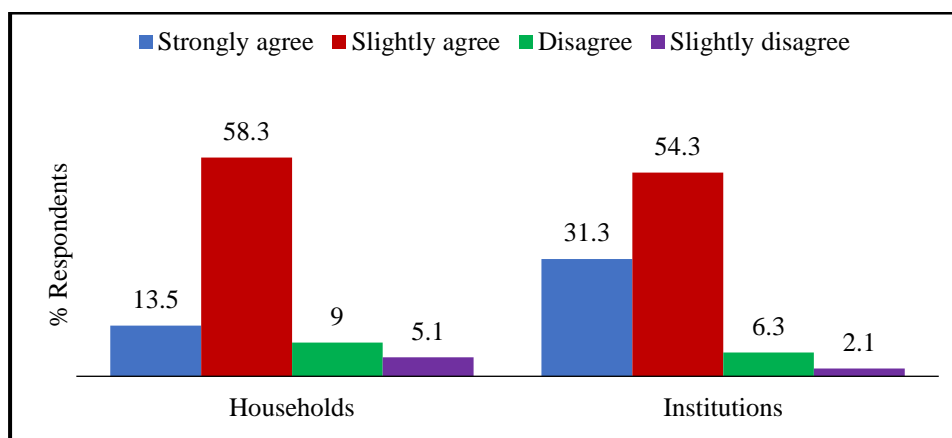

Figure 6.4: Agreement that Computer E-Waste is Harmful

Figure 6.4 shows that overall, the majority of respondents from both households and institutions endorsed the claim that waste from computer components and accessories contain harmful chemicals (71.6% and 85.5% combined respectively). Only 14.1% and 8.4% (combined) in the household and institutions category of respondents respectively responded in the negative.

More specifically, the respondents (from households and institutions) opinions on harmful implications of improper disposal of waste from computer components and accessories to the environment and human health of urban residents were sought. The responses to the question on this attribute were as presented in Table 6.1.

Table 6.1: Views on Potential Effects on Human Health and Environment of improper Computer E-Waste Disposal Management Approaches

Respondents' view	Households		Institutions	
	Frequency	Percent	Frequency	Percent
Harmful	126	80.8	46	95.8
Not harmful	8	5.1	0	0.0
Uncertain	5	3.2	1	2.1
No response	17	10.9	1	2.1
Total	**156**	**100**	**48**	**100**

Table 6.1 shows that majority of the respondents from both households (80.8%) and institutions (95.8%) viewed improper disposal of computer e-waste as harmful to environmental quality and human health status of city residents.

To the supplementary question that followed, the respondents were asked to articulate how harmful improper disposal of computer e-waste is to the environment as well as to human

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health. The responses to this question were examined about how they resonated with the conceptualisation of environmental sustainability and human health dignifying compliance in the study. In this way, they were resolved into three thematic typologies: accurate but not concise; accurate and concise, and not accurate. Thus classified, the responses were presented in Table 6.2.

Table 6.2: Judgments about Potential Effects of Computer E-Waste Disposal Management Approaches on Human Health and Environment

Respondents' Judgments on	Households		Institutions	
	Frequency	Percent	Frequency	Percent
Environment				
Accurate but not concise	68	43.6	16	33.4
Accurate and concise	29	18.6	22	45.8
Not accurate	0.0	0.0	5	10.4
No response	59	37.8	5	10.4
Total	**156**	**100.0**	**48**	**100.0**
Human Health				
Accurate but not concise	68	43.6	14	29.2
Accurate and concise	14	9.0	25	52.0
Not accurate	0	0.0	3	6.3
No response	74	47.7	6	12.5
Total	**156**	**100.0**	**48**	**100.0**

As Table 6.2 shows, slightly over half of the respondents from households were found to be able to articulate the environmental (62.2%) and human health (52.6%) ramifications of improper disposal of computer e-waste. This pattern of response was more pronounced in the case of respondents from public institutions in which 79.2% and 81.2% articulately pronounced environmental and human health risks in their judgments respectively. The respondents from institutions also reported *'accurate and concise'* judgments on the environmental (45.8%) and human health (52%) implications than their counterparts drawn from households (18.6% and 9% respectively).

Asked whether they know the dangers of computer e-waste, one of the respondents living at the Dandora dumpsite had this to say: *"From what I know, open air burning of e-waste produces smoke that is harmful and that there are alarming chest problems common in Dandora. However, I do not have another choice. Which one is better…to die of smoke or lack of food?"*

To further ascertain the centrality of level of awareness and attitudes regarding proper computer e-waste disposal management approaches in the Nairobi City County, an open-ended question

was posed in the questionnaire for households. It sought to enlist their opinions on appropriate options towards reducing the harmful effects of waste from computer components and accessories. To this end, the proposals solicited were as presented in Table 6.3. (n=48).

Table 6.3: Suggestions for Reducing Potential Harmful Human Health and Environmental Effects of Computer E-Waste Disposal Management

Suggested action	% Respondents from households
Greater public awareness/attitude change campaigns	54.3
Intense government-led programmes	20.0
Strict enforcement of compliance with legal requirements	28.6
Close linkages with recycling plants	20.0
Promoting environmentally sound disposal management practices	14.3
Promoting health responsive disposal management practices	2.9
Enhancing the economic status of actors in the disposal management chain	5.7
Expanding infrastructure for disposal management practices	5.7

The corresponding magnitude of responses presented in Table 6.3 show that creation of public awareness and attitude campaigns regarding computer e-waste disposal management approaches was the most outstanding suggested option for actions towards reducing the harmful effects of the e-waste (54.3% respondents from households). Focus on promotion of environmentally sound and human health responsive disposal management practices was echoed in the responses of very few institutions (14.3%) and households (2.9%). Notably, only 5.7% of respondents from households suggested that consideration of social economic conditions of the people engaged in e-waste collection within the County would be useful. This is a viable option for reducing computer e-waste flow to urban solid waste streams and its attendant environmental and human health risks.

Table 6.3 further shows that a substantial size of residents in City County ascribe to the position that the government has a prime role to play towards decreasing the bulk of computer e-waste in the urban area, either by way of formulating intense related programmes (20%), or through strict enforcement of legal requirements for disposal management practices (28.6%), including those that close the linkage between disposal and recycling plants in the computer e-waste management loop (20%).

6.2.3   Willingness to Pay for Disposal Expenses

One of the widely documented current deterrents to sustainable solid waste disposal management in the cities of low-income countries is the dwindling financial capacity of the city administration authorities to maintain an effective and efficient solid waste disposal management system that cuts across the trajectories of the waste disposal loop. To this extent, residents have been prevailed upon or compelled to foot the bills relating to the disposal management services for the waste they generate. In the same vein, this study sought to enlist from the households whether citizens would be willing to pay for the collection of the waste from computer components and accessories they generate. The responses were as presented in Figure 6.5.
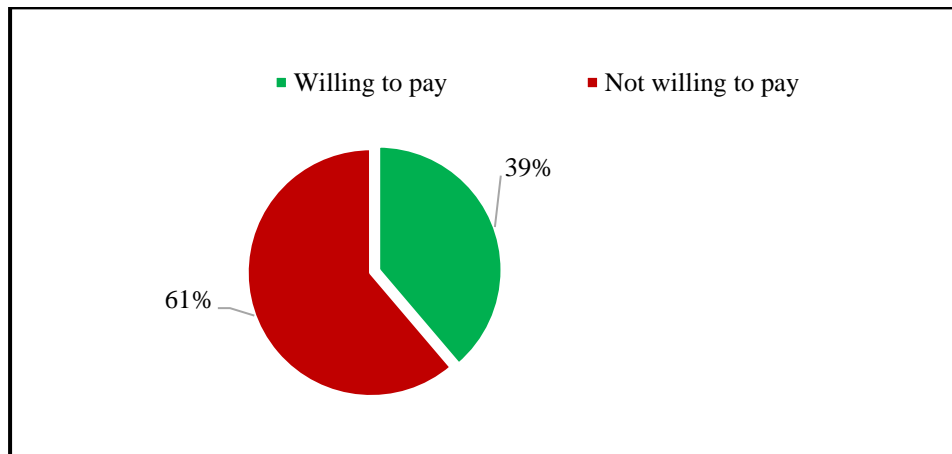
Figure 6.5: Willingness to Pay for Computer E-Waste Collection Services

As depicted in Figure 6.5, only very few respondents from households (39%) pledged that they were willing to individually pay for the collection of computer e-waste from their houses. The rest were not committed to paying for this service (61%). Those who did not want to pay indicated that it is the task of the Nairobi City County to deliver the services free of charge since they spend on a service charge to the County Government.

6.2.4   Media for Education and Public Awareness

Given that this study was done in the contemporary world in which a wide range of mass media outlet technologies are available for enhancement of public awareness campaigns and education regarding human health and environmental issues in cities, this aspect was also included in the study. Respondents from households and institutions were presented with a wide range of options for transmission of messages and enabling education on waste from computer components and accessories in the questionnaire. These included electronic media

outlets such as television, radio, internet, print media outlets such as newspapers and magazines, use of environmental groups, public forums and friends. They were also granted the liberty of indicating any other possible outlet that they would favour. The result of those who responded to this question were as presented in Figure 6.6.
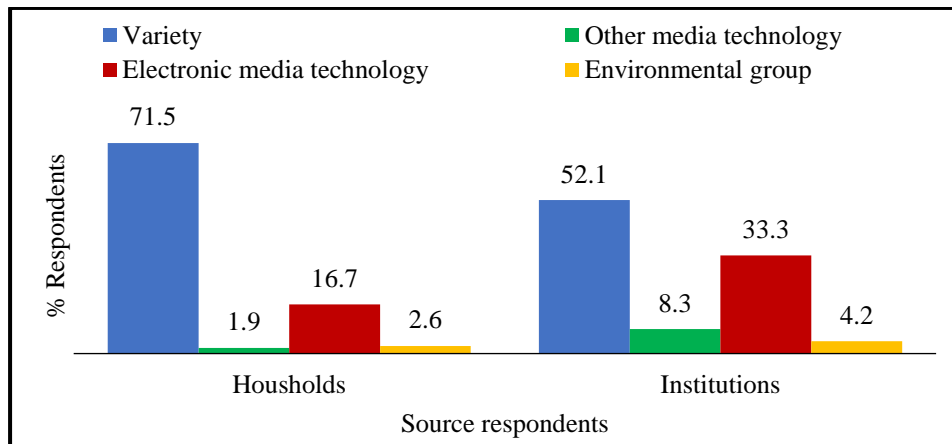

Figure 6.6: Suggested media for public education on computer e-waste disposal management

As presented in Figure 6.6, the majority of respondents from households (71.5%) and from institutions (52.1%) were of the view that a variety of media outlets could be used for public awareness and education campaigns about computer e-waste disposal management in an environmentally sound and human health responsive way. This was followed with favour for the use of electronic media outlets by respondents from households (16.7%) and institutions (33.3%). Resort to environmental groups as outfits for education and awareness raising campaigns on this subject was acknowledged by only a small size of respondents - 4.2% and 2.6% of respondents from institutions households respectively.

6.2.5 *Relative Perspective on Computer E-waste Disposal Management Approaches*

The study also sought to unravel the perspectives of respondents regarding disposal of waste from computer components and accessories relative to the types of waste in the county solid waste stream. To this end, respondents from households and institutions were asked to rate, on a Likert scale, their thoughts on the appropriateness of throwing computer e-waste alongside other types of waste. The result of those who responded in the affirmative to this question were as presented in Figure 6.7.
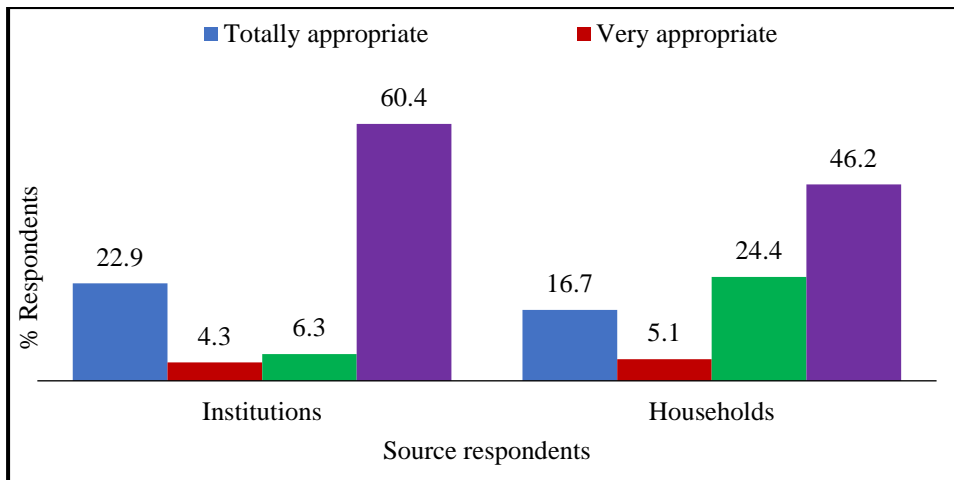
Figure 6.7: Considerations for Disposal of Computer E-Waste with other Wastes

The responses presented in Figure 6.7 show that a sound majority of respondents from both institutions (60.4%) and households (46.2%) considered discarding waste from computer components and accessories alongside other types of waste generated as not appropriate. Only 33.5% and 46.2% respondents from institutions and households respectively thought that this practice was appropriate.

Photo 6.1: Photos of Dandora Dumpsite Showing Various Activities.

Observation of the dumping site revealed that open air burning of waste was used as a way of reclaiming valuable e-waste components such as copper wires. Interview from one of the e-waste pickers indicated that once the copper wires, plastics and other metals are extracted from the e-waste, they are sold to the traders who operate within the dumping site and others who come from Ngala Market. A cross-check of one of the traders (yard shop operators) situated near the dumpsite indicated that they buy the materials such as plastics, metals from the e-waste

pickers/scavengers who live at the Dandora dumpsite, sort them out by colour and type, wash, dry and package them for sale mainly to the local industries. Further, they sometimes sell to foreigners mainly from China who usually come to buy the metals from them at a higher fee.

6.3   Discussions

Computer e-waste is the outcome of human activities and therefore the need for involvement of all stakeholders including public institutions, private companies and households in its disposal management. Despite the majority's affirmation consideration that waste from computer components and accessories as waste from the institutions, they lacked the knowledge to link it with its negative impacts to human health and environmental risks if disposed of in an unsound manner. Hence the majority of respondents did not rate the gravity of concern to the computer e-waste flows to the environment as a serious problem in the urban area. This compares well with the conclusions by Saritha *et al*., (2015), Nath *et al*., (2018) and Iyer *et al.,* (2018) that consumers lacked knowledge of computer e-waste disposal management approaches. According to Shah *et al*., (2014) and Patil (2016), the consumers also did not know the types of human health risks and environment-related hazards that Shah *et al*., (2014) associated with improper disposal management of computer e-waste.

The fact that respondents gave other reasons for considering computer e-waste as serious instead of human health and environment-related is a clear indication that they were not aware of the consequences of human health risks and environmental degradation of the urban area. Similarly, UNEP, (2006); Robinson, (2009); Widmer *et al*., (2005) and Fikrom *et al*., (2016) observed that generation of solid waste had become a growing environmental and public health challenge everywhere in the world, especially in cities with low-economy. One of the aims of computer e-waste disposal management is to ensure appropriate disposal to improve the quality of the environment and minimize risks to human health.

The study established that despite the majority of the respondents at the household level having a university education, likely access to information regarding the cost and benefits of computer e-waste disposal management, they were unwilling to pay for the collection of the e-waste.

This is contrary to the Tietenberg *et al*., (2010), on the theory of demand for environmental goods, which assumes that many years of schooling, translates to the need for improved environmental quality. The Nairobi City County scenario may be due to perceived belief that disposal management of computer e-waste is the preserve of the government and City County

and that the respondents do not have responsibility for the disposal management of the computer e-waste they produce or due to perceived beliefs that the computer e-waste contains valuable components that could be sold to the e-waste pickers/scavengers. The result compares well with findings in Table 6.3 which shows that a substantial size of respondents in Nairobi City County ascribe to the position that the government has an important role to play in reducing the bulk of computer e-waste in the urban area, either by way of formulating related programmes, or through strict enforcement of legal requirements for disposal management approaches, including those that close the linkage between disposal management and recycling plants in the computer e-waste management loop. The respondents lack knowledge that the computer e-waste disposal management is the responsibility of all consumers including the government for purposes of improving human health and the environment of the urban area.

Due to the perceived value of the computer e-waste, and unwillingness to pay for collection service, the respondents prefer to wait for e-waste pickers/scavengers to buy instead of paying for the collection. This is the same reason advanced when the respondents store the computer e-waste in their houses and prefer that someone may come and purchase it from them without the knowledge that they are extending the lifespan of the computer components and accessories thus delaying their disposal in the landfill. This information is reflected in chapter four (Figure 4.12), where respondents preferred storage of computer e-waste disposal management practices in their premises or throwing away with other wastes into the urban solid waste stream. This is a clear indication that the respondents lack the knowledge of the risks to human health and the environment and hence they do not want to contribute to the sustainable computer e-waste disposal management of the e-waste they produce.

Despite the harmful components in computer e-waste there is low awareness on the types of harm to human health associated with its improper disposal, Saritha *et al*., (2015) identified lack of awareness and capacity to disposal management of waste from computer components and accessories. Kalana, (2010), and Islam *et al*., (2016) established that there was low knowledge level on impacts of the e-waste on human health and the environment especially when they are disposed of together with county solid waste (CSW) at the end-of-life. This is because the respondents are still throwing away computer e-waste together with other CSW and storing the computer e-waste in their premises instead of taking the waste to the recycling facility.

The level of awareness on potential risks to human health and the environment by computer components and accessories is high in institutions than at the household level. According to Suja *et al.*, (2014), proper waste disposal management approaches by institutions is the development of internal disposal management systems. Melnyk *et al.*, (2003) adjudge that the main aim of such type of management system is to ensure that the firm is able to reduce the waste from computer components and accessories while at the same time improving its overall performance. This may be in the form of environmental sustainability policies including the handling of computer e-waste in an institution, existence of environmental sustainability committees in both the public institutions and private companies. Despite this being a requirement under the public-sector performance contract, the study established that very few institutions had displayed them in their premises. This situation depicts the seriousness of human health and environmental concerns when it comes to impact from improper disposal management of waste from computer components and accessories in the institutions and private companies.

Asked if they perceive any human health hazards in dealing with computer e-waste, the management of the WEEE Centre said: *"Handling computer e-waste with inadequate safety gear while using inappropriate methods is a sure human health hazard due to some toxic elements that they contain. That is the reason why at the WEEE Centre, we provide for adequate safety gear and methods."*

Asked whether he is aware that the dumpsite has the potential to negatively affect human health and the environment, one of the respondents living a few metres from the Dandora dumpsite said:-*"Yes I know that this is possible and several people have complained of chest pains, but we do not have a choice because the City County has always said that the dumpsite would be relocated but we do not know when."*

Yet another respondent working at the dumpsite said: - *"Even if the waste at the site has potential negative impacts on human health and the environment, I have lived in this environment for over ten years and this is where I derive my livelihood."*

Another respondent living a few metres from the dumpsite said: - *"The dumpsite should be relocated in an area which is not habited to avoid similar problems being transferred to other people in another location."*

Observation of those working at the yard-shops revealed that they sort out, wash, dry and bulk waste from computer components accessories including plastics, motherboards and metals from computers, using bare hands. Asked, whether they know that the waste from computer components and accessories they handle may have potential to negatively impact on their health they had this to say: - *"I do not know and since I have done this work for over 5 years, I have not experienced sickness that I have associated with the handling of this waste."*

Besides, Table 6.1 shows that majority of the respondents from both households (80.8%) and institutions (95.8%) viewed improper disposal management of computer e-waste as harmful to environmental quality and human health status of city residents.

The study found that delay in purchasing new computers was not an option to computer e-waste disposal management. There was also an overwhelming majority of respondents from institutions and households who were in favour of having computer technology users engage in separation and transmission to recycling plants of waste from computer components and accessories.

The study established that there was need to use various methods to adequately educate the public on human health risks and environmental degradation of the urban area. However, a variety of media outlets were the preferred choice for public education and awareness campaigns for both the institutions and the households. In addition, some of the respondents stated that the best way to get information on impacts of waste from computer components and accessories and its disposal management approaches was from the electronic media, environmental groups and other media technology. This compares well with the findings of the Shah community in Malaysia (Kalana, 2010).

Both the institutions and households consider as '*not appropriate*' to discard waste from computer components and accessories alongside other types of wastes generated but they do not relate this to the human health risks and environmental degradation of the urban area. It was observed that public awareness was the major one challenge in the computer e-waste disposal management.

The situation is confirmed by Kalana, (2010) who established that many people are not aware of the potential negative impacts of waste from computer components and accessories to human health and degradation of the environment mainly when washed into the solid waste stream at the end-of-life. The study established (Figure 6.4) that more than half of the

respondents in both the households (58.3%) and institutions (54.2) '*lightly agreed*' with the statement that some computer components and accessories contain harmful chemicals while less than 15% and 30% from households and institutions respectively '*strongly agreed*' that the computer components and accessories contain harmful chemicals. Most of the respondents (54.3%) however, highlighted the greater need for public awareness/attitude campaigns and indicted the need for intensive government-led programmes (20%).

The study, however, gave a strong indication that there is hope in the computer e-waste disposal management because there was evidence of the decreasing purchase and use of the desktop computers with the lead bearing CRT display monitors and increasing purchase and use of desktop computers with LCD monitors and laptops. This is also an indication that the potential risks to human health and degradation of the environment can sustainably be controlled for socio-economic development of the county and by extension the whole country.

Analysis of the data on the level of knowledge and public awareness on the effects of computer e-waste on human health and the environment of the urban area concluded that there is a low level of awareness and insufficient knowledge of toxic components in computer e-waste and, therefore, the respondents are exposed to serious health hazards. The respondents do not know the proper computer e-waste disposal management approaches. This explains the reason why they store the computer e-waste in their houses and offices and also throw the same together with other CSW. They also kept the same in their houses and offices because there is no information on where and how to dispose of the computer e-waste in an environmentally sound manner (Macauley *et al*., 2003). The study has revealed that the respondents who store or throw away the computer e-waste with other wastes do not know how to and where to dispose of the waste from computer components and accessories. The respondents' level of awareness is assumed to be related to the approaches and attitude in computer components and accessories disposal management at the EoL. The study concludes that the respondents who knew how to dispose of the computer e-waste also knew that the e-waste is hazardous.

6.4   Chapter Summary

Computer e-waste disposal management is a responsibility of all stakeholders. Although respondents at the institutions acknowledged that computer e-waste is an outcome of their activities, they did not link its harmful effects to human health and environmental degradation of the urban area. The level of awareness has not been influenced by many years of schooling and hence the households stored their waste in their premises because they lacked the

knowledge of how and where to discard of. Due to the perceived value of computer e-waste, the respondents stored and waited for e-waste pickers to buy their computer e-waste or threw away the same into the county solid waste stream. Due to lack of awareness of the potential effects on human health and the environment, the respondents, therefore, fail to contribute towards computer e-waste disposal management.

Although proper computer e-waste disposal management is through the development of internal disposal management systems by institutions and private companies, most of them failed to establish environment sustainability committees to spearhead the environmental issues in the institutions and private companies. This reflected lack of seriousness towards potential effects of computer e-waste on human health and environment if not properly disposed of. On the other hand, the e-waste pickers/scavengers also lack awareness about the potential impact on human health and environmental degradation because they dismantle the computer e-waste with crude and rudimentary tools without safety gears. Unlike the informal sector, the formal recycling facility such as WEEE Centre processes the computer e-waste using the best available technology and best environmental practices.

Respondents identified the use of electronic media, environmental groups as the best way to disseminate information on the potential adverse effects of computer e-waste disposal management on human health and the environment. Although computer e-waste has potentially negative effects on human health, the respondents at the Dandora dumpsite said that they have no choice because they derive their livelihood from the dumpsite. The Nairobi City County through the County E-waste Disposal Management Authority (CEDMA) should enhance public education and awareness by developing programmes on the need to participate in the disposal management of computer e-waste by promoting the Waste Hierarchy – reduce, reuse, recycle and reduce in order to mitigate the effects of computer e-waste disposal mangement approaches on human health and the environment. The authority should involve all the stakeholders including the electronic media and environmental groups to disseminate the relevant information on computer e-waste management approaches.

CHAPTER 7: PLANNING, POLICIES AND REGULATORY INTERVENTIONS FOR SUSTAINABLE COMPUTER E-WASTE DISPOSAL MANAGEMENT

7.1 Introduction

This section presents results on the fourth objective of the study: - *the planning, policies, and regulatory interventions for the promotion of sustainable computer e-waste disposal management approaches in Nairobi City County.*

The options on this objective have been highlighted in so far as they emerged from the views presented by respondents from the solid waste management policy domains in Kenya and built on a significance synthesis of the current waste management policy frameworks on computer e-waste disposal management practices in City County. To further determine whether the views and concerns raised by key decision makers are consistent with the positions of their counterparts in the lower cadre of influence, the views provided in the filled-out questionnaires are also presented.

The chapter is divided into two sections. First, an account of the pertinent data used for this specific study objective. A detailed description of the methodology from which the results in this chapter is obtained is as earlier presented in Chapter 3 of this thesis. Part two, the results section, is the most elaborate component of the chapter and it allows integration of human health and environmental perspectives to be the emphases of analysis in all aspects considered. It is structured into three overlapping themes: drivers of computer e-waste disposal management approaches; status of institutional re-engineering in favour of computer e-waste disposal management approaches; computer e-waste disposal responsive human health and environmental management systems; and stewardship on computer e-waste disposal management approaches. Part four includes the discussions related to this objective are then detailed

The relevant policies, planning, institutional frameworks and regulations are evoked and examined for their strong and weak support for sustainable computer e-waste disposal management approaches in Nairobi City County. Finally, a reflection on the sustainability framework for computer e-waste disposal management is delved into with a view to pointing

out critical areas for attention in relation to computer e-waste disposal management in Nairobi City County.

7.2   Results

7.2.1   Computer E-waste Disposal Management and Existing Human Health and Environmental Governance Tools and Structures

The study sought views of respondents regarding the scope and relevance of existing environmental and human health governance tools and structures in Kenya for application to computer e-waste disposal management. The comments enlisted from a large size of key informants attested to the position that policy tools, legislation and institutional frameworks are the major determinants of computer e-waste disposal management approaches, with no particular attachment to human health and environmental sustainability values in their own right. Statements such as, *"how can we not do the right thing? You can't even think of anything, otherwise, because NEMA will definitely catch up with you, and the fine is too much!"* as one respondent (Key Informant, Private Company) framed it, were typically common in the responses.

However, evidence pointing to the potential of existing policy, legislative and institutional capability to facilitate computer e-waste disposal management in Nairobi City County sustainably was found to be largely weak. For example, one officer said that, *"There is inadequate institutional framework, especially in the area of sector specific-regulations, and this sometimes makes it very difficult for us to enforce the law in cases such as e-waste disposal management that were born only recently after EMCA came into operation"* (Key Informant, NEMA), a striking comment considering that it came from an employee of the institution mandated with enforcement of overall environmental laws in the country.

7.2.2   Drivers of Computer E-waste Disposal Management Approaches

Arising from lessons learned from the literature on factors that drive the pursuit of disposal management approaches to various types of county waste, this study examined the conditions that propel institutions, private companies and households towards adopting multiple disposal management approaches for computer e-waste. Central to this attribute of the study were human health, environmental, social responsibility obligations, policy provisions, regulatory interventions and their associated institutional framework arrangements for enforcement. For

all these analytical parameters, the questions were raised in such a way as to allow the views and opinions sought out to emerge deliberately from the respondents themselves.

While human health and environmental factors have been highlighted in a variety of both classical and recent writings as prime movers of transitions in waste disposal management approaches (WCED, 1987; Porter, 2002; Wilson *et al.*, 2006; UN, 2012), their intrinsic value in driving computer e-waste disposal management approaches, particularly in urban settings, remain inconclusive. Against the backdrop of this uncertainty, the responses by key-informants were examined for underscoring human health and environmental factors as drivers of computer e-waste disposal management approaches. For example, one respondent summed up this commonly shared position by pointing out that, *"There are opportunities in the resource recovery and reuse of valuable resources through the creation of new businesses and employment within the green economic growth agenda; and the climate change mitigation by reduction of emissions of greenhouse gases. Reuse of waste from computers can ease pressure on non-renewable source metals, and the country would earn foreign exchange through export of extractions as raw materials for the electronic industry"* (Key Informant, Ministry of Environment and Natural Resources).

Participatory Approach towards Computer E-Waste Disposal Management

A sustainable systems approach to waste disposal management underscores the centrality of integration in which a participatory approach becomes a critical element of transition towards sustainable solutions to the problem of waste from computer components and accessories. In this thinking, the government is supposed to play a facilitative role, rather than being the prime agent of the desired change (Mol, 2010; Schluep *et al.*, 2009; Sikor *et al.*, 2014; Moore, 2015; Thyberg *et al.*, 2015).

One respondent from the Communication Authority of Kenya (CA) tacitly emphasized on regulations. He said, *"Yes! There is a need to audit, regulate and register the imported computer components and accessories by the regulatory agencies such as this one, KEBS and KRA. The audit should be a responsibility of CA, KRA and NEMA; regulation by CA, KEBS, and NEMA; and CA and NEMA should keep the register. Regulation of imports of computer components and accessories in Kenya should be made by KEBS and KRA and should be limited to 3 years."*

The specific direction of actions expected of government was concisely voiced in the responses by a key-informant from the WEEE Centre as reported, *"The Government needs to put a proper regulatory framework in place. Proper and efficient enforcement should also support this. The government should also provide funding for research and development. I think that there is need for the government to conduct high profile public education and awareness campaigns on the potential dangers of computer e-waste on human health and the environment and direct them to acceptable disposal sites"* and added that, *"public-private-partnerships can be important means of dealing with computer e-waste disposal management not only in the county but country at large."*

Level of Awareness on Potential effects of Computer E-Waste Disposal Management Approaches on Human Health and Environment

Despite the provision of public awareness in the Constitution and the environmental legislation (GoK, 1999; 2015), the study established that a gap still exists in public awareness and education regarding the computer e-waste disposal management at the institutions, private companies and the household level. However, when the information on the issue was shared with them, they were able to link the impacts of computer e-waste improper disposal management to risks on human health and the environmental degradation of the urban area. Despite some awareness about the issue, most of the respondents were totally unaware of the best way to dispose of the computer e-waste. One of the respondents indicated that: - *"the government needs to put in place public awareness education programmes to enlighten the wider public on the need to dispose of their waste from computer components and accessories in an environmentally sound manner".*

The respondents also indicated that: - *"it is the responsibility of the government to formulate policies and legislation and enforcement of compliance while the institutions, businesses and households have the responsibility to segregate the computer e-waste from the source."*

Resource Value of Computer E-Waste

The economic benefits of computer e-waste, which allows a large number of urban poor in the informal sector (e-waste pickers/scavengers and yard shop operators) to eke a living from thrown away materials was found to be a key driver in the sustainable computer e-waste disposal management (Wilson *et al.,* 2006). The yard shop operators buy computer e-waste

from e-waste pickers/scavengers. It is cleaned and sorted out by their workers (about 2-3 per yard shop) and packaged in bulk and mainly sold to the local industries.

One of the yard shop operators (50 years old) in Dandora Township said: *"Computer e-waste is sold in kilogrammes, but at much higher prices than plastics and scrap metals. The price of computer e-waste varies from the type of components and accessories. A computer motherboard costs Kshs. 180 per kilo. We sell the computer e-waste for approximately Kshs. 60 per kilo or more, thus making up a profit margin. Further, the purchase price depends on what the purchasers are willing to pay. Computer e-waste items such as laptops comprise small quantities of valuable metals, such as gold, palladium, silver and platinum less of metals such as gallium and indium which are more common in newer devices such as touch screens and tablets".*

Photo 7. 1: A Waste Picker/Scavengers Weighing E-waste at Dandora Market in Nairobi
Source: Sam Wolson

The yard shop operators also usually source computer e-waste from institutions and households (Beukering, 1994). They value add their materials by cleaning, sorting, separation and packaging it in bulk ready for delivery to the local industries.

7.2.3 *Status of Institutional Re-Engineering for Computer E-Waste Disposal Management Approaches*

In chapter two, literature review on planning, policies, regulatory/legislation interventions on human health and environmental management were considered. In addition, the institutions established for these purposes were also highlighted in the chapter. A combination of these

initiatives is meant to be platforms for users of computers to adopt sustainable computer e-waste disposal management approaches. Based on documented practices across the world on corporate environmental responsibilities (Hyden, 1998; Zotos *et al*., 2009; Tsalis *et al*., 2013), a wide range of innovative measures are open to institutions and private business entities bent upon elevating their computer e-waste disposal management approaches. Against this background, this study assessed the options government institutions and private entities have put in place in response to this environmental sustainability necessity.

7.2.4 *Computer E-waste Disposal Responsive Human Health and Environmental Management Systems*

The internal human health and environmental management systems for computer e-waste disposal management were examined in this study. To this effect, the question of the existence of written formal requirements and guidelines for reducing accumulation of waste from computer components and accessories in the institutions was raised. The corresponding responses were as presented in Figure 7.1 (n=48).
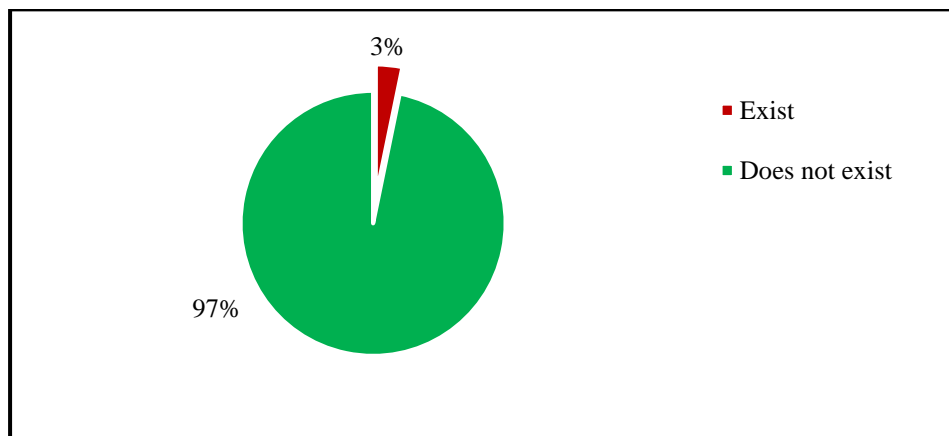
Figure 7.1: Official Guidelines on Computer E-Waste Disposal Management

As illustrated in Figure 7.1, a large number of responses contained in the filled-out questionnaires from institutions indicated that several institutions (97%) had not put in place official systems for computer e-waste disposal management. Only two institutions (3%) gave an affirmative response.

A related question delved into the channels for disposal of waste from computer components and accessories by institutions. As Figure 7.2 indicates, over half of the respondents (55%) were of the view that their affiliate institutions had no clearly defined channels for disposal management of waste from computers and could take any direction or form. Of the rest whose

responses were on the contrary, there was an explicit expression in favour of the view that environmental and human health aspects (32% and 13% respectively) were the major cornerstones of the approaches embedded in the disposal management channels (n=48).
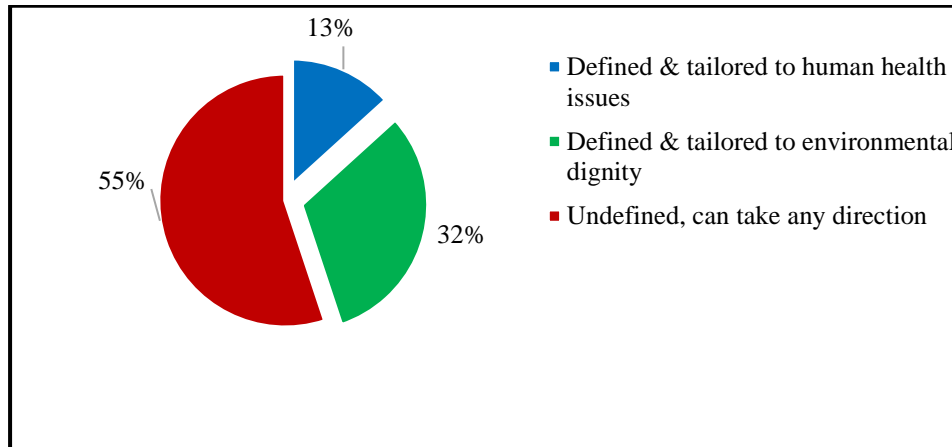

Figure 7.2: Computer E-Waste Disposal Management Approaches Channels Status within Institutions

This picture points to the position that for many institutions, human health and environmental implications of computer e-waste are recognised but going a notch higher to establish enabling structures for their disposal management remains elusive.

Another dimension of institutional re-engineering examined in this study was the presence of internal environmental performance policies that embrace computer e-waste disposal management aspects. To this end, the management quality assurance (MQA) statements of the institutions were examined for highlighting computer e-waste management attributes with a particular focus on their internal policy statements, rules and regulations. The results were as presented in Figure 7.3 (n=48).
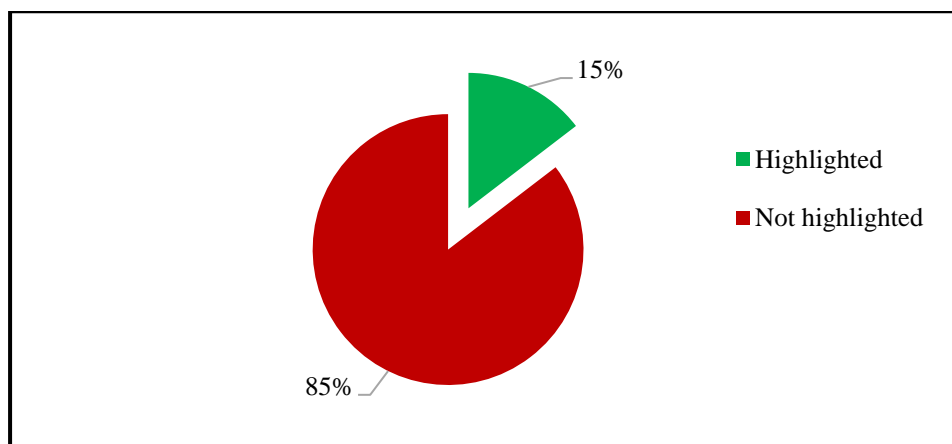
Figure 7.3: Computer E-Waste Disposal Management Approaches Highlighted in MQA Statements

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As Figure 7.3 shows, of the 48 institutions interviewed, a large proportion of them (85%) had not highlighted computer e-waste disposal management dimensions in their internal MQA statements.

The 15% in the affirmative were analyzed for responses to the question on factors that had prompted the institutions to include computer e-waste disposal management in their MQA statements. Only in three cases were human health imperatives and environmental sustainability considerations mentioned. Other factors featured were attempts to adhere to county government directives or by-laws, promoting an effective computer e-waste disposal management culture within the institution and response to public concerns about computer e-waste generation. When asked about their thoughts on the possibility for future inclusion of computer e-waste disposal management in their internal MQA statements, the results were as presented in Figure 7.4.
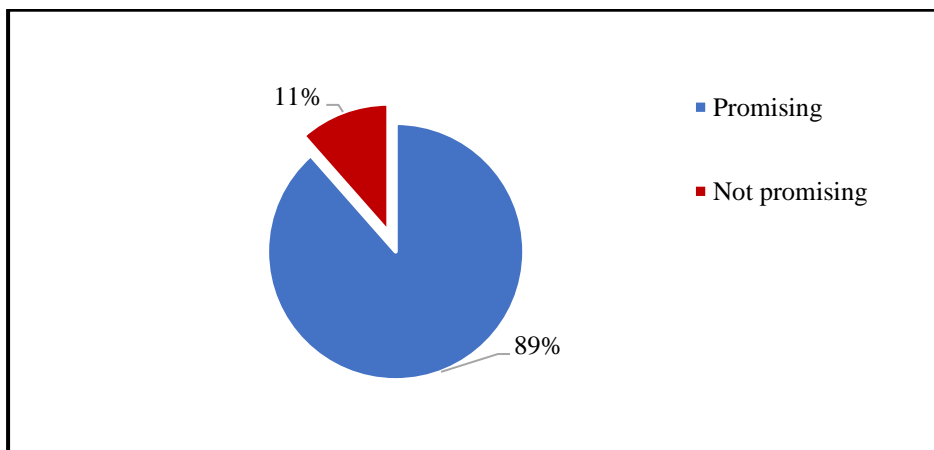
Figure 7.4: Prospects for Integration of Computer E-Waste Disposal Management Approaches in Internal   MQA Statements

Figure 7.4 shows that majority of the respondents (89%) were optimistic about prospects for the inclusion of computer e-waste disposal management components in their internal service charter. Those in the non-promising category were only 11%. Further, they were asked to provide the major reason they considered it important to integrate computer e-waste disposal management aspects. As Figure 7.5 shows, the three most outstanding reasons advanced were compliance with national legal frameworks (46%), compliance with County Government directives or by-laws (33%). Environmental sustainability (17%) and human health (4%) related reasons were provided by a very small number of respondents.

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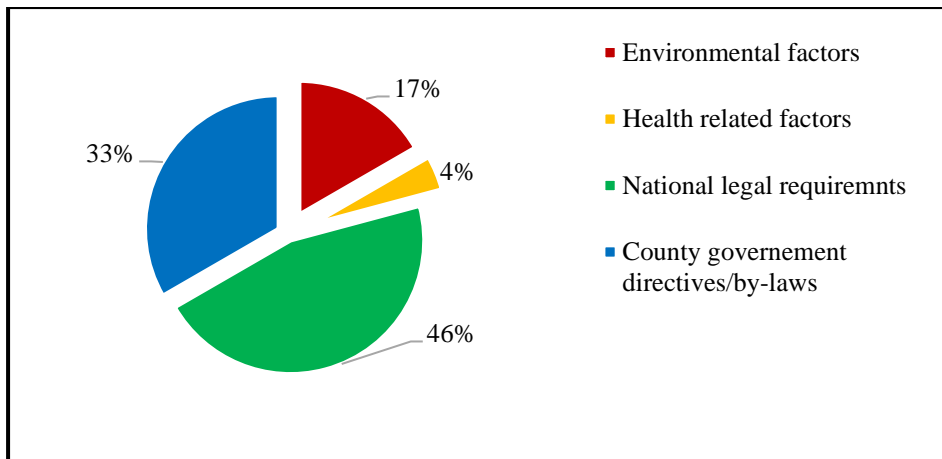
Figure 7.5: Rationale for including E-Waste Disposal Management Approaches Aspects in the MQA Statements

Asked what the institution has done to ensure that environmental sustainability issues have been taken into consideration, one of the respondents from NEMA had this to say: *"Environmental sustainability is a mandatory target in implementation of Public Performance Contracting through a directive from the Central Government and each public institution is expected to make quarterly and annual reports to NEMA. The target includes the establishment of structures to address the impact on human health and the environment and compliance with the subsidiary legislation under EMCA (2015) that relate to e-waste."*

A number of fundamental issues pointing to weaknesses in institutional orientations to computer e-waste disposal management were unveiled from interviews with key informants. First was lack of technical, financial and material resources they need to fulfill the computer e-waste disposal management mandates. Accordingly, a respondent from the City County Government remarked that: - *"Lack of mechanisms for collection, disposal as well as the absence of treatment sites hamper our waste disposal management activities, including the waste from computers. Also, there are several informal waste collection sites in Nairobi, and bringing them together to do things uniformly is a big challenge as the traders involved are always competing for the money they make from the sale of waste"* (Key Informant, Nairobi City County Government).

Second, several respondents expressed the view that: - *"Low public awareness about environmental and human health implications of careless computer e-waste handling was a major drawback to efforts by various institutions. For example, NEMA has established the Department of Environmental Education, Information and Public Participation (EEIPP) that provides strategies for education and awareness creation activities. The function of this*

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Department is to develop, publish and disseminate environmental education materials and pass them on to the public during public engagement meetings such as Agricultural Society of Kenya annual shows, trade fairs, international environment day and the public service week.''

On the same account, another Officer from NEMA tacitly expressed the view that: - *"Low public awareness and education is a serious issue here, but since the responsibility of NEMA is mainly enforcement, we do not do a lot in terms of educating people on what the laws require, and why those laws have been put in place. What the Department created within NEMA for this role does, I can say, is on a very small scale! Even if we were to come up with a large scale programme on public awareness creation, I don't think we would achieve much due to inadequate financial allocation to NEMA from the Ministry of Environment and Natural Resources''* (Key Informant, NEMA).

7.2.5   Stewardship on Computer E-Waste Disposal Management Approaches

Robust stewardship platforms are central to many successful environmental sustainability programmes. This is borne of the fact that conventional environmental governance space constitutes several actors, namely the public sector, civil society organisations and the private sector. Each of these actor groups bring in their unique interests, capabilities and power influences to bear on the outcomes of ultimate decisions and actions. Thus, the presence of a leadership structure that galvanises these diverse perspectives is central to the common sustainability goal sought out. Since the role of the government in providing leadership has recently emerged in the waste disposal management literature as an important driver of sustainability, assessing perceptions about the place of the government in completing this stewardship loop was important for the objectives of this study.

In this regard, respondents from institutions were asked whether they endorsed the view that the government should be more involved in the disposal management of waste from computer components and accessories. As Figure 7.6 shows, majority (66%) agreed with this position while only 34% cases fell in the contrary.
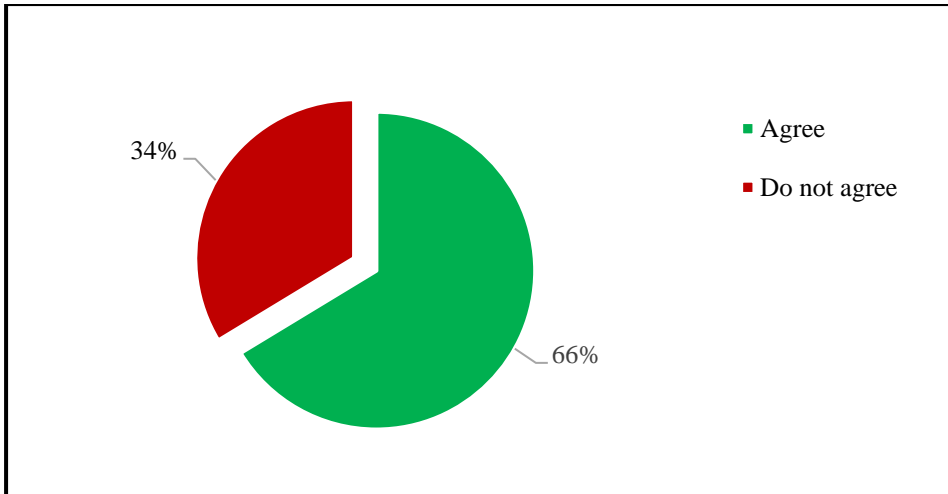
Figure 7. 6: Government should be More Involved in the Disposal Management of Computer E-Waste

An examination of suggestions from institutions on preferred specific roles of the government with respect to awareness strengthening and legislation revealed the overall results presented in Figure 7.7.
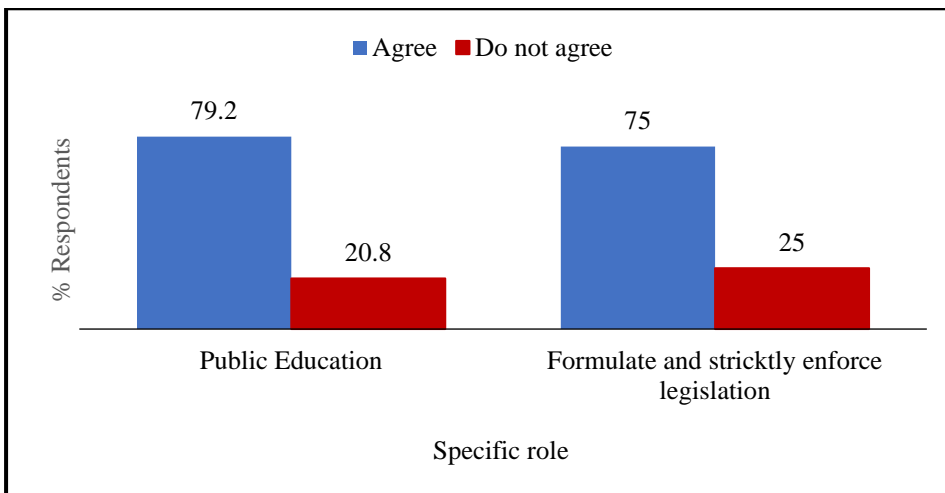

Figure 7.7: Preferences for Greater Focus on Public Education and Legislation as Roles of Government in Computer E-Waste Disposal Management Approaches

As the findings in Figure 7.7 depict, there was a sound agreement that these two directions (public education, formulation and enforcement of legislation) were critical roles for the government.

However, comments from several respondents tended to indicate that non-state actors and private sector actors have not been adequately integrated in the decision-making processes and actions on computer e-waste disposal management approaches in the City County. A waste trader from a temporary collection site (yard shops) attested to this exclusive tendency in his remark: *"Kanjo* (City County Government) *does not appreciate the important role we play in*

cleaning up this city. The 'askaris (County Government by-laws enforcement officers) *do not listen to us! Even if you have a good thing to tell them, they harass you and push you to their vehicle. They are only interested in getting money from us-which they claim is fine, but the fact is that they 'eat it'* [put into their pockets] - *they do not take it to their office. Surely! What can we do?"* This ordeal is characteristic of the culture of bullying and corruption that has been cited in some studies as common drawbacks to shared visions and actions on waste disposal management in the Kenyan urban environments (Furrady, 1992; Odegi-Awuondo, 1994; Njeru, 2006; Oyake-Ombis, 2012; Nyakang'o, 2015).

In addition, one key informant from the Ministry of Environment and Natural Resources summarised the challenges the government face with regard to disposal management of computer e-waste:- *"The management of waste from computers have been hampered by an uncoordinated approach across line ministries and agencies; lack of public education and awareness on the need for computer e-waste disposal management system; commitment to establishment of mechanism to implement the policy intentions; lack of national capacity to process and separate the e-waste from county solid waste stream and a structured system of e-waste collection. The country has not encompassed the principle of extended-producer-responsibility and purchase of new IT has continued to be a mirage to many citizens. Lack of proper guidelines and collection systems has led to waste from computers stockpiling in homes, offices and repair shops; and capacity to manage the waste has been limited."*

Given this scenario, he further noted that *"It is the view of this Ministry that e-waste will continue to be a challenge, especially in the cities like Nairobi, since it is not possible to do away with technology. Since waste from computers is not like general waste, it needs to be managed properly using existing laws and also put in end-of-life policies. The disposal management of the waste is everybody's responsibility. The Ministry is encouraging more investors to engage in the waste disposal management and also urging institutions to demonstrate and put in place frameworks to manage their waste from computer components and accessories."*

For KRA, *"problems such as tax evasion and fraud, illegal import documentation is rampant, and it is possible, therefore, for counterfeit or waste from computers to enter into the country illegally" (*Key Informant, KRA).

Another challenge to be addressed was concisely brought out by a key informant from the Nairobi City County Government who said that, *"public awareness on the potential impact of computer e-waste disposal management on human health and the environment is lacking and the economic venture this waste presents is not taken seriously. There is also lack of separation of the waste from computer components and accessories at the source; lack of capacity on its disposal management and only few recycling facilities exist."*

On the issue of responsibility of computer e-waste disposal management one respondent from Safaricom said: - *"it is the onus of all generators of computer e-waste to establish viable collection centres and create awareness if we are to solve the problem of computer e-waste disposal management in Kenya".* The respondent was also of the opinion that, *"the producers of waste from computer components and accessories should keep inventories of the computer flows in their facilities"* (Key Informant, Safaricom).

Asked what the government's role in computer e-waste disposal management should be, one of the respondents said that, *"the government is supposed to develop appropriate policy guidelines and legislation for e-waste disposal management; regularly monitor the e-waste disposal management practices; regulate and control the number of recycling facilities in a geographical area; create public awareness among producers of the waste; and approve appropriate technologies"* (Key Informant, Ministry of Environment and Natural Resources).

An interview with a respondent from the Ministry of Health said that, *"in my view the major challenge facing most of the producers of computer e-waste in Kenya is the technology to handle the waste. Some of these wastes from computers are very toxic, but at the same time some of the metals are very precious. The question is...do we have the right technology and skill to handle all these […]"* (Key Informant, Ministry of Health).

Asked whether computer technology users should pay money at the point of purchase to defray disposal management costs, 85.4% of the respondents were of the opinion that they should not (Figure 7.8).
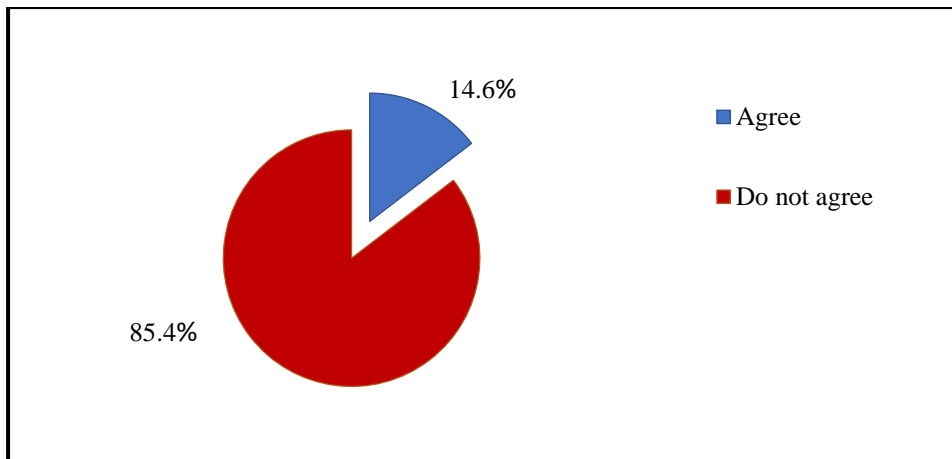
Figure 7.8: Computer Technology Users Should Pay Money at Point of Purchase to help Pay for Disposal Expenses

7.3 Discussions

7.3.1 Sustainability of Computer E-Waste Disposal Management Approaches

The study established that the current market is flooded with waste from computer components and accessories that continue to impact on the market economy in a big way. This is attested by the volumes of computer e-waste that continue to pile up in offices and also at the households. This means that the manufacturing industry continues to consume resources at a higher rate than they are being generated and this, if not checked, may turn into out-of-control system-that would impact profoundly on the sustainability aspects. The findings of this study point to the possibility that the phenomenon of computer e-waste disposal management in Nairobi City County has not acquired a multifaceted perspective in which the social and economic considerations are brought in to pool together with environmental aspects as required of sustainability programmes. In particular, this result confirms that popular market-based tools such as the polluter-pays-principle that have traditionally exerted pressure on actors along production and consumption chains are yet to assume strong establishments in the computer e-waste disposal management in the Nairobi City County. In this section, issues such as stakeholders, environmental, economic, socio-cultural, and technical aspects, that make computer e-waste disposal management system sustainable are considered and a summary of stakeholders' involvement is provided in Table 7.1.

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Table 7.1: Summary of Sustainability Issues for Computer E-Waste Disposal Management Approaches in Nairobi City County

Drivers of sustainability	Contribution to Sustainability
Stakeholders	• The stakeholders in this study are i) formal dumpsite ((Dandora), ii) Informal (e-waste pickers/scavengers and yard-shops operators) dumpsite, iii) Private companies, iv) Public institutions (Research institutions, Government Ministries and Agencies), v) Universities (Public and Private), and vi) Households. Involvement of stakeholders in recycling is key to the achievement of a sustainable computer e-waste disposal management system at Nairobi City County (NCC). • The County Government: Can promote cooperation between the public-private-partnerships to develop a sustainable computer e-waste disposal management system for NCC.
Environmental	• Unlawful dumping of computer e-waste from high-income to low-income countries should be controlled since it is a key sustainability challenge in computer e-waste disposal management in the County. • Toxic chemicals directly leaching into the environment from computer e-waste is a major challenge.
Technological	• Technology has a critical role to play in computer e-waste disposal management in Nairobi City County. • Potential effects of computer e-waste on human health and environment in the urban area can be reduced by recycling using best available technologies and best environmental practices and research on new solutions to the emerging problems.
Economic	• Sustainable computer e-waste disposal management approaches can economically benefit the Nairobi City County. • The yard-shops operators (informal sector) collect computer e-waste, add value by sorting, dismantling in order to improve livelihoods. • Transportation and logistics of waste from computer components and accessories should be a main sustainable economic issue of concern by the County. • The income and economic activities of the informal recyclers and computer e-waste pickers/(scavengers) should be prioritised. • Informal recycling sector, especially in the low-income countries, should be integrated in the mainstream activities for economical sustainability of computer e-waste disposal management system in Nairobi City County.
Social	• Computer e-waste disposal management system is unsustainable without consideration of social matters such as unemployment, occupational safety and effects on human health and the environment. • The potential effects of computer e-waste on human health and environment increase due to manual handling, lack of protective clothes and equipment, leading to direct contact with the computer e-waste. • Manual handling of computer e-waste, direct contact with broken glass, harmful chemicals (e.g. lead, mercury, cadmium e.t.c.) may cause risks to human health and the environment.

	• Sustainable computer e-waste disposal management system should comply with the need for the informal sector, who are socially excluded, in order to improve their living conditions. • Nairobi County government can invest in the computer e-waste disposal management system which positively impacts on the society through job creation.

Environmental Management System and Computer E-Waste Disposal Management Approaches

An institution or business with an environmental management system (EMS) in place is differentiated from a traditional one mainly by how it integrates pollution prevention and resource conservation into its activities and decisions. According to the findings of this study, planning, policy and regulatory tools including legislation and institutional frameworks are crucial to computer e-waste disposal management approaches. However, it was observed that the existing management plans, policies, legislation/regulatory and institutional capability of the Nairobi County to sustainably facilitate the computer e-waste disposal management was very weak especially the sector-specific regulations. This scenario, however, mounts a major challenge in enforcement especially in the emerging problem of computer e-waste, which had not been taken care of by EMCA (1999, 2015).

7.3.2 *Planning, Policies, Regulatory and institutional Frameworks*

Consideration of relevant planning, policies, regulatory and institutional frameworks guiding the computer e-waste disposal management revealed that several policies, strategies, law, and plans are inexistent (though implied), both at the national and county level.

The Constitution provides for public awareness on issues of national importance. However, the study observed that there is lack of coordinated approach to the policy-making process perhaps due to the different times of their formulation and also due to funding by external partners whose main agenda may be different to national interests. Furthermore, there was lack of evidence on impacts, strengths and weaknesses of the existing policies and hence the failure for consideration of the same in the new policies and legislation.

On international policies, the Bamako convention bans imports of hazardous wastes into Africa and the control of the trans-boundary movement of hazardous wastes. It, however, exempts the trans-boundary movement of hazardous wastes generated within Africa subject to very stringent regulatory control. This creates a major gap and therefore setback towards

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sustainability as more developed countries within Africa can willingly transport computer e-waste to less developed countries within Africa.

Policy Restriction of use of Hazardous Substances (RoHS) in electrical and electronic equipment (Directive (2002/95/EC) has existed since 2003. The Directive restricts the use of hazardous substances in electronic equipment (European Commission, n.d.). The RoHS, however, allows exemptions for lead in high melting temperature type solders and copper alloy containing up to 4% lead by weight. The acceptance of exemptions on RoHS directive poses challenges to environmental conservation due to presence of a certain percentage of toxic chemicals in the products.

> According to Lindhqvist (2000), promotion of extended producer responsibility will remove responsibility from consumers to the manufacturers and therefore minimise potential effects on human health and the environment.

The recognition of non-state actors by the Constitution (2010) is laudable specifically because their actions or omissions are relevant to the computer e-waste disposal management. Although the Vision 2030 provides for harmonization of environment-related legislation for enhanced environmental planning and governance (GoK, 2007), these are not explicit though this may also provide a window for reviewing the relevant laws specifically for the inclusion of elements to protect human health and the environmental degradation of the urban area.

Lack of operationalisation of the e-waste management guidelines and lack of clear policy has created a gap in computer e-waste disposal management in the Nairobi County including the government. The challenge is similar to what is experienced in other countries especially in the low-income counties. Likewise, the Kenya Health Policy (2014-2030) in Policy objective 5 stipulates the promotion of good health and prevention of environmental threats by [computer e-] wastes. One of the major policy objectives in the National Water Policy (2012) is to prevent pollution of water bodies by enforcing existing regulations through the polluter-pays- principle and other relevant actions stipulated by the water regulator and advocated by EMCA (2015) and other relevant legislation. However, the polluter-pays-principle has remained a mirage and has not translated to a reduction of pollution by toxic chemicals leached to the water sources from the waste such as the computer e-waste. Although this water policy fails to commit to pollution prevention, it recognises water as a socio-economic good and therefore determines financial payments for water resource management to water users and the polluters. However,

inadequate information sharing and reporting; inadequate funding for water resource management; weak regulation and enforcement; and different institutional mandates have remained a challenge. There is, therefore, need to review the Water Policy in line with the current Water Act, 2016.

As Haregu *et al.,* (2017) observe, sector-specific waste management policies are usually formulated and implemented by different sectors at the country level. The writers reiterate that though the harmonisation of these policies may be safeguarded through the policy formulation process and validation, there is often no evidence for their integrated implementation, a view that was observed in this study. The United Nations (2011) stipulates the need for all-inclusive policy framework that encourages reuse and recycling of special waste streams (such as computer e-waste) as resources.

The EMCA (amendment, 2015) is the supreme statute for environmental governance in Kenya aimed at facilitating a coordinated response to environmental management (EMCA Cap 387). The Act commits to the principle of public participation especially in issues of environmental impact assessment and audits. It provides for the use of the precautionary principle of the polluter-pays-principle. The potential effects of computer e-waste on human health and environment was not highly rated as a serious source of risks in the institutions and also in the private companies. While EMCA is not clear on pollution prevention, the study revealed that some private companies engaged certified NEMA computer e-waste collectors, while still another private university leased the computers to prevent the potential effects of their waste on human health and environment at the end-of-life. EMCA has several subsidiary regulations relevant to computer e-waste disposal management from a human health and environmental sustainability perspective. They include Water Quality Regulations (2006); EIA/EA Regulations (2003); Occupational Health and Safety Regulations (2006); Waste Management Regulations (2006). The E-waste Regulations (2016), which is yet to be gazetted and operationalised, advocates for the extended producer responsibility (EPR) for manufacturers to be responsible for the cost of reprocessing of the products. The regulations specifically provide that those who introduce new or used electronic products such as computer components and accessories into the country should shoulder the cost of their reprocessing or refurbishing their commodities once they reach the end-of-life to safeguard human health and environment instead of leaving the burden to the public or the County. They also advocate for a declaration of the amount of electronic equipment imported by product type. This, in essence, would

enable NEMA to monitor the amounts of waste from computer components and accessories likely to be generated.

Despite these subsidiary regulations advocating for the protection of human health and the environment from pollution by various types of wastes, and providing for the appropriate disposal management, the promotion of human health didn't receive direct attention. However, analyses of most of these regulations, information on [computer] e-waste disposal management is still scarce and almost absent in the literature. Apart from the specific e-waste management regulation (2006), all the other regulations have not addressed specific wastes such as computer e-waste. Though not specific on e-waste, promotion of human health from toxic chemicals is mostly articulated among sector Acts namely: The Occupational Safety and Health Act, The Factories Act; the Food, Drug and Chemical Substances Act and The Radiation Act.

While computer e-waste disposal management is implied in human health and environmental policies in the country, it explicitly emerged only in the Public Procurement and Asset Disposal Act, (2015) and the Environmental and Management Coordination Act (e-waste) Regulations, 2006, rather than a component along with other types of waste.

There is need for Nairobi County to adopt specific acts and regulations with robust enforcement mechanisms to govern the end-of-life of computer components and accessories. Article 4(7) of the County Government Bylaws, stipulates that the resident and trade premises within the boundary of the City County be responsible for the waste arising from the premises. However, there is no significant mention of [computer] e-waste, and this may create challenges if not reviewed to specifically cater for the handling of waste from computer components and accessories. Article 8(4), of the Bylaws, provides for segregation of wastes from non-hazardous materials. Despite this provision, the County Government has limited capacity for enforcement, labour and knowledge of computer e-waste and hence the challenge of its disposal management.

Section 68 of the Public Procurement and Asset Disposal Act (2015) provides for the development of an inventory of stores and assets management system; disposal management committees; Disposal procedure and compliance on time of disposal for unserviceable and obsolete computer components and accessories. Similarly, the Act provides for licensed persons to disposal of and to handle e-waste under section 88 of the EMCA (2015). However, by the time of collection of data, the act had not been popularized especially to the institutions

which continues to store the computer e-waste in their premises between 1-3 years before being disposed of. There is need to operationalize the Act as it provides for disposal of e-waste by NEMA certified collectors. The new Act, however, is guided by principles for Public Procurement and Asset Disposal Act (2015) for state departments, agencies and public entities based on values stipulated by the constitution of Kenya (2010) - which stipulates maximisation of value for money and incorporation of local content.

Section 126 of the Public Health Act (2012), entrusts the Minister in charge of health with policies, award powers and execution of activities related to carrying out enforcement by local authorities, magistrates, owners as listed in part (d) - the disposal of offensive liquids and the disposal of trash including all waste matters. However, the act does not provide for mitigation activities towards prevention of risks to human health and environmental degradation of the urban area, public-private partnerships, access to information and civic education of the urban populace on issues that impact on human health and the environment.

The Medium-Term Plan (2013-2017) stipulates the need for a review of the relevant policies and legislation for purposes of harmonisation with sectoral policies, legislation and regulations. This would strengthen the relevant institutions in human health and environmental regimes that are charged with computer e-waste disposal management. There is also need to maintain open government policy and continuously inform the public and the state actors the role they play in the prevention of risks to human health and the environment.

Despite the provisions of the platforms as mentioned above, the challenge is how to ensure that these elements translate into plans, policies and legislations relating to computer e-waste disposal management to provide a shift towards sustainable waste management systems approach. With the development of the National Environment Policy (GoK, 2014), and in compliance to the Stockholm and Rio Declarations Principle 21/Principle 2 (which gives responsibility to countries to exploit their natural resources according to their environmental and development policies), the County in liaison with the National Government is able to drive the environmental agenda and operationalise the Vision 2030 through adherence to the Medium-Term Plan (2013-2017).

Previous research on e-waste disposal management are centered on the general solid waste management system but no study has been undertaken with a focus on computer e-waste in

institutions, private businesses and households despite the rapid rise of use of computers which has resulted in increased volumes in waste from computer components and accessories.

7.3.3 Drivers of Sustainable Computer E-Waste Disposal Management Approaches

The study established that the following drivers are relevant in the computer e-waste disposal management namely: i) human health factors; environmental factors; economic factors; cultural factors; stakeholder attitudes; resource value; duration of use; age at purchase of new computer; technology update; broken & unrepairable; technology obsolescence; high cost of repair; and end-of-life.

It was found that respondents were in strong support of the position that human health and environmental considerations are critical to emergence, uptake and diffusion of computer e-waste disposal management approaches in Nairobi County. While such statements strongly pointed to a solid appreciation of human health and environmental importance of proper computer e-waste disposal management, they are mostly not understood by the wider public. This is because similar views were absent in the responses from middle-income households.

Participatory Approach towards Computer E-Waste Disposal Management

Many institutions and households alike indicated that the government is at the centre of the change concerning the provision of infrastructure, development of policies, legislation and policy implementation and executing stringent enforcement of regulations relating to computer e-waste disposal management. Similarly, the Nairobi County is responsible for planning and identifying disposal sites for waste emanating from its jurisdiction. This position confirms the proposition widely made in the analysis of the transforming governance space for waste management world over in which cities of developing countries are still sentenced to overreliance on governments as the chief drivers of change, with very minimal inputs from other stakeholders (Njeru, 2006; Oosteveer, 2009; Geels *et al.*, 2015).

Further, the Kenya Constitution (2010) commits state organs, non-state actors and citizens in the overall to play significant roles in preventing harm to human health and the environment. This legal stipulation is also respected under EMCA (2015) to the extent that the law creates several additional regulations and decision-making structures for public engagement, namely Environmental Impact Assessment and Environmental Audit (EIA/EA); Regulations of 2003;

the Waste Management Regulations of 2006; the Water Regulations, 2006; and Public Complaints Committee.

This policy and regulatory space are laudable considering that collective responsibilities are central to reconfiguring sustainable environmental management approaches including safe computer e-waste disposal management (UN-HABITAT, 1996; Furrady, 1992; Arora, 2008; GoK, 2015; Sikor *et al.*, 2014).

Environmental Management Systems and Computer E-Waste Disposal Management Approaches

The study observed that some businesses supported computer e-waste disposal management. These organisations were found to have strong leadership in addition to commitment of the top management to environmental protection as noted in some agencies such as KRA. The organisation had developed an environmental sustainability policy and formed an environmental management committee to implement the environmental sustainability policy.

Institutions explicitly expressed that human health and environment were the major drivers towards computer e-waste disposal management but establishing enabling structures for their disposal management remained a mirage. These results mirror the findings of Florida *et al.*, (2001) that organisational factors mattered in the adoption of environmental performance conscious and those of Henriques *et al.*, (2017) that managerial motivations on decisions regarding environmental practices were essential.

The study noted that despite a number of institutions (Figure 7.4) indicating that they had included computer e-waste disposal management in their MQA statements, the issue of adherence to the same tenants was compelled by County Government directives and performance contracting targets requirements featured prominently as opposed to compliance with human health and environmental factors. The study however established that the respondents were optimistic on prospects of including the same in their service charter (Figure 7.5).

Voluntary ISO certifications (ISO 14001:2008 EMS and ISO 9001:2004 quality system) were found to be the other organisational innovations taking place in the public institutions and private companies. Although voluntary certification is one way of showing commitment to going beyond compliance in environmental practices, there was no compelling evidence that certification of most of the public institutions with ISO 14001:2008 EMS had triggered the

emergence of culture and superior environmental performance especially on computer e-waste disposal management as was evidenced by lack of an e-waste management policy in several institutions and private companies. This is unlike the findings of Melnyk *et al*., (2003) who found that certification with the European Union Environmental Management System (EU-EMAS regulatory standard) has been associated with stronger overall environmental performance by institutions.

The findings of this study on ISO 14001:2008 EMS certification, supports the position postulated in the literature that many certified firms/institutions often fail to comply with national regulations and legislation (Prakash *et al*., 2014). For example, Dasgupta *et al*., (2000) found that adoption of ISO 14001 improved Mexican facilities' self-reported compliance with the public law. Equally Yin *et al*., (2007) found that less than 30% (as low as 10% in some cases) of ISO 14001 certified firms/institutions in China redesigned their manufacturing procedures to protect the environment. This could explain the case of most of the private companies' scenario which did not ascribe to a certified EMS, but a commitment by the top management to environmental excellence provided for waste from computer components and accessories disposal management a reality.

It is important to note that NEMA's process has a lot of bias on addressing environmental sustainability issues while the Ministry of Devolution process is wider and include economic and social facet which may have escaped NEMA's interest. Establishment of environmental units within the firm's organisational structure was assessed as one of the indicators of its commitment to integrating ecologically responsive practices. In four private companies, an environmental unit had been established. This is attested by the many government institutions and agencies that are implementing the environmental sustainability target as part of the Performance Contracting-a central Government directive to measure performance by public servants.

Weak financial position, particularly for public institutions and agencies, contributed to the inability to embrace the computer e-waste disposal management as concisely stated by NEMA. This finding reflects the charge often labelled as to institutions/private companies do not automatically embrace activities that would reduce risks to human health and environment if they are not convinced of the immediate potential of increasing their profit margins (Murphy, 2000; York *et al*., 2003a). However, robust internal leadership strategies were found to influence computer e-waste disposal management, especially with the private companies.

Public Awareness on Computer E-Waste Disposal Management Approaches

Despite the provision of public awareness in the Constitution (GoK, 2010) and the relevant legislation (GoK, 2015), the study established that a gap exists in level of public awareness vis-à-vis the computer e-waste disposal management at the institutions, private companies and the household level. Public awareness was however found to be an important driver towards sustainable computer e-waste disposal management in the Nairobi City County. There was an indication that several means of media options could enhance the public awareness on computer e-waste disposal management. In the long run the wider public would change their perceptions of poor disposal management of the computer e-waste. The study indicates that the government is responsible for public awareness and formulation of policies and strict enforcement of legislation (Figure 7.7). This unanimous standpoint mirrors the policy position of the Government as enshrined in Chapter V of the Constitution (2010) which domiciles the state to spearhead sustainable waste disposal management systems by acknowledging the regulatory tools such as environmental impact assessments and environmental audits for monitoring environmental performance.

This policy-practice trade-off raises the possibility that the state including the County Government has not ventured to put in place strategies to operationalise the provisions in the constitution to support environmental sustainability agenda, an eventuality that supports the claim often made in the environmental policy analyses in the context of low-income countries that perquisites for successful policy implementation tend to be weak (Oosteveer, 2009; World Watch Institute, 2013).

7.4   Chapter Summary

The research findings indicate that computer e-waste disposal management in Nairobi City County has not cyclonised the relationship between the social and economic and environmental aspects as required of sustainability programmes. This is an indication that the polluter-pays-principle is yet to be applied in prevention of pollution of water sources, air and soil by computer e-waste in the County. Existing management plans, policies, legislation/regulatory and institutional capability of the Nairobi County to sustainably facilitate the waste from computers is very weak especially the sector-specific regulations. Several policies, legislation, management plans relevant to computer e-waste disposal management are in existence at the county level. Overlaps among them were noted, and these sector-specific policies address different [computer e-] waste disposal management within the sector or across various sectors.

Both WRMA and NEMA has regulations on water resources management. WRMA feels that this is their mandate and NEMA feels that issues on environment as they affect water resources is their mandate. The policy-making process has been hindered by an uncoordinated approach due to the formulation at different timelines and funding by external partners with different interests. There was lack of evidence on impacts, strengths, weaknesses, opportunities of the existing policies to inform the development of new policies and legislations.

Exceptions to transboundary movement of hazardous wastes generated within Africa and of lead by the ROHs directive and lack of domestication of the Basel Convention is a major challenge and setback towards sustainability. Lack of implementation of the extended producer responsibility has hampered the shift of responsibility from the county to the manufacturers and therefore waste from computers continues to pose potential effects on human health and the environment. Lack of a national e-waste policy has hampered the operationalization of the e-waste guidelines.

The study observed that most of the regulations are developed under EMCA. They, however, all address protection of the environment but fail to incorporate protection of human health (except in the e-waste regulations) aspect. Lack of harmonisation of environmental legislations as stipulated in the Vision 2030; lack of operationalisation, unclear policy and gazettement of e-waste guidelines has been a significant challenge. Though voluntary, ISO certification is a commitment towards environmental sustainability; there was, however, no compelling evidence that this had triggered a culture and superior environmental performance especially on computer e-waste disposal management. Lack of environmental management systems in most of the institutions and private companies was a clear indication that issues of human health and environment were not a major concern as far as potential effects on human health and environment were concerned. Legislations, planning and EMS were found to be some of the enabling factors for sustainable computer disposal management approaches in the County Government. There is also a need for efficient and effective relevant regulations, which are compliant with the international standards to avoid negative impacts on human health and the environment from open computer e-waste disposal management approaches.

CHAPTER 8: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1   Summary

The use of computer components and accessories has played a significant role in making the daily activities comfortable and smooth. The study considered the sustainability of computer e-waste disposal management approaches in the public institutions, private companies, households and disposal sites under the jurisdiction of the Nairobi City County. This was inspired by the fact that despite the existence of sector-specific policies, legislation, bye-laws, management plans and e-waste guidelines governing the [computer e-] waste disposal management in Kenya, computer e-waste continues to increase.

From the waste management theory promoting the 3-Rs waste management hierarchy to the Zero e-waste management theory promoting the 7-Rs (zero waste management or zero landfill hierarchy), the research addressed four specific objectives namely: i) to identify the computer e-waste disposal management approaches; ii) to determine the potential effects of the computer e-waste disposal management approaches on human health and environment iii) to evaluate the level of public awareness of computer e-waste disposal management approaches on human health and environment; and iv) to establish planning, policy and regulatory interventions for sustainable computer e-waste disposal management approaches in Nairobi County. The public institutions, private companies and households, e-e-waste pickers/scavengers and yard shop operators provided the population of the study.

The study observed that several types of computer e-waste disposal management approaches are practiced by respondents in the households with storage in the premises being the main disposal management approach. The study also observed that the main computer disposal management approaches used by the public institutions is auctions while private companies make donations to staff and to sell to NEMA certified e-waste pickers.

All the disposal management approaches practiced by the public institutions, households and the private companies were found unsustainable. Despite becoming an everyday necessity due to changing lifestyles of the respondents, the computer e-waste, when not disposed of properly, threaten to potentially affect human health and the environment in Nairobi City County. The study also found out that there is low level of public awareness on effects of computer e-waste on human health and the environment. It was also observed that there is non-enforcement of the existing management plans, regulations and lack of hamonisation of the relevant policies.

8.2 Conclusions

Specific conclusions are presented as aligned in the research objectives of the study. The synthesis of the sustainable systems approach leads to the conclusion that environmental factors, human health factors, stakeholders' attitude resource value, and cultural factors are the key drivers towards a sustainable computer e-waste disposal management and no particular aspect of the drivers can work in isolation. The study also revealed that planning, policies, legislation, regulations, institutional frameworks, public awareness, public-private partnerships including research and development are the enablers towards a sustainable computer e-waste disposal management system. The conclusions on the scope of the research objectives are highlighted below.

8.2.1 Computer E-Waste Disposal Management Approaches

The study concluded that the public institutions and households have the riskiest e-waste disposal management approaches as far as human health and environmental degradation are concerned. This is because even the proportions of computer e-waste that are donated may end up in unqualified hands as far as the final disposal is involved. Besides, even for the other disposal management approaches, it is only the proportion of computer e-waste from private companies to certified e-waste disposal companies that may be following the appropriate procedures. However, there is need to investigate how the NEMA certified e-waste collectors and vendours who lease out computers manage the disposal of the computer e-waste they collect. These findings conclude that the majority of the computer e-waste disposal management approaches used by the public institutions, private companies and the households are not sustainable and calls for a stringent approach to computer e-waste disposal management at the Nairobi City County.

8.2.2 Potential Effects of Computer E-Waste Disposal Management Approaches on Human Health and Environment

Several pointers towards potential effects of computer e-waste on human health and environment were identified. These are the level of education and ownership of computer components and accessories; the average age of computer purchased in the institutions; duration at which they are replaced; and type of computer at the institution, private company and the household level. Different types of computer e-waste disposal management approaches were used most of which had potential effects on human health and the environment if not disposed of in an environmentally sound manner.

The Public Procurement and Asset Disposal Act (GoK, 2015) was found to contribute towards unsustainable computer e-waste disposal management approaches because it makes available the broken down and unserviceable computers to the informal sector, where the same is dismantled using crude tools without any regard to human health and environmental degradation of the urban area. The broken down and unserviceable computer e-waste remaining after the public auctions are thrown away into the landfill. If this e-waste is allowed to weather in the landfill, it releases toxic materials such as cadmium, lead and mercury into the water sources, contaminates soils and pollutes the air thus directly and indirectly negatively impacting on human health and degrades the environment of the urban space.

The process of extraction of valuable materials from waste from computer components and accessories through open burning was found to expose the workers and respondents living close to the vicinity of the dumping site to toxic chemicals thus compromising their health and degrading the environment through pollution of air, soils and water sources.

Leasing computers was found to remove the potential effects on human health and the environment from the respondents since ownership is retained by the vendor until the specified time (usually 3 years for the private university). However, leasing removes the potential effects on human health and the environment once the computer e-waste is collected by the vendor. Urban mining was found to reduce the potential effects on human health and the environment of computer e-waste.

In addition to the various disposal management approaches practiced by the stakeholders, the study concludes that risks to human health and the environment will continue due to the hidden flow of waste from computer components and accessories from high -income countries and the existence of unsustainable computer e-waste disposal management approaches.

8.2.3 *Level of Awareness on effects of Computer E-Waste Disposal Management Approaches on Human Health and Environmental Sustainability*

Despite most respondents having attained university education, the analysis of the data on knowledge level on awareness of the impact of computer e-waste on human health and environmental degradation of the urban area is low. The and knowledge of toxic components in computer e-waste is insufficient or lacking completely, and therefore, the respondents are exposed to serious human health hazards. This is an indication that the respondents lack awareness on the proper computer e-waste disposal management approaches. This might be

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due to lack of information on the potential hazards and how to dispose of the same in an environmentally sound manner. The respondents, therefore, were found to store the computer e-waste in their houses and offices or threw it away together with other county solid waste. This scenario is also echoed by Schmidt (2005) who noted that the current awareness regarding the existence and dangers of e-waste are extremely low in low-income countries than in high-income countries. The respondents' knowledge level is presumed to be related to the practice and attitude on computer e-waste disposal management approaches at the EoL partly because even when sensitization and awareness on e-waste are carried out, the stakeholders are often unwilling to participate in their disposal management. The study assumed that the respondents who know that computer e-waste is hazardous and negatively impact on their health and environmental degradation of the urban area, also know how to dispose of the computer e-waste. This is attested by the high accumulation of waste from computer components and accessories in homes and offices and low concern on the gravity of the computer e-waste flows to human health and the urban environment. The respondents were also found to lack knowledge that computer e-waste disposal management is a responsibility for all stakeholders and not the County Government alone. Likewise, the respondents living at the vicinity of the dump site, though aware of the potential effects of the waste from computer components and accessories on human health and the environment were found to value economic aspects of the e-waste as opposed to toxic effects on their health.

The study concludes that there is need for deliberate efforts towards public education and awareness campaigns on the effects of computer e-waste on human health and environment; e-waste segregation and why the e-waste should not be thrown away together with CSW through various media outlets to all stakeholders.

8.2.4 *Planning, Policy and Regulatory Interventions for Sustainable Computer E-Waste Disposal Management Approaches*

It is concluded that the County does not have strong and well-implemented management plans and policies to guide the disposal management of computer e-waste. International conventions related to computer e-waste disposal management are yet to be domesticated despite the provisions in the Constitution. As a result, the e-waste guidelines and the e-waste regulations, which are yet to be gazetted, remain inapplicable, ineffective and non-enforceable without the relevant support of relevant national policies and this has created a loophole in the e-waste disposal management system not only at the central government but also at and county

government. Sector-specific laws and policies present gaps in formulation and coordination on environmental and human health legislation because the sectoral institutions under these laws often find themselves in regulatory inconsistencies and hence the competitions. Although EMCA provides for an improved legislative and administrative coordination of the various sectoral programmes for purposes of improving the national capacity of the disposal management, it can also be concluded that the full implementation of the Act is not realized due to political interference by powerful individuals, lack of implementation of EMCA to operationalize the financial provisions in Section 57, after compliance incentives and enforcement on environmental initiatives of the relevant laws have almost made it impossible to implement the Act fully.

This scenario is compounded by factors at the corporate and institutional level such as commitment and monitoring of performance on EMS. This unfortunate scenario, exacerbated by lack of formulation and enforcement of the current management plans, policies and legislation for computer e-waste disposal management has heavily affected the sustainability of computer e-waste disposal management in the county government. This problem is compounded by human resource, reduced financial allocations and infrastructural constraints which make it difficult to enforce the existing regulations.

The study concludes that the current computer e-waste disposal management approaches have primarily focused on the short-term impacts, such as human health, environmental pollution of the air, water sources and land degradation and hence unsustainable.

8.3   Recommendations

Recommendations arising from the foregoing conclusions of this study present fundamental implications for waste from computer components and accessories disposal management in the Nairobi City County. The recommendations are based on computer e-waste disposal management approaches; potential effects of the e-waste on human health and the environment; the level of public awareness and the existing management plans, policies, regulatory interventions of computer e-waste disposal management approaches. In light of the glaring discrepancies, a lot of interventions are necessary to prevent potential effects on human health and environment. These actions border on bolstering the disposal management approaches that are aligned to multifunctional capabilities, re-engineering of policy frameworks and reimaging planning processes to solve or address computer e-waste disposal management sustainability.

8.3.1   *Computer E-Waste Disposal Management Approaches*

Since all the computer disposal management practiced by the various stakeholders are not sustainable, the study recommends the establishment of a systematic collection of computer e-waste towards zero computer e-waste or zero landfills implemented by a coordinating body. This would be done through the establishment of spatially located strategic drop off point at the residential/commercial/neighbourhood areas and county computer e-waste recycling centre where processing, sorting, reuse, refurbishing, processing and recycling will be made.

The respondents from residential/commercial/neighbouhoods, public institutions and private businesses should be encouraged to take their computer e-waste to the drop off points and the county computer e-waste recycling centre. Through this disposal management system, risks to human health and environmental degradation of the urban will be reduced. The county will engage in public-private-partnerships (PPP) in order to build a strong and sustainable infrastructure to facilitate an environmentally sound computer e-waste disposal management system. The coordinating body would also establish community centres at every Ward where old computers which are working and repairable or out of technology from the county e-waste recycling centre can be used by the communities for purposes of citizens' literacy in computer technology.

Being a responsible citizen means that one should play a role in computer e-waste disposal management by donating them for reuse, which, in itself extends the end-of-life, thus delaying disposal of the same to the landfill. There is a need to purchase computers with less toxic components, use recycled components, energy efficient and those designed for easy upgrading and separation for disposal and /or reuse.

The study also recommends the initiation of capacity building programmes and investment in relevant technology and thus reducing the potential effects on human health and the environmental degradation of the urban area. Meanwhile, there is need to follow up on what the certified computer e-waste collectors and vendours do with the computer e-waste to confirm the safety of the final disposal management approach adopted.

8.3.2 Potential Effects of Computer E-Waste Disposal Management Approaches on Human Health and Environment.

Recycling, reuse (through donations, selling as second-hand material) and refurbishment were found to extend the end-of-life of the computer e-waste thus delaying the e-waste disposal into the landfill and reducing its potential risks to human health and environment.

The study recommends the establishment of a computer e-waste disposal management system towards zero e-waste landfill. The management system will ensure that computer e-waste from all generators is disposed of sustainably and ensure zero computer e-waste and hence reduce the potential effects of the computer e-waste to human health and the environment.

8.3.3 Level of Public Awareness about Computer E-Waste Disposal Management Approaches and effects on Human Health and the Environment

The study recommends establishment of Computer E-waste Disposal Management Authority to be situated at the department of Environment at NCC or at Communication Authority of Kenya. The Authority will have the mandate to develop outreach programmes and make information available through appropriate means (e.g. websites, workshops/seminars, campaigns, media, environmental fora) and by identifying target groups with tailor-made solutions towards sustainable computer e-waste disposal management. Such outreach programmes should include the need to segregate the waste from computer components and accessories from the non-hazardous wastes. The programmes would also include the information on where to take the computer e-waste at the end-of-life.

8.3.4 Planning, Policy and Regulatory Interventions for Sustainable Computer E-waste Disposal Management Approaches

The study recommends the domestication of the Basel and Bamako Conventions; implementation of the extended producer responsibility, development of a national e-waste policy to operationalise the E-waste Guidelines and E-waste Regulations. It also recommends the formulation and enforcement of the current management plans, policies and legislation for computer e-waste disposal management. Creation of a County E-waste Management Authority (CEMA) or a department created at the Communication Authority of Kenya or City County Office is recommended to implement a Zero Computer E-waste Policy (ZCEP) in the County. In addition, the Nairobi City County fully embraces a comprehensive effective, sustainable

computer e-waste disposal management system which must include all stakeholders in the entire computer e-waste disposal management decision-making process.

8.4   Recommendation for Future Research

From this study, there is both the fundamental spatial-sector scope, as well as methodological and theoretical inferences identified for further studies related to computer e-waste disposal management practices in the Nairobi City County. While the results of this study apply to wastes from computer components and accessories, new research is required to explore possible variations when extended to all types of e-waste in the County. Similar studies should be undertaken in all counties of Kenya to quantify and generate information to facilitate planning for and implementation of sustainable computer e-waste disposal management. Further research should include the impact of economic instruments on disposal management of computer e-waste; effective and efficient tools for computer e-waste disposal management (Anfara, 2006; Johnson, 2007). The research should develop a systematic model that takes into consideration how planning, policies and regulatory interventions may affect them; generation of additional factual information to aid in decision making concerning computer e-waste disposal management strategies.

REFERENCES

Abracosa, R. P. (1987). The Philippine Environmental Impact Statement System. Stanford University P1i.D. dissertation, Stanford, CA.

Alberti, M. (1999). Urban patterns and environmental performance: what do we know? *Journal of Planning Education and Research*, *Vol. 19(2),* pp. 151-163.

Afroz, R., Masud, M. M., Akhtar, R., BtDuasa, J. B. (2012). Public Environmental Awareness and performance in Kuala Lumpur City, Malaysia. A Case Study on Household Electrical and Electronic Equipment. Journal of Environment and Urbanization, Vol. 3(2), pp. 385–396.

Adams, W. M. (2006). The Future of Sustainability: Re-thinking Environment and Development in the Twenty-first Century. Report of the UCN Renowned Thinkers Meeting. Retrieved on 13th October, 2017

Agency for Toxic Substances and Disease Registry (ATSDR). (2012). Toxicoloigcal profile for chromium. Atlanta, GA. US Department of Health and Human Services, Public Health Service.

Ahmed, S. A. (2004). Partnership for solid waste management in developing countries: linking theories to realities. Habitat International, Vol. 28, pp. 467-479.

Amechi, A. P. (2009). Poverty, Socio-Political Factors and Degradation of the Environment in Sub-Saharan Africa: The Need for a Holistic Approach to the Protection of the Environment and Realisation of the Right to Environment. Environmental and Development., 107.

Andreola, F. B. (2005). Cathode ray tube glass recycling: an example of clean technology. *Journal of Waste Management and Research, Vol. 23,* pp. 1-4.

Anfara, V. M. (2006). Theoretical Frameworks in Qualitative Research. S*age Publications Inc.*

Arora, R. (2008). Best practices for e-waste management in developing nations. GTZ-ASEM. Retrieved from http://www.ieewaste.org/pdf/9674946,

Asante-Duah, Kofi D., Frank, S., Shortreed, J. H. (1992). The Hazardous Waste Trade: can it be Controlled". *Environmental Science and Technology. Vol.26 (9)*, American Chemical Society.

Babayemi, J. O. (2009). Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria. *Journal of Applied Sciences and Environmental Management, Vol. 13 (3)*, pp. 83-88.

Balakrishnan, R. B. (2007). Electrical and Electronics waste: A global environmental problem. *Journal of Waste Management and Research, Vol. 25.*

Balakrishnan, R. B., Anand, K. P., and Chiya, A. B., (2007). Electrical and electronic waste: a global environmental problem. *Journal of Waste Management and Research, Vol. 25*, pp. 307-317.

BAN, (1991). Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa. Basel Action Network (BAN).

BAN, (2007). Basel Action Network. Silicon Valley Toxics Coalition. Exporting Harm: The High-Tech Trashing of Asia. http://www.ban.org/e-waste/ technotrashfinalcomp.pdf (Retrieved on October 2017)

Bannerman, M. (2004). Phone recycling claims called into doubt, Australia Broadcasting Commission. Retrieved on 3rd May 2015, from www.abc.net.au/7.30/content/2004/s /260911.html.

Barasa, M., Catley, A., Machuchu, D. (2008). Foot-and-mouth disease vaccination in South Sudan: Benefit–cost analysis and livelihoods impact.55. *Transboundary and Emerging Diseases, Vol. 55 (8),* pp. 339-351.

Barletta, I. L. (2016). Towards an Assessment Methodology to Support Decision Making for Sustainable Electronic Waste Management Systems: *Automatic Sorting Technology. Sustainability, Vol. 8 (1),* pp. 84. doi:doi:10.3390/su8010084

Basel Action Network (BAN). (2005). The Digital Dump: Exporting High-Tech Re-use and Abuse to Africa.

Basiago, A. (1999). Economic, social, and environmental sustainability in development theory and urban planning practice. T*he Environmentalist, Vol. 19,* pp. 145-61.

Belis, P. V., Bovea M. D., Ibáñez-Forés, V. (2014). An in-depth literature review of the waste electrical and electronic equipment context: Trends and evolution. *Waste Management & Research*, pp. 1-27.

Bell, A. (1993). Some experiments in diagnostic teaching. *Educational studies in mathematics, Vol. 24 (1),* pp. 115–137.

Bernache, G. (2003). Anticipatory governance for social-ecological resilience. *Bioplastics, Vol. 24,* pp. 1863-7999.

Beukering, V. P. (1994). An Economic Analysis of Different Types of Formal and Informal Enterpreneurs: Recovering Urban Solid Waste in Bangalore, India. *Resources, Conservation and Recycling, Vol. 12*, pp. 229-252.

Bhutta, M. K. S., Omar, A., Yang, X., (2011). Electronic Waste: A Growing Concern in Today's Environment. *Economics Research International, Vol. 11*, Article ID 474230, 8 pages.

Bradley, E. H., Curry,L. A., Devers, K. J. (2007). Qualitative Data Analysis for Health Services Research: Developing Taxonomy, Themes, and Theory. *Health Services Research, Vol 4*, pp. 1758-1772.

Bolaane, B. (2006). Constraints to promoting people centered approaches in recycling. *Habitat International, Vol. 30 (4)*, pp. 731-740.

Borthakur, A. S. (2013). Electronic Waste Management in India: A Stakeholder's Perspective. Retrieved on 5th February 2016, from https://escholarship.org/uc/item/1cq3j0b0

Boulding, K. (1980). Science: our common heritage. *Science, Vol. 207 (4433)*, pp. 831-836.

Boyd, E. N. (2015). Anticipatory governance for social-ecological resilience. A*MBIO, Vol. 44 (1)*, pp. 149–161.

Bubba, N. L. (1991). Local Government in Kenya. *Environment and Urbinization, Vol. 3 (1)*, pp. 37-59.

Campbell, S., and Fainstein, S. S. (2003)."Introduction: The Structure and Debates of

Planning Theory", in Campbell S., and Fainstein, S. S., (eds.), Readings in

Planning Theory. Malden, MA: Blackwell Publishing.

Carisma, B. (2009). Drivers of and barriers to e-waste management in the Philippines (Master's thesis). Master's thesis, Lund University, Sweden.

Castells, M. (1994). The Information City: Information Technology, Economic Restructuring and the Urban-Regional Process. In Blackwell, B., the Information. Oxford.

Charmaz, K. (2006). Constructing grounded theory: A practical guide through qualitative. CA: Sage: Thousand Oaks.

Chawla, P. N. (2012). Generation amount prediction of hazardous substances from computer waste: a case study of India. *International of Emerging Technology and Advanced Engineering, Vol. 2 (3),* pp. 482-490.

Chung, S-W., Murakami-Suzuki. (2008). A comparative Study of e-waste regulatory systems in Japan, South Korea and Taiwan fom the EPR perspetive: Implications for developing countries.

Clarke, G. (1995) Re-appraising the urban planning process as an instrument for sustainable urban development and management. In: Mosha A. C (ed) A reappraisal of the urban planning process. UN Habitat, New York, 13-28.

Cobbing, M., (2008). Toxic tech: Not in our backyard. Uncovering the hidden flows of e-waste. Report from Greenpeace International.

Coffey, M., Coad, A. (2010). Collection of Municipal Solid Waste in Developing Countries. Malta: UN-HABITAT.

Balde, C. P., Vanessa, F., Vanessa, G., Ruediger, K., Paul, S. (2017). The Global E-waste Monitor: Quantities, Flows and Resources. United Nations University, International Telecommunication Union, and International Solid Waste Association

Cui, J., Forssberg, E. (2003). Mechanical recycling of waste electric and electronic equipment: *A Review. J. Hazard, Vol. 99*, pp. 243-263.

Davis, C. (2006). Ask Earth Trends. Why is electronic waste a problem? Earth Ttrends. Environmental Information. Retrieved on 2nd June 2017, from http://earthtrends.wri.org/updates/node/130.

Davis, C. (2006). Why is electronic waste a problem? Earth trends.

Deng, W. L. (2006). Atmospheric levels and cytotoxicity of PAHs and heavy metals in TSP and PM2.5 at an electronic waste recycling site in southeast China. *Atmospheric Environment, Vol. 40 (36),* pp.6945-695.

Directive 2012/19/EU. (2012). European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment, WEEE.

Donald, J. W. (1992). The Bamako Convention as a Solution to the Problem of Hazardous Waste Exports to Less Developed Countries. *Environmental Law, Vol. 419.*

Dunlap, J. F. (2014). Sustainability. What is at Stake.

Durban Declaration. Retrieved on 10th May 2008 from http://ewasteguide.info/Durban_declaration

El-Haggar, S. (2007). Sustainable Industrial Design and Waste Management: Cradle-to-cradle for Sustainable Development. Burlington, MA, USA: Elsevier Academic Press.

Environment Protection Agency (EPA). (2007). EPA Guidelines for Environmental Management of Landfill Facilities (Municipal Solid Waste and Commercial and Industrial General Waste). South Australia: EPA

European Union (EU). (2003). Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE). *Official Journal, Vol.* 24-39.

European Union (EU) (2003). European Union Waste Electrical and Electronic Equipment (WEEE) Directive. Brussels: EU

European Union, (2008). Environment – Waste Electrical and Electronic Equipment [Internet]. Available from: (Retrieved on 3rd February 2009).

European Union, (2003a). EU RoHS Directive 2002/95/EC [Internet]. Available from: (last Retrieved on 4th May 2008).

European Union, (2003b). EU WEEE Directive 2002/96/EC [Internet]. Available from: (last Retrieved on 4th May 2008).

European Union. (2011). EU RoHS Directive, 2011/65/EC, D. (2011) on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast). *Official Journal of European Union, Vol. 1 (7).*

European Union. (2005). EuP Directive 2005/32/EC [Internet]. Available from: (Retrieved on 4th August 2015).

European Union (EU). (2011). Directive 65/EC. European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast). *Official Journal of European Union, Vol. 1 (7).*

Extended Producer Responsibility (EPR) as a form of incentive-based environmental policy. (1993). Journal of Resource Management and Technology, Vol. 21 (14).

Eygen, E. V. (2016). Resource savings by urban mining: The case of desktop and laptop computers in Belgium. Resources, Conservation and Recycling, Vol. 107, pp. 53-64.

Fagbohun. (2011). An overview of Nigeria's regulatory approach. International Summit on Regulations and Management of E-waste. Lagos. Retrieved on 5th June, 2016, from http:/elring.org/Ewaste%20Summit%20Presentation on-LAWMA.pdf

Farhan, B., Murray, A. T. (2006). Distance decay and coverage in facility location planning. *Annals of Regional Science, Vol. 40(2)*, pp. 279-295.

Fikrom, G., Kote, D. M., Abera, K., Mehamed, T. Z., AndamlakGizaw, A. (2016). Assessment of Knowledge, Attitude and Practices Among Solid Waste Collectors in Lideta Sub-city on Prevention of Occupational Health Hazards, Addis Ababa, Ethiopia. Science *Journal of Public Health, Vol 4*, pp. 49-56.

Florida, R., Davison, D. (2001). Why do firms adopt environmental practices (and do they make a difference)?", in Coglianese, C. and Nash, J. (Eds), Regulating from the Inside: Can. Washington, D.C: Resources for the Future Press.

Frazzoli, C. O., Mantovani, A. (2010). Diagnostic health risk assessment of electronic waste on the general population on developing countries' scenarios. *Environmental Impact Assessment Review, Vol. 30, (6),* p. 388–399.

Furrady, C. (1992). Garbage: exploring non-conventional options in Asian cities. *Environment and Urbanization, Vol. 4 (2)*, pp. 42-54.

Gaidajis G., Angelakoglou, A. (2010). E-waste: Environmental Problem and Current Management. *Engineering Science and Technology, Reviews, Vol. 3(1)*, pp. 193-199.

Gao, Z. L. (2004). Electronics and the Environment. I*EEE International Symposium*, pp. 127-138.

Gautam, E. N., (2017). A Study on Awareness on Electronic Waste. International Journal of *Research in Business Studies ISSN: 2455-2992, Vol. 2 (1)*, pp. 128-137.

Geels, F. M. (2015). A critical appraisal of sustainable Consumption and production Research: The reformist, revolutionary and reconfiguration positions. *Global Environmental change, Vol. 34*, pp. 1-12.

Glaser, B. G. (1967). Discovery of grounded theory: Strategies for qualitative review. Chicago, IL: Aldine.

Golev, A. Schmeda-Lopez, D. R., Smart, S. K., Corder, G. D. (2016). Where next on e-waste in Australia? *Waste Management, Vol. 58*, pp. 348-358.

Government of Kenya. (2015). Environment Management Coordination Act. *Nairobi: Government Printers.*

Government of Kenya. (1999). Environmental Management Coordination Act. *Nairobi: Government Printer.*

Government of Kenya. (2003). Environmental Management and Coordination (Environmental impact assessment and Audit) Regulations. *Nairobi: Government Printer.*

Government of Kenya. (2005). Public Procurement and Disposal Act. *Nairobi: Government Pinter.*

Government of Kenya. (2006). Environmental Management Coordination (Waste Management) Regulation. *Nairobi: Government Printer.*

Government of Kenya. (2006). Public Procurement and Disposal Regulations. *Nairobi: Government Printer.*

Government of Kenya. (2007). Water Resources Management Rules. *Nairobi: Government Printer.*

Government of Kenya. (2007). Environment Management Coordination (Controlled Substances) Regulation. *Nairobi: Government Printer.*

Government of Kenya. (2007). Environment Management Coordination (Water Quality) Regulation. *Nairobi: Government Printer.*

Government of Kenya. (2008). Vision 2030. Nairobi: Government Printer.

Government of Kenya. (2009). Environment Management Coordination (Air Quality) Regulation. *Nairobi: Government Printer.*

Government of Kenya. (2010). Constitution of Kenya. Nairobi: Government Printer.

Government of Kenya. (2012). Water Policy. *Nairobi: Government printer.*

Government of Kenya. (2014). National Environment Policy. Nairobi: Government Printer.

Government of Kenya. (2015). Public Procurement and Asset Disposal Act. *Nairobi: Government Printer.*

Government of Kenya. (2016). Environmental Management Coordination (E-waste) Regulation. *Nairobi: Government Printer.*

Government of Kenya. (2016). Water Act. *Nairobi: Government printer.*

Grant, K. G.-N. (2013). Health consequences of exposure to e-waste: (T. L. Health, Ed.) ScienceDirect, 1 (6), e350-e361. Retrieved from www.thelancet.com/lancetgh.

Greenpeace website: http://www.greenpeace.org/raw/content/international /press/reports/switching on/

Grimes, D. A. (2002). Bias and causal associations in observational research. *The Lancet, Vol. 359*, pp. 248–252.

Guerrero, L. A. (2013). solid waste management challenges for cities in developing countries. *Waste Management, Vol. 33*, pp. 220-232.

Gutberlet, J. (2015). Cooperative urban mining in Brazil: Collective practices in selective. *Waste Management*, pp. 1-10.

Hake, A. (1977). African Metropolis Nairobi's self-help city. London: Chattus and Windu.

Hammal F., Mock, J., Ward, K. D. (2005). Settling with danger: conditions and health problems in peri-urban neighbourhoods in Aleppo, Syria. *Environment and Urbanization, Vol. 17 (2)*, pp. 113-125.

Hanapi, B. M. (2006). Selective Liquid=liquid extraction of precious metals from semiconductor wastes. University, Teknlogi, Chemical Engineering Faculty of Chemical and Natural Resources Engineering. Retrieved on 23rd May, 2015, from http://eprints.utm.my/2743/1/72157.pdf

Haregu, T. N. (2017). An assessment of the evolution of Kenya's solid waste management policies and their implementation in Nairobi and Mombasa: analysis of policies and practices. *Environment and Urbanization, Vol. 29 (1)*.

Heacock, M. K. (2016). E-Waste and Harm to Vulnerable Populations: A Growing Global Problem. *Environ Health Perspect, Vol. 124 (5)*, pp. 550–555.

Heacock, M.; Kelly, C. B.; Asante, K. A.; Birnbaum, L. S.; Bergman, Å. L.; Bruné, M.-N.; Buka, I.; Carpenter, D. O.; Chen, A.; Huo, X.; et al., (2015). E-Waste and Harm to Vulnerable Populations: A Growing Global Problem. *Environ. Health Perspect. Vol. 124,* pp. 550–555.

Henriques, I. S. (2017). The Relationship Between Environmental Commitment and Managerial Perceptions of Stakeholder Importance. Academy of Management, 42 (1). Retrieved on 12th May, 2017, from https://doi.org/10.5465/256876

Henslin, J. M. (2001). Sociology: A Down-to-Earth Approach. Boston: Allyn & Bacon.

Herat, S. A. (2012). E-waste: A problem or an opportunity? Review of issues, challenges and solutions in Asian countries. *Waste Management & Research,* pp. 1-18.

Hicks, C. D. (2005). The recycling and disposal of electrical and electronic waste in China-legislative and market responses. E*nvironmental Impact Assessment Review, Vol. 25*, pp. 459-471.

Hirji, R. F. 1990. Institutionalizing Environmental Impact Assessment in Kenya. Stanford University. Ph.D. dissertation. Stanford. CA.

Hischier, R. W. (2005). Does WEEE recycling make sense from an environmental perspective: The environmental impacts of the Swiss takeback and recycling systems for waste electrical and electronic equipment (WEEE). *Environmental Impact Assessment Review, Vol. 25,* pp. 525-539.

Horne R. E., G. J. (2006). A Literature Review on the Environmental and Health Impacts of Waste Electrical and Electronic Equipment-2. International Policy and Regulation.

Hossain. (2010). E-waste: Bangladesh Situation. Study Report. Environment and Social Development Organization (ESDO). In D. Dewitt, D. Haglund, & J. Kirton (Eds.). Building a new global order: Emerging trends in international security.

Hostovsky, C. (2000). Integrating planning theory and waste management-an annotated bibliography. *Journal of Planning Literature, Vol. 15 (2)*, pp. 305-332.

Hyden, G. (1998). Governance and conservation and development. In Hyden, G. (ed). Governance issues and Conservation and Development. *Gainesville, Fla. Conservation and Development Forum*, pp. 1-9

Islam, M. T., Abdullah, A. B., Shahir, S. A., Kalam, M. A. Masjuki, H. H., Shumon, R., Rashid, H. (2016). A public survey on knowledge, awareness, attitude and willingness to pay for WEEE management: Case study in Bangladesh. *Journal of Cleaner Production Vol. 20,* pp. 728-740.

ITC (2004). "Urban Poverty and Slums in Nairobi". International Institute for Geo-Information Science and Earth Observation. *http://www.itc.nl/news_events/archive/projects/ urban_poverty_nairobi.asp* (Retrieved on 18th November 2018)

ITU (2014). Obtained at ITU News: http:/www.itu/ITU-T/newslog/New+agenda+seeks+To+Transform+Ewaste+into+Opportunity.asp ex.

Iyer, L. S., (2018). Knowledge, Attitude and Behaviour (KAB) of Student Community Towards Electronic Waste – A Case Study. I*ndian Journal of Science and Technology, Vol 11(10)*, DOI: 10.17485/ijst/2018/v11i10/109038.

Jain, R. K. (1984). Formulation of environmental regulations. *Journal of Environmental Engineering, Vol. 110 (4)*, pp. 770 – 779.

Japan International Cooperation Agency (JICA). (1998, April, 2015 5). The study on solid waste management in Nairobi City in the Republic of Kenya final report. Japan International Cooperation Agency (JICA); in collaboration with CTI Engineering and Environmental Technology Consultants. Retrieved from http://lvzopac.jica.go.jp/external/library.

Jessen, M. (2003). Discarding the Idea of Waste: The Need for a Zero Waste Policy Now. Nelson, Canada: Zero Waste Services.

Johnson, B. C. (2007). Educational Research Quantitative, Qualitative, and Mixed Research.

Kahhat, R., Kim, J., M., Xu, Allenby, B., Williams, E., Zhang, P. (2011). Exploring E-waste Management Systems in the United States. *Resources, Conservation and Recycling, Vol. xxx,* pp. 1-10

Kalana, J. A. (2010). Electrical and Electronic Waste Management Practice by households in Shah Alam. *International Environmental Sciences, Vol. 1 (2)*, pp. 132-144.

Kang, H. Y. (2005). Electronic waste recycling: A review of U.S. Resources, *Conservation and Recycling, Vol. 45*, pp. 368–400.

Kenya National Bureau of Statistics (CBS), Ministry of Finance and Planning. (2009). Statistical Abstract. Nairobi: Government Printer.

Kennedy, C., Pincetl, S., Bunje, P., (2010). The study of urban metabolism and its applications to urban planning and design, *Environmental Pollution, Vol. xxx*, pp. 1-9

Kerlinger, F. N., (1993). Behavioral Research: A conceptual approach. New York: Holt Reinhert and Winston Inc.

Kerlinger, F. N. (1983). Foundations of Behavioral Research (2nd Edition). New Delhi: Surject Publications.

Khetriwal, D. S. (2009). Producer responsibility for e-waste management: Key issues for consideration. *Journal of Environmental Management*, pp. 1-13.

Kiddee, P. N. (2013). Electronic waste management approaches: An overview. *Waste Management, Vol. 33,* pp. 1237-1250.

Kimani N. (2010). Participatory Aspirations of Environmental Governance in East Africa. 6/2 Law Environmental and Development Journal, pp 200. Available at http//www.lead.journal.org/10200.pdf, Retrieved on 1st September, 2017.

King, M. F. Gutberlet, J. (2013). Contribution of cooperative sector recycling to greenhouse gas emissions reduction: A case study of Ribeirão Pires, Brazil. *Waste Management, Vol. 33 (12)*, pp. 2771-2780.

Kombo D. K., Tromp T. D. (2006). Proposal and thesis writing: An introduction. Paulines Publications Africa.

Kothari, C. (2004). Research methodology: Methods and techniques. New Delhi: New Age International (P) Limited Publishers.

Kuehr R., M. F. (2009). Recycling-from e-waste to resources, Sustainable innovation and technology transfer industrial sector studies. United Nations Environment.

Kuehr, R. (2003). Managing PCs through Policy: Review and Ways to Extend Lifespan. In Kuehr, R. and Williams, E (Eds.). Computers and the Environment: Understanding and Managing.

Kuhn, T. (1962). The structure of scientific revolutions. Chicago. Chicago: University Press.

LeBel, S. (2012). Wasting the future: The technological sublime, communications technologies, and e-waste. *Communications +1, (Article 7),* pp. 1-19.

Lee, C. H. (2004). An overview of recycling and treatment of scrap computers. *Journal of Hazardous Materials, Vol. 114*, pp. 1–3).

Lee, J. Y. (2009). Novel pre-treatment process for liberation of metals from waste printed circuit boards using organic solution. Washington, DC, USA: Patent Publication No.: WO/2009/064063.

Leedy, P. D. (2005). Practical Research Planning and Design (5thed.). New Jersey: Pearson Merrill Prentice Hall.

Lewa, S. (2012). Management and Organisation of Public Procurement in Kenya. A Review of proposed changes, discussion paper No. 92, Institute of Policy Analysis and Research, Nairobi.

Lifset, R. (1993). Take it back: Extended producer responsibility as a form of incentive-based environmental policy. Journal of Resource Management and Technology.

Lifset, R. L. (2008). Producer responsibility at a turning point? *Journal of Industrial Ecology. Journal of Industrial Ecology, Vol. 12(2)*, pp. 144-147.

Lilian, Y. (2006). The Basel Convention and Global Environment (Non) Governance: T*rasformismo and the Case of Electronic Wastes. Vol. 3 (1),* pp. 23-33..

Lindhqvist, T. (2000). Extended Producer Responsibility in Cleaner Production: Policy Principle to Promote Environmental Improvements of Product Systems. Ph.D Thesis. *Sweden: IIIEE, Lund University.*

Lis, C. J. (1993). Limits of pollution prevention. *Society, Vol. 30 (3)*, pp. 49-55.

Lober, D. J. (1995). Resolving the siting impasse: modeling social and environmental location criteria with a Geographic Information System. *Journal of the American Planning Association, Vol. 61(4),* pp. 482-495.

Lumbreras, M. J. (2014). Comprehensive solid waste management: The Ciudad Saludable model in Peru.

Macauley, M., Palmer, K., Shih, J. S. (2003). Dealing with electronic waste: modeling the costs and environmental benefits of computer monitor disposal. *Journal of Environmental and Management, Vol. 68 (1),* pp. 13-22.

Makokha, G. L., Chris, S. (2010). Trends in Mean Annual Minimum and Maximum Near Surface Temperature in Nairobi City, Kenya. *Hindawi Publishing Corporation Advances in Meteorology Volume 2010, Article ID 676041*, pp. 1-6 .

Mallawarachchi, H., Karunasena, G. (2012). Electronic and electrical waste management in Sri Lanka: suggestions for national policy enhancements. *Resour Conserv Recycl Vol. 68,* pp. 4-53.

Mathias, S., Christian, H., Ruediger, K., Federico, M., Claudia, M., Christina, M., Esther, T. M., Wang, Feng, W. (2009). Recycling - from e-waste to resources. *United Nations Environment Programme and United Nations University. Germany.*

Matrix Development Consultants (1993). "Nairobi Informal Settlements: An Inventory". *US Agency of International Development/DISC, Arlington, USA*

Melnyk, S., Sroufe, R. P., Calantone, R., (2003). Assessing the impact of environmental management systems on corporate and environmental performance. *Journal of Operations Management Vol. 21*, pp. 329–351.

Mansell, R. (1998). Knowledge Societies: Information Technology for Sustainable Development, Oxford: Published for the United Nations Commission on Science and Technology for Development. *Oxford University Press. Mansfield, E. (1963).*

Marini, M. M. (1988). Causality in the social sciences. *Sociological Methodology, Vol. 18,* pp. pp. 347-409.

Marshall, R. E. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste Management, Vol. 33*, pp. 988-1003.

Martín, J, L., García, L. F., (2014). Comprehensive solid waste management: The Ciudad Saludable model in Peru. Retrieved 10th February 2016. *http://idbdocs.iadb.org/wsdocs/getDocument.aspx?DOCNUM=39168981*

Mayers, K., Lifset, R., Bodenhoefer, K., Wassenhove, L. K. V. (2013). Implementing individual producer responsibility for waste electrical and electronic equipment through improved financing. *Journal of Industrial Economy. https://doi.org/10.1111/j.1530-9290.2012.00528.x.* Retrieved on 4th March, 2015.

Mbugua, J. P. (1992). Integrating environments with physical planning. *A Review in A.C. Mosha (Ed) Ibid*, pp. 132-141.

McDonough, W., Braungart, M. (2002). Cradle to Cradle: Remaking the Way We Make Things, 1st ed. New York, USA: North Point Press.

Melnyk, S. A. (2003). Assessing the impact of environmental management systems. *Operations Management, Vol. 21*, pp. 329-351.

Meskers, C. (2009). Umicore Precious metals Refining. Guest Lecturer presentation for e-waste recycling. Delft, Netherlands: Delft University of Technology.

Milea, A. (2009). Waste as a social dilemma: Issues of social and environmental justice and the role of residents in Municipal Solid Waste management. *Master's Thesis, Lund, Sweden. Delhi, India.*

Miles M. B., Huberman, M. A. (1984). Drawing Valid Meaning from Qualitative Data: Toward a Shared Craft. American Educational Research Association. *Educational Researcher, Vol. 13 (5),* pp. 20-30.

Ministry of Devolution and Planning (MoDP). (2013). Second MediumTerm Plan 2013-2017. Nairobi.

Ministry of Environment and Natural Resources. (2010). Guidelines for E-waste Management in Kenya. Nairobi: National Environment and Natural Resources (NEMA).

Ministry of Health (MoH). (2014). Kenya Health policy 2014-2030. Policy 2014–2030, Ministry of Health, Nairobi.

Ministry of Information, Communication and Technology (MoICT). (2016). National Information and Communication Technology Policy. Nairobi: Government Printer.

Mitullah, W. (2003). "Understanding Slums: Case Studies for the Global Report on Human Settlements 2003: The Case of Nairobi, Kenya". *UNHABITAT, Nairobi*.

Moeller, D. W. (2005). Environmental Health (3rded.). Cambridge, MA: *Harvard University Press. Cambridge, MA: Harvard University Press.*

Mol, A. P. (2010). Social theories of environmental reform: towards a third generation. In M. Gross & H. Heinrichs (eds.). (p.19-38). *London: Springer. Environmental Sociology: European perspectives and Interdisciplinary Challenges*, pp. 19-38.

Moore, J. W. (2015). Putting Nature to Work In C. Wee, J. Schönenbach, J. & Arndt O. (Eds.). Supramarkt: *A micro-toolkit for disobedient consumers, or how to frank the fatal forces of the Capitalism, Irene Books, Gothenburg,* pp. 69-117. History & the Crises of Capitalism, P.M Press, Oakland

Mosler, H-J., Tamas, A., Tobias, R. (2008). Deriving Interventions on the Basis of Factors Influencing Behavioral Intentions for Waste Recycling, Intentions for Waste Recycling, Composting, and Reuse in Cuba. *Environment and Behavior, Vol. 40 (4),* pp. 522-544.

Mou, P. W. (2004). Deriving interventions on the basis of factors influencing behavioral intentions for waste recycling, composting and reuse in Cuba. IEEE *International Symposium on Electronics and the Environment*, pp. 237-242.

Mrayyan, B. H. (2006). Management approaches to integrated solid waste in industrialized zones in Jordan. *Waste Management, Vol. 26 (2)*, pp. 195-205.

Mugenda, O. M. and Mugenda, A. G. (2003): Research Methods: Qualitative and Quantitative Techniques. Africa Centre for Technology Studies, Nairobi, Kenya.

Mulwa, J. K., Gaciri, S. J., Barongo, J. O. (2005). Geological and Structural influence on groundwater distribution and flow in Ngong area. *Africa Journal of Science and echnology, Science and Engineering Series, Vol. 6 (1)*, pp. 105-115.

Mureithi, M. W. (2008, April 10). E-waste Management in Kenya. Kenya ICT Action Network (KICTANet).

Nakamura, K. (1967). City temperature of Nairobi. *Japanese Progress in Climatology*, pp. 61-65.

Nartey K. V. (2016). Environmental and Health Impacts of Informal E-waste Recycling in Agbogbloshie, Accra, Ghana: Recommendations for Sustainable Management. Bonn, Germany: Rheinische Friedrich-Wilhelms-Universität Bonn.

Nairobi population (2019). **worldpopulationreview.com.** http://worldpopulationreview.com/world-cities/nairobi-population/. Retrieved on 9th March 2019.

Nakamura, K., (1967). City temperature of Nairobi. *Japanese Progress in Climatology*, pp. 61-65.

National Environment Management Authority (NEMA). (1999). Nairobi: NEMA.

Nath, B., Kumari, R., Gupta, V., Vaswhani, N. D., Lekhwani, S. (2018). A community-based study on e-waste disposal in Srinagar. I*nternational Journal of Community Medicine and Public Health. Vol 5(8),* pp. 3429-3434.

National Environment Management Authority. (2010). Kenya State of the Environment and Outlook. Nairobi: NEMA.

National Council for Population Development (NCPD), Sessional Paper No. 3 (2012). *Population Policy for National Development.*

Network, B. A. (2005). The digital dump: exporting re-use and abuse to Africa. Basel Action Network (BAN). In: Puckett J, editor. A project of Earth Economics.

Njeru, J. (2006). The urban political ecology of plastic bad waste problem in Nairobi, Kenya.*Geoforum, Vol. 37,* pp. 1046-1058.

Njoroge, B. N. (2007). Nairobi e-waste dump threatens lives of hundreds of children. Retrieved on 13th May 2016, from http://www.terradaily.com/reports/Nairobi_e-waste_dump_threatens_lives_of_hundreds_of_children_999.html

Nnorom, I. C, Osibanjo, O. (2008) Overview of electronic waste (e-waste) management practices and legislations, and their poor applications in the developing countries. *Resource Conservation Recycling, Vol. 52(6),* pp. 843-858

Nsengimana, H. B., Bizimana, J. P. (2011). Assessment of e-wastes status and trends in Rwanda and development of recommendations for the prevention and management of e-wastes. REMA, Rwanda.

Nyakang'o, J. (2015). Application of ecological modernisation in effluent pollution prevention: Analysis of innovations and drivers in the sugar industry within Nyando Basin, Kenya. *Ph.D Thesis. Nairobi, Kenya.*

Obisanjo, I. N. (2007). The challenges of electronic waste (e-waste) management in developing countries. Waste Management & Research, International Solid Waste Association, 6, 489-501. *Waste Management & Research, International Solid Waste Association, Vol. 6 (25),* pp. 489-501.

O'Connell, E. J. (2011). Increasing public participation in municipal solid waste reduction. *Geographical Bulletin, Vol. 52 (2),* pp. 105-118.

Odegi-Awuondo, C. (1994). Garbage Collection: A survival strategy for Nairobi's urban poor. In Odegi-Awuondo, C., Haggai, Namai, B., & Mutsoto, M. (eds.) *Masters of survival. Nairobi: Basic Books,* pp. 45-62.

OECD, by Smith, S. (2005). Analytical framework for evaluating the costs and benefits of extended producer responsibility programmes.

Ongondo, F. W. (2011). How are WEEE doing? A global review of the management of electrical and electronic wastes. *Waste Management, Vol. 31*, pp. 714-730.

Oosterveer, P. (2009). Urban environmental services and the state in East Africa; between neo-developmental and network governance approaches. *Geoforum, Vol. 40 (6)*, pp. 1061-1068.

Oteng-Ababio. (2012). Electronic Waste Management in Ghana-Issues and Practices Book on Sustainable Development. Authoritative and Leading-Edge Content for Environmental Management. http://cdn.intechpen.com / pdf / 38097 / InTech_elctronics_waste_management_ghana_issues_and_practices-pdf. Retrieved on 5th January 2016.

Oyake-Ombis, L., van Vliet, B. J. M., Mol, A. P. J. (2015). Managing plastic waste in East Africa: Niche innovations in plastic production and solid waste. *Habitat International, Vol. 48*, pp. 188-197.

Oyake-Ombis, L. (2012). Managing plastic waste in urban Kenya: *Niche innovations in production and recycling, Ph.D Thesis. Wageningen, Netherlands.*

Peeranart, K., Ravi, N., Wong, Ming, W. (2013). Electronic waste management approaches: An overview. *Journal of Waste management (New York), Vol. 33*

Palinkas, L. A., Horwitz, S. M., Green, C. A., Jennifer P. Wisdom, J. P., Duan, N., Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Adm Policy Ment Health. Vol. 42(5)*, pp. 533–544.

Palmer, P. (2005). Getting to Zero Waste. USA: Purple Sky press.

Patil, K, (2016). Macro Perspective: E-Waste Environmental impacts. *International Journal of Applied Engineering Research ISSN 0973-4562 Vol.11 (7)*, pp. 4866-4873.

Pérez-Belis, V., Bovea, M. D.,Ibáñez-Forés V. (2014). An in-depth literature review of the waste electrical and electronic equipment context: trends and evolution. *Waste Management and Research, Vol. 33 (1)*, pp. 3-29.

Phillip, P. C. (2002). UK county sustainable waste management program. *International Journal of the Environment and Sustainable Development, Vol. 1 (1)*, pp. 2-19.

Polanyi, M. (1968). Logic and psychology. *American Psychologist, Vol. 23(1)*, pp. 27-43.

Pongrácz, E. (2002). Re-defining the Concepts of Waste and Waste Management Evolving the Theory of Waste Management. Doctoral Desertation, *University of Oulu, Process and Environmental Engineering, Oulu.*

Porter, R. C. (2002). The Economics of Waste, Resources for the Future. Washington D.C:

Poswa, T. (2001). A comparison of attitudes towards and practices of waste management in three different socio-economic residential areas of Umtata. *Master's Thesis, Durban University of Technology. KwaZulu-Natal, South Africa.*

Pradhan, J. K, Kumar S. (2014). Informal e-waste recycling: environmental risk assessment of heavy metal contamination in Mandoli industrial area, Delhi, India. *Environ Sci Pollut Res*, *Vol. 21*, pp. 7913-28.

Prakash, A. P, Potoski, M. (2014). Global Private Regimes, Domestic Public Law: ISO 14001 and Pollution Reduction. *Comparative Political Studies, Vol.14 (3).*

Pratt, B., Loizos, P. (1992). Choosing research methods. Data collection for development workers. *Development Guidelines Vol. 7.*

Puckett, J. W. (2005). The digital dump. Exporting re-use and abuse to Africa. Basel Action Network, Seattle.

Puckett, J., Byster, L., Westervelt, S., Gutierrez, R., Davis, S. (2002). Exporting harm: the high-tech trashing of Asia. The Basel Action Network (BAN) and Silicon Valley Toxics Coalition (SVTC).

Quaghebeur, M., Laenen, B., Geysen, D., Nielsen, P., Pontikes, Y., Van Gerven, T., Spooren, J. (2013). Characterization of landfilled materials: screening of the enhanced landfill mining potential. *Journal of Cleaner Production, Vol. 55*, pp. 72-83.

Rao, L. N. (2014). Environmental Impact of Uncontrolled Disposal of E-Wastes. *ChemTech Research, Vol. 6 (2),* pp. 1343-1353.

Rakodi, C. (1997). "The Urban Challenge in Africa: Growth and Management of its Large Cities". United Nations, University Press, Tokyo. http://www.unu.edu/unupress/unupbooks/uu26ue/uu26ue00.htm (Retrieved on 29th December 2018)

Resource savings by urban mining: The case of desktop and laptop computers in Belgium. (2016). *Resources, Conservation and Recycling*, pp. 53-64

Eygen, E. V., Meester, S. D., Phuong, H. T., Dewulf, J. (2016). Resource savings by urban mining: the case of desktop and laptop computers in Belgium. *Resources conservation and recycling. Vol. 107*. pp. 53-64

Ribeiro, E. F. (1992). Inter-sector coordination in the planning and implementation of sustainable human settlements development management. In the A.C. Mosha Ibid.

Ritu S., Shalini, A. (2013). Knowledge of E-waste Among Young Adults. International *Journal of Engineering Science Invention, Vol. 2 (7)*, pp. 39-41.

Robinson, B. H. (2009). E-waste: an assessment of global production and impacts. *Science of the Total Environment, Vol. 408 (2)*, pp. 183-191.

Robinson, J. T. (1998). Reconciling ecological economic, and social imperatives. The corner stone of development; integrating environmental, social, and economic policies. *In J. Schnur & S. Holtz (eds.) (pp. 9-4). Boca Raton, FL: Lewis Publishers.*

Rousis, K. (2008). Multi-criteria analysis for the determination of the best. *Waste Management, Vol. 28*, pp. 1941–1954.

Ruchi, K. G. (2017). A review paper on perspective of e-waste and environmental impact. *Journal of Advanced Technology for Science & Engineering Research, Vol. 2 (7)*, pp. 37-47.

Sachs, N. (2006). Planning the Funeral at the Birth: Extended Producer Responsibility. *Harvard Environmental Law Review, Vol. 30*, pp. 51-98.

Saggerson. (1991). Geology of the Nairobi area. Government of Kenya, Mines & Geological, Nairobi.

Saritha, V., Kumar, S. K.A., Srikanth, V. N. (2015). Consumer attitudes and perceptions on electronic waste: an assessment. *Pollution, Vol. 1 (1)*, pp. 31-43.

Sasaki, K. (2004) Examining the Waste from Electrical and Electronic Equipment Management Systems in Japan and Sweden. *Dissertation, Lund University, Sweden.*

Sasitharan, N. R. (2012). Issues on Construction Waste: The Need for Sustainable Waste Management - *Scientific Figure on ResearchGate.*

Scholarly articles for (1977). Privacy Protection Study Commission. Personal Privacy in an information society.

Satvir, K. (2016). E-Waste Management: A Burning Issue In Present Scenario. *International Journal of Innovative Research and Advanced Studies, Vol. 3 (11).*

Saxena, M. K. (2014). E-waste awareness, generation, strategies and programmes. *International Journal of Education for Human Services, Vol. 4 (2).*

Schluep M., Hagelüken, C., Kuehr, R., Magalini, F. (2009). Recycling–from E-waste to Resources. *United Nations Environment Programme and United Nations University. German.*

Schmidt, C. W. (2002). E-junk explosion. Environ. *Health Perspect, Vol. 110*, A188-A194.

Schmidt, C. W. (2006). Unfair trade -E-waste in Africa. *Environ Health Perspect. Vol. 114*, A232–235.

Seadon, J. B. (1999). Towards zero waste in Aukland City. *Second Asia-Pacific Cleaner Production Roundtable*. Brisbane, Australia.

Shah, A., Dhakal, T., Pandey, T., (2014). An Assessment of Public Awareness Regarding E-Waste Hazards and Management Strategies; Independent Study Project (ISP) Collection, SIT World Learning-India: *Sustainable Development and Social Change*, pp. 1-48.

Sepúlveda, A. S. (2010). A review of the environmental fate and effects of hazardous substances released from. *Environmental Impact Assessment Review, Vol. 30*, pp. 28-41.

Shamim, A. A. (2015). E-Waste Trading Impact on Public Health and Ecosystem Services in Developing Countries. *International Journal, Vol. 5 (4).*

Sikor, T. N. (2014). Globalising Environmental Justice. *Geoforum, Vol. 54*, pp. 151-157.

Silveira, G. T. R., Chang S-Y. (2010). Cell phone recycling experiences in the United States and potential recycling options in Brazil. *Waste Management Vol. 30(11)*, pp. 278–229

Sookman, D. A. (2005). Subtypes of Obsessive-Compulsive Disorder: Implications for Specialized Cognitive Behavior Therapy. *Behavior Therapy, Vol. 36 (4)*, pp. 393-400.

Suja, F., Rahman, R. A, Yusof, A., Shahbudin, M. (2014). E-Waste management scenarios in Malaysia. J*ournal of Waste ManagementVol.2014:609169.*

Sunil, H. A. Periathamby, A. (2012). E-waste: a problem or an opportunity? *Waste Management & Research*, pp. 1-18.

Terada, C. (2012). Recycling electronic waste in Nigeria: Putting environ. NW. *International Human Rights, Vol. 10 (3)*, pp. 154.

Thorndike R. L., Hagen, E. (1955). Measurement and evaluation in psychology and education. New York: Joahn Wiley & Sons.

Thyberg, K. L. (2015). Drivers of food waste and their implications for sustainable policy development. Resources. *Conservation and Recycling*, pp. 1-30.

Tiep, H. S. (2012). Factors influencing household electronic waste recycling intention. A*dvanced Materials Research Vol. 622-623*, pp 1686-1690

Tiep, H. S. (2015). E-Waste management practices of households in Melaka. *International Journal of Environmental Science and Development, Vol. 6* (11), pp. 811-817.

Tietenberg, T. L. (2010). Environmental economics and policy. Pearson, New York. Pearson.

Tocho, J. A. (2013). Towards an e-waste management framework in Kenya. info. *The journal of policy, Vo. 15 (5)*

Tsalis, T. A., Nikolaou, I. E., Grigoroudis, E., Tsagarakis, K. P. (2013). A framework development to evaluate the needs of SMEs in order to adopt a sustainability-balanced scorecard. *Journal of Integrative Environmental Sciences, Vol. 10 (3-4)*, pp. 179-197

United Nations Environment Programme (UNEP). (1989). Basel convention on the control of transboundary movements of hazardous wastes and their disposal, United Nations Environment Programme/Secretariat of the Basel Convention. Retrieved on http:/www.basel.int/text/documents.html.

United Nations Environment Programme (UNEP). (2006). Basel Convention. Creating innovative solutions through the Basel Convention for the environmentally sound management of electronic wastes. In Conference. Geneva.

United Nations Environment Programme (UNEP). (2006). Call for Global Action on E-waste.

United Nations Environment Programme (UNEP). (2009). Recycling-From e-waste to Resources: Nairobi: Sustainable Innovation and Technology Transfer Industrial Sector Studies.

United Nations Environment Programme (UNEP). (2010). Press release: *Urgent need to prepare developing countries for urge in e-waste.* Nairobi.

United Nations Environment Programme (UNEP) and Basel Convention. (2012). *Pan-African Forum on E-waste.* Nairobi.

United Nations (UN). (1972). *Conference on the Human Environment* . Stockholm.

United Nations. (1995). Beijing Conference Report.

United Nations. (2011). *Shanghai Manual–A Guide for Sustainable Urban Development in the 21st Century.*

United Nations Centre for Human Settlement (UNHABITAT). (2009). *Solid Waste management in the World's Cities:.* Nairobi: UN-HABITAT.

United Nations Conference on Environment & Development (UNCED). (1992). *Sustainable Development.* Rio de Janerio.

United Nations Environment Programme (UNEP), (2012). Urgent need to prepare developing countries for surges in e-waste. Retrieved on 12th October, 2016, from http://www.unep.org/Documents.Multilingual/

United Nations Environment Programme (UNEP), (2012). Pan-African Forum on E-waste. Nairobi.

United Nations Environment Programme (UNEP). (2010). *Integrated Solid Waste Mangement PLan (2010-2020).* Nairobi.

United Nations Environment Programme (UNEP). (2006). Call for Global Action on E-waste, United Nations Environment Programme.

United Nations Environment Programme (UNEP). (2005). The Hidden Side of IT Equipment's Manufacturing and Use: *Early Warnings on Emerging Environmental Threats no. 5.*

United Nations Environmental Programme (UNEP). (2006). *Nairobi ministerial declaration on the environmentally sound management of electronic and electrical waste.* Nairobi.

Wäger P. A., Hischier, R., Eugster, M. (2011). Environmental impacts of the Swiss collection and recovery systems for waste electrical and electronic equipment (WEEE): a follow-up. *Science Total Environnment, Vol. 409(10)*, pp. 1746–1756.

Wath, S. B, Dutt, P. S., Chakrabarti, T. (2011). E-waste scenario in India, its management and implications. *Environ Monit Assess, Vol. 172*, pp. 249–262.

Wath, S. B. (2010). E-waste scenario in India, its management and implications. *Environ Monit Assess, Vol. 2 (5)*, pp. 436-458.

Wath, S. B., Vaidya, A. N., Dutt, P. S., Chakrabarti, T. (2010). A roadmap for development of sustainable E-waste management system in India. Science of The Total Environment, *Vol. 409 (1)*, pp. 19-32.

Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D. (2005*)*. Global perspectives on E-waste. *Environmental Planning and Management, Vol. 25 (5)*, pp. 436-458.

Waltner-Toews, D., Kay, J., Lister, N. M. E. (2008). The ecosystem approach: complexity, uncertainty, and managing for sustainability. *New York: Columbia University Press*

Williams, E. (2003). Extending the PC lifespan through secondary markets for future work. *IEEE International Symposium on Eloectonics and the Environment*, pp. 255-259.

Wilson, D. C. (2006). Role of informal sector recycling in waste management indeveloping countries. *Habitat International, Vol. 20*, pp. 797-808.

Wilson, D. C. (2007). Development drivers for waste management. *Waste Management Research, Vol. 25*, pp. 198–207.

Wilson, D. V. (2006). Role of informal sector recycling in waste management in developing countries. 30. *Habitat International, Vol. 30*, pp. 797-808.

Wong, C. S. C., D-Aydin, N. S., Wong, H. M. (2007). Evidence of excessive releases of metals from primitive e-waste processing in Guiyu, China. *Environment Pollution, Vol. 148*, pp. 62–72.

World Commission on Environment and Department (WCED). (1987). *Our Common Future.* London: Oxford University Press.

World Resources Institute, UNEP, UNDP, World Bank (1996). World Resources, *The Urban Environment. New York: Oxford University Press.*

Xuefeng, W. Y. (2005). Study on metals recovery from discarded printed circuit boards by physical methods, electronics and Environment. IEEE *International Symposium*, pp. 121-128).

Yadong L. i., Richardson, J. B., ; Aaron K. Walker, A. K., Pao-Chiang Yuan, P-C. (2006). TCLP heavy metal leaching of personal computer components. *Journal of Environmental Engineering, Vol. 132 (4)*, pp. 497-498.

Yang, H. L. (2011). Leaching copper from shredded particles of waste printed circuit boards. *J Hazard Mater, Vol. 187(1)*, pp. 393-400.

Yin, H. S. (2007). *Does ISO 14001 Certification Enhance Environmental Perfomance? Conditions under which Environmental Perfomance Improvement Occurs.* Risk Management and Decision Processes Center,, The Wharton School of the University Pennsylvania.

Zeng, X. Y., Mathews, J. A., Li, J. (2018). Urban Mining of E-Waste is becoming more cost-effective than Virgin Mining. *Environmental Science Technology*, *Vol. 52 (8)*, pp. 4835-4841.

Zeng, X. Y. (2016). Innovating e-waste management: From macroscopic to microscopic scales. *Science of the Total Environment*, *Vol.575*, pp. 1-5.

Zotos G., Karagiannidis, A., Zampetoglou, S., Malamakis, A., Antonopoulos, I.-S., Kontogianni, S., Tchobanoglous, G. (2009). Developing a holistic strategy for integrated waste management within municipal planning: Challenges, policies, solutions and perspectives for Hellenic municipalities in the zero-waste, low-cost direction. *Waste Management, Vol. 29*, pp. 1686-1692.

APPENDICES

APPENDIX A

INTRODUCTORY NOTE TO RESPONDENTS

My name is Margaret Wanjugu Maimba, currently enrolled as a Doctor of Philosophy Degree (Ph.D) research student in Urban and Regional Planning at the School of Built Environment of the University of Nairobi. I am in the process of writing my Ph.D Thesis on '*Sustainable Computer E-waste Disposal Management Approaches in Nairobi City County, Kenya'*. In order to assist in the above-mentioned study, your contribution in this research project is important and completely voluntary and you may decline altogether or leave blanks to any questions you do not want to respond to. If you decide to participate in this study, please respond to the questions provided in the questionnaire accurately. Your answers to this questionnaire will remain anonymous and confidential and will be used for research purposes only and will not be divulged to any other person. A copy of accreditation to collect data and Government Research Permit from the University of Nairobi and National Commission for Science, Technology and Innovation respectively is available for your perusal.

Thank you very much for your time and effort in assisting to collect this valuable information for this study.

Sincerely

MARGARET W. MAIMBA
PRINCIPAL INVESTIGATOR

QUESTIONNAIRE FOR INSTITUTIONS

Questionnaire Number:	
Name of the enumerator	
Name of Institution:	

Background of the respondent

1. Sex of respondent   [1] Male ☐   [2] Female ☐

2. Duration the respondent has worked in the institution ☐
   [1] Less than 12 months ☐ [2]   1-3 years ☐   [3] More than 3 years

3. In your judgment, how would you rank the usage of the following type of computers on a scale of 1, 2 and 3 in order of their availability at your offices/premises? **[Multiple choices allowed]**

Computer type	Availability for use		
	[1] Most common	[2] Second common	[3] Least common
Desktop Computer with traditional monitors (CRT)			
Laptops			
Desktop computer with flat screen monitors (LCD)			

4. Where do you mostly obtain your computer components and devices/accessories from? ☐
   [1] Direct import of international brand
   [2] Via international brand (e.g., IBM, Dell, HP) retail outlets ☐
   [3] Local assembler without own brand (Refurbished)
   [4] Any other source (**specify**)_____ ☐

5. (a) Do you keep an inventory of the types of computer components and accessories?
   [1] Yes ☐   [2] No ☐   [3] Not sure ☐

   (b) On average, how many of the following types of computer components and accessories are purchased in this institution per year?

Item	Average number purchased per year			
	≤50	51-100	101-200	≥201
[1] Central Processing Unit (CPU)				
[2] Desktop Computer with CRT display monitors				
[3] Desktop Computer with LCD monitors				
[4] Laptops				

   (c) What is the average age of the following types of computer components and accessories purchased in this institution?

Item	Average age at purchase		
	Less than 3 years	3-5 years	More than 5years
[1] Central Processing Unit (CPU)			

[2] Desktop Computer with CRT display monitors			
[3] Desktop Computer with LCD monitors			
[4] Laptops			

(d) On average, how many of the following types of computer components and accessories are currently not in use?

Item	Number not being used			
	≤50	51-100	101-200	≥201
[1] Central Processing Unit (CPU)				
[2] Desktop Computer with CRT display monitors				
[3] Desktop Computer with LCD monitors				
[4] Laptops				

(e) Do you keep records of computer components and accessories purchased?

[1] Yes ☐   [2] No ☐   [3] Not sure ☐

(f) Do you keep records of computer components and accessories disposed of? ☐

[1] Yes ☐.   [2] No ☐   [3] Not sure

6. (a) When you buy the following computer components and accessories, do you put into consideration the question of warranty duration?

[1] Yes ☐   [2] No ☐   [3] Not sure ☐

(b) What major reason would you give for putting into consideration the question of warranty duration when purchasing computer components and accessories?

_____
_____
_____

7. (a) Do you consider used computer components and accessories as a form of waste in the urban environment?

[1] Yes   [2] No ☐   ☐

(b) In your view, how serious is the issue of computer components and accessories waste in this institution?

[1] Very serious ☐   [2] Slightly serious ☐   [3] Not s☐ous   [4]Can't tell ☐

(c) What reason would you give for your consideration on level of seriousness about comp☐ components and accessories waste in this institution?

_____
_____
_____

8. (a) How does this institution manage its used computer components and accessories?

_____
_____
_____

(b) What happens to the following computer components and accessories when no longer in use for office purposes? (**Please tick [√] as appropriate**).

Management approach	Desktop Computer with CRT display monitor	Desktop with LCD monitor	Laptop
[1] Store them in own premises			
[2] Sell off as second-hand material items			
[3] Donate them to other users			
[4] Auctioning			
[5] Open air burning			
[6] Throw away alongside other wastes			
[7] Organise for their transportation to the CSW disposal site			
[8] Others (**Please specify**)			

(c) In what condition were the computer components and accessories when they were no longer in use? (**Multiple responses applicable**)

[1] Broken down and could not be repaired

[2] Broken down but could have been repaired

[3] In good condition, functioning but technologically out of date

[4] Can't remember exactly

(d) If any of your responses in 11(b) is (i): **Storing computer components and accessories not in use** in own premises, what is the **major reason** for this approach?_____
_____
_____

(e) For the computer components and accessories stored after use, please indicate, on average number of **years** this takes place?

Computer equipment	1	2	3	4	5	>5	Not Applicable
[1] Desktop computers with CRT display monitor							
[2] Desktop computers with LCD monitor							
[3] Laptop							

9. (a) Are there established procedures for identification and management of computer components and accessories waste in this institution?

[1] Yes ☐   [2] No ☐   [3] Not sure ☐

(b) If yes in 12 (a), please explain the key requirements of these procedures.

_____
_____
_____

(c) In your view, how appropriate are the existing procedures for identification and management of computer components and accessories waste in this institution?

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_____

_____

_____

10.In your view, do you think that improper disposal of computer components and accessories can be harmful to:

	Yes	No	Do not know
[1] Health			
[2] Environment			

a) What are the effects of computer components and accessories on:

[1] Health	
[2] Environment	

11. To what level do you agree with the statement that, "**Some computer components and accessories contain harmful chemicals".**
[1] Strongly agree ☐   [2] Slightly agree   ☐   [3] Disagree   ☐
[4] Strongly disagree ☐

12. (a) In your view, how appropriate do you consider throwing computer components and accessories alongside other types of waste?
    [1] Very Appropriate ☐
    [2] Somehow Appropriate ☐
    [3] Not Appropriate ☐
    [4] Totally Not Appropriate ☐

(b) Kindly explain the reason for your view in 13 (a).

View	Reason for consideration	Not Applicable
[1] Very Appropriate		
[2] Somehow Appropriate		
[3] Not Appropriate		
[4] Totally Not Appropriate		

13. In what condition would you want your computer components and accessories collected for disposal? **(Please explain).**
_____

_____

14. (a) What official arrangements have been put in place by this institution to reduce accumulation of waste from computer components and accessories? **Please elaborate as many as possible**.
    i)   _____
    ii)   _____
    iii)   _____
    iv)   _____
    v)   _____
     (b) What channels for disposal of waste from computer components and accessories are used by this institution?
    _____

    _____

15.   (a) Is electronic waste management included in the internal policy statement, rules and regulations of this institution?
    [1] Yes ☐   [2] No   ☐   [3] Not sure   ☐

(b) If **Yes** in 17 (a), what **major factors** prompted the management to take this action?

_____

_____

(c) If **No** in 16 (a), do you see the need for having one put in place?

[1] Yes ☐   [2] No ☐   [3] Not sure ☐

(d)If **Yes** in 16 (c), what is the **major reason** you consider it important to include electronic waste management aspects in the internal policy statement, rules and regulations of this institution?

_____

_____

_____

(e) In your view, what key issues on electronic waste management should be highlighted in such an internal policy statement, rules and regulations of this institution?

_____

_____

_____

16. Among the following options, which one(s) should be the responsibility of the Government in disposal management of waste from computer components and accessories? **[Multiple responses allowed].**

[1] Be more involved in the disposal. ☐

[2] Educate the consumers on their roles. ☐

[3] Formulate and enforce laws and regulations to ensure proper disposal. ☐

17. What should be the responsibility of computer technology users in the in the management of waste from computer components and accessories? [**Multiple responses allowed**].

[1] Postpone buying new computer components and accessories when old ones can still serve. ☐

[2] Pay money at point of purchase to help pay for disposal expenses. ☐

[3] Separate and drop off computer components and accessories from the county solid waste for recycling purposes. ☐

18. Which of the following media do you think would be most effective in educating the public about health and environmental effects of waste from computer components and accessories?

[1] Electronic media ((e.g., TV, Radio, Internet) ☐

[2] Environmental Groups ☐

[3] Print media (e.g., Newspapers, magazines) ☐

[4] Public forums ☐

[5] Friends ☐

[6] Others (**Please specify**)_____

19. Do you have any suggestions that you would like to make regarding disposal management of waste from computer components and accessories in relation to conservation of the Nairobi urban environment?

_____

_____

_____

20. Do you have any suggestions that you would like to make regarding disposal management of waste from computer components and accessories in relation to maintaining high health standards in Nairobi City County?

_____

_____

_____

QUESTIONNAIRE FOR HOUSEHOLDS

Questionnaire Number	
Name of the enumerator	
Name of Estate	

Residential category

    [1] High Grade   ☐   [2] Middle Grade ☐

Background of respondent

1. Age in completed years
   [1] 15-25 ☐   [2] 26-35 ☐   [3] 36-45 ☐
     [4] 46-55 ☐   [5] 56+   ☐

2. Sex of respondent
   [1] Male   ☐   [2] Female ☐

3. What is the level of education completed?
   [1] University ☐
   [2] Tertiary ☐
   [3] Secondary ☐
   [4] Primary ☐

4. What is the average monthly income of this household in Kshs.?_____ ☐

(a) Has any member of this house ever had a computer for use at home?

    [1] Yes   ☐   [2] No ☐

(b) Is there a computer in this house currently?

    [1] Yes   ☐   [2] No ☐

(c) If **Yes** in (b), what is the type of the computer currently available in this house?

Type of computer	Currently in use in the household		
	Yes	No	Not sure
Desktop computer with CRT display monitor			
Desktop computer with LCD monitor			
Laptop			

(d) From which source did the computer currently used in this house come from? ☐

    [1] Donation
    [2] Purchased ☐
    [3] Leased ☐
    [4] Other source (**Please specify**)_____

(e) What was the condition of the computer at the time you received it?
    [1] New ☐
    [2] Second-hand but in a usable condition ☐
    [3] Broken and not in a usable condition ☐

    [4] Other condition (**Please specify**)_____

5. If **New** in 5(e), for about how long did you use the computer before you decided to replace it with another computer?

Type of computer replaced	Average time taken before replaced	Not Applicable
Desktop computer with CRT display monitor		
Desktop computer with LCD monitor		
Laptop		

6. (a) Which computer components and accessories have been discarded from this house in **the last five years?**

Type of computers discarded	Yes	No	Can't Remember
Desktop computer with CRT display monitor			
Desktop computer with LCD monitor			
Laptop			

(b) For any type of computer components and accessories discarded as indicated in 7 (a), what was

the **major** reason for the disposal?

[1] High repair cost in comparison to new one
[2] Malfunctioning during use
[3] Outdated technology

7. (a) In what condition was the computer when you found it not useful?

[1] Working
[2] Completely broken down
[3] Broken, but repairable

(b) If yes in 8(a), which of the following options describe the method of disposal of the computer components and accessories applied? [**Multiple responses allowed**].

Mode of disposal	Desktop with CRT display monitor			Desktop with LCD monitor			Laptop		
	Yes	No	Can't Recall	Yes	No	Can't recall	Yes	No	Can't recall
Threw away with other waste									
Gave out/sold off to waste collectors									
Donated									
Directly sold out to a recycling plant									
Stored at some place within the compound									
Sold out as second-hand material									
Other (Please specify)									

(c) If your response to any part of 8 (b) is **stored at some place within the compound,** which among the following statements describe the reason for the decision for the storage? **[Multiple responses allowed]**

Reason for storing computer component/accessories	Yes	No
[1] I don't consider it appropriate to throw it out as garbage		
[2] I don't know what to do with it		
[3] It is of low market value when sold off		
[4] I intend to repair or upgrade it		
[5] I haven't thought of a good disposal method, or not yet found a recycling end user for it		
[6] I intend to donate it		
[7] I paid too much for the product just to throw it away		
[8] I intend to sell it out		
[9] I may use it as a back-up for the computer I currently use		
[10] I am worried about data stored		
[11] Other (**Please specify**)		

8. Would you want to **specifically** pay for collection of your waste from computer components and accessories?

    [1] Yes ☐   [2] No ☐

9. (a). In your view, do you think that improper disposal of computer components and accessories can be harmful to:

	Yes	No	Do not know
[1] Health			
[2] Environment			

(b) What are the effects of computer components and accessories on:

[1] Health	
[2] Environment	

10. (a) To what extent do you agree with the statement that, **"Some computer components and accessories contain harmful chemicals".**

    [1] Strongly agree ☐   [2] Slightly agree ☐
    [3] Disagree ☐   [4] Strongly disagree ☐

(b) What, in your opinion, should be done to minimise the harmful effects of waste from computer components and accessories?

_____

_____

11. (a). In your view, how appropriate do you consider throwing computer components and accessories alongside other types of waste?

    [1] Very Appropriate ☐   [2] Somehow Appropriate ☐
    [3] Not Appropriate ☐   [4] Totally Not Appropriate ☐

(b) Kindly explain the reason for your view in 12 (a).

View	Reason for consideration	Not Applicable
Very Appropriate		
Somehow Appropriate		
Not Appropriate		
Totally Not Appropriate		

12. What should be the responsibility of computer technology users in the in the management of waste from computer components and accessories? **[Multiple responses allowed]**

[1] Postpone buying new computer components and accessories when old ones can still serve. ☐

[2] Pay money at point of purchase to help pay for disposal expenses. ☐

[3] Separate and drop off computer components and accessories from the county solid waste for recycling purposes. ☐

13. Which of the following media do you think would be most effective in educating the public about health and environmental effects of waste from computer components and accessories?

[1] Electronic media ((e.g., TV, Radio, Internet) ☐
[2] Environmental Groups ☐
[3] Print media (e.g., Newspapers, magazines) ☐
[4] Public forums ☐
[5] Friends ☐
[6] Other **(Please specify)**_____

14. Do you have any suggestions that you would like to make regarding disposal management of waste from computer components and accessories in relation to conservation of the Nairobi urban environment?

_____

_____

15. Do you have any suggestions that you would like to make regarding disposal management of waste from computer components and accessories in relation to maintaining high health standards in Nairobi City County?

_____

_____

**INTERVIEW SCHEDULE FOR E-WASTE PICKERS/SCAVANGERS& YARD SHOP
OPERATORS**

1. Name of Respondent_____

2. Gender:
   [1] Male ☐   [2] Female ☐

3. What is the name computer e-waste activity you are involved in? ☐
   [1] Yard shop ☐   [2] Waste Picker

4. What type of waste do you collect?
       [1] Metal ☐
       [2] Organic ☐
       [3] Paper/Cardboard ☐
        [4] Bones ☐
       [5] Electronic waste ☐
       [6] Clothes ☐

5. What is the state of the e-waste when you receive it?
       [1] Clean ☐   [2] Sorted & Separated ☐   [3] Unsorted ☐

6. Please describe what you do here at the dumpsite?
   _____
   _____

7. I observe that you separate your waste according to types. What happens to them after
   you separate them?
   _____
   _____

8. What kind of health issues do you get from working with e-waste?
   _____
   _____

APPENDIX E

OBSERVATION GUIDE FOR FORMAL AND INFORMAL COUNTY SOLID WASTE DISPOSAL SITES

1. From where and from whom does the facility collect computer electronic waste (e-waste)?
2. What do you with computer e-waste that is functioning?
3. What do with computer equipment e-waste that is not functioning?
4. For defective computer e-waste, what components or materials are most valuable (to the recycling facility)?
5. What methods do you use to dismantle and recycle computer e-waste (**Please explain**)?
6. What are the valuable components are extracted from the computer e-waste?
7. Which are the hazardous elements of the computer e-waste? (**Please list them**)
8. How do you treat the hazardous components of the computer e-waste?
9. What do with the computer e-waste that is not recyclable?
10. In your opinion, do you perceive any health hazards in dealing with computer e-waste that you collect? (**Please list them**)
11. Do you ever interact with computer equipment producers? If so, **please describe your interactions**?
12. Do you think the government should do anything to assist you in your work? (**Please indicate**)?
13. Who do you think should have the responsibility of dealing with computer e-waste in Kenya?
14. Who is responsible for the growing amount of computer e-waste in Kenya?

INTERVIEW SCHEDULE FOR POLICY-MAKING AND REGULATORY AGENCIES

Schedule Identity No.	
Name of Agency	
Mandate of the Agency	
Interviewee	
Position held in the Agency	
Duration worked with the Agency	

Issues of interest to the study

1.   (a). Key role of agency in waste disposal management. **Probe** into actions taken by the Agency to reduce **environmental and health** risks of improper disposal of waste from computer components and accessories in the urban area.

(b). What are the prime factors that necessitated adoption of this role? **Probe** into relative considerations of **environmental and health perspectives** on these prime movers of the Agency's role on waste disposal management.

(c). Any key opportunities and challenges these roles present to proper disposal management of waste from **computer components and accessories** in Nairobi by this Agency?

(d). **Probe** into provisions (apportioning of roles, legal & policy stipulates, actors involved, time-lines, objectives & targets), enforcement (registering, auditing and regulating flows of imported computer components and accessories) and resources (financial, technical and human) needed for realisation of this mandate.

(e). Solicit **suggestion for remedial actions**, where fundamental discrepancies are noted (with respect to **limiting age of computer components and accessories** imported into the country, developing an **internal e-waste disposal management policy** with a focus on **environmental and health perspectives** on the urban landscape as well as **public awareness**, and increased **responsibilities for the Government and different actors**, including Computer users).

(d). Any emphasis on public awareness aspects? **Probe** into existing and possible programmes relating to promoting public awareness about **environmental and health implications of electronic waste** disposal management (**focus attention to computer components and accessories in the county solid waste stream**).

2.   (a). Structures and requirements for execution of the waste disposal management role. Seek elaborations on approaches and methods used to meet this mandate in relation to **environmental and health concerns in Nairobi**.

(b). Any striking strengths and weaknesses embedded in these standards and modes of operation on waste disposal management? **Probe** for the bearings of these strengths and weaknesses on effective management of waste from computer components and accessories. Unravel the contributions of public awareness about environmental **and health aspects of improper disposal of this type of waste.**

(c).   Delve into **environmental and health relevance and usefulness** of these structures and requirements for electronic waste disposal management. **Probe** for particular focus on disposal management of waste from computer components and accessories.

3. (a). Comments on key policy and legislations in Kenya governing waste disposal management.

(b). **Probe** for sources of pressure for these policy/ legal provisions (for example, external influences from **international environmental and health governance space-especially in relation to**

International Agreements, Conventions And Treaties/Principles. Any focus on the **Basel Convention**? or internal pressure from members of the public).

(c). **Any** suggestions concerning waste disposal management for computer components and accessories in Nairobi?

APPENDIX G

OBSERVATION GUIDE ON ENVIRONMENTAL MANAGEMENT SYSTEMS

1. Institutional environmental policy statements (mission, objective, values, strategies). Focus on inclusion of e-waste, disposal management; compliance with relevant regulations.
2. Measures put in place for monitoring, controlling waste from computer components and accessories (including reuse, reduce and practices: What stimulated the desire to include these measures. (What were the drivers?).
3. Whether company has Environmental Sustainability Committees to spearhead the environment agenda in the institution/company.
4. Pointers to commitment towards computer e-waste disposal management: e.g. Coloured segregated bins etc.

RELEVANT DOCUMENTS: ANALYSIS OF COMPUTER E-WASTE DISPOSAL MANAGEMENT

1. Minutes of meetings (Reports of the environment related department)
2. Annual reports of the institutions, private companies
3. Financial statements (specifically for the environmental related department)
4. Research and training programmes (evidence on emphasis on e-waste).
5. Internal monitoring and evaluation (Environmental Impact Assessment and Audit reports)
6. Institution/private company environmental sustainability policy
7. Environmental certifications (within and outside of the institution, private company)
8. Financial reports (allocation to environment and sustainability)
9. Staff appraisal forms
10. Presence of discernible research and development aspects on e-waste management
11. Environmental policy statement: Is the vision, scope and content adequately addressing e-waste disposal management?

APPENDIX I

RESEARCH   PERMIT

THIS IS TO CERTIFY THAT:
MS. MARGARET WANJUGU MAIMBA
of NACOSTI, 0-200 nAIROBI,has been
permitted to conduct research in
Nairobi County

on the topic: *ANALYSIS OF COMPUTER*
EQUIPMENT- BASED E-WASTE
GENERATION AND DISPOSAL BY
INSTITUTIONS AND HOUSEHOLDS IN
NAIROBI, KENYA

for the period ending:
28th November,2016

....
Applicant's
Signature

Permit No : NACOSTI/P/13/7933/458
Date Of Issue : 4th December,2013
Fee Recieved : Kshs khs2000.00

Secretary
National Commission for Science,
Technology & Innovation

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice.

REPUBLIC OF KENYA

NACOSTI

National Commission for Science,
Technology and Innovation

RESEARCH CLEARANCE
PERMIT

Serial No. A 745

CONDITIONS: see back page

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University of Nairobi
Department of Urban and Regional Planning
School of The Built Environment
P.O. Box 30197, 00100 GPO Nairobi, Kenya
e-mail:durp@uonbi.ac.ke

UON/CAE/DURP/B80/93524/2013   29th April, 2015

TO WHOM IT MAY CONCERN

**RE: REQUEST FOR DATA FOR ACADEMIC RESEARCH: B80/93524/2013
       MAIMBA MARGARET WANJUGU**

Ms Maimba Margaret Wanjugu is a PhD student in the Department of Urban and Regional Planning, University of Nairobi. She has embarked on data collection in the field for her PhD thesis on the title: **Analysis of Computer Equipment Bases E-Waste Generation and Disposal by Institutions, Private Organizations and Households in Nairobi, Kenya.**

The National Commission for Science Technology & Innovation has issued her with Research Permit No. Permit No. NACOSTI/P/13/7933/458 to enable her access data collection from above mentioned sources. We wish to request you to give her necessary support to accomplish her academic project.

Any assistance accorded to her will b highly appreciated.

DR. KARANJA MWANGI *MKIP FKIP*
CHAIRMAN
DEPARTMENT OF URBAN & REGIONAL PLANNING

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