TITLE: PRODUCT-SERVICE SYSTEMS DESIGN FOR E-WASTE MANAGEMENT: A CASE OF WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT CENTRE, (WEEE CENTRE) NAIROBI COUNTY

A Research Project Submitted in Partial Fulfillment for the Degree of Masters of Arts in Design of University of Nairobi

2018
DECLARATION

I, Hildah Koki declare that this research project is my original work and has not been submitted for a degree in any other university. The ownership and intellectual property rights which may be described in this project is vested in the university of Nairobi, School of the Arts and Design and may not be available for use by a third party without written permission of the university which will prescribe the terms and conditions of such agreements.

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ABSTRACT

This study focuses on determining the existing e-waste management systems in Waste Electrical and Electronic Equipment Centre and in Nairobi County. It also investigates how Switzerland and India manage the waste from electronics. This study endeavors to develop a product service system for e-waste management in Nairobi County.

Globally, among all other streams of waste, e-waste has surfaced to be one of the hastily growing streams due to the increased consumption of electronic products an outcome from technological product obsolescence because of the global rapid economic development. E-waste poses one of the greatest environmental challenges regionally as it is estimated that 3000 tons of e-waste from electronic devices is generated yearly in Kenya. Due to improper management system for e-waste, informal recycling procedures are still been used such as dumping and open air burning regardless of the fact that Nairobi undertakes formal e-waste recycling practices. Due to the potential hazards the e-waste posses, evaluation and establishment of efficient integrated e-waste management system is critical.

The study utilized mixed methods research design. Purposive and random sampling was deployed to obtain study subjects. Surveys were used to obtain relevant data from study subjects. Data was analyzed using qualitative and quantitative methods and presented by the use of graphs and tables. From the study, it was revealed that there were existing gaps in collection, transportation, financing, producer responsibility, consumer awareness, stakeholder collaboration and in lack of e-waste flow monitoring policies. Information obtained from this study was used to develop a product service system that advocates for a shift from provision of products to provision of systems of products and services, collectively with stakeholders’ collaboration towards efficient e-waste management.
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DEDICATION

This thesis is dedicated to my entire family and friends for their endless support and encouragement. Their prayers and moral support have been the driving momentum that has enabled me to achieve the targeted goal in my studies.
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LIST OF ABBREVIATIONS

SWICO- Swiss Association for Information, Communication, and Organizational Technology

PROs - producer responsibility organizations

INOBAT - Stakeholder Organization for Battery Disposal

EPR - Extended Producer Responsibility

SENS - Stiftung Entsorgung Schweiz

EoL - End of Life

WEEE - Waste Electrical & Electronic Equipment

PPOA - Public Procurement Oversight Authority

ICTs - Information and Communications Technologies

UNEP - United Nations Environment Programme

EPR - Extended Producer Responsibility

SLRS - Swiss Light Recycling Foundation

ARF - Advance Recycling Fee

NEMA - National Environment Management Authority

MoIC - Ministry of Information and Communications

PSS - Product- Service Systems
JKUAT- Jomo Kenyatta University of Agriculture and Technology.
CHAPTER ONE

1.0 Introduction

The research study is introduced in this chapter, which is divided into the following subsections: background of study, problem statement, research objectives, research questions, significance of the study, justification of the study, assumptions and limitations of study.

1.1 Background of the study

Internationally, the electronics and electrical equipment waste formed in a year are estimated to be 40-50 million tons based on a study done by United Nations Environment Program and European Environment Agency, (Manual, 2007). Compared to any other types of household waste, the production of e-waste is escalating three times more rapidly. Due to its chemical components, when disposed inappropriately it causes unfavorable ecological and human health, (Asiimwe, 2010). Electronic scrap skillful recycling in support of a lucrative recovery of important materials for reuse and for ecological environment has been found to be essential despite the fact that it is considered as a big setback in the facing the society of today, (Song et al. 2013). Since they have a variety of material types incorporated within them, end of life electronics are much complex to recycle in comparison to properly set up metallic scrap recycling.

E-waste efficient recycling primarily for the recycling industry is not only a challenge but also significant insufficient consumer awareness, unsatisfactory and poor collection efficiencies and structures for the environmental, cost-effectiveness in terms of on saving raw materials and energy, (Debnath et al. 2016).

The growth of electrical and electronic waste from both local users and recycled second-hand items generated has mainly been caused by the economic rapid growth in emerging countries.
The vast elastic electronics demand is been brought about by the usefulness of Information and Communications Technologies mainly computing gadgets like computers and mobile phones, (Écroignard 2006). Consequently, those refurbishing and dismantling e-waste are at danger and the environment too because of the toxic chemicals e-waste releases to it. In Africa, most sub-Saharan countries collect electronic waste and recycle it using inappropriate processes, therefore, that most of them lack sustainable systems of managing e-waste, (Herat 2007).

Disposal of electronics and electrical equipment in developing countries like Kenya adds to the waste management problem. Similarly, to other countries, Kenyan governmental bodies and private consumers are taking up ICTs at a fast rate hence production of large quantities of waste from the electrical and electronic items which are expected to increase, (Asiimwe 2010). Based on a UNEP & International Environmental Technology, (2011) report, refrigerators generated 11,400 e-waste tons, TVs generated 2,800 tons, personal computers raised 2,500 tons, printers generated 500 tons, and mobile phones generated 150 tons in the year 2010.

In his study, argues that a massive e-waste amount in Kenya stays in storage as there is no policy, legislative framework, and convenient e-waste management system. Because extra e-waste is been continuously created as years go by and there is no management system is in place to deal with it, a gap of possible future e-waste danger is been formed, (Prof. Waema & Muriuki 2008).

In the, study there was a need to explore the responsibilities of various stakeholders in e-waste management in Kenya and how they dispose of e-waste and what challenges they face. The study also looked into how other countries manage e-waste and the lessons Kenya can learn from them. The aim of this study was to design a product service system for e-waste
management to monitor e-waste material flow, e-waste collection handling, transportation, recycling and its safe disposal in Kenya.

1.2 Statement of the problem
In Nairobi, electrical and electronic equipment use is increasing rapidly, subsequently resulting to amplified amounts of e-waste. Unfortunately, in Kenya, there is inefficient management system to address how to collect, transport, treat, safely dispose and monitor of electronics waste flows, (Waema & Muriuki, 2008). Furthermore, due to unproductive waste management system, stakeholders do not take up their responsibilities in regard to e-waste disposal. It is estimated that most lands into informal recycling procedures such as open air burning and dumping of monitors, which possess adverse effect of the environment. Therefore, establishment of proper e-waste management system is imperative.

1.3 Research Objectives

1.3.1 Broad objective
The broad objective of this study is to propose a Product- Service System for e-waste management in Nairobi County

1.3.2 Specific Objective

1. To determine the existing e-waste management system in Nairobi County
2. To determine the e-waste management system at WEEE Centre as an exemplar.

1.4 Research questions

1. What is the existing e-waste management system at WEEE Centre?
2. What is the existing e-waste management system in Nairobi County?
3. Can a PSS system be used for e-waste management in Nairobi County?
1.5 Significance of the study

With the upcoming need for industrial growth in Kenya brought about by the vision 2030 and a constitution that embraces county government, industrial growth, e-waste management problem is an international issue, a problem likely to grow to unmanageable levels if the problem is not addressed. The study therefore aimed at accessing the problem of e-waste management by manufacturers and consumers and thereafter come up with an efficient design system to encourage proper e-waste management hence reducing significantly the human and environmental effects that are brought about by the industry mismanagement. The study was also determined to define roles of different e-waste management stakeholders on matters concerning e-waste management, thus, closing the gaps that have been left on e waste management cycle.

1.6 Scope of the study

The research and data collection was limited to Nairobi. This is because most of the stakeholders involved in the e-waste management chain are located in Nairobi County. The data obtained from the respondents was analyzed and later translated to aid in designing a product service system for e-waste management.

1.7 Limitations of the Study

1. Topic of study sensitivity: the topic of been studied might be sensitive to some of the people to be interviewed and therefore they might not willingly disclose all the information they have.

2. Inadequate technical information: some respondents may not have technical information on e-waste and therefore anticipated quality information may not be obtained.
1.8 Definition of terms

E-waste – refers to end-of-life and disposed electronics products varying from computers, ICT equipment, appliances in households, video and audio items, (Song et al. 2013)

Product service System – refers to a product and services scheme with a sustaining infrastructure and network designed for being viable, fulfill consumer needs and contain an inferior ecological impact than usual business models”, (Corvellec & Stål 2017)

Illegal Dumping- refers to inappropriate throwing away of waste in undesignated areas.

System design - refers to preparation of an assemblage of techniques and procedures unified by collaborative relations to form an organized whole, (Sassanelli et al. 2016)
CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

E-waste and general waste management systems relevant literature is emphasized in this chapter. The study reviewed various literatures on both local and international policies, institutional framework and systems regarding e-waste management. The researcher discusses how other countries manage e-waste and what lessons Kenya could learn. Two countries are studied namely- Switzerland and India. International policies such as the Basel conventions and Bamako conventions are also reviewed in the chapter.

2.2 E-waste basic mass flow

Generic representation as one shown in figure 2.1 below can be used to show movement of each e-waste systems, (Tocho & Waema 2013).

![Diagram of E-waste country assessment methodology](image)

Figure 2.1 E-waste country assessment methodology, (Tocho & Waema 2013).

According to Waema et al., (2008), the consumer purchases the electronic either from a manufacturer or an importer who then through a retailer, directly makes them available to the market. On reaching its end of life, the electronic disposal procedure begins, (Tocho &
Informal or formal collection system is available for collecting the electronic in well-organized frameworks of e-waste management. The electronics lifecycle is prolonged by being refurbished after been taken to second-hand markets a procedure done to make it operational by change or repairing its parts. The repaired electronic is put for sale to consumers as second-hand product and if it cannot be repaired, it is dismantled for recovering its constituent material which is a process that is repeated (Tocho & Waema 2013).

2.3 Global existing systems of e-waste management

2.3.1 Switzerland e-waste management systems

Globally, Switzerland is majorly known as the pioneer country to design and implement an e-waste management scheme that is formal and well-organized entailing collection to disposal of e-waste materials (Wath et al. 2010a). Legislatively, Swiss Federal Office for the Environment introduced e-waste management based of the principle of “The Return-Back and Disposal Basis” of e-waste.

The Producer responsibility organization (PROs) began voluntary programs that are entirely recognized for collecting and managing e-waste. At present, Switzerland has four non-profit PROs which run all varieties of electronic products form house-hold to office commodities as well as consumer relaxation products and equipment used for lighting. The organizations are tasked with the duty to ensure e-waste is management appropriately through collection, disposal, system control, and financing of the scheme. Among the four PROs, there are two major PROs are Stiftung Entsorgung Schweiz , (SENS) and Swiss Association for Information, Communication and Organizational Technology , (SWICO). Both organizations bear a an operational history describing how the whole system evolved that is significant together with handling the prime e-waste streaming section , (Nnorom & Osibanjo 2008).
Brown goods which comprise of equipments such as radios, television sets and computers are managed by SWICO. On the other hand, white goods which comprise of ovens, refrigerators, and washing machines are handled by SENS, (Sinha et al. 2007) According to the European Parliament & The Council Of The European Union, (2012), it is argued that on behalf of their affiliate producers, SWICO and SENS are accountable for system operations and management. This is done following the WEEE European directives’ description as illustrated in Figure 2.3.

The systems operational and legal framework is supported by the Extended Producer Responsibility, (EPR) An ecological safety approach in which an electronics exporter, producer or manufacturer remains accountable for the whole life of an electronic. This is principally in handling, returning back and products final disposal, (Wath et al. 2010a)

The Swiss system works under a recycling fee that based on products. To ensure that there is enough funds for running the system, an Advance Recycling Fee (ARF) is gathered from all buyers as they purchase fresh electronics (Figure 2.2). This fee funds operations of the whole system, as the manufacturers incur the full implementation responsibility and operating e-waste from all brands in the WEEE field, (Widmer et al. 2005). In addition, the fee equals to the differences among entire system cost and sum of e-waste value recovered. By this system operation, there is no consumer responsibility, hence, a reduced amount of waste that ends up in the landfills.
From the system in figure 2.3, importers, manufacturers and retailers are expected to freely get back their appliance for handling in an ecologically acceptable manner. Those companies meeting these requirements are given a contract by specific owners of a system for processing the pieces of electronics that they take back from consumers. Sinha-Khetriwal et al., (2005) states that two self-governing management systems - SWICO and SENS- constantly monitor a total of 30 companies - 14 of which are in a contract with the two holders of systems as shown in Figure 2.3. He states further that in Switzerland the year 2002, a 60-70% was projected as the general IT equipment recovery, (Wäger et al. 2011). In the year 2004, approximately 75,000 electrical and electronic tones are estimated to have been gathered, separated and taken into pieces for treatment through the two systems attempt Wäger et al., (2011) whereas in 2003 the collection was approximately 68,000 tones.
Dissimilar Switzerland, the India’s system for e-waste management majority of activities right from the collection to recycling are manual and operated by sectors that are unorganized with . For a majority of India’s people electronic waste is a fine income generating source since it is a wealthy spring of precious material that is can be reclaimed , (Wath et al. 2011).
According to Wath et al., (2010a) Indian e-waste scenario life cycle is divided into three levels based on research and analysis.

**Level I — EEE generation**

This is the entry phase of the collected electrical and electronic items. These materials range from assemblies to sub-assemblies raw products and components which are arising from products of manufactures in form of manufacturing or imports from other countries. Given that they are not the actual users the EEE products and raw material, distributors, producers and raw material suppliers are simply viewed as team members of EEE generation phase and not WEE generations. In India, the sector is systematically organized up to this level apart from few EEE items which ‘Assemblers’, who acquire the locally produced components from
product manufacturers and raw materials suppliers. They then amass them and at a much cheaper price, in comparison to the branded products, directly put up for sale the assembled products to the grey market consumers, (Wath et al. 2010b). However, the major obstacle to the success of EPR programs is the presence of such producers who are non-identifiable, (Wath et al. 2010b).

**Level II — WEEE generation**

This stage entails the WEEE or E-waste generation. The ultimate users of EEE are the household and office consumers who acquire these generated original EEE from the players in EEE generation phase. Habitually, so as to meet their present needs, most consumers dispose off their obsolete products for the most up-to-date versions, features and preferences, (Chatterjee 2006). In India, the used EEE can be can resold or donated to a next of kin or an acquaintance for further use by the original consumer. Official consumers as well offer the used EEE as charitable donation to economically disadvantaged communities such as orphanage, hospitals and schools (Figure 2.4).

**Level III — WEEE re-processing**

This phase is sub-divided into two stages, namely; the pre-reprocessing and reprocessing. In pre-reprocessing stages e-waste collection is mainly performed by the informal sectors such as scrap dealers and traders. Under this sector, e-waste together with other solid recyclable waste is bought from the end user and sold through small-scale traders or wholesalers who thereafter sorts and separates varies forms of e-waste equipment. However, this is contrary to Switzerland e-waste management program, where consumers are entitled to subscribe a recycling fee, (Sinha-Khetriwal et al. 2005).
The small-scale collectors sell the collected materials to traders who in turn separate and sort out different forms of waste items sell them to recyclers, who dismantle them to recover any metals component. The sorted waste materials are finally sold to recycling and disposing plants for reprocessing. Auctioning of these recyclables is done through advertisements in many government and private associations. Recyclers dismantle any reusable and recyclable e-waste materials such as glass, cable-wires, plastics and sell back to raw material suppliers for reuse, (Figure 2.4). The e-waste that remains after is reprocessed to pick up the worth able metals such as gold, copper, aluminum and silver from them. The residue waste is then disposed-off the either in an incinerator or in a landfill, (Joseph 2007).

An field exploratory study by Schluep et al., (2008) indicate that the three levels under WEE re-processing system are typically based on existing network amongst the manufactures, traders, recyclers and consumers. Each key player in the scheme is tasked to provide value addition, job creation at every point of processing chain in which in turn is also the cascade of activities involved in the reuse, recycling and disposal of e-waste. Due to low capital investment needed to startup a collection, dismantling and sorting firms, many small-scale entrepreneurs are attracted to join the lucrative industry. The motive behind the key players is monetary gain and no intention of creating environmental or social awareness. However, they provide channels for direct or indirect employment to vast groups of people, (Baud et al. 2001). The huge challenge facing the Indian e-waste management system is the unstrained release of hazardous pollutants into the air, water and soil. The health related problems emanating from emission of fumes, ashes and unsafe chemicals is of great concern both the workers who are in close contact with the e-waste and also the environment at large, (Sinha-Khetriwal et al. 2005).

Contrary to Switzerland’s collection, transportation and recycling scheme, the Indian e-waste system was originally designed as a natural division of the scrap industry which acquires
scrap materials from old ships, written off vehicles and construction wastes, (Sinha-Khetriwal et al. 2005). Due to technological advances, most of electronic and electrical equipment began to become obsolete and in turn the already functioning Indian scrap metal industry engrossed this new stream of wastes to recover the worth metals. The recovered metals were sold to steel mills and non-iron smelters and refiners as raw materials, (Balakrishnan 2007). In the end, as described by Jatindra & Sud, (2009) the Indian e-waste management system is a benchmark of successful industrial symbiosis which is self-organized and with market-driven policies.

2.4 E-waste situation in Kenya

According to Otieno & Omwenga, (2015) the Kenyan ICT industry has been growing at a fast rate in comparison to other East African countries. A huge demand for electronics and electronic products has been created due to the launch of the e-government strategy which aimed at mainstreaming ICT in Kenya. This subsequently led to the government abolishing electronic tax importation levies. The situation became more complex due to the emergence of the telecommunication firms with elevated use of mobile devices, (Otieno & Omwenga 2015).

2.4.1 Statistics e-waste

According to UNEP, the amount of WEEE generated in Kenya in the year 2010 was estimated to be approximately 11,400 tons from fridges, 2,800 tons from TVs sets, 2,500 tons from PCs and 150 tons from cell phones, (NEMA, 2010). Otieno & Omwenga, (2015) argue that, local e-waste recycling in Kenya’s informal sector is in a verge of rapid growth and its complexity is actively becoming similar to those experienced in Nigeria, China and India. It is foreseen that the due to escalating market demand for electronics goods together with the current dynamics in the ICT sector and free importation of ICT equipment that the amount of WEE generated to rise in near future, (Otieno & Omwenga 2015).
2.4.2 Flow of e-waste in Kenya

According to Asiimwe & Åke, (2012) Kenya imports nearly all of its electronic products from European countries, Asia and USA, though the acquisition of second hand products is discouraged. Despite the imposed measures to counter second-hand importations, significant quantity of old or refurbished electronic products still find their way into the country through charitable donations from NGOs to schools and other government institutions. According to UNEP, the major sources of e-waste dumping witnessed in the developing countries are through exports from developed countries with their notable vision of “bridging the digital gap” (Unep et al. 2010). According to (Ii et al. 2014), the flow of e-waste among Kenyan consumers can be summarized as shown below , (Figure 2.5).

![Figure 2.5 Flow of e-waste in Kenya (Ii et al. 2014)](image)

2.4.3 ICT policy and regulatory framework in Kenya

Kenya is an associate to both the Bamako Conventions and Basel convention. The Basel conventions’ objective was to create a framework that controls the trans-boundary movements of hazardous wastes, (Wath et al. 2010a). Bamako convention conversely controls the importation of products as well as trans-boundary movement of harmful wastes in Africa , (Asiimwe 2010).

At policy level, NEMA’s is an organization whose responsibility is to manage and control environmental pollution and to give guidelines on waste management. It is the prime organ of
the government mandated to execute all policies related to the environment, (NEMA, 2010). According to NEMA strategic plan of 2005-2010, its main objective entails ensuring universal conformity and implementation of environment policies as well as making standards and laws to prosecute offenders who violate the prescribed provisions. Moreover, it monitors and formulates policies governing e-waste recyclers, vendors and collectors, (NEMA, 2013). Correspondingly, the laid down strategies gives the organization room to coordinate environmental matters of waste management among the affiliated agencies and stakeholders.

Kenya has regulations governing environment, although these laws are not particularly formulated for managing e-waste. They consist of; first, the management of waste regulation of the year 2006 which NEMA enforced. These regulations help in monitoring the creation, managing, hauling, disposal together with storage of waste, which is considered as a threat to public health and environment.

Second is the ICT policy framework of 2006 which was instituted by Ministry of Information and Communications (MoIC). The regulation necessitates the electronic merchants to display their keenness in minimizing effects posed by electronic equipment on the surroundings so that they are eligible for license renewal, (Tocho & Waema 2013).

,(Tocho & Waema 2013), developed and proposed an e-waste management framework which takes care of e-waste collection, transportation, processing, recycling, dumping and monitoring e-waste flow in Kenya. In his framework he suggested that private and corporate consumers to take back their e-waste to a convenient collection point then the e-waste is taken to the refurbisher or processor. He also proposed the consumers to be paid some money at a determined rate as an incentive. Additionally, collection points to provide a venue to commune information on e-waste to the consumers through the use of information slips on...
containers and leaf let’s explaining the importance of safe e-waste disposal. (Tocho & Waema 2013) argue that retailers and traders presently in Kenya do not take any responsibility in e-waste gathering in comparison to developed countries such as Switzerland. While selling new products they should encourage buyers to take them back at EoL and given discounts when acquiring new EEE when they return the old ones, (Figure 2.6).

According to Tocho & Waema (2013) system, the government’s role should be coordinating by giving e-waste rules addressing the roles of producers, consumers, recyclers and consumers. Producer Responsibility Organizations can offer administrative element of the structure logistic and e-waste processing. In the projected framework it ought to be the task of EEE manufactures to form PROs and ensure that they are operational in Kenya. Learning bodies particularly the universities should be collaborate with other academic institutions, benefactors, and government institutions to come up with an e-waste curriculum and implement the same in bodies of higher learning, (Figure 2.6).
Figure 2.6 Proposed e-waste management framework source, (Tocho & Waema 2013).
2.4.4 E-waste management system in Kenya

According to assessment study by Prof. Waema & Muriuki, (2008), it emerged that Kenya does not have regulatory policies governing management of e-waste. It further points out that the country fall short of recycling policies specifically for electronic goods. This is in concordance with Public Procurement Oversight Authority (PPOA) report that states that currently there are no legislations governing e-waste in Kenya. PPOA which runs government procurement processes itself has not taken serious deliberations on the dead effects of the electronic good it procures, (Asiimwe & Ake 2012). Unlike other developed countries such as Switzerland, the Kenyan’s system for managing e-waste is poorly and informally designed, (Li et al, 2014).

Li et al, (2014) elaborates that it is regrettable that most developing and industrializing nations including Kenya, have no legislation or management system dealing particularly with e-waste. If formulated and followed, legislation and effective systems would be extremely of significance to such countries. It is further argued that moderate environmental regulations tend to jeopardize safety standards, amplify unemployment rates and create room for cheap labor force and have subsequently resulted into lots of informal recycling business which leads to environmental and health problems, (Anahide, 2007). Schluep, Dittke, et al., (2008) also argues that, in Kenya similarly to other countries, use of electronic goods is growing vividly, resulting into enormous e-waste creation despite been short of legislative policies on e-waste as well as inefficient e-waste management system. Currently, some of the e-waste is recycled at the minority e-waste recycling companies such as WEEE Centre in Nairobi and East Africa Compliant Recycling working in collaboration with some manufacturers, distributors and assemblers such as Hewlett Packard, Safaricom and Dell in e-waste recycling, (Schluep et al. 2009). These centers facilitate in collection of end-of-life IT items
from consumers as they deliver new ones. Some of the few producers and assemblers recompense for safe final disposal of their e-waste.

2.4.5 Product-service systems design for e-waste management

According to ABED, (2006), a Product-Service System, (PSS) are described as a scheme of products and services with a sustainable set of connections and infrastructure which are developed to offer viable and fulfilling customer needs together with a minor ecological impact rather than customary business framework. Policy pressures and environmental concerns have driven the use of new business systems. These systems are being applied for e-waste management essentially based on coming up with more reasonable and sustainable pricing schemes, (for example “pay-as-you-throw”). Its objective is to sustain the move from a tax based approach to a pure service based system, where the end-user pays for the real utilization of the waste management service rendered, (Elia et al. 2016).

ABED, (2006) argues that for customers, e-waste PSS signify a transformed system enticing purchasing services and system solutions rather than purchasing products, which is likely to reduce the consumer needs and wants ecological impacts. These systems imply a top level of accountability for producer and service providers. PSS may at times involve transfers of owner’s property rights for both consumers and producers. The principal objective of PSS is to lessen ecological impacts posed by means of using electronic items.

ABED, (2006), continues to argue that understanding PSS can as a result aid in formulating policies which encourage sustainable consumption ways and lifestyles. PSSs have the capability to present an innovative approach to understand and influence stakeholder associations and create a perceived view of product networks, which at length may assist advancement of more proficient policy frameworks.
Simultaneously, it is anticipated that advertising the new services or adopting alternative products and substitute systems of product-service utilization can assist in new job creation. Additionally, employment opportunities may be created through labour-services such as take back systems, repair, refurbishment and disassembly, (Elia & Gnoni 2015).

On the other hand, consumers gain from a product-service system by obtaining a greater variety of options of electronics in the market; various payment schemes; repair services and the vision of diverse systems of electronic utilization, which are suitable to them on basis of possession responsibilities. In that, consumers are free from the responsibility of an electronic; this is absolutely under the ownership of the producer in its whole life span. Through PSS, buyers can learn more on ecological properties of electronics as well as how they can contribute to reduce the environmental effects arising from electronic consumption. PSS’s have the potential to reduce the sum of products by the introduction of substitutes of product use such as pooling, sharing or leasing to end-users, without affecting the product design. Through PSS, manufacturers are becoming more accountable for their product and services lest material cycles are closed, (Adrodegari et al. 2015).

Manufactures are encouraged to retract their commodities, improve, renovate and put them for use. Eventually, less e-waste ends up in incineration or open landfills. PSS approach has transformed the current economic pricing systems as cost of production is becoming smaller in reference to cost incurred while making a product accessible to the end-user. This implies that the end-user do not pay for the product rather for the service offered which in turn can perceived as technical improvement of dematerialization, (Corvellec & Stål 2017).

In the end, the development of an appropriate PSS with a well-organized take back scheme might possibly entice end-user to return their End-of-Life electronics. Second it will ensure that electronics at disposal stage have a worth market value. In the third state of a cost-
effective PSS is to adopt a substitute scenario of product application to generate extra profit. For instance, the legislation can require that a producer of an electronic to take care of their electronics after they are sold out. Under such scenario, the maintenance of the product accrues an extra cost. In case the manufacturer, rather than selling the electronic, decides to offer its utility, it typically becomes a profit maker and a incentive to minimize the utilization of the electronic that is favorable for the consumer as well, (Sousa & Miguel 2015). The PSS designed recommends the use-oriented services approach, which may include;

*Product leasing*; it is whereby the ownership of the product does not change. The ownership rights are reserved for the producer, who often takes the responsible of maintaining, repairing and controlling the product. The end-user pays value charges mainly for product utilization and normally has limitless access to the leased product, (Tukker 2004).

*Product renting*; here, the producers generally owns the product and is also accountable for maintenance, repair and control of the product. The end-users are charged for making use of the item, however, the end-user has limited access to the product implying that different end-users can utilize the same product at other times, (Tukker 2004).

*Product pooling*; this is much similar to product renting, although it encompasses synchronized utilization of the product, (Tukker 2004).

### 2.5 Theoretical framework

#### 2.5.1 General Systems Theory, (GST)

Von Bertalanffy (1968) defines a general system as a complex of interacting elements that are connected. Heil (2010) states that individual elements of a system should not be considered in isolation, but as a whole, with a particular focus on the interaction of the elements within the system. Additionally, each individual element affects the functions of the whole system.
System theory considers all potential sources of the problem, observes one at a time and identifies the function of each in the system. Towards the objective of upgrading "goodness of fit" linking subjects to their environment, this theory helps us in understanding the clients system properties and components for interpreting problems and developing intercession strategies that are balanced, (Friedman & Neuman 2011).

Helou & Caddy, (2006) explains that for one to consider a system to be a living system, it ought to have these sub-systems: reproducer, margin, investor, distributor, converter, producer, matter-energy storage sub-system, extruder, motor, supporter, input transducer, internal transducer, channel or net, decoder, associate, decider, encoder, and output translator

A system develops through exchanging energy amid a system along with its environment, a procedure whose possibility highly depends on the permeability possessed by its boundary. Tangible energy sources can be housing, money or other elements contributing to the systems physical maintenance. Intangible energy can be information, which can be demonstrated once a systems affiliate is literate or possesses useful knowledge for helping the system. The higher the permeability of a boundary, the bigger the degree that the system can interact with its environment.

According to Henzinger & Sifakis, (2006), systems design can simply be defined as the process of deriving a systemic representation, which a desired system can be generated from automatically. Industrial production is on rapid expansion and calls for immediate adoption of more efficient systems to address the imperative changes of consumers’ needs and behaviors in much more personalized ways. This shift was first recognized in managerial and marketing disciplines, although now often becoming component of the design discipline. Designers have relevant role in this shift, since many systemic solutions to common problems are possible when different stakeholders pool their efforts together to achieve a common goal.
It means that every individual ought to take full responsibility in creating future in a more co-evolutionary and interdisciplinary atmosphere and taking into account the social and physical environment through the power of understanding its traits and necessities. The emergence of evolutionary design culture among communities can often be realized when groups of people with a common goal are engaged in purposeful systems design, (Laszlo & Krippner, 1998).

**Product-Service Systems**, (PSS)

These are systems that allow the achievement of sustainability by providing a variety of social, environmental and economical benefits for business propositions, (Sousa & Miguel 2015). According to Adrodegari *et al.*, (2015) PSS can be defined into five configurations which are further divided into two different categories; ownership and service oriented as shown in Figure 2.7.

![Figure 2.7 PSS Types](image)

In ownership-oriented type of PSS, services act as add-on to the products, which are the major source sales returns. One can sell the services without a contract or agreement or they may use an approach of maintenance contracts. In service-oriented types of PSS, the main source of returns is the services that are firmly connected to the product to be used, and a customer is not given the chance to own a product.
2.5.2 The theory of managing waste

Introducing a Waste Management Theory (WMT) which is a cohesive body involving waste management knowledge aided in channeling design from ecological sciences. This body is an attempt to bring together the different stakeholders involved in the chain managing waste to create a system with the combination of theories that are relevant for example the product-service system and design theories.

2.6 Conceptual framework

A study’s variables relationships can be conceptualized by a researcher and represented in graphics or diagrams, (Creswell 2014).

![Conceptual Framework](image)

**Figure 2.8** The proposed conceptual framework for this study.

The schematic diagram in figure 2.8 indicates the various factors that affect or enhance sustainable e-waste management. The various manufacturers and distributors are able to provide product-service systems for electronics, which promote selling of use of electronics rather than selling the electronics themselves for consumer ownership. Using this system, no e-waste is handled by consumers. The government and other stakeholders can implement policies and institutional frameworks that can be utilized to deal with the e-waste management challenge in the county.
CHAPTER THREE
MATERIALS AND METHODS

3.1 Introduction
In this chapter, the following areas was discussed; the area of study, research design, population targeted, sample size, procedure used for sampling and methods applied in collecting data utilized to investigate the study problem. In addition, techniques to be applied in analyzing quantitative and qualitative data gathered from the field are also discussed.

3.2 Study Area
The research and data collection was conducted at WEEE Centre which is located in Mihango, Embakasi, off the Eastern By-pass in Nairobi, Kenya. This is a company that mainly recycles e-waste together with offering collection of e-waste services, dismantling and processing services that are automated in Nairobi and other numerous key Kenyan cities. WEEE Centre mainly gets e-waste from the public, private sector, and domestic sector using collection campaigns. This organization, which was first facility to begin recycling of e-waste in East Africa, came about though collaboration with World Loop, Close the gap, Safaricom Foundation and Computer Aid International organizations.
3.3 Research design

Mixed methods was used to collect data and for comprehensive data analysis. Strategy of enquiry was convergent parallel mixed methods where both qualitative and quantitative data were merged by the researcher so that the research problem is provided in a comprehensive analysis, (Creswell 2014). Quantitative data was obtained from numeric description from opinions, attitudes and trends of the key informants such as consumers, Hewlett Packard and WEEE centre on the use of a product-service system for e-waste management through structured questionnaires and interviews. Further, qualitative data was obtained from the case study in which the researcher developed an in-depth analysis of a case using in depth unstructured interviews, observation and desktop study to provide comprehensive information.

3.4 Target population

According to Prof. Waema & Muriuki, (2008), “the e-waste ‘universe’ in Kenya consists of stakeholders such as distributors, assemblers, retailers, consumers, refurbishes, recyclers and
final waste disposers to policy-makers”. The target population of this study was WEEE Centre, (encompasses recyclers, refurbishers), Hewlett Packard and private consumers that bring their e waste to WEEE Centre.

3.5 Sampling procedure
Purposive sampling was utilized to select key informants that include WEEE Centre four departments, which are, managerial, recycling department, refurbishing and education department and Hewlett Packard who are crucial in explaining the e-waste phenomenon in Nairobi County. To choose respondents from private and corporate consumers who frequently deliver e-waste at WEEE centre, the researcher used simple random sampling.

3.6 Sample size
The sample size from the case study consisted of four respondents from the organizations departments. From the organizations database, there were 28 frequent private and 2 corporate consumers. The researcher aimed to gather data from 10 consumers only therefore, all the corporate consumers were interviewed and 8 randomly selected from private consumes. Therefore, the total number of respondents aimed at was 15.

3.7 Data collection methods
Both qualitative and quantitative approaches were used for data collection. The instruments for data collection was pre-tested, (piloting) and readjusted to ensure accurate capturing of the required data for writing the final report.

3.7.1 Interviews and site visits
Mainly, the study was qualitative involving utilizing interviews with the use of a set of unstructured interview schedules for the key informants, which was confidential. This will allow much greater freedom to seek clarification, in case of need, allow development of supplementary questions or omission of certain questions that might have been tackled or
solved from the subject’s reaction. The researcher conducted site visits to WEEE Centre, and HP distributors and conduct face to face interviews so as to understand better the existing situations together with assessing the quality of the work done as well as the processes used. All responses was written down for later analysis. Focus group semi-structured group interview guide was used to get information on consumers’ perceptions, opinions, beliefs, and attitudes towards current e-waste management procedure and the product service system concept. Notes were written down during the discussion for later analysis.

3.7.2 Observation
Observation was done to inform or show type of e-waste delivered in WEEE Centre and how it is handled. As one of the core data collection methods, the researcher to directly seek and obtain information from the subjects in the case study without necessarily seeking their responses, used observation. In collecting and keeping record of the observed data, the researcher used digital cameras to gather and store observed data for later examination.

3.7.3 Desktop study
The secondary data was obtained from the previous documented information about NEMA and WEEE Centre in Kenya to get more information on how they handle their e-waste management in Nairobi County.

3.8 Data analysis and management

3.8.1 Quantitative Method
Data collected was analyzed using descriptive statistics whereby all numerical information gathered in the field was analyzed using rankings, percentages and frequencies. This was determined by the nature of variables under investigation such as types of e-wastes in storage, knowledge of collection points and e-waste collection. Data results were presented in tables and figures for interpretation.
3.8.2 Qualitative Method

All data collected using qualitative methods such as key informant interviews and questionnaires in this study was sorted and arranged into themes and descriptions which were represented in a qualitative narrative to convey the findings of the analysis. An interpretation of the data was done aiding in designing the product service system for e-waste management.
CHAPTER FOUR
DATA ANALYSIS AND RESULTS

4.0 Introduction

The presentation, analysis and discussion of findings from the field study was done between November 2017 and January 2018 from the case study and its stakeholders in Nairobi on existing systems of e-waste management in Nairobi County is discussed in this chapter.

4.1 Response rate and analysis.

For the convenience of data analysis and discussion, the sample size for the study consisted of four respondents from the organizations’ departments, 10 consumers and one producer who is a stakeholder of the case study.

All interviews from case study departments were answered together with those of the producer and two corporate consumers collaborating with the case study as shown in the table 4.1. The number of questionnaire and interviews issued is presented in brackets whereas those next to them represent the replies given. As the statistics show in the figure below, 100% of the projected interview from WEEE Centre, producers and corporate consumers were replied while 75% out of the projected private consumers answered questionnaires giving 86% responses.

Table 4.1 Response rates of the key informants

<table>
<thead>
<tr>
<th>Interviews</th>
<th>Number of interviews issued and replies received.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews for WEEE Centre</td>
<td>(4) 4 = 100%</td>
</tr>
<tr>
<td>Interview for Producer</td>
<td>(1) 1 = 100%</td>
</tr>
<tr>
<td>Questionnaire</td>
<td>Number of questionnaire issued and replies received.</td>
</tr>
<tr>
<td>Questionnaire for private consumers</td>
<td>(8) 6 = 75%</td>
</tr>
</tbody>
</table>
Qualitative data gathered was analyzed using descriptive statistics whereby all numerical information gathered in the field was analyzed using rankings, percentages, and frequencies. This was determined by the nature of variables under investigation such as types of e-wastes in storage, knowledge of collection points and e-waste collection. Data results were presented in tables and figures for interpretation.

All data collected using qualitative methods such as key informant interviews and questionnaires in this study was sorted and arranged as per the research study objectives which were presented in a qualitative narrative according to the various categories of the stakeholders and parts of the objectives as follows:

1. E-waste management system at WEEE Centre as an exemplar
2. Existing e-waste management system in Nairobi County
3. Product service system for e-waste management in Nairobi County

An interpretation of the results and findings aided the researcher in designing the product service system for e-waste management. The table 3.2 below is a summary of the categories of informants and theme and subjects of concern depicted on the data collection tools.

<table>
<thead>
<tr>
<th>Questionnaire for corporate consumers</th>
<th>(2) 2 = 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>= 86 %</td>
</tr>
</tbody>
</table>
Table 4.2 Summary of the categories of summary of the categories of informants and theme

<table>
<thead>
<tr>
<th>CATEGORIES OF INFORMANTS</th>
<th>THEMES AND SUBJECTS OF CONCERN</th>
<th>LIST OF INFORMANTS BY CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEEE Centre</td>
<td></td>
<td>Head of recycling department, (WEEE Centre)</td>
</tr>
<tr>
<td>• Managerial Department</td>
<td>• Broad company’s information</td>
<td></td>
</tr>
<tr>
<td>• Recycling Department</td>
<td>• e-waste responsibilities of the organization</td>
<td></td>
</tr>
<tr>
<td>• Refurbishing department</td>
<td>• channels and strategies employed in collecting e-waste</td>
<td></td>
</tr>
<tr>
<td>• Collection department</td>
<td>• The material fractions obtained in the recycling process</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fee paid for recycling procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Equipments and approximate number of units refurbished on a monthly basis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Key obstacles facing appropriate e-waste collection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Existing system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sustainability priorities</td>
<td></td>
</tr>
<tr>
<td>Producers</td>
<td>• Existing system</td>
<td>Waste management agent, (Hewlett Packard)</td>
</tr>
<tr>
<td></td>
<td>• Hindrances of appropriate management of electronic waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Extended Producer responsibility</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• funding mechanisms</td>
<td></td>
</tr>
<tr>
<td>Consumers</td>
<td>Private consumers</td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corporate consumers</td>
<td></td>
</tr>
<tr>
<td>- Product- services provision to consumers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Equipment storage and disposal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Collection and transport services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Paying e-waste recycling fee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Influence of the existing system</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Appropriate processing and disposal of e-waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Renting and returning end of life electronics to retailers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Data is protection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4.3 Existing system of managing e-waste at WEEE Centre

#### 4.3.1 General information about the company

WEEE Centre is a National Environment Management Authority licensed organization that has 26 employees where by 14 are men and 12 are women as shown in Figure 4. 1. There are no specific qualifications needed for one to be an employee in this organization as the firm trains their own workers on waste management for a period of one year.
From the case study’s managerial department, on the question about the processes the company carries out, it was reported that they sort out products, manual dismantling, shredding, separating shredded fractions, recycling, and refurbishing e-waste. To promote e-waste management, the organization also collaborates with other firms and institutions, such as Oracle, Safaricom, JRUAT, Multimedia University, Kenya Airways and Computer Aid International who open doors to the management of e-waste from different types of electronics. Safaricom and JRUAT collaborate by bringing its e-waste to the organization for recycling while Kenya Airways partners in airlifting the hazardous e-waste that WEEE Centre does not have capacity to recycle to Europe. Oracle and Computer Aid International are organizations that collaborate with the centre by advocating for the re-use of computers.

4.3.3 Collection and transport of e-waste

During an interview session with the respondent from the managerial department, it was pointed out that the organization gets e-waste such as medical equipments, household equipment and office equipments from several private and cooperate consumers who drop off the waste to the firm. Only the cooperate consumers are charged for bringing in their waste while it is free for household consumers and public learning institutions since their fee is paid by the government. The respondent was not free to share to exact amount they charge the cooperate consumers. It was also reported that a number of consumers did not understand
why they have to pay to have their e-waste to be recycled. In addition, the organization also gives consumers with large amounts of e-waste a chance to do a pick-up application from their website.

To determine the number of units refurbished annually, it was reported that 200-250 tones are received annually despite the fact that the organizations capacity to deal with e-waste was reported to be 350 tons per year. The less amounts received were attributed to be probably due to the fact that many consumers lack awareness of the existence of the facility. A higher percentage of the respondents reported that they collect their e-waste through the community based organizations and transport it to the WEEE Centre using their own means as shown in Figure 4.2. Based on these findings, the product-service system to be proposed should therefore address the creation of awareness and financial issues.

![Figure 4.2 Collection and transport collection and transport services responses](image)

**Figure 4.2** Collection and transport collection and transport services responses
4.3.4 Treatment and disposal of e-waste

It was reported that end of life products are delivered to the facility whereby some of them end up in the refurbishing department while those that are totally worn out are taken to the recycling department. To match the data obtained through the use of interviews and questionnaires, the researcher took photographs during the site visits through the permission of the manager for ethical reasons.

Refurbishing department

In the refurbishing sector, the devices are firstly is checked for identifying the faults on them followed by data cleaning for safe guarding users information. All the hardware parts that are damaged are then repaired and if completely damaged, they are reinstated with new ones, or refurbished components that are functioning. Software upgrades and installations of new authorized operation are done on the repaired devices. The electronics are then carefully and thoroughly cleaned. See figure 4.3 below.

Figure 4. 3 (a) electronics brought in for refurbishing , (b) a laptop been prepared for refurbishing process

Tests are then run on the devices such as mouse operation checks, keyboard functioning, sound and display. If the electronics are functioning properly, they pass to the final stage for
safe packaging. Finally, the electronics are dispatched back to the owners or donated to schools. This sector also maintains electronics for consumers at a fee. See Figure 4. 4.

Figure 4.4 WEEE Centre computer refurbishing process

Recycling department

In this sector, electronics beyond repair from the refurbishing department, commercial and private consumers are received, (Figure 4. 5). These include wide variety of e-waste such as computers, cell phones, radios, medical equipments, televisions, monitors, DVD players and laptops. The facility mainly uses manual disassembly of assets and mechanical shredding of e-waste.

Figure 4. 5 Electronics delivered in the recycling department

All items are then picked and disassembled by hand into different categories such as steel, plastic, power supply, CD/DVD, Circuit breakers, aluminum, lead, batteries, hard-disks and
so on depending on the material composition of different parts of the devices as shown in Figure 4.6. All workers are required to wear protective clothing while handling the e-waste.

**Figure 4.6** Images showing separation and containment of dismantled e-waste materials.

Once the hazardous components are removed, using high-capacity shredders the objects are then crushed into bits as small as 100mm for preparing the e-waste for a thorough sorting process and destruction of consumers’ data as shown in Figure 4.7.
When asked what the company does with material fractions arising from the company’s recycling processes the respondent reported that materials such as plastics and metals are recovered and sold to small companies for making items such as recycled plastic posts. Harmful materials recovered in the process are exported to Europe for further recycling for ecological and health preservation as shown in figure 4.8.

Receiving e-waste
Dismantling/separation
Plastics & metals
Shredding/crushing
Hazardous waste
Sold to other firms
New Materials
Shipped to Europe for further processing

Reacting to the question on the measures of health and safety undertaken by Safaricom, the respondent stated that the company has an e-waste programme founded in 2012 to aid in managing the end of life electronic gadgets dropped by their consumers such as laptops, mobile phones and accessories. As part of a sensitization programme on e-waste management, in 2013, public campaigns to educate people on the impacts of improper e-
waste disposal on the environment were launched by the firm. This entails collecting and storing end of life electronics from consumers via the Safaricom retail centers which is disposed by the Waste Electricals and Electronic Equipment Centre , (WEEE) in conjunction to the National Environment Management Authority , (NEMA) e-waste guidelines. Safaricom also encourages all members of the public to drop their worn out electrical and electronic products for ensuring that there is zero e-waste expulsion and nominal landfills for environmental and health protection.

4.3.5 Monitoring e-waste flows

On the question regarding the organizations collaboration with other organizations for monitoring e-waste, it was revealed that the firm collaborates with the National Environment Management Authority ,(NEMA). This is an agency of the Kenyan government responsible for all policies involving the environment together with the management of the environment. It was reported by one respondent that currently there is no legal framework in Kenya for e-waste management meaning that e-waste generators cannot be held liable for improper handling of e-waste. In addition, it was also reported that the 2006 Act e-waste is not categorized alone but under hazardous waste. Another respondent mentioned that, an e-waste bill was drafted in 2013 but unfortunately it has been pending in parliament up to date. Another interviewee stated that, most of the original electronics and electrical equipment manufacturers were said to be irresponsible for their end of life products despite the existence of the extended producer responsibility.

Hence, it can be concluded that the government should enforce the producer responsibility for appropriate e-waste management so that producers, manufacturers, or distributors take full responsibility of their electronics and stakeholders to work hand in hand so as to achieve the zero e-waste goal. From the response, therefore, it was noted that a system and policy should be developed to aid in appropriate management e-waste so that little or no –waste lands on
landfills. Additionally the pending e-waste bill should be passed into a law so that manufacturers can take responsibility of their e-waste seriously. Creating awareness to consumers about e-waste management is also seen also a major input in managing e-waste in the country.

Concerning the services offered to consumers, the respondent from the distributors reported that they offer after sales services of installation, maintenance and take back of their electronics such as of printers, desktops, laptops, tablets, desktops to consumers. The research study revealed that few consumers return their end of life products to the consumers. It was also observed that the company delivers some of its e-waste to the recycling facility. Towards reduction of e-waste discarding practices that are not safe, Hewlett-Packard also supports trainings and information campaigns on management of e-waste. It was reported that the firm also consults with the Kenyan government to aid in developing state legislation, registration together with infrastructure for responsible management of waste from electronics and electrical products.

On a question about their perception on the current system, (Figure 4. 9, it was revealed that there were key obstacles facing appropriate e-waste collection. It was also reported that management of e-waste was expensive therefore; no other formal companies have ventured into it meaning that the e-waste not dropped off in the firm lands in informal recycling processes. Besides these, many people lack awareness on e-waste management therefore they not only do not know where to dispose their e-waste but also the harm inappropriate e-waste disposal poses to them.
4.4 Existing e-waste management system in Nairobi County

4.4.1 Collection and disposal of e-waste

All consumer informants agreed to have discarded their e-waste at one point through the pay as you throw mechanism to the solid waste collectors. All claimed that they have no knowledge of where that e-waste was discarded. Responding to the question on whether by any chance they have ever delivered electronic waste to a point of collection before, 83% of the household consumers admitted to have never delivered their e-waste to any e-waste
collection point before they got to know about WEEE Centre recycling facility as shown in Figure 4. 10.

![Delivering e-waste to a collection point](image)

**Figure 4. 10** Response of consumers on e-waste delivery to designated collection points.

All informants agreed to having at least some end of life electronics in their houses whereby 20% claimed that they kept them as souvenirs, 60% did not know where to take it and 20% for future use as shown in Figure 4. 11. Based on a previous study, (Tocho & Waema 2013) and, (Anahide 2007) similar findings were reported whereby a significant number of respondents stored end of life electronics in their houses since they did not know where to take them to or for future use. Hence, it can be concluded that the level of e-waste collection and disposal awareness is wanting and collection program trainings programs need to be conducted.
Figure 4.11 Response of consumers on end of life disposal and storage

4.4.2 Treatment of e-waste

All respondents replied the appropriate treatment of e-waste was very important. Reacting to the question on whether NEMA should give a pledge that processing and disposal of e-waste was done appropriately; all informants thought it would be important for National Environment Management Authority to ensure that e-waste is managed in the appropriate manner in the country.

4.4.3 Financing and monitoring e-waste flows

Reacting to the question as to why Extended Producer Responsibility for management of e-waste has not been effective in Kenya, the respondent stated that the main reason might be that consumers expect to payment for bringing back the end of life products. Furthermore, that many consumers do not know that there are HP collection points despite the fact that there are around 40 collections points in the country, (Figure 4.12). In addition, the government has not provided e-waste policies.
Responding to the question of whether they would rent products to consumers the respondents thought it would be a good idea as the demand would go high due to the low prices. The only concern was that some consumers might not bring back product after getting the services. Reacting to the question of who they propose to be more responsible in paying e-waste recycling fee 50% of the consumers responded that manufacturers and distributors should be responsible. A percentage of 25 of the consumer respondents thought recyclers should be responsible while the remaining equally thought consumers and the government should bear the financing responsibility as shown in Table 4. 3.

Figure 4. 12 One of the HP collection points in Ngara. This point serves as a major collection point of e-waste in Nairobi.
Table 4.3 Response rate on paying e-waste recycling fee

<table>
<thead>
<tr>
<th>Category</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturers/Distributors</td>
<td>(4) 50%</td>
</tr>
<tr>
<td>Consumers</td>
<td>(1) 12.5%</td>
</tr>
<tr>
<td>Recyclers</td>
<td>(2) 25%</td>
</tr>
<tr>
<td>Government</td>
<td>(1) 12.5%</td>
</tr>
</tbody>
</table>

Answering the question on the method, they would find suitable and easy, between owning electronics and return the e-waste freely after its end-of-life, renting electronics at cheaper prices and return to retailers after use or having e-waste pick up services at their houses at a fee, 50% of the consumers found the first option to be the most suitable. Renting electronics at cheaper prices and returning them to retailers after use 37.5% would me suitable for 37.5% while pick up service at their houses for end-of-life electronics at a fee would be less, (Table 4.4)

Table 4.4 Responses of subjects on method they would find suitable and easy between owning, renting or pick up services.

<table>
<thead>
<tr>
<th>Method</th>
<th>Most suitable</th>
<th>Suitable</th>
<th>Less suitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own electronics and drop-off, (return) the e-waste freely after its end-of-life</td>
<td>4 (50%)</td>
<td>3 (37.5%)</td>
<td>1 (12.5%)</td>
</tr>
<tr>
<td>Rent electronics at cheaper prices and return to retailers after use</td>
<td>3 (37.5%)</td>
<td>3 (37.5%)</td>
<td>2 (25%)</td>
</tr>
<tr>
<td>Pick up service at your house for end-of-life electronics at a fee</td>
<td>1 (12.5%)</td>
<td>2 (25%)</td>
<td>5 (62.5%)</td>
</tr>
</tbody>
</table>
Given an opportunity to rent and return electronics to retailers after use, 50% of the consumers answered that they would do so as it is cheaper. Another 20% claimed that it was an option for them as they will not end up with obsolete items while the rest preferred this option as they will have not have to pay any maintenance fee as shown in Table 4. 5.

Table 4. 5 Consumers responses on why they would rent electronics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is cheaper to source</td>
<td>50%</td>
</tr>
<tr>
<td>I don’t end up with obsolete items</td>
<td>25%</td>
</tr>
<tr>
<td>No maintenance fee</td>
<td>25%</td>
</tr>
</tbody>
</table>

The research study revealed that, if assured that their data is protected by been erased using a trusted software, 60% of the informants replied that they would rent electronics as it is cheaper to source.

Both private and cooperate consumers reported that the current system, (Figure 4.13) has certain loop holes in the producer responsibility, consumers awareness, collection, transport, treatment, safe disposal and monitoring of electronics waste flows as shown in Table 4. 6. Therefore a reviewing the existing system for e-waste management by the concerned authorities is important.
Table 4.5 Consumers responses on the current e-waste management system

<table>
<thead>
<tr>
<th>AREAS</th>
<th>COMPETENT</th>
<th>MODERATE</th>
<th>INCOMPETENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer responsibility</td>
<td>6.3%</td>
<td>18.8%</td>
<td>75.0%</td>
</tr>
<tr>
<td>Consumer awareness</td>
<td>13.0%</td>
<td>37.5%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Collection of e-waste</td>
<td>12.5%</td>
<td>50.0%</td>
<td>37.5%</td>
</tr>
<tr>
<td>Transport of e-waste</td>
<td>0%</td>
<td>25.0%</td>
<td>75.0%</td>
</tr>
<tr>
<td>Treatment and safe disposal</td>
<td>18.8%</td>
<td>31.3%</td>
<td>50.0%</td>
</tr>
<tr>
<td>Monitoring of electronics</td>
<td>0%</td>
<td>37.5%</td>
<td>62.5%</td>
</tr>
</tbody>
</table>

System flow.

Figure 4.13 Existing e-waste management system in Kenya based on research findings
4.5 Product-service systems design for e-waste management

From the data collected in the study, the researcher developed a product-service system as the best method to help solve the e-waste management challenge in the country. This system is based on a shift from selling electronics to provision of a unit of satisfaction to consumers, stakeholder collaboration, and access to services rather than ownership of electronics, (figure 4.14). The Product-Service System design for e-waste management was based on the following approaches:- Stakeholder configuration approach, which mainly is based on the interaction of stakeholders in the system, satisfaction approach that is related to satisfying consumer demands in relation to products and services. Lastly, the sustainability approach which relates to economical, social and economical beneficial solutions.

<table>
<thead>
<tr>
<th>SELLING</th>
<th>PRODUCT</th>
<th>TO “UNIT OF SATISFACTION”</th>
</tr>
</thead>
<tbody>
<tr>
<td>INNOVATION</td>
<td>TECHNOLOGICAL</td>
<td>TO STAKEHOLDER CONFIGURATION</td>
</tr>
<tr>
<td>CUSTOM. VALUE</td>
<td>INDIVIDUAL OWNERSHIP</td>
<td>TO ACCESS</td>
</tr>
</tbody>
</table>

Figure 4.14 Product-service systems design process, (Tischner & Vezzoli 2009)

4.5.1 Interaction of stakeholders in the system

A field exploratory study by Schluep et al., (2008) indicated that the waste e-waste re-processing systems are typically based on existing collaborative network amongst the manufactures, traders, recyclers and consumers. Each key player in the scheme is tasked to provide value addition, job creation at every point of processing chain in which in turn is also the cascade of activities involved in the reuse, recycling and disposal of e-waste. Using this idea a concept-profiling map involving different stakeholders was developed as shown figure 4.15.
From figure 4.15, consumers are to rent large electronics from producers and pay for them for the use. The consumers are required to return the electronics to the manufacturers or distributors after use. For the existing electronics and small equipments, the consumer will purchase them from consumers but with an additional advance-recycling fee.

Figure 4.15 Concept profiling Map using SDO toolkit, (Source; case study findings)
After the end of life of these products, the consumer will be required to take them freely to
the manufacturers take back collection points similarly to the Switzerland e-waste collection
system that mainly relies on extended producer responsibility. This fee will be used to
finance the whole e-waste management process, which includes collection, transport of e-

waste, recycling, and training. The informal sector participants can get employment from the
different take back collection centers. The manufacturers and distributors will be responsible
for taking this e-waste to recycling and refurbishing centres at a fee. Raw materials recovered
from the system were sold to other companies to make new products.

4.5.2 Satisfaction and sustainable approaches for Product-Service System for e-
waste management

In this system, manufacturers will offer large electronics to consumers on rental terms rather
than selling them. This lessens the initial purchase fees, which was originally too high,
therefore electronics would be accessed more easily by all consumers through selling the
“unit of satisfaction” rather than the electronic. Simultaneously, it is anticipated that
advertising the new services or adopting alternative products and substitute systems of
product-service utilization can assist in new job creation. Additionally, employment
opportunities may be created through labour-services such as information services on design,
collection systems, take back systems, repair, refurbishment and disassembly will offer
support training and, process of installation repair, maintenance together with treatment of
their End-of-life components, (Elia & Gnoni 2015). On the other hand, consumers gain from
a product-service system by obtaining a greater variety of options of electronics in the
market; various payment schemes; repair services and the vision of diverse systems of
electronic utilization that are suitable to them on basis of possession responsibilities. In that,
consumers are free from the responsibility of an electronic; this is absolutely under the
ownership of the producer in its whole life span.
Through Product-Service System, buyers can learn more on ecological properties of electronics as well as how they can contribute to reduce the environmental effects arising from electronic consumption. Product-Service System’s have the potential to reduce the sum of products by the introduction of substitutes of product use such as pooling, sharing or leasing to end-users, without affecting the product design. To compliment this offer, the manufacturer will be responsible for maintenance, repairing, upgrading their electronic components and the treatment of their end-of-life components thus reducing the unexpected small costs incurred by consumers. Through Product-Service System, manufacturers would become more accountable for their product and services lest material cycles are closed, (Adrodegari et al. 2015). Manufactures are encouraged to retract their commodities, improve, renovate, and put them for use. Eventually, less e-waste ends up in incineration or open landfills.

Product-Service System approach will transform the current economic pricing systems as cost of production will become smaller in reference to cost incurred while making a product accessible to the end-user. This implies that the end-user do not pay for the product rather for the service offered which in turn can be perceived as technical improvement of dematerialization, (Corvellec & Stål 2017).

In the end, the development of an appropriate Product-Service System with a well-organized take back scheme for the small and already existing e-waste with consumers will possibly entice end-user to return their End-of-Life electronics as shown in figure 4.16. Second it will ensure that electronics at disposal stage have a worth market value. In the third state of a cost-effective Product-Service System is to adopt a substitute scenario of product application to generate extra profit. For instance, the legislation can require that a producer of an electronic to take care of their electronics after they are sold out. Under such scenario, the maintenance of the product accrues an extra cost. In case the manufacturer, rather than selling the
electronic, decides to offer its utility, it typically becomes a profit maker and an incentive to minimize the utilization of the electronic that is favorable for the consumer as well, (Sousa & Miguel 2015).

**Figure 4.16** Proposed Product Service System for e-waste management, (Source: case study findings)

The Product-Service System proposed (figure 4.7), also recommends the use-oriented services approach, which may include Product leasing whereby the ownership of the product does not change. The ownership rights are reserved for the producer, who often takes the responsible of maintaining, repairing and controlling the product. The end-user pays value charges mainly for product utilization and normally has limitless access to the leased product ,(Tukker 2004). In addition Product renting can also be utilized whereby the producers generally owns the product and is also accountable for maintenance, repair and control of the
product. The end-users are charged for making use of the item, however, the end-user has limited access to the product implying that different end-users can utilize the same product at other times, (Tukker 2004). Lastly, product pooling, which is much similar to product renting, can be utilized, although it encompasses synchronized utilization of the product, (Tukker 2004).

In the system, the government can execute institutional frameworks and policies that could be put in place to deal with the management of e-waste challenge in the county. Therefore, the product service system was developed from the findings of the study and mainly relies on collaborative and consultative process with all e-waste stakeholders.
CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

Based on the research study, this chapter discusses and concludes the findings with the aid of the research objectives. The chapter is divided into three sections; conclusions, recommendations, and recommendations for further areas of study.

5.2 Discussion of the findings

5.2.1 Existing system of managing e-waste at WEEE Centre

WEEE Centre is a National Environment Management Authority licensed organization that mainly refurbishes and recycles end of life products. To promote e-waste management, the organization also collaborates with other firms and institutions. Safaricom and JKUAT collaborates by bringing its e-waste to the organization for recycling while Kenya Airways partners in airlifting the hazardous e-waste that WEEE Centre does not have capacity to recycle to Europe. Oracle and Computer Aid International are organizations that collaborate with the centre by advocating for the re-use of computers. This portrays that WEEE Centre interacts with its environment and does not perform its functions on its own. The firm also gives back to the community by creating employment to youths who they train freely.

The organization gets e-waste such as medical equipments, household equipment and office equipments from several private and cooperate consumers who drop off the waste to the firm. Only cooperate consumers are charged for bringing in their waste while it is free for household consumers and public learning institutions. Electronics that end up in the refurbishing sector are repaired, tested, safely packaged and finally dispatched back to the owners or donated to schools. This is a key finding since it shows that the household
consumers who tend to have most of their e-waste stored in their houses, based on the findings, have an advantage as they are allowed to drop off their waste freely.

200-250 tones of e-waste are received annually although the company can recycle up to 350 tons per year. This can be attributed to consumers lack of awareness of the existence of the facility. This result is related to a similar finding by Kimeli, (2014) and (Otieno & Omwenga, 2015) that many consumers lack awareness on the existence of formal e-waste recycling facilities and the negative effects of improper e-waste disposal. Therefore, the system to be designed should pay special attention on this problem. During the recycling process, electronics are picked, disassembled by hand into different components, separated, and then shredded into fractions. All workers are required to wear protective clothing while handling the e-waste. Material fractions arising from the company’s recycling processes is recovered and sold to small companies for making new products. Harmful materials that the company cannot handle recovered in the process are exported to Europe for safer recycling. This findings show that the centre has a zero-dumping e-waste management system as none of the fractions recovered from the end of life products ends up in landfills.

Safaricom and H.P who collaborates with the centre has an e-waste take back system and takes all its e-waste to WEEE Centre for recycling. There is however a challenge as many consumers lack awareness of the existence of the take back systems and collection points. Similar results were reported by (Tocho & Waema, 2013). Both companies conduct public trainings to educate consumers on the importance of safe e-waste disposal.

The WEEE current system faces financial and lack of awareness challenge. As at now, there is no legal framework in Kenya for e-waste management therefore e-waste generators cannot be held liable for improper handling of e-waste. An e-waste bill drafted in 2013 has been pending in parliament up to date. Due to this, original electronics and electrical equipment...
manufacturers are irresponsible for their end of life products despite the existence of the extended producer responsibility.

5.2.2 Existing e-waste management system in Nairobi county

According to the study, 83% of consumers have never delivered electronic waste to a point of collection before they knew about WEEE Centre recycling facility. All agreed to have some end of life electronics in their houses either as souvenirs, for future use or they did not know where to take it. Therefore, similarly to the WEEE Centre system, public awareness needs to be created on existence of recycling and collection points. Furthermore, Extended Producer Responsibility for management of e-waste has not been effective in Kenya. This could be consumers expect compensation for bringing back the end of life products and most of them are not aware of e-waste collection points available. In addition, it could be due to the fact that few manufacturers are willing to be responsible for the e-waste their product generate as the government has not provided e-waste policies for guiding all stakeholders.

Research findings show that 50% of the consumers propose that manufacturers and distributors should finance e-waste disposal process. A percentage of 25 of the consumer respondents thought recyclers should be responsible while the remaining equally thought consumers and the government should bear the financing responsibility. Therefore, from this finding the product service system designed advocates for introduction of an advance-recycling fee that consumers pay as they purchase electronics. After the end of life, the consumers can then return the devices to the manufacturers at no fee. This ARF will finance the whole system. Another option proposed in the system is the introduction of the renting of electronics approach whereby consumers only rent device for a specific period of time, therefore at no point do they end up with end of life electronics.
The study notes that 50% of consumers find owning electronics and return the e-waste freely after its end-of-life most suitable, 37% prefer renting electronics at cheaper prices and returning them to retailers after use while 62.5% find the pickup service to be less suitable. If assured of data protection, the consumers welcomed the idea of the rent and return electronics to retailers after use as it is cheaper than buying the devices. This shows that consumers are willing to shift from the current service whereby their waste is picked from them at a fee to take back and renting approaches as previously discussed.

Both private and cooperate consumers reported that the current system has certain loop holes in the producer responsibility, consumers awareness, collection, transport, treatment, safe disposal and monitoring of electronics waste flows. Therefore, a review of the existing system for e-waste management by the concerned authorities is important.

5.2.3 Product-service systems design for e-waste management

From the findings, the current system in Nairobi County is not efficient for monitoring collection, disposal, recycling and financing e-waste management. Kimeli, (2014) states that in African countries, one of the e-waste management problems is the inadequacy of efficient collection, recycle and reuse system. Imperative actions are required to address this problem; therefore, the researcher proposes a product service system that looks into the specific areas of weaknesses in the current system as previously discussed in chapter four.

5.3 Conclusions

This study was conducted with the aid of three objectives whose findings are concluded below.

5.2.4 Existing system of managing e-waste at WEEE Centre

The study revealed that the current environment e-waste in WEEE Centre is partially sustainable as it allows collaboration of different stakeholders, creation of jobs, reduces
amount of e-waste in landfills and creates awareness to the public and so on as discussed in the findings. Unfortunately, the system has its shortcoming in financing, consumers’ insufficient awareness and inadequate policy adoption by the producers.

5.2.5 Existing e-waste management system in Nairobi County

The study concludes that consumer informants have discarded their e-waste at one point through the pay as you throw mechanism to the solid waste collectors. Most respondents revealed that the methods used to collect, dispose and recycle e-waste are not efficient as there is no existing mechanism of collecting e-waste that is clear. The Extended Producer Responsibility of electronics no adhered to in the current system. In addition, Kenyan policies guiding e-waste management and generation are not strong and well implemented. Proposed guidelines by NEMA have not been passed into law therefore creating a e-waste management loop hole. It is concluded that appropriate treatment of e-waste is very important and accountability necessity for the stakeholders involved. The proposed system offers ways by which stakeholders are held responsible through the EPR and ARF approaches.

5.2.6 Product-service systems design for e-waste management.

The study concludes that application of a product -service system design could be the best method to help solve the e-waste management challenge in the country. This system is based on a shift from selling electronics to provision of a unit of satisfaction to consumers, stakeholder collaboration, and access to services rather than ownership of electronics. This system could aid in addressing the collection, transportation, treatment, monitoring of electronic waste flows and in ensuring that stakeholders take up their responsibilities regarding e-waste disposal. Eventually, zero or smaller amount electronic waste will end up in incineration or open landfills. Furthermore, the study notes that 50 % of consumers find
owning electronics and return the e-waste freely after its end-of-life most suitable, 37% prefer renting electronics at cheaper prices and returning them to retailers after use.

5.4 Recommendations

5.4.1 Existing system of managing e-waste at WEEE Centre

For improving the efficiency of the current WEEE Centre e-waste management system, it is recommended that the government should execute institutional frameworks and policies to deal with the management of e-waste challenge in the county. Additionally, public awareness on e-waste management and its importance should be created by the concerned authorities to curb the e-waste menace in the county.

The government should also pass the e-waste bill proposed into a law to enact the extended producer responsibility on all producers and distributors so that little e-waste lands on consumers hands. Introduction of an advance-recycling fee that will aid in financing the entire system is also recommended.

5.4.2 Existing e-waste management system in Kenya

Based on the findings from the study it is revealed that the current system is not efficient in tackling the e-waste menace in the county. Similar to the WEEE Centre, the existing Kenyan e-waste management system lacks policies and laws that guide the ownership, collection, financing, disposal and recycling of electronic and electrical products waste. Due to this, large amounts of e-waste end up in the informal sector, landfills causing environmental, and health effects on people.

It is recommended that the formal sector should collaborate with the informal sector for appropriate collection, disposal, and recycling of e-waste to create a zero-dumping system. Additionally, it is recommended that NEMA should develop appropriate e-waste management systems in the country as well as reinforcing the take back systems.
5.4.3 **Product-service systems design for e-waste management.**

Based on the fact that majority of the respondents from the study were willing to adopt the use and return to distributor or producer and renting of electronics to the current pick up method, it is recommended that the government should adopt the user oriented PSS approach. Additionally NEMA is been recommended to adopt the proposed product service system for managing e-waste in the country.

5.5 **Recommendations for further areas of study**

1. Further study should be done in different counties to determine whether similar findings will be obtained.

2. A study on consumer awareness on take back systems, product ownership, and e-waste education is encouraged to develop a system or framework that fully encourages public trainings on e-waste management.

3. Moderating problems caused by e-waste needs an understanding on materials flow used to generate e-waste. Additional study should therefore be done to track and examine e-waste materials flow and tools employed in procuring long-term, environment friendly electronics.
REFERENCES


Chatterjee, D.S., 2006. Electronic Waste India. *Green.Tv - Technologies*. Available at:


APPENDICES
Appendix I Consumers Questionnaires

Declaration

The information gathered from this questionnaire is solely for the purpose of an academic research and the researcher will treat it with confidentiality. Your names should not be written on this questionnaire.

Tick where applicable.

General Information

Electronic waste, or e-waste, stands obsolete, end of life or electronics that are no longer working or wanted by consumers.

Did you know about e-waste before you read the above? YES/NO

1. Equipment storage and disposal

<table>
<thead>
<tr>
<th>Equipments</th>
<th>No. of members with unwanted</th>
<th>No. of members who have Collected/ discarded items</th>
<th>No. of members who donated Equipments</th>
<th>No. of members who have taken back items to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD player</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VCR/DVD/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Television</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Printer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fax Machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telephone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell phone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toaster</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleaner</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vacuum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dryer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing Machine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(b) If you have some equipment stored, why do you keep it?

<table>
<thead>
<tr>
<th>Reason</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>You do not know where to take it</td>
<td></td>
</tr>
<tr>
<td>For future re-use</td>
<td></td>
</tr>
<tr>
<td>As a souvenir</td>
<td></td>
</tr>
<tr>
<td>To donate</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
</tbody>
</table>

(c) In case you disposed some items, explain how you discarded it? (Give many answers as you can)

…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………

2. (a) Have you by any chance delivered electronic waste to a point of collection before?

   YES/NO..............................

(b) If never. Explain why? (Give as many responses as possible)

…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………
…………………………………………………………………………………………………………

(c) Who provides the collection and transport services for you? Tick against any of these that could be providing waste collection services in the area at any given time.

<table>
<thead>
<tr>
<th>Service Provider</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipality collectors</td>
<td></td>
</tr>
</tbody>
</table>
Private firm collectors
CBO collectors
Self-help groups e.g. women groups
Yourself
Others

3. What is your perception of the following areas in the current e-waste management system in Kenya

<table>
<thead>
<tr>
<th>AREAS</th>
<th>COMPETENT</th>
<th>MODERATE</th>
<th>INCOMPETENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Producer responsibility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumers awareness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment and safe disposal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring of electronics waste flows</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Which way would be more suitable and easy for you, (note down in numbers; 1 acting as the most suitable and the 3 least)

- Own electronics and drop-off, (return) the e-waste freely after its end-life
- Rent electronics at cheaper prices and return to retailers after use
- Pick up service at your house for end-of-life electronics at a fee

5. Given an opportunity to rent and return electronics to retailers after use would you do it?

YES/NO…………..
If yes tick reasons

<table>
<thead>
<tr>
<th>Reason</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>It is cheaper to source</td>
<td></td>
</tr>
<tr>
<td>I don’t end up with obsolete items</td>
<td></td>
</tr>
<tr>
<td>No maintenance fee</td>
<td></td>
</tr>
</tbody>
</table>

6. Propose who find more responsible in paying e-waste recycling fee

<table>
<thead>
<tr>
<th>Role</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturers/Distributors</td>
<td></td>
</tr>
<tr>
<td>Consumers</td>
<td></td>
</tr>
<tr>
<td>Recyclers</td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td></td>
</tr>
</tbody>
</table>

7. NEMA gives a pledge that processing and disposal of e-waste was done appropriately.

<table>
<thead>
<tr>
<th>Importance Level</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Not important</td>
<td></td>
</tr>
<tr>
<td>Important</td>
<td></td>
</tr>
<tr>
<td>Very important</td>
<td></td>
</tr>
</tbody>
</table>

8. Is owning an electronic very important for you…………………………………………………

If yes, please explain

…………………………………………………………………………………………………………………………

…………………………………………………………………………………………………………………………

9. Would you be ready to rent or lease an electronic and return it to the seller after use?

…………………………………………………………………………………………………………………………

Explain your answer above

…………………………………………………………………………………………………………………………

10. If assured that your data is protected by been erased by a trusted software, would you allow someone else to rent the electronic such as a computer that you had rented?

Yes/No………………………………………………………………………………………………………………

Explain your answer above……………………………………………………………………………………...
Appendix II WEEE Centre interview guide

Declaration

The information gathered from this interview is solely for purposes of academics and the researcher will treat it with confidentiality.

Introduction

Prior to the interview, the researcher shall introduce himself/herself to the manager of the organization.

I am ……………………….., (interviewers name) from …………………………………

I am collecting e-waste management and generation data for the purpose of

.................................................................................................................................................................

Thank you for offering to participate in my study.

<table>
<thead>
<tr>
<th>Broad company’s information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization’s Name</td>
</tr>
<tr>
<td>Location</td>
</tr>
<tr>
<td>Number of workers</td>
</tr>
<tr>
<td>Establishment Year</td>
</tr>
<tr>
<td>Role of contact individual</td>
</tr>
<tr>
<td>Phone Number</td>
</tr>
<tr>
<td>E-mail address</td>
</tr>
<tr>
<td>What are the e-waste responsibilities of the organization?</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Is the organization ISO 14001 approved?</td>
</tr>
<tr>
<td>Questions</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1. Are you aware what electrical and electronic equipment or electronic waste is?</td>
</tr>
<tr>
<td>2. What channels and strategies does your organization employ in collecting e-waste?</td>
</tr>
<tr>
<td>3. Do you involve any stakeholders in your operations? How?</td>
</tr>
<tr>
<td>4. What are the key obstacles facing appropriate e-waste collection?</td>
</tr>
<tr>
<td>5. For purposes of collection, do you work hand in hand with other authorities?</td>
</tr>
<tr>
<td>□ YES</td>
</tr>
<tr>
<td>□ NO</td>
</tr>
<tr>
<td>Fractions of materials obtained from WEEE</td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>1. From your organizations recycling operations, what materials are obtained?</td>
</tr>
<tr>
<td>2. What use do you make of the material fractions obtained in the recycling process?</td>
</tr>
<tr>
<td>3. Is there a fee given/paid by any stakeholder for the recycling procedure?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electric and electronic equipment refurbishment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Questions</td>
<td>Answers</td>
</tr>
<tr>
<td>1. What sort of electrical and electronic equipments do you refurbish in your company?</td>
<td></td>
</tr>
<tr>
<td>2. What approximate number of units are refurbished on a monthly basis?</td>
<td></td>
</tr>
<tr>
<td>3. Where are refurbished equipments taken to?</td>
<td></td>
</tr>
<tr>
<td>4. How do you utilize the parts or products that are not fit for refurbishment?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Broad questions on e-waste recycling and treatment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Which procedures are carried out by your company?</td>
<td></td>
</tr>
<tr>
<td>☐ Products sorting</td>
<td>☐ Burning</td>
</tr>
<tr>
<td>☐ Leaching</td>
<td>☐ Shredding</td>
</tr>
<tr>
<td>☐ Physical dismantling</td>
<td>☐ other:</td>
</tr>
<tr>
<td>☐ Separating fraction that are shredded</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2.</td>
<td>What number of employees are involved in the recycling process?</td>
</tr>
<tr>
<td>3.</td>
<td>To avoid releasing harmful materials, what ecological measures are undertaken by your company?</td>
</tr>
<tr>
<td>4.</td>
<td>What measures of health and safety are undertaken by your company?</td>
</tr>
<tr>
<td>5.</td>
<td>What is your perception of the current e-waste management system in Kenya?</td>
</tr>
</tbody>
</table>
Appendix III Manufacturer/Distributors interview schedule

Declaration

The information gathered from this interview is solely for purposes of academic research and all information was confidential.

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
<th>Questions can be enhanced through the use of comments, suggestions and details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which basis does your company work on?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ informal</td>
<td>□ formal</td>
<td></td>
</tr>
<tr>
<td>Does our organization work under any recyclers association or body?</td>
<td>□ YES</td>
<td>if yes: name of body/association?</td>
</tr>
<tr>
<td>□ NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does your company cooperate with other authorities or companies in collecting and recycling e-waste?</td>
<td>□ YES</td>
<td>if yes: name? details?</td>
</tr>
<tr>
<td>□ NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What do you think are the main hindrances of appropriate management of electronic waste?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>...........................................................................................................</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>5</td>
<td>Do you take back end of life electronics from consumers?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If yes, what is the approximate number who bring back their e-waste annually?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Why do you think the Extended Producer Responsibility for management of e-waste has not been effective in Kenya?</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>What do you think can be done to aid in application of effective management of waste?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Do the current e-waste management funding mechanisms affect the company?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ YES □ NO</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>If no: which area should be improved? (for example, collection, policies and regulations, recycling fee, company/manufacturer responsibility, (EPR))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Explain</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Given a chance, would you lease out electrical products to consumers? (yes/no) explain.</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your general opinion on the introduction of selling services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rather than selling electronics to consumers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thank you for taking part in this study.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix IV Observation guide

1. Who is taking part in the activity?
2. What is the number of participants?
3. What is the nature of the activity and working approach?
4. What is the timing and location of the activity?
5. How are the activities organized?
6. What are the roles and responsibilities each participants
7. What materials and tools are been used in the whole process?
## Appendix V Logical frame

<table>
<thead>
<tr>
<th>RESEARCH QUESTIONS</th>
<th>RESEARCH OBJECTIVES</th>
<th>DATA COLLECTION TOOLS</th>
<th>DATA SOURCES</th>
<th>DATA COLLECTED</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the e-waste management system at WEEE Centre</td>
<td>To determine the e-waste management system at WEEE Centre</td>
<td>Interviews (Semi-structured) Observation • Photography • Note taking</td>
<td>WEEE Centre</td>
<td>General information Stakeholders involved System used Sustainability of system</td>
<td>WEEE Centre e-waste management system</td>
</tr>
<tr>
<td>What is the existing e-waste management system in Nairobi</td>
<td>To determine the existing e-waste management system in Nairobi</td>
<td>Questionnaires (Self administered Semi-structured questionnaires)</td>
<td>Consumers</td>
<td>Stakeholders responsibilities Sustainability of system Transport Collection Financing</td>
<td>E-waste management system</td>
</tr>
<tr>
<td>Can a PSS system be used for e-waste management in Nairobi County</td>
<td>To propose a PSS system for e-waste management in Nairobi County</td>
<td>• Questionnaires • Interviews</td>
<td>• Consumers • Producers</td>
<td>Product provision Service provision EPR</td>
<td>Product-service system</td>
</tr>
</tbody>
</table>