UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

PROPER INVENTORIZATION OF E-WASTE IN COMPANIES AS AN E-WASTE

MANAGEMENT STRATEGY IN KENYA

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DECLARATION

This research project is my original work and has not been presented for examination in any other university.

Signed ……………… Date…………………

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Supervisor

This research proposal has been submitted for examination with my approval as the candidate's university supervisor.

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Abstract

E-waste is considered to be growing faster than any other waste stream in the globe. While many countries have invested in recycling of e-waste, most of it ends up in dumpsites. For this reason, it is important for a solution to be found upstream rather than downstream through reducing the amount of e-waste produced by consumers especially companies. Nonetheless, most companies in Kenya do not have data on the amount of e-waste they produce partly because of the complexity in inventorization of e-waste. Lack of data limits waste management action. Moreover, companies do not take action of reducing e-waste because they are unaware of the health hazard of e-wastes. The aim of the study was identifying the factors that need to be considered in developing an e-waste inventory system for use in companies. It also aimed at determining the costing methods for e-waste and finally coming up with an inventory system that could be used for monitoring the amount of e-waste produced by companies. Mixed method of research was used for the research. Data was collected through interviews, observation, literature review and questionnaires.

Data analysis indicated that having an e-waste management system raises awareness about the hazardous components in ICT equipment as well as their effect both to health and environment. As a result, organizations take e-waste management actions aimed at reducing the amount of e-waste they produce. Some of the e-waste reduction action identified includes buying high-end ICT equipment, reuse and refurbishing, purchasing ICT equipment that have more than one uses, developing policies specific to disposal of e-waste, collaborating with manufacturers and vendors, proper maintenance and purchasing environmental friendly ICT equipment. Some of the factors that need to be considered in developing an e-waste inventory system include weight, cost, risk factor and type of e-waste. The result indicated that the cost incurred by company as a

result of producing e-waste can be estimated by calculating the cost of storage as well as the cost of transporting it to the point of disposal. The e-waste inventory system developed is capable of capturing data on the type of e-waste whether computer, photocopy or an accessory, its weight and the cost incurred. After capturing this data the system generate information on the hazardous components on the equipment and its environmental and health effect. The conclusion made is that proper inventorization of e-waste can lead encourage e-waste management actions aimed at reducing the amount of e-waste produced in companies. Testing of the system would take a long time given that companies generate e-waste after at least one year; meaning that it is not possible to collect this information within the limited time allowed for this project. Further research is recommended to test the system and determine its effectiveness in organizations.

Key Words: E-waste, inventory system, companies, lack of data, costing of e-waste.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

STeP	Solving the E-waste Problem
EOL	End-of-life
ICT	Information Communication Technology
UNEP	United Nation Environmental Programme
NEMA	National Environment Management Authority
WEEE	Waste electric and electronic
IT	Information technology
BFRs	Brominated Flame Retardants.

CHAPTER ONE

INTRODUCTION

1.1 Introduction and Background

The ICT sector has experienced a rapid growth in recent years especially because companies and nations are leveraging its power to acquire competitiveness. Moreover, with the increase in economic growth, urbanization, population growth, and change in lifestyle orientation, the number of people acquiring computers has increased and it is expected to continue increasing into the future. The growth in the use of the internet, coupled with the decrease in its price has also encouraged many people in developing and developed countries to adopt the use of ICT related electronics. These factors together with the high obsolescence rate of ICT equipment has led to an upsurge of the e-wastes generated in the world. Lundgren (2012) posits that e-waste comprises the largest waste stream. Estimates by UNEP (2015) indicate that every year the world generates about 41 million tons of e-wastes from products like computers and smart phones. Predictions by UNEP show that by 2017, the amount of e-waste may increase to about 50 million tons.

A report by UN Environment released in 2014 indicated that the waste generated in the world in 2014 represented about 6.8 kg per every individual in the world. Balde et al (2015) indicates that the amount of e-waste generated in the world was about 41.8 Mt. The amount is expected to increase to about 50Mt in 2018. Out of the total amount of e-waste generated in 2014, about 3.0 Mt came from IT equipment including personal computers, printers and mobile phones. Lundgren (2012) asserts that ICT equipment and related accessories forms about 30 percent of the e-waste generated.

It is estimated that every year, the United States of America sends about 15000 tons of computer and mobile phone to Kenya for recycling (PBS.org, 2014). The amount waste is in additional to the e-waste that Kenya generates from its own use of electronics. Data by UNEP indicates that Kenya generates about 17000 metric tons of e-waste. Out of the waste about 2500 tons is from computers and around 500 tons from printers (Munene, 2011). A baseline study by Waema and Muriithi conducted in 2007 and some part of 2008 indicated that annually, Kenya produces about 3000 tons of e-waste from computers. Besides receiving e-waste from United States, other reasons for increased e-waste in Kenya includes the short life cycle of the electronics bought. Most consumers buy second hand or prefabricated computers that have a short life span. Computers and ICT equipment have become more affordable in Kenya because the government have made them tax free and the implementation of e-governance and e-learning in high education. Moreover, there are a lot of donations from other countries.

Kenya has invested a lot in recycling of e-waste with companies like Hewlett Packard, Waste Electric and Electronic Center (WEEE), Computer for School Kenya and East African Computer recycling and many informal recycling yards stepping up to reduce the menace. In June 2015, President Uhuru Kenyatta signed a regulation requiring consumers to dispose their e-waste in facilities that are licensed by the government and that meet international standards. Nonetheless, a study by NEMA indicated that even with the various recycling plants about 605 tons of e-waste is sent for disposal by refurbishers and recyclers meaning it accumulate in the environment (Munene, 2011).The e-waste is dumped together with other solid wastes in dumpsite especially in *Dandora* dumpsite and *Kibera* in Nairobi.

Lundgren (2012) asserts that e-waste is complex. Electronics contain a variety of different materials. For example a personal computer is made up of 23% plastic, 32% ferrous metals, 18%

non-ferrous metals, 12% electronic boards and about 15% glass (Saritha, Kumar & Srikanth, 2015). A single computer contain up to 2% lead. The multifaceted mixtures of the components that make computers make recycling very difficult. A report by the Global mixture (2014) indicated that the composition of electronic waste stream, with its constituents having both toxic and non-toxic substances, makes management of e-waste a complex endeavour.

While the waste hierarchy (see figure 1) cites prevention and minimization as the most preferable methods of dealing with waste, Kenya has embraced recycling as the main method of dealing with the e-waste menace. However, the many recycling companies are not able to recycle all the waste partly due to lack of capacity and complexity of e-waste. The growing needs for computers in the country means that it is not possible to stop import. It also means that recycling may not be the best solution to the growing problems of e-waste and the solutions must be found upstream either in the way manufacturers make the electronics or the way the consumers use electronics. Additionally, the economic, environmental and social effects of e-wastes call for minimization. Hence, the research aims at investigating whether monitoring of e-waste generated at company level can help in reducing e-waste in Kenya.

Figure 1: Waste Hierarchy

Source:(NSW EPA, 2015)

1.2. Problem Statement

Kenya is committed to management of e-waste through the Ministry of Environment, Natural Resources and Regional Development Authorities in order to promote healthy, clean and sustainably-managed environment for economic and social development (Ministry of Environment, Natural Resources and Regional Development Authorities, 2016). In this regard it is important for the various stakeholders to collaborate in the management of e-waste. Companies are the major stakeholders because most of them use different ICT equipment. However despite the government commitment, most companies in Kenya lack information on the amount of e-waste they produce due to what Waema and Anyango refer to as complexity in inventorization of e-waste. The difficulties in inventorization coupled with lack of awareness by companies' employees on the effect of e-waste hinder companies from taking the initiative of managing their e-waste.

While much of the research in the area of e-waste management has concentrated on take back initiatives by manufacturers and recycling, little or no research has been conducted on the effect that inventorization or monitoring of the waste produced on the company may have on e-waste management. The research thus aimed at determining whether inventorization of e-waste would lead to any e-waste management action. In this regard, the research focused on identifying the factors to consider in coming up with an inventory system for e-wastes produced in a companies. Additionally, the research aimed at determining the costs associated with-waste. Finally, an e-waste inventory system for companies was developed.

1.3. Assumptions of the Study

The assumption made in the study was that if companies were more aggressive in tracking the amount of e-waste they produce within a certain period and the associated costs and effects of

4

these wastes, they would be more aggressive in coming up with ways of managing these e-wastes. Consequently, this will help the country in dealing with the problem of e-waste or in reducing e-waste in the country.

One of the methods proposed by the United States Environmental Protection Agency for minimizing waste from food is measuring and tracking the quantity, category and reason for the packaging and food being discarded. The researcher assumed that the fact that data and knowledge helps in minimizing food waste and other type of waste in the world, it would also apply in the minimization of e-waste produced in companies

The other assumption was that the data obtained from the organizations that took place in the study was a perfect representation of all companies in the country and thus the system could be used by any company.

1.4. Purpose of the Study

The main purpose of the study was developing a monitoring system with the capability of providing information to companies on the amount of e-waste they produce as well as the associated impact in terms of social, economic and environmental cost.

1.5. Research Objectives

I. To determine e-waste management actions as a result of implementing an inventory system.

II. To determine the various methods used for costing e-waste.

III. To determine the factors to put into consideration while developing an e-waste inventory system.

IV. To find out the level of awareness on the effect of e-waste among employees.

V. To develop an inventory system that companies can use to monitor the levels of e-waste generated at a particular time together with their associated costs.

1.6. Research Questions

I. What are some of the e-waste management actions that employee may take after implementation of an inventory system.

II. What are the metrics used for costing e-waste?

III. What are some of the factors/parameters to consider in developing an effective e-waste inventory system for use in organizations?

IV. What is level of awareness on the effect of e-waste among employees in organizations?

1.7. Scope or Delimitation of the Study

The study was carried out in Kenya giving special emphasize on Nairobi County. Nairobi County was considered because many companies in the country are based in Nairobi. Further, Nairobi consumes the highest amount of ICT products and it thus faces the most difficulty in managing e-waste (Waema and Muriithi, 2008).

Electronic wastes include wastes from all kind of electronics including refrigerators, televisions, radios, computers, printers, mobile phones, VCRs, copiers, stereos, fax machines and washing machines. However, the research concentrated on e-waste generated from IT related s used in organizations including printers, copiers, monitors, computers, laptops, and other computer related accessories.

1.8. Justification of the Study

Despite the establishment of recycling plants in Kenya a lot of e-wastes still find its way into dumpsites. Most of the solutions provided in dealing with e-waste are downstream including reuse, and recycling. Upstream research includes producer extended responsibility. While research has been conducted on the downstream solutions for dealing with the menace and the role of other stakeholders in this sector, little or no research have been conducted on upstream solutions that can be provided by consumers especially companies. Further, while one of the problem in management of e-waste has been cited as inventorization, not much research have been conducted in identifying the role that inventorization of e-waste would play in e-waste management. The result of the research helps consumers and policy makers in managing the amount of e-waste produced in the company. It also encourages policy makers to develop legislations for management of e-waste. Further, it adds to the knowledge base in the area of e-waste management.

CHAPTER TWO

LITERATURE REVIEW

The section explores previous research in the area of e-waste management. Review and synthesize of previous research is done to identify research gaps.

2.1. Effects of Improper Disposal of E-waste

Improper dumping of e-waste raises a lot of concerns. The concerns are especially because of the danger that poorly disposed off e-wastes pose to the environment and to human beings. Computers contain poisonous substances including mercury, cadmium, chromium, copper, arsenic and lead. The people who collect the e-waste from dumpsites incinerate them to salvage useful components like copper. Incinerating e-waste lead to production of greenhouse gases which lead to the depletion of the ozone layer something that contributes to climate change with unpredictable weather patterns including floods, and droughts. The non-biodegrability of most computer parts makes computer and the computer accessories pose a challenge to waste management to the County Council of Nairobi because they even block water channels.

Heavy metal like lead are radioactive hence detrimental especially when they leach into the soil or find their way into the water (Grant, et al., 2013). When people drink water with lead they are exposed to lead poisoning. A recent study by UNEP on school going children living near the Dandora dumpsite showed that 50 % had low levels of haemoglobin. It also showed about 30% of them had staining and size abnormalities of the red blood cells a condition called microcytosis (Kimani Njoroge and UNEP, 2007). Other children in the study had iron deficiency anaemia. These conditions are brought about by intoxication from heavy metals like lead.

The study also indicated that about 52% of the children in the study had an increased level of white blood cell called pulmonary eosinophilia. The condition can result to respiratory conditions like asthma, chronic rhinitis and conjunctivitis and dermatitis. Beside the conditions identified in the study, lead poisoning can also impair verbal and cognitive activity in children. In severe conditions, it may lead to a coma, paralysis and even death. Substances like chromium and arsenic are known to be carcinogenic (Singh, Pal, Gangwar, Gupta1s & Tripathi, 2015). Arsenic can also cause diseases like cardiovascular disorders while chromium leads to irritation of the skin.

The diseases that result from e-wastes have economic impacts including increase in public budget on healthcare. Further, the country is forced to incur huge investment on expensive and complex remedies like recycling. Establishing of a recycling plant is very expensive and in a developing country like Kenya, the money used for such could be used to take care of other priority issues like education and health care.

2.2. Different E-waste Management Methods across the World

One of the major methods of management of e-waste around the globe has been recycling. The e-waste are collected and dismantled to recover any valuable metals and parts, which are then used in making different things. Recycling of computers leads to recovery of about 95% of useful materials. Recycling e-waste using appropriate technology have very minimal environmental effect. However, use of inappropriate methods like those used in developing countries including burning lead to very diverse effects on the environment. Additionally, even with recycling most of e-waste end up in landfills because most countries do not have the capacity for recycling all the electronics that have reached their end-of-life.

Extended producer responsibility in e-waste management involves requiring the producers to take back the computers and peripheries when they reach their EOL. The e-waste management initiative helps in reducing the impact of e-waste on the environment by ensuring that they do not release hazardous materials to the environment. It also helps to give the manufacturers the incentives of producing electronics that can easily be recovered in order to reduce recovery costs. The incentives that manufacturers take include reducing the amount of hazardous materials, increasing reusable and recyclable materials incorporated in the electronics. However, (Atasu & Subramanian, 2012) asserts that the implementation details of most of the waste directives concerning take-back undermines the desired outcomes. As a result, manufacturers do not get the incentives of reducing the hazardous substances in their products.

Pramila, Fulekar and Bhawana (2012) cite land filling as one of the method that is widely used in disposing e-waste. The method involves making trenches on the surface. The soil from the trenches is excavated and the e-waste buried in them and then they are covered with the soil. The modern landfills have impervious liner made using clay or plastic and a leachate collection basin for collecting and transferring leachate to treatment plant. While the landfill with liners may be safe, those without it lead to leaching of hazardous substances like lead and BFRs.

Incineration is another method of managing e-waste and it involves complete and controlled burning of e-waste. One advantage of using this as a mean of treating or managing e-waste is that the volume of e-waste is significantly reduced. Further, some incinerating plants are able to remove iron from the resulting slug and environmentally hazardous materials are reduced to less hazardous form. However, one of the shortcomings of this method is that substances like cadmium and mercury are emitted to the air.

2.3. E-waste situation in Kenya

Like any developing country, Kenya is struggling with the menace of e-waste. The e-waste produced in the country has been increasing on a daily basis with most of it being dumped together with solid waste into dumpsites. This exposes the environment to the dangerous effects of e-waste. A study conducted by Waema and Muriithi (2008) indicated that Kenya generates about 3000 tonnes of e-waste from computers, printers, notebooks and related accessories alone per annum. They further pointed out that this amount would continue to increase because of importation of computers and their continued use in subsequent years. Most of the waste generated remained in storage because of the absence of a legislative framework or policy as well as a practical e-waste management.

Otieno (2015) asserts that the ICT industry in Kenya grows at a faster rate compared to other East African countries. The growth is due to the launch of e-government strategy, promotion of e-learning and elimination of tax levies on computer and computer accessories. Moreover, the number of internet users has also increased and data from the Communication Authority of Kenya indicates that the country has experienced a tremendous growth in the number of internet users. Data released in 2014 shows that Kenya has around 22 million internet users. Most of ICT products in Kenya are imported from countries like Malaysia, Britain and China and the country discourages importation of old ICT s. Nonetheless, through donations by Non-governmental organizations to schools and government institutions, refurbished and old ICT products get their way into the country.

 These factors have in turn contributed to the increase in the number of e-waste produced in the country. Lack of a proper e-waste management system in the country has led to a tremendous growth of the informal recycling sector. The informal recyclers dismantle the waste electric and

electronics and reuse the old parts for repair or for reuse. The activities undertaken by the downstream vendors are usually unregulated and do not take into consideration the environmental effects and the safety of the people. Further, the informal recyclers and refurbishers send about 605.2 tons for disposal together with other solid waste in Dandora dumpsite exposing the environment to serious effects and jeopardizing the safety of people and animals living around those areas.

Due to lack of proper e-waste management as well as lack of awareness, there are many e-waste stored in offices and stores. Organizations also give away computers and computer peripheries that have reached their end- of- life to recyclers without being concerned of the disposal methods that will be applied. Most of the e-wastes from government organizations are auctioned. However, due to storage for a long time, the auction value of the computer is reduced and by the time it is resold, it has probably reached it EOL. This means that the buyers cannot use the computers and they thus dispose them together with the other solid wastes.

2.4. Challenges facing E-waste Management in Kenya

Otieno and Omwenga (2015) cite donation of old computers and computer accessories coupled with importing of second hand and refurbished computers by consumers who cannot afford new electronics as one of the major challenge in management of e-waste. The second- hand and refurbished computers have a short life span contributing to an increase in the amount of e-waste.

The low-level of awareness among consumers on the effects of e-waste on their health, safety and the environment has also been cited as a major challenge in dealing with e-waste. The harmful effect includes polluting the environment especially when burnt or disposed off together

with the solid waste, releasing heavy metals into the environment, exposing human beings to diseases like cancer, blocking drainage systems and destruction of ozone layer.

Songa and Lubanga (2015) allude to lack of a policy to guide disposal of ICT waste as the main challenge to management of e-waste. This is buttressed by Otieno and Omwenga (2015) who point out that despite the fact that Kenya is signatory to conventions like Bamako that guides management of e-waste, the country does not have an adequate regulatory framework for effectively managing e-waste. A study by Tocho and Waema (2013) indicated a lack of procedures and policies for management of e-waste as well as lack of enforcement of the available policy framework.

Oluwo (2012) asserts that the European Union, the United States, Japan, and other developed countries started dealing with this menace during the 1990s by setting up e-waste recycling facilities and tightening the regulatory framework on disposal of e-wastes. However, not all the developed countries have the capacity for handling the increasing levels of e-wastes and some are not willing to recycle the e-waste on their own backyard. They thus resorted to exporting these e-wastes to developing countries especially in Africa and Asia, most of which do not have adequate legal frameworks to deal with e-wastes (Herat &Agamuthu, 2012, Orisakwe, 2010). Some of the African countries mostly affected by the problem include South Africa, Ghana, Nigeria and Kenya. The Obsolete and near death electronics ends up into dumpsite or in the hand of informal recyclers and this is posing a great challenge in management of e-waste in Kenya.

2.5. Connection between Data and Waste Management

A research conducted by Godfrey, Scott, Difford and Trois (2012) indicated that waste data influences the way organization manage their waste. The waste data helps in generating

knowledge on waste and also raises the level of awareness on the effect of waste among employees. Consequently, operational response is triggered. Kwatra, Pandey and Sharma (2014) buttress this by indicating that people who have information on e-waste are able to link the effect of improper e-waste management with harmful health outcomes. The ability to link injurious health outcome with inappropriate e-waste management may encourage employees within an organization to take the initiatives of properly managing e-waste or even reducing the amount of e-waste produced.

Godfrey, Scott, Difford and Trois (2012) opine that knowledge is a precursor to behavioral and resultant intent and resultant action for waste reuse, compositing and recycling. Godfrey, Scott, Difford and Trois (2012) assert that collecting, interpreting and internalization of data help in raising awareness via the learning process. Consequently, information is considered to be a basis of generating information, environmental awareness and concern. The role of information in raising awareness and generating information plays a significant role in changing people's behavior especially in situation where there are environmental problems. In the part 1 of their research Godfrey, Scott, Difford and Trios (2012) find out that data on waste influences how organizations manage their waste.

2.6. Method of Monitoring E-waste

The UN has developed a framework for measuring the flow of e-waste in the world (see figure 2). The framework traces the electronics from the point of sale to the point of disposal. After the sale of electronics, they remain in the public sector, offices or households for sometimes. The time that the electronic remains in the different places is its lifetime or product residence time. The resident time includes the selling of the second hand products to other consumers. After the residence time the electric and electronic is disposed or it generate e-waste. The e-waste

14

generated can then be collected in four different scenarios including official take back system, waste bin, and trade either legal or illegal outside the take back system (Balde, Wang, Kuehr, and Huisman, 2015). The measurement framework is used for measuring e-waste for countries. While it would be difficult to calculate the cost using the measurement framework, an inventory system will only need to apply some mathematical computations (addition) to calculate the total costs associated with e-waste produced in the company over a particular period of time.
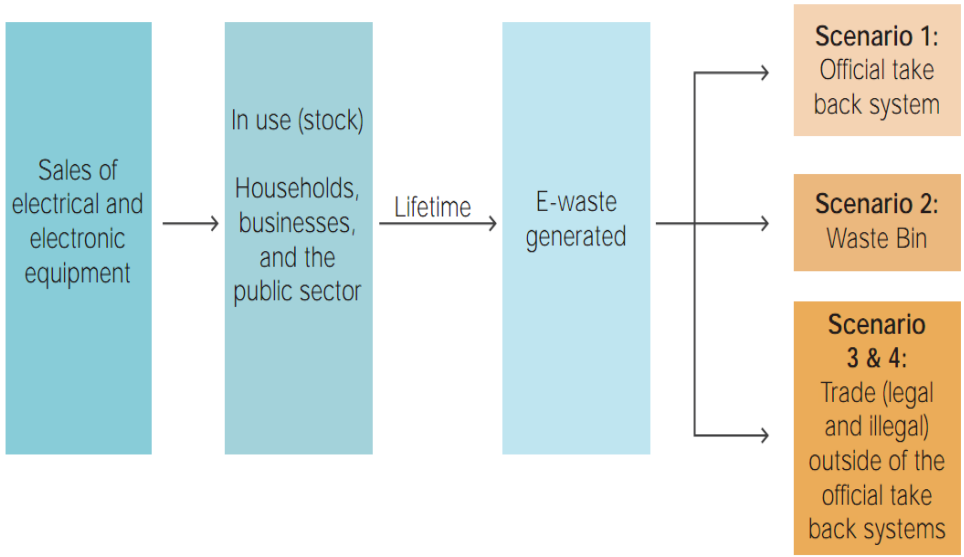
Figure 2: E-waste Measurement Framework

Source: Balde, Wang, Kuehr, and Huisman (2015)

2. 7. Conceptual Architecture

The proposed system aims at helping companies to keep an inventory of the amount of e-waste they produce. Further, the system calculates the cost of the e-waste to the company as well as the

effect of improper disposal to the environmental and human health. Figure 3 shows the conceptual architecture for the study.

Input (e-waste

Data Collection (Create an Inventory for e-waste generated)

Inbuilt database (Hazardous materials in different e-waste

Database (e-waste and associated hazardous material)

Costs to the company, weight, health implication (Graphical data)

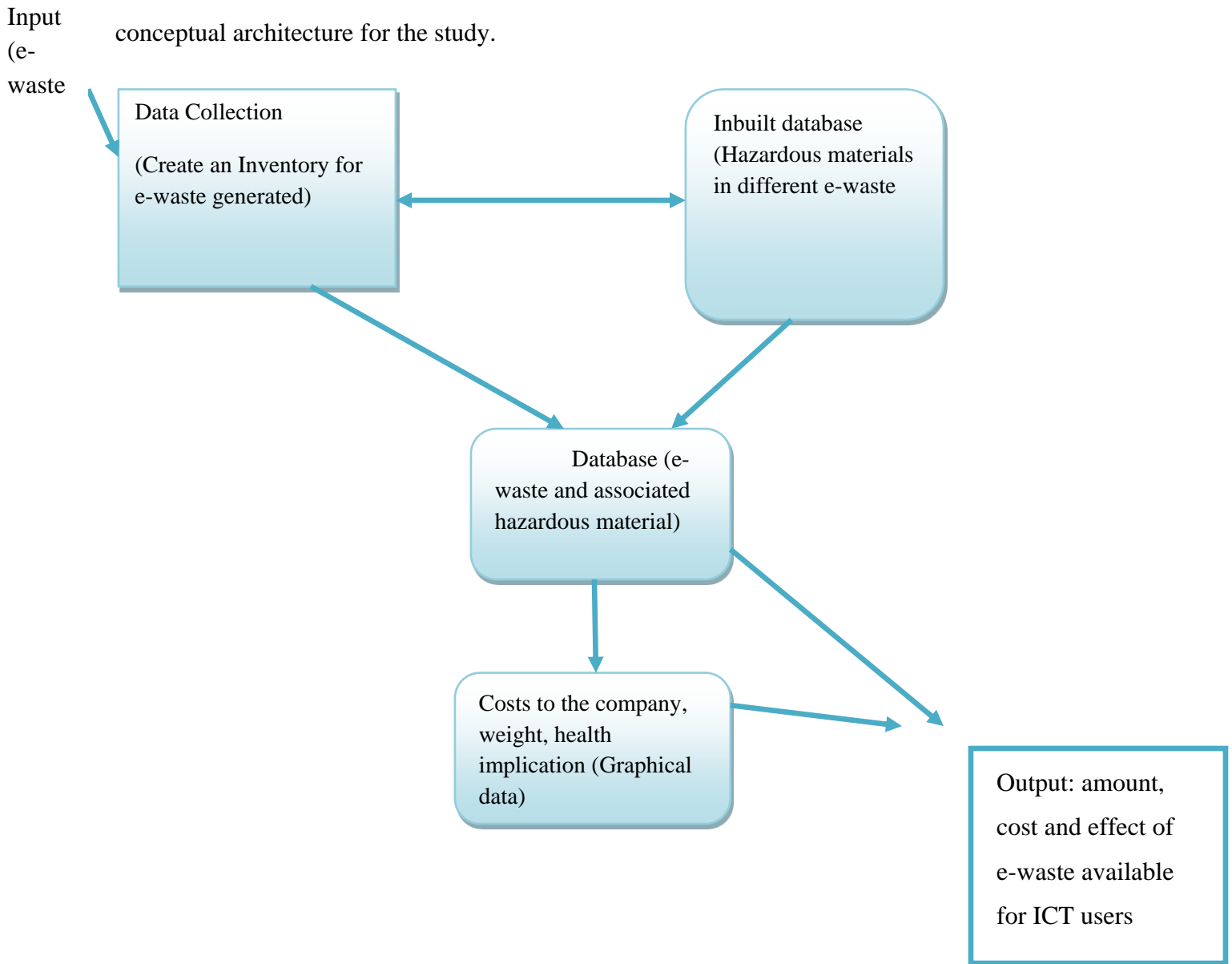Output: amount, cost and effect of e-waste available for ICT users

Figure 3: Conceptual Architecture

CHAPTER THREE

METHODOLOGY

The chapter gives the research methodology that was used in order to meet the research objectives of the project. The chapter covers the design, population, data collection and data analysis method. It also covers the system methodology or the model adapted for developing the e-waste inventory system.

3.1. Research Approach

Saunders, Lewis and Thornhill (2009) describe two major research approaches, inductive and deductive approach. Deductive approach involves development of a theory or a testable hypothesis. On the other hand, inductive study involves collection of data first and using the data to develop a theory. The study took the inductive approach and this meant that the researcher first collected data from the subjects and then analyzed the data to develop a theory. Inductive approach was particularly appropriate because the study was exploratory and with an inductive method it was be possible to understand the context rather than just the relationship between the different variables. Further, since the study was exploratory in nature, it would not have been possible for the researcher to develop a theory first then prove it by collecting data. Moreover, the limited information on the area of monitoring the amount of e-waste in organizations meant that the researcher would not have been in a position to come up with a hypothesis beforehand (Saunders, Lewis and Thornhill, 2009).

3.2. Research Design

The study adopted a mixed research method that is both qualitative and quantitative research method. Kothari defines qualitative research as one that involves kind or quality as opposed to quantity. On the other hand, quantitative method involves numbers and percentage. It is data that

can be quantified and presented in numerical terms. The qualitative research design was particularly relevant for the study because it aimed at exploring human behaviour in management of e-waste. Further as Kothari (2004, p. 4) puts it, qualitative research can be used in identifying the different factors that motivate people in behaving in particular ways and therefore appropriate for the study because one of its objective is establishing some of the factors that should be considered in developing an e-waste inventory system. Quantitative method was used for providing a summary result of the research in numerical terms. It was particularly important for the closed-ended questions in the questionnaires and it was used to provide the frequency in percentage of occurrence of certain answers.

3.3. Data Collection

Data for the study was collected through the use of literature review, in-depth interviews, observations and questionnaires. The researcher personally interviewed ICT head of departments or managers in the organizations that took part in the research. Interview was an appropriate method of data collection in this study because it provided in-depth information pertaining to the experiences as well as the viewpoints of the respondents pertaining to the topic (Turner, 2010). Questionnaires were issued to IT personnel in order to supplement the information collected through the use of interview and to give the researcher comprehensive information to analyze. The questionnaire had a mix of both open and close ended questions. The use of open ended questions allowed the respondents to express their point of views and reinforced the close-ended questions. Further, the open-ended questions helped in providing qualitative data relating to the topic under study.

During collection of data, the researcher gave the participants information about what the study entailed to ensure that they voluntarily took part. The conversation between the researcher and

the ICT heads was recorded using a mobile phone in order to ensure the information could be

accessed later during analysis. The researcher also made notes during the interview. The

questionnaires were issued to IT personnel in hard copy form and the researcher dropped the

questionnaire in the respective companies and collected them once the respondents had filled

them.

3.4. Target Population

The population is the whole group of objects or people to which a researcher aspires to

generalize the findings of the study. It is the objects or people that meet the criteria that interest a

researcher. Kothari (2004) defines it as the complete list of all the items in a field of inquiry. The

study focused on Kenyan companies listed in the Nairobi Stock exchange. These are about sixty

five companies in total. A sample was drawn from this population using purposive sampling. The

companies listed in the Nairobi Security Exchange were chosen for the study given that they are

large in terms of their market capitalization. One of the requirements for company to be listed in

the Nairobi Security Exchange is that it should have assets worth about one hundred million

shillings. Further, these companies have over fifty employees and this mean their dependence on

ICT is probably high. High dependence on ICT also means that the companies produce high

levels of e-waste.

Table 1: Study Population

Category	Company
Investment	Home Afrika Ltd.
	Kurwitu Ventures
	Olympia Capital Holdings Ltd.

	Centum Investment Co. Ltd.
	Trans-Century Ltd.
Investment Services	Nairobi Security Exchange Ltd
Manufacturing and allied	B.O.C Kenya Ltd.
	British American Tobacco Kenya Ltd.
	Carbacid Investments Ltd.
	East African Breweries Ltd.
	Mumias Sugar Co. Ltd.
	Unga Group Ltd.
	Eveready East Africa Ltd.
	Kenya Orchards Ltd.
	A.Baumann CO Ltd
	Flame Tree Group Holdings Ltd.
Telecommunication and Technology	Safaricom Ltd.
Real Estate Investment Trust	Stanlib Fahari-REIT
Agricultural	Eaagads Ltd.
	Kapchorua Tea Co. Ltd.
	Kakuzi
	Limuru Tea Co. Ltd.
	Rea Vipingo Plantations Ltd.
	Sasini Ltd.
	Williamson Tea Kenya Ltd.
Automobiles and Accessories	Car and General (K) Ltd.

	Sameer Africa Ltd.
	Marshalls (E.A) Ltd.
Banking	Barclays Bank Ltd.
	CFC Stanbic Holdings Ltd.
	I & M Holdings Ltd.
	Diamond Trust Bank Kenya Ltd.
	HF Group Ltd.
	KCB Group Ltd.
	National Bank of Kenya Ltd.
	NIC Bank Ltd.
	Standard Chartered Bank Ltd.
	Equity Group Holdings
	The Co-operative Bank of Kenya Ltd.
Commercial and Services	Express Ltd.
	Kenya Airways Ltd.
	Nation Media Group.
	Standard Group Ltd.
	TPS Eastern Africa (Serena) Ltd.
	Scangroup Ltd.
	Uchumi Supermarket Ltd.
	Hutchings Biemer Ltd.
	Longhorn Publishers.
	Atlas Development and Support Services.

Construction and Allied	Athi River Mining
	Bamburi Cement Ltd.
	Crown Berger Ltd.
	E.A Cables Ltd.
	E.A. Portland Cement Ltd.
Energy and Petroleum	Kenolkobil Ltd.
	Total Kenya Ltd.
	KenGen Ltd.
	Kenya Power & Lighting Co Ltd.
	Umeme Ltd.
Insurance	Jubilee Holdings Ltd.
	Pan Africa Insurance Holdings Ltd.
	Kenya Re-Insurance Corporation Ltd.
	Liberty Kenya Holdings Ltd.
	Liberty Kenya Holdings Ltd.
	Britam Holdings Ltd.
	CIC Insurance Group Ltd.

3.5. Research Sample

Purposive sampling was applied in selecting the sample to take part in the study. Kenyan commercial and services companies listed in the Nairobi Security Exchange and which have their headquarters in Nairobi formed the sample for the study. The category was considered as

the sample for the study because most of the companies have their headquarters in Nairobi. The interview targeted the IT managers as well as IT personnel in the organizations. This group of respondents was chosen for the study because they are the people directly involved with deciding the IT equipment to be purchased, maintaining of IT equipment in the company as well as the removal of the equipment that have reached their end-of life. IT managers and IT personnel are also involved in the procurement of ICT equipment and commissioning of the same.

Companies usually have one ICT managers and this means that only one manager was interviewed in each selected companies. However, the researcher chose IT personnel from each organization depending on their number. The IT personnel filled the questionnaires. The number of respondents for each organization was reached at using convenience sampling. Convenience sampling was used to select the number of IT personnel that would be easily accessible in any of the company chosen to take part in the study.

The companies in the sample includes: Kenya Airways, Express Ltd, Nation Media Group, Standard group Ltd, Tips Eastern Africa (Serena) Ltd, Scangroup Ltd, Uchumi Supermarket Ltd., Hutchings Biemer Ltd and Longhorn Kenya Ltd.

Table 2: Study Sample

Company	Sample	
	ICT manager	ICT personnel
Express Ltd.	1	1
Tips Eastern Africa (Serena)	1	2
Scangroup Ltd	1	2

Uchumi Supermarket Ltd.	1	4
Longhorn Kenya Ltd.	1	2
Standard Group	1	4
Kenya Airways Ltd	-	-
Nation Media Group	-	-
Hutching Biemer	-	-
Atlas Development and Support Services	-	-
Total	6	15

3.6. System Methodology

The system methodology adopted for the study was modified waterfall model. The waterfall

model was adopted for the study because the researcher simultaneously collected data and

developed the system. Through the research the researcher determined the system requirements

and included them in the system iteratively. With modified model the researcher could move

back to the various stages of system development including requirement collection, design,

implementation, verification and maintenance. In other words, during the process of conducting

the research the researcher was also developing the basic parts of the system and in case they got

results different from what they had included in the system, the system would be changed.

Essentially, this was the reason for the use of the modified waterfall model instead of the

waterfall model. The waterfall model is inflexible and backing up to address mistake is

sometimes difficult. However, the modified waterfall model is flexible and one can implement

the hard areas without waiting the easy ones. Further, with the modified waterfall model it is

possible to backtrack to previous step to address any problem in the system and to capture

additional information obtained from research.

3.7. Data analysis

Data collected through the use of interviews was analyzed using qualitative and quantitative data

analysis method. The qualitative data was analyzed through condensation or summarizing of

meaning as well as grouping and categorization of the meanings obtained from the data. The

data was summarized from the notes collected during the interviews as well as the recordings.

From this data, a summary was produced through compressing long sentences into brief

statements that contain the rephrased statements. Summarizing the data enabled the researcher to

understand the themes emerging from the interview and questionnaire.

Categorizing of the data involved developing categories of data and subsequently giving

meaning to the categories. Categorizing of data enabled the researcher in identifying the

relationships that exist. It also helped in development of propositions and thereby enabled the

researcher to make conclusions. Qualitative data collected using the questionnaire was also

analyzed through summarizing and categorization. The closed ended questions in the

questionnaires including those with yes and no answer were analyzed using Microsoft Excel

PivotTable. The answer were coded and put in an excel sheet and the PivotTable wizard run in

order to determine the number of time certain answers were given by the respondents in form of

percentage. In other words, PivotTable was used for identifying the frequencies for the closed

ended questions that had a yes or no question and those that used Likert scales. Quantitative data

helped in summarizing data.

CHAPTER FOUR

RESULTS

The section gives the result of analysis of data collected for the study. Section 4.1 gives the result of the first objective of the study, to determine e-waste management actions as a result of implementation of an e-waste inventory system. Section 4.2 give the results of objective . Section 4.3 covers the

4.1. Waste Action as a Result of Implementation of e-waste

The finding indicated a consensus among the respondents that knowledge of the amount of e-waste produced in the company, its associated cost as well as health and environmental impact may encourage actions towards reduction of e-waste in companies. A 100 percent of the respondents that filled the questionnaires indicated that knowing the amount of e-waste produced in the company, its associated costs to the company and its effects on health and the environment would encourage certain actions towards reduction. The respondents suggested a number of actions that they would take towards reduction of the e-waste produced in the company.

4.1.1. Procurement of Reusable ICT equipment and Peripheries

One of the methods of reducing e-waste suggested was procuring ICT equipment that can be reused for a different purpose. That is, companies could buy ICT equipment that could be put into more than one use. For example, companies could buy monitors that could be slightly modified and used as television. It was also suggested that where possible e-waste could be reduced by purchasing ICT equipment that can be put into more than one use at the same time. One of the examples cited in this case was buying a printer that serves also as a photocopier.

4.1.2. Purchasing When Necessary

Companies could reduce the amount of ICT equipment bought by buying only when it is absolutely necessary. For computers or computer accessories that can no longer meet the needs of one user , for example a programmer, but is still in a condition for use to users handling lighter tasks, these ICT equipment and especially computers could just be redeployed in the same organization instead of disposing them and buying new ones.

4.1.3. Upgrading or Refurbishing

In cases, where companies need changes such that their current ICT equipment like computers may not meet their needs, the company may take actions like upgrading their computers or ICT equipment. The company may also take actions like refurbishing a computer that is no longer meeting the needs of the company.

4.1.4. Purchasing Environmental-friendly ICT Equipment

Some of the respondents suggested that this information would also encourage organization in buying only ICT equipment that are friendly to the environment.

4.1.5. Buying High-end ICT equipment

The results indicated that companies would reduce the amount of e-waste they produce by avoiding purchase of equipment that might become obsolete in a short time and instead invest in quality and high-end ICT equipment.

4.1.6. Application of Modern or Advanced Technology

 Applying technologies that minimizes the number of ICT related electric and electronic was also cited as an appropriate method of reducing e-waste generation in organization. Some of the advanced technologies that were cited included the use of solar technology in place of

uninterruptible power supply and the use of cloud computing to reduce the number of ICT equipment like servers.

4.1.7. Development of Policy

 Some of the respondents pointed to the fact that lack of a legal framework or company-level policy for controlling management of e-waste has led to improper disposal of e-waste. They thus suggested that one of the actions that they would take is encouraging the company to come up with a policy that guides disposal of e-waste in the organization. Companies could also encourage the government to develop a legal framework that would help different consumers in disposing e-waste as well as enforce quality control. Enforcement of quality control prevents importation or buying any ICT equipment with a short life cycle or equipment that are not environmental friendly.

4.1.8. Maintenance

Some of the ICT personnel indicated that some ICT equipment reach their end-of- life in a shorter period due to user carelessness and neglect. They thus suggested that investing in proper maintenance of computer and all the other ICT equipment would ensure that their life was prolonged and prevented them from reaching their end-of-life sooner. As a result, the amount of e-waste produced in the company at a particular period of time is reduced.

4.1.9. Creating a Comprehensive list of ICT items and their Effects

ICT departments would create a list of the ICT items and the components as well as the effects that they have on health and environment. The information could be used for making recommendation for disposal and for raising awareness among the different ICT users within the organization.

4.1.10. Liaising with vendors and Manufacturers

Some of the respondents suggested that they would liaise with manufacturers of some of the ICT equipment and vendors in order to ease disposal for some of ICT equipment that cannot be put into any use. The manufacturers or the vendors can take back the ICT equipment for extraction of useful components.

4.1.11. Recycling

It was suggested that to prevent e-waste from getting into the environment, those computers and computer accessories that have become obsolete and cannot be put into any use in the company could be recycled. Recycling was suggested given that ICT equipment contain valuable and rare metals that could be used for making other parts. Further, other parts of the ICT equipment could be used for making totally different products including jewellery.

4.2. Methods of Costing E-waste

The result indicated that for most companies the cost that the company incurs from dealing with e-waste is the cost of storage and especially because most company have to keep their e-waste in storage for a long time awaiting disposal. Another major cost that most companies incur as a result of producing e-waste is the cost of transport. Companies have to incur a cost in transporting the e-waste they produce to the point of disposal.

4.3. Level of Awareness on the Effect of E-waste

61 percent of the respondents indicated that they were aware of the effects that e-wastes have on the environment and on health. 30.77 percent were fully aware while only 7.69 percent indicated that they were unaware of the effects of improperly disposed off e-wastes. However, most of the respondents were unable to point out that they were aware some of these effects. They admitted

that most of the users especially in other departments may not be aware of these effects. Some of the effects cited included the fact that the e-waste contains hazardous chemical like lead that may leach into the soil or in water bodies reducing their quality. Leaching into the soil means that the chemicals may end up in plants exposing human beings to diseases.

The e-waste disposal methods used by most by the companies involved in the research include reuse, returning to manufacturers, selling at auctions, and giving away to refubishers and recyclers. 84.62 percent of the respondents were unaware of where the computer and computer accessories disposed off from the company ended up. Only 15.38 percent were aware of where the e-waste from the company goes after leaving the company.

4.4. Factors to Consider in developing an E-waste Inventory System

4.4.1. Ability to Monitor

The result indicated that one of the factors to consider in developing an e-waste inventory system is ability to monitor. The electronic waste should be tracked or monitored from the point of purchase. Tracking in this case include identifying the number of times that the ICT equipment has had issue as well the number of times it has been maintained. It would also be important to track the number of parts or the parts of the equipment that have been replaced.

4.4.2. The type of E-waste

The type of e-waste in this case would be the general categories including whether the e-waste is a computer, a printer, photocopy or uninterrupted power supply.

4.4.3. Risk Factors

The result indicated that it is important to consider the risk factor of e-waste. The risk factor in this case refers to hazardous component of e-waste as well as the effect that the component may have both to the environment and on human health.

4.4.4. Cost Implication of the Equipment

The cost implication to the company as a result of having to deal with the e-waste is an important factor to consider. The cost in this case involves the cost of storage of the ICT equipment that has reached their end-of-life. This is an important cost implication given that the rooms where the wastes are stored can be utilized for other uses. The other major cost of e-waste to the company would be the cost of transporting the e-waste for disposal.

4.4.5. The lifespan of the ICT Equipment

The lifespan is the number of years that the company has used the ICT equipment. The lifespan of the ICT equipment should be calculated from the date the equipment was commissioned and the disposal date.

4.4.6. Weight of the E-waste

The weight of the e-waste should also be included in either tons or kilograms. Such data is crucial in determining the amount of e-waste produced over a certain period of time.

4.5. System Description

4.5.1. System Overview

The e-waste management system is a web-based inventory management system for electric and electronic waste produced in a company. The system allow different companies to create an account that they can use to track the amount of e-waste produced over a certain period of time,

together with their associated costs. The system also show the effects that these wastes could have if they are improperly disposed off, for example, into dumpsites together with other waste produced in the company. The system helps in generating information that can be used in educating employees. In other words, the system is aimed at generating information that can be used for raising awareness of company employees and policy maker concerning e-waste.

Additionally, the system can also assist a company in making decisions on the kind of ICT equipment to purchase through generating information on the type of ICT equipment that are more durable than others and from which manufacturers. Further, the system allows an organization that has more than one branch to use a single account to trace the amount of e-waste they generate. The system can be used by the Ministry of Environment in collecting data on the amount of e-waste produced by companies in the country. Collection of this data enhances e-waste management given that lack of data has been cited as one of hindrances to proper e-waste management.

4.5.2. Functional Requirement Description

4.5.2.1. User Side

Figure 4: User's Use Case
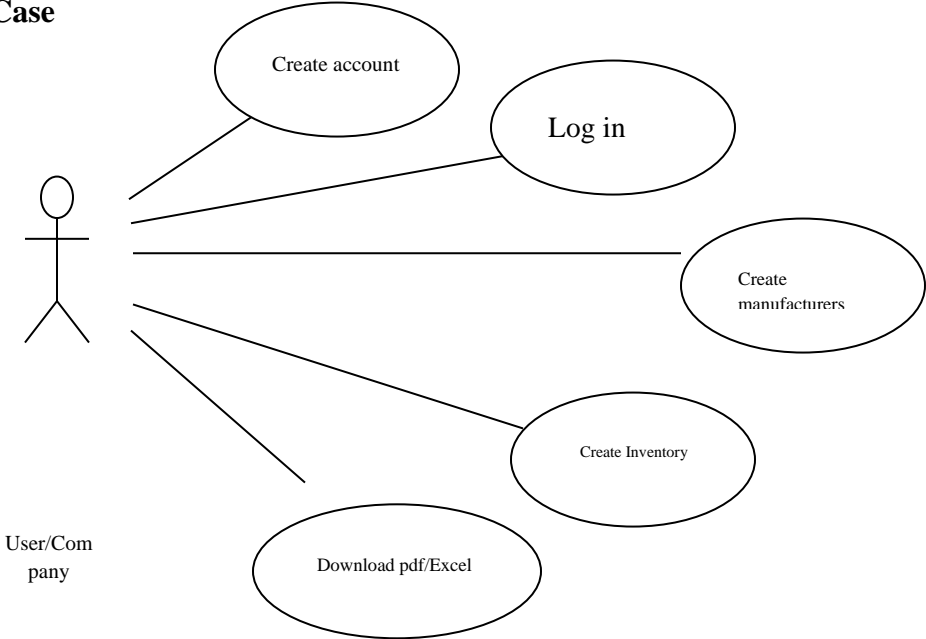
The user has a number of use cases:

Creating an Account or Signing Up

To gain access to the system a user need to create an account or sign up. Sign up entail providing the name of the company and the email that will be used for setting up the account.

Company Information

After creating an account, the individual responsible for creating the inventory of the e-waste produced in the company need to provide information about the company including the different branches. Creating the different branches helps in clearly identifying which branch generated certain e-waste.

List of Manufacturers

The next step is creating a list of manufacturers for the different ICT equipment used in the company. This information is crucial as it assists in making decision on what brand of ICT equipment the company should purchase in future depending on their durability.

Creating an Inventory

With this information provided, the user can then proceed to creating an inventory of the e-wastes produced in the company. The user need to enter into the system the information of ICT equipment once it has been declared an e-waste. The user should provide the cost that the company could incur or incurs as a result of generating the e-waste. The cost in this case could

be the cost of storage or the cost of transporting the e-waste for disposal. Once this information is provided the hazardous component and the health and environmental impacts are automatically generated.

Downloading Pdf or Excel

The system also allow for the user to either download a pdf document or an excel sheet of all the e-waste generated in the company within a certain period of time. Further, it provides an analysis of the e-waste generated in the company by use of graphs that are available on the system dashboard.

4.5.2.2. Administrator Side

Figure 5: Administrator's Use Case
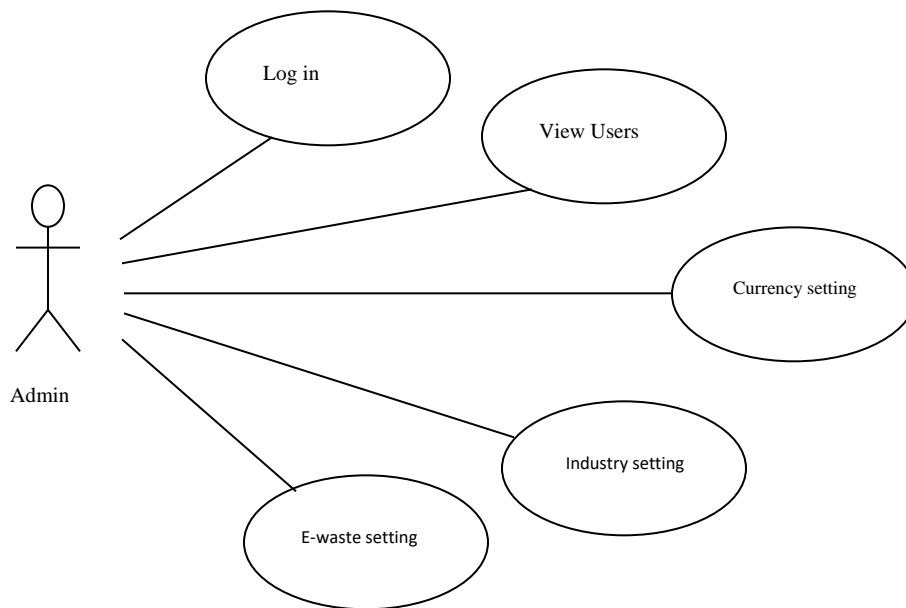
The administrator side has a number of use cases:

Log in

The administrator need to log into the system using the logging details provided.

View User

The administrator can see all the companies that have created an account into the system or that are using the system to monitor the amount of e-waste they produce.

Currency Setting

The administrator needs to put data on the different type of currency that are in use so that they can be available for use on the user side.

Industry Setting

The administrator creates a list of the number of industries or type of the company so that this information can be available for system users when they are creating a company profile.

E-waste Setting

The administrator creates a database of the different categories of e-waste, type of hazardous components in each of the e-waste category and the effects of these hazardous component to health and to the environment. Once a user creates a list of e-waste generated in the company, their effects are automatically added on the database.

4.5.3. Database Design
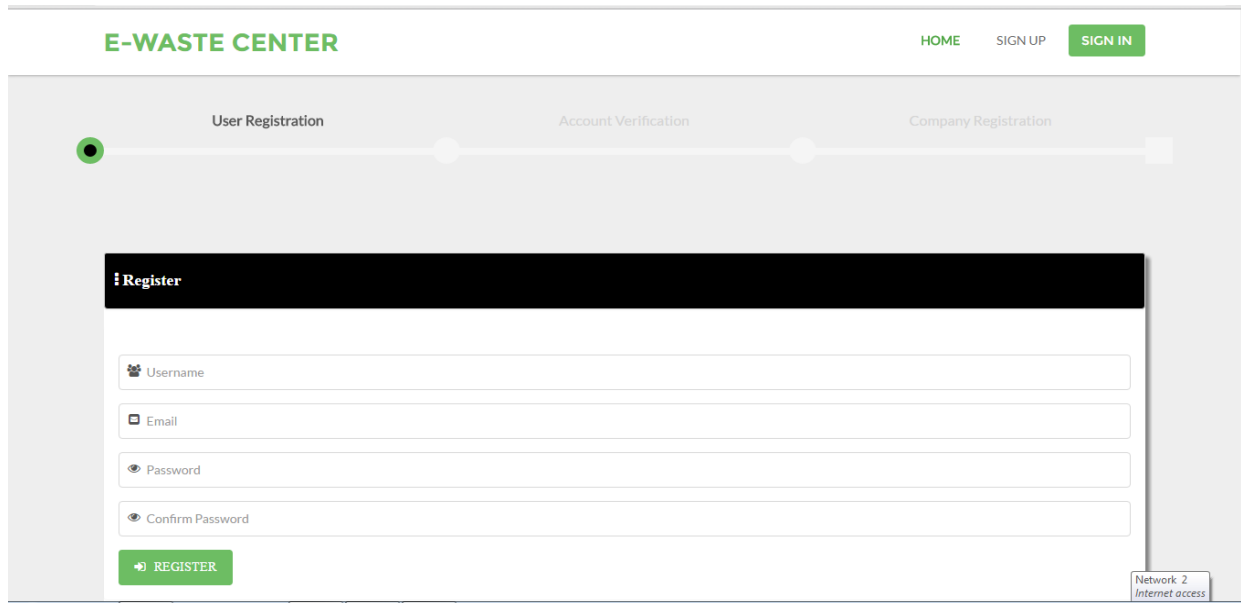
Figure 6: Database Architecture
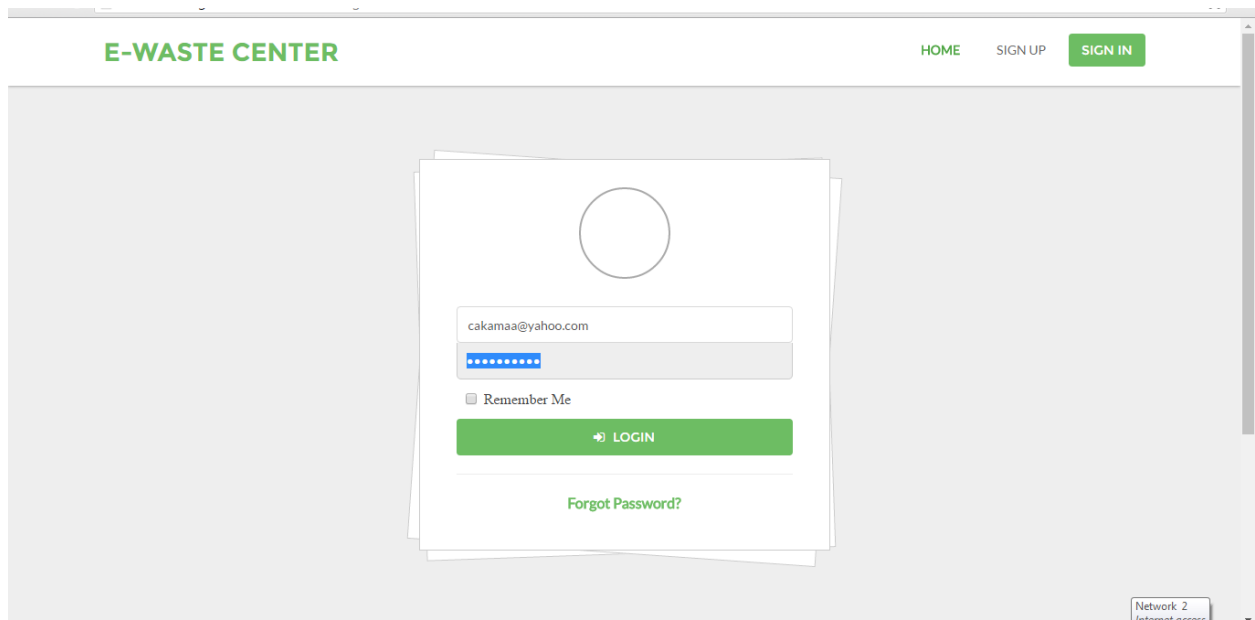
E-WASTE DATABASE ARCHITECTURE
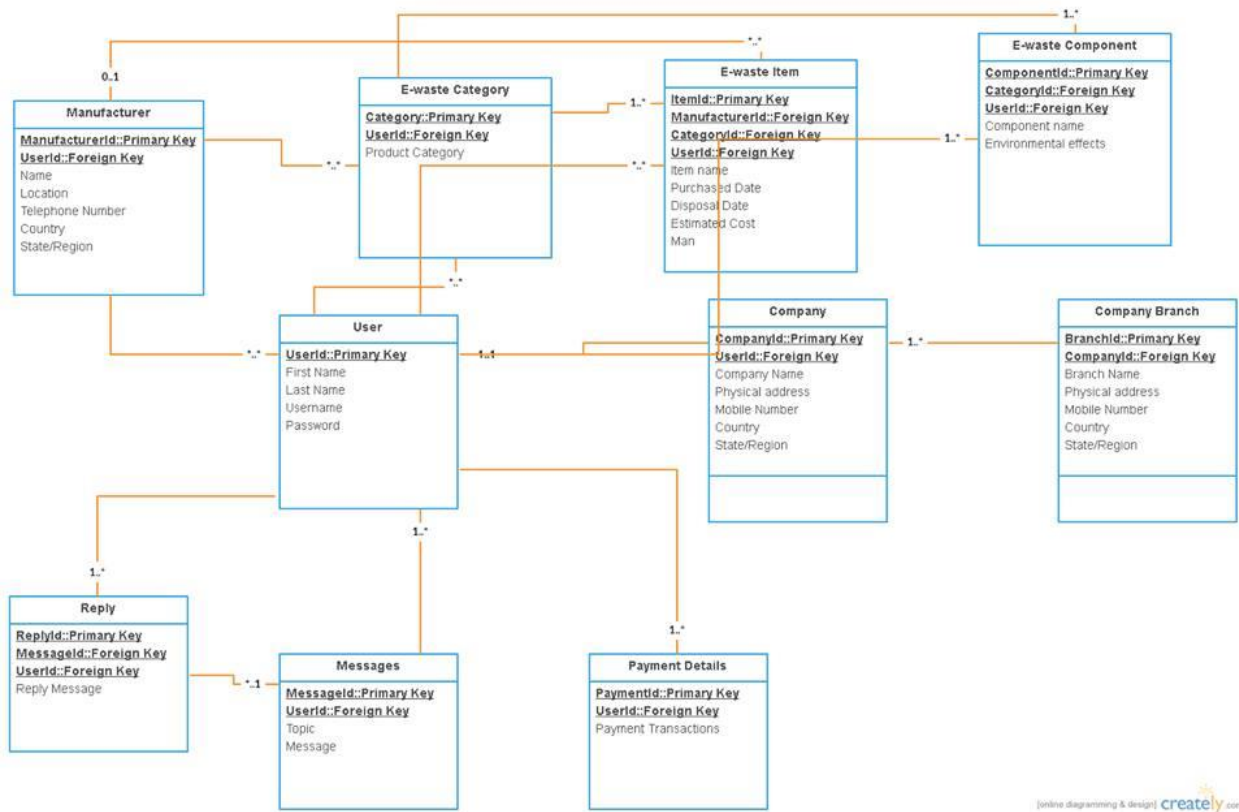
4.6. System Test Results

Figure 7: Creating an Account

Figure 8: Logging to the Account

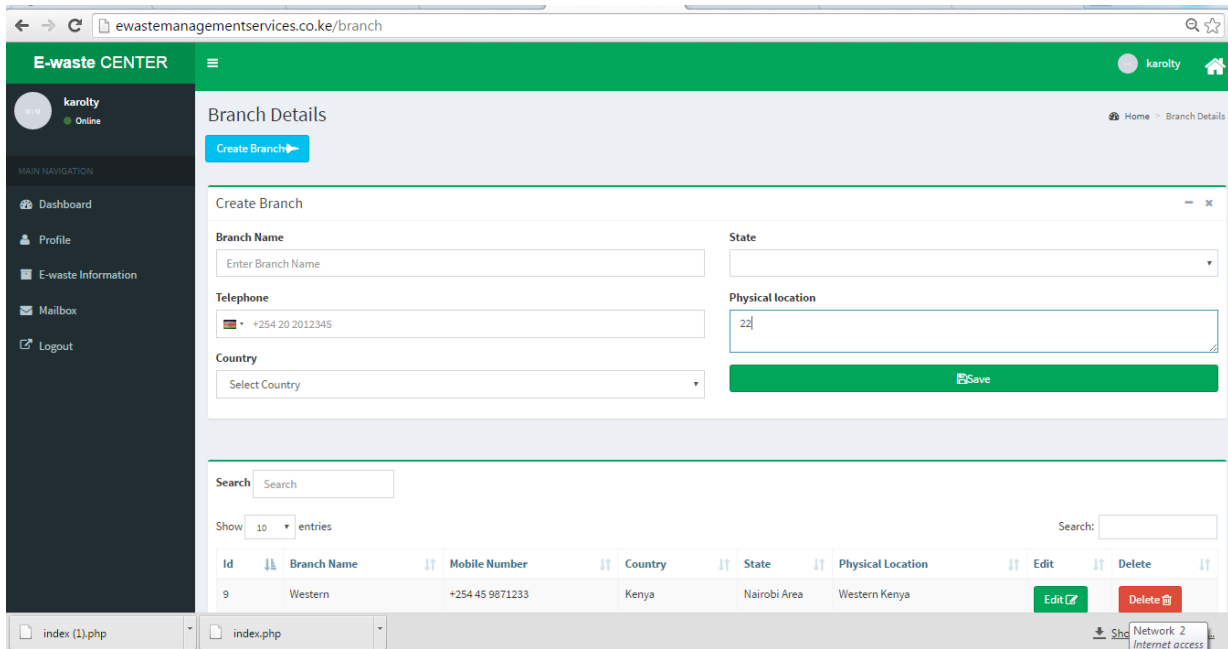

Figure 9: Creating Branches
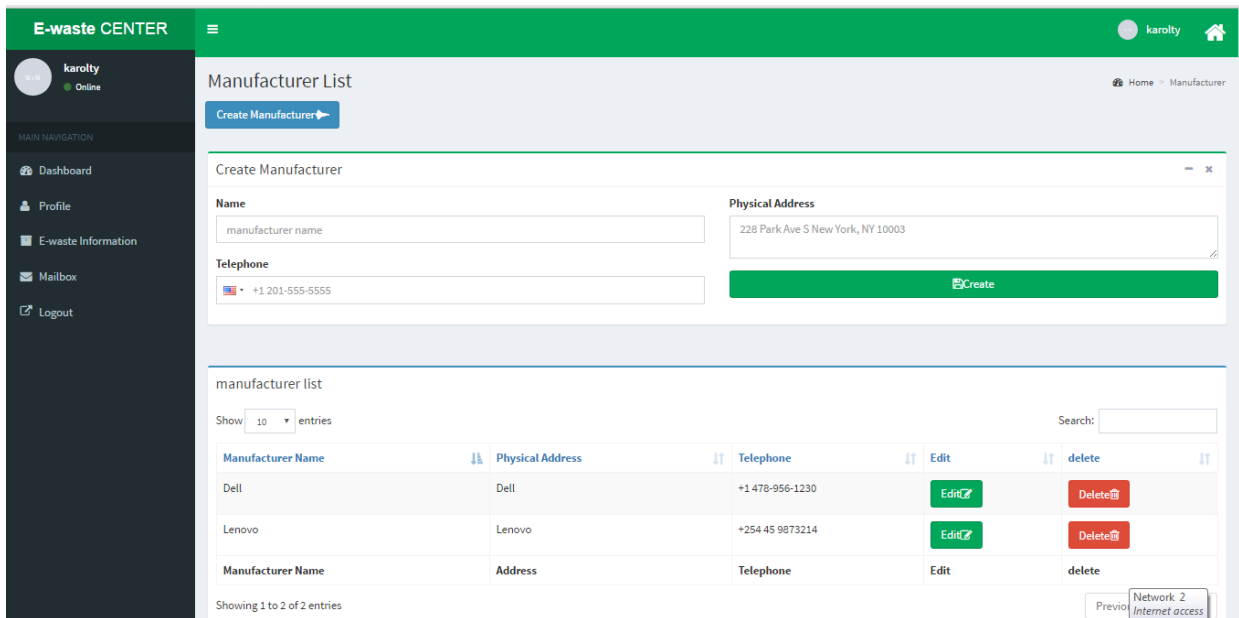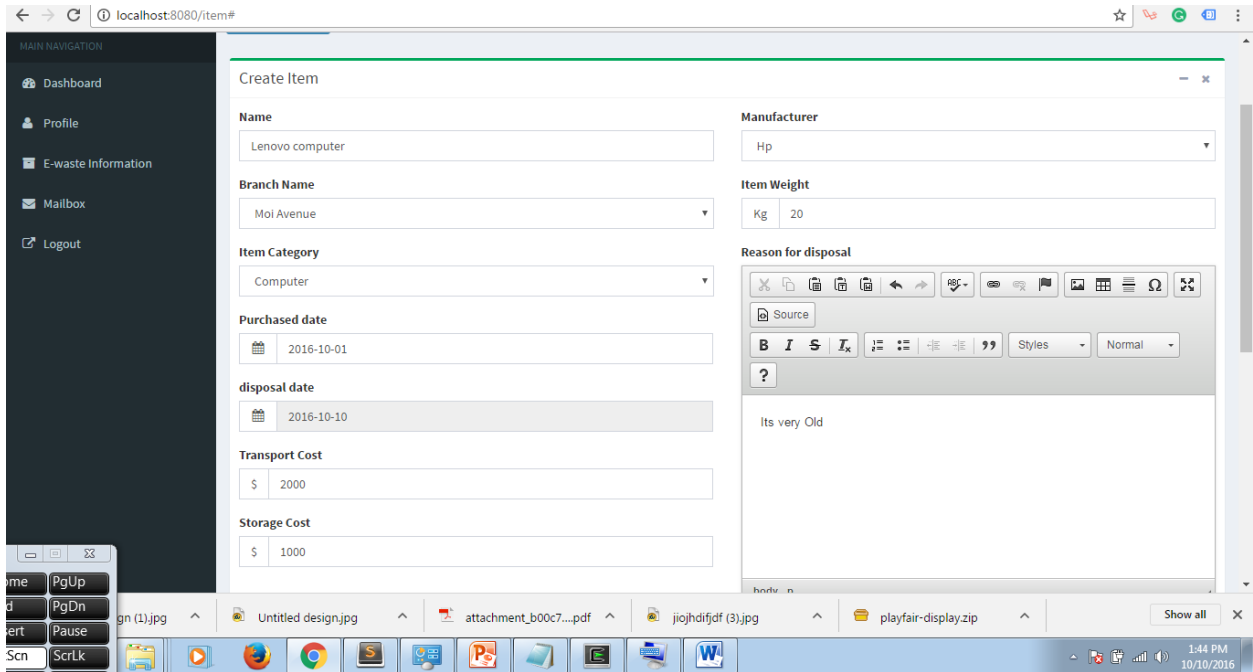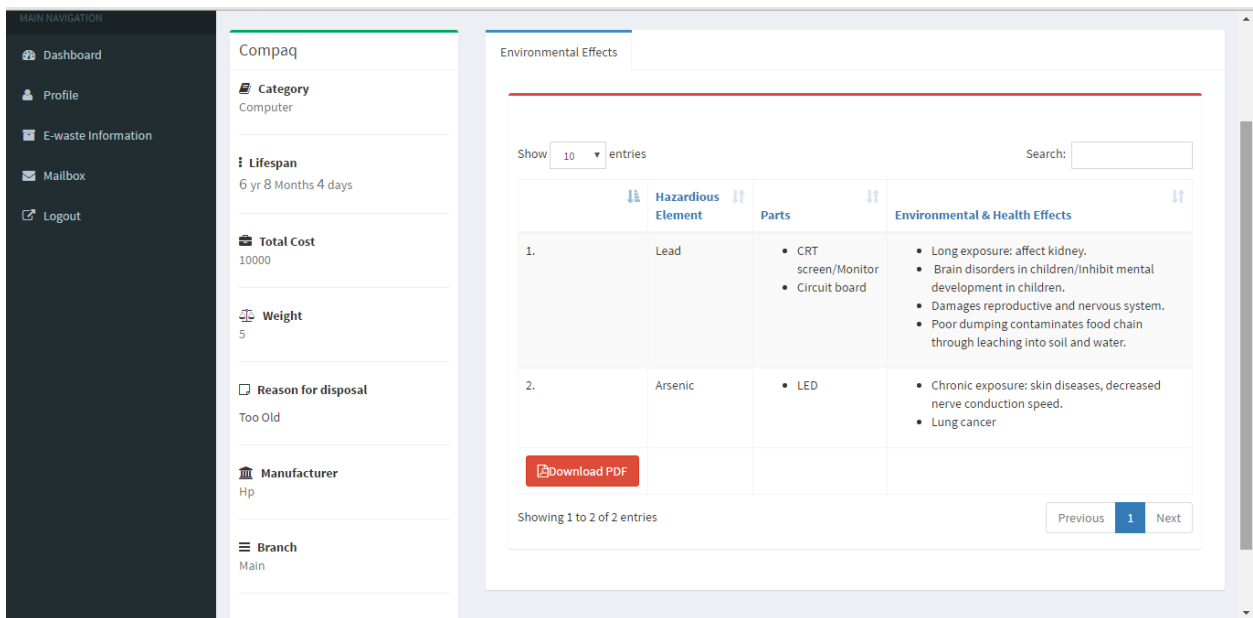
Figure 10: List of Manufacturers

Figure 11: Creating Inventory

Figure 12: Information on ICT equipment

Figure 13: List of E-waste

CHAPTER FIVE

DISCUSSIONS

The section gives explanations for the results and show whether that is what the researcher anticipated for each set of outcomes. The section also relates the result to previous research in the area or related areas. There is a comparison of the finding of the study to findings from other studies. Further, there are deductions including how the results of the study can be applied or its implications.

5.1. E-waste Management Action

The result indicated a consensus among the respondents that applying an inventory management system for e-waste would lead to reduction of e-waste produced in the company. This was consistent with other research in the area of waste data on waste management. A research by Kwatra and Sharma, for example, indicates that when people get information about e-waste management, they are in a position to link the effect of inappropriate e-waste management with health impact. A research by Scott, Godfrey, & Trois (2012) also support the result of the finding because one of the finding is that waste data positively affect the way organizations manage their waste. The positive effect on the way organization manage data in this case is associated with the knowledge that the waste data generate among employees as well as the raised awareness level (Scott, Godfrey & Trois, 2012). Scott et al (2012) posits that waste data help in shaping the knowledge, ensuing waste behaviour and intention in organization. One of the steps provided by EPA on reducing the amount of food waste is tracking and measuring the type, amount as well as the reason for disposal. The results of the study are consistent with this given that most of the respondents (100 percent) indicated that by having data on the amount of e-wastes produced within the organization would lead to reduction. Tracking generation of e-waste and any other

waste provides information on some of the causes of its generation. As a result, it is possible to take actions towards reduction. This explains the reason why some of the waste actions suggested included maintenance, purchasing quality or high end ICT equipment, purchasing when necessary and use of modern technology like cloud computing aimed at reducing the amount of e-waste produced within the company.

5.2. Factors to consider in developing an e-waste Inventory System

The inventory system is aimed at not only identifying the amount of e-waste that companies produce but also in raising the awareness of the employees on some of the effects that improper disposal could have on the environment and people's health. For this reason, the factors identified are relevant. One of factors is the hazardous components found in e-waste and their associated effect on the environment. Including this aspect on the inventory system would be important in helping companies understand why they need to properly manage their e-waste and even dispose them off in a way that does not expose people and the environment. The cost of the e-waste generated in a company is also an important factor. A high cost influences the company towards reduction. The weight of the e-waste produced is an important factor because it enables companies to have data of the amount of e-waste they produce over particular period of time. Researchers have identified lack of waste data as one of the reason for poor e-waste management meaning that in this case knowing the amount of e-waste that companies produce over a period of time will encourage proper e-waste management. Including functionality that enables the company to know the lifespan of their ICT equipment is important because it enables companies in making important decisions like the kind of ICT equipment to buy in the future.

5.3. Level of Awareness

The result indicated that all the respondents were aware of the health and the environmental

effects of improper disposal of e-waste. The finding contradicts some of the researches that have

investigated the level of awareness of different users. For example, a research by Anyango and

Waema (2013) indicated that 33.3 percent of the respondents were unaware of any negative

effects of improper e-waste handling on the environment and on health. The research further

indicated that only 9.5 percent of the research participants were aware of certain health hazards

like eye sores, breathing problems and cancers caused by improper management of e-waste.

Otieno and Omwenga (2015) also buttresses the findings by Anyango and Waema by indicating

that one of the challenge facing e-waste management in Kenya is low awareness among the

citizens. Nonetheless, the fact that the respondents for this research were IT professional could

be the reason why there are aware of the different harmful components of ICT s and their effects

to the environment and health.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

The study indicated that data on e-waste is crucial in encouraging proper e-waste management. Collecting data on the amount of e-waste generated in the company, together with the associated cost and health and environmental effects if improperly disposed; helps in raising awareness in organizations. As a result, organizations are encouraged to take waste management action towards reducing the amount of e-waste they produce. Some of the e-waste reduction actions that companies may take include buying high-end or quality ICT equipment, buying ICT s, reuse and refurbishing, recycling, proper maintenance, buying reusable ICT equipment or equipment with more than one use, development of ICT equipment disposal policy and use of modern technologies like cloud computing.

The study suggested that some of the factors that need to be considered in coming up with an e-waste inventory system may include cost of e-waste at the time of disposal, weight of the ICT component being disposed off, the hazardous components of the e-waste, the health and environmental effects of e-waste as well as the lifespan of the ICT equipment.

6.2. Recommendations

The result indicated that some companies dispose ICT s after using them for between 1-3 years (53.85%), others dispose after 5-6 years (15.38%) while others use ICT s for more than 6 years (23.08%). This implies that testing the effectiveness of the system may take over a year and thus beyond the scope of this project. It is thus recommended that further research be conducted especially on testing how effective the inventory system would be in management of e-waste.

44

The system only capture information related to the weight, cost and health implication of the ICT equipment that has been marked as e-waste ready for disposal. The result of the study indicated that 84.62% of the respondents were unaware of where the e-waste disposed off either through auction, donations or giving recyclers end up when they can no longer be of any use. Only 15.38% of the respondent traced their e-waste to their final disposal points. For this reason, it is recommended that the system be expanded to include a way of tracking e-waste produced by the company beyond the company's storage either by use of serial number of the ICT equipment or through the use of other technologies like RFID. Tracking the e-waste beyond the company premises prevent improper disposal by other stakeholders including refubishers or recyclers.

Reference List

Anyango, T., J. and Waema, T., M. 2013. Towards an e-waste management framework in Kenya. *Emerald Insight*. 15(5). 99-113.

Atasu, A. and Subramanian, R., 2012. Extended Producer Responsibility for E-Waste: Individual or Collective Producer Responsibility?.*Production and Operations Management*. *21* (6).1042-1059.

Balde, C., P. Wang, F., Kuehr, R., and Huisman, J. 2015.The Global e-waste monitor- 2014, United Nations University, IAS-SCYCLE, Bonn, Germany.

Gaidajis, G., Angelakoglou, K. and Aktsoglou, D. 2010. E-waste environmental Problems and Current Management. *Journal of Engineering and Technology Review*. 3(1). 193-199.

Godfrey, L., Cott, D., Difford, M. and Trois, C. 2012. Part 1: The role of waste data in building knowledge: The South African waste information system. *Waste Management*. 32(11). 2154-212.

Godfrey, L., Scott, D., Difford, M. and Trois, C. 2012. Part II- the effect of the data on waste behavior: The south African waste information system. *Waste Management.* 32(11). 213-217.

Grant, K., Goldizen, F.C., Sly, P.D., Brune, M.N., Neira, M., van den Berg, M. and Norman, R.E., 2013. Health consequences of exposure to e-waste: a systematic review. *The Lancet Global Health*, *1*(6), pp.e350-e361.

Herat, S. & Agamuthu, P. 2012. E-waste: a problem or an opportunity? Review of issues, challenges and solutions in Asian Countries. *Waste Management & Research.* 30(11). 1113-1129.

Kahhat, R. et al. 2008. Exploring e-waste management systems in United States. *Resources, conservation and Recycling.* 2(7). 955-964.

Kothari, C. R. 2004. *Research Methodology: Methods and Techniques*. New Age International (P) Limited, Publishers: New Delhi.

Kwatra, S., Pandey, S. and Sharma, S. 2014. Understanding public knowledge and awareness on e-waste in an urban setting in India: A case study for Delhi. *Management of Environmental Quality: An International Journal*, *25*(6), pp.752-765.

Lundgren, K. 2012. The Global impact of e-waste: Addressing the global challenge. Retrieve from: http://www.ilo.org/sector/Resources/publications/WCMS_196105/lang--en/index.htm

Ministry of Environment, Natural Resources and Regional Development Authorities. 2016. Ministry is committed in e-waste management, says CS Prof Judi Wakhungu. Available on: http://www.environment.go.ke/?p=883

Munene, S. 2011. E-waste management in Kenya. WEE/ E-waste management workshop, 13-15 July 2011, Osaka, Japan.

Mureithi, M. and Waema, T., 2008. E-waste Management in Kenya. Nairobi: Kenya ICT Action Network (KICTANet).

Ni, W., Huang, Y., Wang, X., Zhang, J. and Wu, K., 2014. Associations of neonatal lead, cadmium, chromium and nickel co-exposure with DNA oxidative damage in an electronic waste recycling town. Science of the Total Environment, 472, pp.354-362.

Olowu, D. 2012. Menace of E-Waste in Developing countries: An Agenda for Legal and Policy Responses. *Law, Environment and Development Journal*. 8(1). 61-75.

Orisakwe, O., E. and Frazzoli, C. 2010. Electronic Revolution and Electronic Wasteland: The West/ Waste Africa. *Journal of National and Environmental Sciences*. 1(1).43-47.

Osibanjo, O. 2007.The Challenge of electronic waste (e-waste) management in developing countries. *Waste Management & Research.* 2(5). 489-501.

Otieno, I. & Omwenga, E. 2015. E-waste management in Kenya: Challenges and opportunities. *Journal of Emerging Trends in Computing and Information Sciences*. 6(12).661-666.

PBS. 2014. Kenya takes on e-waste problem with new recycling hub. Available from: http://www.pbs.org/newshour/bb/kenya-takes-e-waste-problem-new-recycling-hub/

Pramila, S., Fulekar, M.,H. and Bhawana, P., 2012. E-waste-A challenge for tomorrow. *Research Journal of Recent Sciences. ISSN, 2277*, p.2502.

Saritha, V., Kumar, S., K., A. and Srikanth, V., N. 2015. Consumer attitudes and perceptions on electronic waste: An Assessment. *Pollution*. 1(1).31-3.

Saunders, M., Lewis, P. &Thornhill, A. 2009.*Research methods for business students*. Pearson Education Limited: Harlow, England.

Singh, A., Pal, R., Gangwar, C., Gupta1s, A. and Tripathi, A., 2015. Release of Heavy Metals
from Industrial Waste and E-Waste Burning and Its Effect on Human Health and
Environment.

Songa, J. and Lubanga, B. 2015. The health Risk of Electronic waste in Kenya: Challenges and
Policies. *Pinnacle Medicine & Medical Sciences*. 2(7). 805-808.

Turner, D. W. 2010. Qualitative interview design: A practical guide for novice investigators. *The
Qualitative Report*. 15(3).75-760.

UNEP. 2007. Environmental pollution and impact on public health: Implications of the Dandora
Municipal dumping site in Nairobi, Kenya. Available at <
http://www.unep.org/urban_environment/PDFs/DandoraWasteDump-
ReportSummary.pdf>

UNEP. 2015. Illegally traded and dumped e-waste worth up to $19billion annually poses risk to
health, deprive countries of resources, says UNEP report. Available from: <
http://www.hindawi.com/journals/ecri/2011/474230>

Appendix

I. Interview Guide for ICT Managers

1. What are your roles and responsibilities in the organization as far as management of ICT equipment is concerned?

2. What kind of electronic waste does the company produce?

3. What are some of the methods used by the company in disposing the e-waste?

4. What are some of the methods used in the company in determining the amount of e-waste produced in the company?

5. Which methods does the company use for costing e-waste produced?

6. What are some of the effects to the society and the environment that could be associated with e-waste?

7. Inventorization has been cited as one of the major challenge in management of e-waste. What are some of the factors or parameters do you think should be considered in coming up with an inventory system for e-waste to be used in the company?

8. What are some of the functional requirements that you would you consider in coming up with an e-waste inventory system?

9. Research indicates that lack of awareness about the health implications of e-waste hinder waste management action. What are some of the actions; if any do you think employees in the organization would take following the implementation of an e-waste management system?

10. What are some of methods you would apply in ensuring that the amount of e-waste produced in the company reduced?

II. Questionnaire for ICT Personnel

Instruction

Use a tick √ to select the most appropriate option

Fill in the blank spaces for questions that require answers and explanations

A. General Questions

Date:

1. Name (Optional)

   …………………………..

2. Name of Company:

   …………………………..

3. Company's address:

   …………………………..

4. What is the main activity of the company?

   …………………………..

5. How many employees does the ICT department have?

   …………………………..

6. Where would you categorize your company in terms of dependence on ICT?

    Low dependence [ ]   Medium dependence [ ]   High dependence [ ]

    Type and Amount of e-waste produced in the Company

7. Approximately how many computers and computer accessories does the company own?

    …………………………...

8. What kind of ICT equipment does your organization has? Tick as many as possible.

    Desktop computers   [ ]

    Laptop   [ ]

    CRT monitors   [ ]

    LCDs screens   [ ]

    Printers   [ ]

    Photocopier   [ ]

    UPS   [ ]

9. How often do you have replaced any ICT equipment that has reached its end- of- life?

    Never [ ]   rarely [ ]   occasionally [ ]   frequently [ ]   Very frequently [ ]

10. When replacing, do you replace the whole ICT equipment or do you just replace only the accessories that have reached their end-of-life which in this case may include computer's mouse, keyboard or cables and cartridges that have reached the End-of- life?

    Whole [ ]   Accessories [ ]   Both [ ]

11. What is the life span of the computers and other electronic in the company?

    Less than 1 year [ ]   1-3 years [ ]   5-6 years [ ]   More than 6 years [ ]

Methods of e-waste Disposal

12. Are you aware of the effect of poor disposal of e-waste to the environment and human health?

    Unaware [ ]   Aware [ ]   Fully aware [ ]

13. What happen to electric and electronic that have reached their end of life or that can no longer be used within the organization?

    Giving away to recyclers or for refubishing   [ ]

    Selling at auctions   [ ]

    Disposing together with other solid wastes   [ ]

    Stored within the organization   [ ]

    Giving away as Donation   [ ]

    Return to manufacturer   [ ]

    Reuse   [ ]

    Other (specify)

14. For computers disposed off out of the company, do you know where they end up after they are no longer useful?

    Aware [ ]   Unaware [ ]

    Method of Collecting information and Behaviour Change

15. Do you have a way of knowing the amount of e-waste the company has produced at the end of the year?

    Yes [ ]   No [ ]

16. Do you think such a system would be important for an organization?

    Yes [ ]   No [ ]

17. If you were to develop an inventory system for e-waste produced in the company, what are some of the factors you would consider? Kindly list them down.

…………………………...

18. What methods would you use to give a financial value to the e-waste generated in the organization?

…………………………...

19. Do you think knowing the amount of e-waste produced and its associated costs as well as social, environmental and health impacts may lead to reduction of e-waste?

Yes [ ]   No [ ]

20. If yes, what are some of the ways through which an organization may reduce e-waste production?

…………………………...