



**FRAMEWORK FOR EFFECTIVE E-WASTE MANAGEMENT IN GOVERNMENT  
OF KENYA: A CASE STUDY OF THE MINISTRY OF ICT, INNOVATION &  
YOUTH AFFAIRS**

**By**

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**DECLARATION**

I declare that this proposal is my original work and to the best of my knowledge it has not been presented for any degree in any university.

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## **ABSTRACT**

With the rapid developments in technology, electrical and electronic equipment tend to have a shorter economic life and today people are faced with a new type of waste called electronic waste (Didem & Kiraz, 2019a) . The research aimed at studying the e-waste management practices in government ministries in Kenya and specifically focused on the Ministry of ICT. The objectives included identification of the electronic product used, their impact, challenges, e-waste management practices and recommendations of overcoming the challenges. The research was descriptive in nature and used both qualitative and quantitative research designs for the study. The target population included 451 employees in the ministry while the sample consisted of 110 regular employees (25%) and 11 heads of departments (100%). Random sampling was used to identify the respondents while data was collected through semi structured questionnaires. The data was subjected to WEKA for further analysis and revealed that BayesNes was the most appropriate decision tree model for effective management of e-waste in government ministries based on its high level of accuracy. A framework was developed for ensuring effective management of e-waste in the public sector. The findings revealed that there is a general problem with the management of e-waste in the public sector. Additionally, it was revealed that most employees are not aware of e-waste management practices and have not been trained on e-waste management. Further, the research revealed that no trainings have been conducted on e-waste management and there is no policy to govern the same. The findings could be used by the public sector and other stakeholders in planning for and effectively managing e-waste in Kenya.

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A big thank you to the ministry of ICT, Innovation & Youth Affairs for allowing me to work with them in undertaking this research.

## **DEDICATION**

I dedicate this work to my late Dad, Mum, siblings and my lovely daughter who always believed in me and pushed me to be the best that I could be in life.

## TABLE OF CONTENTS

<b>DECLARATION</b>	<b>ii</b>
<b>ABSTRACT</b>	<b>iii</b>
<b>ACKNOWLEDGEMENT</b>	<b>iv</b>
<b>DEDICATION</b>	<b>v</b>
<b>LIST OF ABBREVIATIONS AND ACRONYMS</b>	<b>ix</b>
<b>LIST OF TABLES</b>	<b>x</b>
<b>LIST OF FIGURES</b>	<b>xi</b>
<b>CHAPTER ONE: INTRODUCTION</b>	<b>1</b>
1.1. Background of the Study	1
1.2. Statement of Problem	2
1.3. Aim of the Study	2
1.3.1. 13	
1.4. Research questions	3
1.5. Significance of the study	3
1.6. Justification of the study	3
1.7. Scope of the study	3
1.8. Limitation of the Study	4
<b>CHAPTER TWO: LITERATURE REVIEW</b>	<b>5</b>
2.1. Introduction	5
2.2. Electronic products used by government	5
2.3. Impact of E-waste	6
2.4. E-waste management practices in developing countries	8
2.5. Effective e-waste Management	9
2.6. Integrated Solid Waste Management Framework	10
2.7. Resource Based Value Theory	11
2.8. The National ICT Policy	12
2.9. Conceptual Framework	12
2.10. Chapter Summary	14
<b>CHAPTER THREE: RESEARCH METHODOLOGY</b>	<b>15</b>
3.1. Introduction	15
3.2. Research Approach	15
3.3. Research Design	15
3.4. Area of the study	15

3.5.	Study Population	16
3.6	Target Population	16
3.7.	Sampling	16
3.7.1.	<b>Error! Bookmark not defined.</b>	
3.7.2.	<b>Error! Bookmark not defined.</b>	
3.8.	Data Collection Techniques	17
3.8.1.	<b>Error! Bookmark not defined.</b>	
3.9.	Piloting	17
3.10.	Data Analysis & Modelling Procedures	18
3.11.	Study Variables	19
3.12.	Ethical Considerations	20
3.13.	Chapter Summary	20
<b>CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS</b>		<b>21</b>
4.1	Introduction	21
4.2	Variable Analysis	21
4.3	E-waste Management Model	29
4.4	Chapter Summary	33
<b>CHAPTER FIVE: DISCUSSION OF FINDINGS</b>		<b>34</b>
5.1.	Introduction	34
5.2.	General information of the respondents	34
5.3.	Electronic products used in the Ministry of ICT	35
5.4.	Impact of e-waste in the Ministry of ICT	36
5.5.	E-waste management practices in the Ministry of ICT	36
5.6.	Challenges in managing e-waste	38
5.7.	Effective E-waste Management Framework	39
5.8.	Conclusion and summary of the findings	41
5.9.	Study Contributions	43
5.10.	Recommendations	44
5.10.1	55	
5.10.2	56	
5.10.3	56	
5.10.4	56	
5.11.	Chapter Summary	46

<b>REFERENCES</b>	<b>47</b>
<b>APPENDIXES</b>	<b>52</b>
Appendix I: Introduction Letter	52
Appendix II: Questionnaire	53
Appendix III: Work Plan	59
Appendix IV: Budget	60

## **LIST OF ABBREVIATIONS AND ACRONYMS**

CPU	Central Processing Unit
EEE	Electrical & Electronic Equipment
E-Waste	Electronic Waste
GoK	Government of Kenya
HoD	Head of Department
ICT	Information Communication Technology
NEMA	National Environment Management Authority
WEEE	Waste Electrical and Electronic Equipment

## LIST OF TABLES

TABLE 1: Study Variables	19
TABLE 2: Gender of respondents	21
TABLE 3: position of respondents	24
TABLE 4: TRAINING ON E-WASTE	27
TABLE 1: Summary of cross validation	29
TABLE 6: Summary of cross validation	29

## LIST OF FIGURES

FIGURE 1: Waste Management strategies	9
FIGURE 2: The ISWM Model	11
FIGURE 3: Conceptual Framework	25
FIGURE 4: Age group of respondents	22
FIGURE 5: Highest education level	22
FIGURE 6: Frequency of use of electronic products	25
FIGURE 7: Knowledge of materials used in e-products	26
FIGURE 8: Awareness on dangers of e-waste	26
FIGURE 9: Involvement in e-waste management	27
FIGURE 10: E-waste management policy	28
FIGURE 11: J48 Modelling results	41
FIGURE 12: BayesNet modelling results	42
FIGURE 13: J48 tree decision	32
FIGURE 14: Effective e-waste management framework	39

## CHAPTER ONE: INTRODUCTION

### 1.1. Background of the Study

Electronic waste (e-waste) is a concern globally. With the rise in technological advancements, the consumption level for electronic products and equipment has equally grown enormously (Didem & Kiraz, 2019b). As electronic equipment rapidly becomes obsolete; new and better equipment come to replace them. The disposal of these overused, broken or obsolete electric and electronic components and materials has been dealt with differently in different countries (Balde et al., 2015). Some countries have recognized the need to deal with this problem and equally adopted practices and measures to curb this problem. Some of the strategies used to deal with these calamities besides the legislation include recycling, refurbishing, reselling, laws among others. But according to ITU (2016), “only 20 percent of global e-waste is recycled. The rest ends up in landfill, burned or illegally traded every year or not recycled at all.”

While recycling seems to be the best approach so far in dealing with e-waste, other alternatives suggested by Nicole Nishizawa, College of Harvard University, is the 3 R's of E-waste: Refurbish, Re-design and Re-purpose (Adhana, 2020). Considerable actions have been taken in implementing such suggested practices (Bueti, 2012). Switzerland, is a leading producer of e-waste. In 2016, it is estimated that they produced 184 kilotons of e-waste and were able to recycle roughly 75 percent of this discarded material. In 2015 134 kilo tones were recovered (ITU, 2016). A major contributing factor for their success is “the strong and convenient voluntary ‘take-back’ system where consumers take e-waste to a dedicated recycling collection point or any electronic shop that sells the same type of equipment throughout the country.”(Celestial, 2018; ITU, 2016).

Kenya has experienced a remarkable growth in the sector of ICT over the last 10 years. Many people in the country currently have access to computer facilities at school, home, business centres and internet cafes. A greater number also have access to mobile phones and this is a large contributor to the development of the Kenyan economy (Shivoga, 2010). According to the national ICT survey report of 2011 about 78% and 37% of the households in Nairobi have at least one mobile phone and computers respectively. The total amount of computers monitors and printers, mobile phones disposed yearly as per 2007 are approximately 2, 984.35 tons. The rate at which these mountains of obsolete electronic products are growing will reach crisis proportions unless measures are taken to manage the menace in Nairobi which is already saddled with the problem of poor solid waste management.

## **1.2. Statement of Problem**

While dealing with management of e-waste is a going concern for many of the countries, its effect on the micro and macro environments cannot be ignored. Previous research revealed that US alone produces over 15 million tonnes of e-waste each year while 78% of Kenyan households had at least a phone in the year 2011. These numbers are obviously very high given the growth in both human population and electronic gadgets used by the people. Consumer awareness, recycling processes, the collection and disposal of electronic waste are the challenges that continue to be faced by most third world countries. Efforts made towards dealing with e-waste seem futile hence the need to be accompanied by taking a collective action regarding sensitization of e-waste and its impact to the users, manufacturers and consumers.

Mostly this is because there is not clear model to guide the sector and the few that are there have various limitations. To achieve this, assessment of the management practices of e-waste that have been put in place by local organizations will help to inform how involved the stakeholders are and how defined their roles are in achieving efficiency of the practices already adopted. Significant stride has been made in an effort to effectively control e-waste by the various stakeholders although this is not the case with most African countries (Government of Kenya, 2019a; OECD, 2016). However, with the increased production and use of electronic materials, there is a dire need to ensure the measures are effective and that users are aware of the same. The issue of how effectiveness can be achieved in management of e-waste is what the research seeks to achieve. A well-designed framework or model is still missing in the public sector and that is what the researcher will establish to develop and recommend.

## **1.3. Aim of the Study**

The aim of the research was to assess the e-waste management practices in government of Kenya and develop an e-waste management framework for Government ministries and Agencies.

### ***1.3.1. Specific objectives***

The specific objectives of the research are:

- i. To identify electronic products used in government ministries in Kenya,
- ii. To explore the impact of e-waste in government ministries in Kenya.

- iii. To examine the electronic waste management practices in government ministries in Kenya.
- iv. To develop a framework for managing e-waste in government.

#### **1.4. Research questions**

The research questions for the study include:

- i. Which electronic products are used by government ministries in Kenya;
- ii. What is the impact of e-waste in government ministries in Kenya?
- iii. What are the e-waste management practices in government ministries in Kenya?
- iv. How well does the proposed framework fit in within the ministry of ICT?

#### **1.5. Significance of the study**

A study on the management practices of e-waste will reveal the extent of consumer awareness towards e-waste and its impacts. This will help identify why some suggested practices have been unsuccessful hence provide room for further research. Adoption of a sustainable development model/ practice helps ensure efficient use of resources and also prevents environmental pollution which is important in controlling material flows nationally and internationally.

#### **1.6. Justification of the study**

With the increasing use of technology in the day to day work, the production of electronic products is definitely rising on a daily basis. The fourth industrial revolution is about machines and mostly, electron machines. There is a continuous focus on technology as an economic enabler. Kenya started an ambitious project of supplying standard one pupils with tablet with an aim of integrating ICT in the education sector. Many other industries are moving from conventional ways of doing things to integration of ICT in their processes. Conducting this study will enable the government and concerned stakeholders to identify specific key areas that they need to address as far as management of electronic waste is concerned. The study will also reveal gaps therein and provide a framework for developing longer lasting solutions both to the government and the corporate sector.

#### **1.7. Scope of the study**

The study will be focusing on the government ministries in Kenya and will narrow down to one ministry only out of the 24 ministries. Further, the study will be dealing with employees who are actively involved in the use and/or disposal of electronic products.

### **1.8. Limitation of the Study**

The study is limited to the government sector in Kenya. Another limitation is the element of time which would require the researcher to complete the project within three months. Another limitation for the research will be finances used to undertake the research which will not enable a comprehensive coverage of the research topic.

## **CHAPTER TWO: LITERATURE REVIEW**

### **2.1. Introduction**

This chapter focused on review of literature previously done in the area of e-waste management. It will look at what the scholars found and stated regarding the topic, their views, what they covered, their recommendations and the limitations of their work. Additionally, the literature review exposes gaps, weaknesses and point out strengths in the area of e-waste management in the government. It also looked at world views and the theoretical framework of the area of research. It equally showed the researcher's reflection and perspective by indicating areas of agreement and also disagreement with the various authors whose literature were reviewed. The literature was reviewed in line with the study objectives and research questions. The chapter started with the literature review as per the objectives of the study followed by the world view and finally the research theory. The researcher employed a thematic literature review which is aligned to the objectives of the research.

### **2.2. Electronic products used by government**

“E-waste can be classified on the basis of its composition and components. Ferrous and nonferrous metals, glass, plastics, pollutants, and other are the six categories of materials reported for e-waste composition (OECD, 2016). Iron and steel constitute the major fraction in waste electrical and electronic equipment (WEEE) materials, with plastics being the second largest (Singh, 2014). Nonferrous materials, including metals such as copper and aluminium, and precious metals such as silver, gold, and platinum are third in abundance and have significant commercial value (Thomson Reuters IP Analytics, 2013). Toxic materials include lead and cadmium in circuit boards, lead oxide and cadmium in cathode ray tubes, mercury in switches and flat-screen monitors, brominated flame retardants on printed circuit boards, and plastic and insulated cables; when these exceed the threshold quantities, they are regarded as pollutants and can damage the environment if disposed of improperly (Miner et al., 2020)”.

“One of the most widely accepted classifications is based on European Union directives that divide e-waste into the 10 following categories (Performance and Innovation Unit, 2000): Large household appliances, Small household appliances, Information technology (IT) and telecommunications equipment, Consumer equipment, Lighting equipment, Electrical and electronic tools, Toys, leisure equipment, and sporting goods, Medical devices, Monitoring and control instruments and Automatic dispensers”.

Back home, the National Environment Management Authority published the “Guidelines for E-waste management in Kenya” where the categories of e-waste are explained in great detail. These include the following (Government of Kenya, 2019a): ICT and Telecommunications equipment, Office electronics, Large Household Appliances, Small Household Appliances, Consumer Equipment, Toys, leisure and sports equipment, Lighting , Medical equipment, Automatic dispensers, Monitoring and control instruments and Batteries.

The government of Kenya adopted e-services and has accelerated the use of the same in the last decade. While this has greatly enhanced efficiency in terms of service delivery, it has equally led to an increase in the number of electronic products in the country. Most government services, for example, tax services, health insurance, social insurance, immigration services and marriage services have been migrated to online platforms in order to leverage on distance and also to minimize in person visits to government offices. There have been claims that the trade deal signed between Kenya and the USA in 2019 was aimed at using Kenya by the USA to dispose off its obsolete electronic products (Ranasinghe & Athapattu, 2020). Kenya imports hundreds of thousands of refurbished electronic products every year. A large percentage of such imports originates from Europe (S. O. Anyango & Munyugi, 2018; Muniafu & Miya, 2016).

With such digitization in the Kenyan government, the need for electronic products has significantly increased as well. Among the electronic products used in the Kenyan government include desktop computers, laptops, phones, scanners, photocopying machines, printers, air conditioners, fluorescence tubes, phones, tablets, microwaves, refrigerators, digital recorders, cameras, video cameras, internet connection devices among others. Given the size of government ministries and the staffing levels, quite a high number of these devices are required for each user. There have been claims of carelessness in handling of these products by the employees (Haregu et al., 2017). This in turn contributes to a higher rate of replacing the same by the concerned parties. Some electronic products also have a shorter life span generally. An example is a phone that generally lasts for up to 5 years at optimum performance. While these electronic products and the digitization process is greatly enhancing service delivery, it is contributing to a great influx of electronic waste.

### **2.3. Impact of E-waste**

E-waste is considered the “fastest-growing waste stream in the world” with 44.7 million tonnes generated in 2016- equivalent to 4500 Eiffel towers. In 2018, an estimated 50 million

tonnes of e-waste was reported, thus the name ‘tsunami of e-waste’ given by the UN. Its value is at least \$62.5 billion annually (ITU, 2016).

Rapid changes in technology, changes in media (tapes, software, MP3), falling prices, and planned obsolescence have resulted in a fast-growing surplus of electronic waste around the globe (University of Guelph, 2019). Technical solutions are available, but in most cases, a legal framework, a collection, logistics, and other services need to be implemented before a technical solution can be applied (Didem & Kiraz, 2019a).

“Display units, processors, memory, and audio components have different useful lives. Processors are most frequently outdated (by software no longer being optimized) and are more likely to become "e-waste" while display units are most often replaced while working without repair attempts, due to changes in wealthy nation appetites for new display technology (Sharma, 2019). This problem could potentially be solved with modular smartphones or Phonebloks (Celestial, 2018). These types of phones are more durable and have the technology to change certain parts of the phone making them more environmentally friendly. Being able to simply replace the part of the phone that is broken will reduce e-waste. An estimated 50 million tons of E-waste are produced each year. The USA discards 30 million computers each year and 100 million phones are disposed of in Europe each year. The Environmental Protection Agency estimates that only 15–20% of e-waste is recycled, the rest of these electronics go directly into landfills and incinerators (Asiimwe, 2016)”.

Like any other waste, electronic waste has devastating effects if not well managed by the relevant parties. The impact of electronic waste can be categorized into two main categories; impact on human life and environmental impact. Health impact refers to the negative effects caused on human beings by electronic waste. Most electronic waste have metal components that are quite harmful to the human health. There have been claims of several cancers caused by the continued use of electronic devices (Fayustov, 2020; Swain et al., 2016). Research has also linked the use of electronic waste to other effects including eye defects, including partial and complete blindness. Additional health impacts of electronic waste include lung sicknesses and infertility. Further research is being done on the impact of e-waste on human health but it is clear that the effects of electronic waste on human health is far and wide. With the increased inventions and developments in the manufacturing of electronic products, the impact is set to increase even further. Developments like the manufacturing of electric cars to replace fuel driven cars are gathering pace world over leading to a further increase in the electronic products in use.

On the other side, the other greatly affected sector by electronic waste is the environment. Environmental degradation and global warming have all been partly attributed to the use and disposal of electronic waste carelessly. Most household electronic devices are disposed off without any consideration for the environment thus causing devastating effects in the long term (Althaf et al., 2020; S. O. Anyango & Munyugi, 2018; Gao et al., 2011; Gök et al., 2017; International Labour Organization, 2019). A degradation in the environment due to disposal of e-waste in turn leads to other potential dangers like food insecurity and global warming. Kenya does not have a properly drafted policy on the disposal of electronic waste and the present guidelines are scarcely known to the masses. This in turn has led to a loophole in the management of e-waste in the country. Kenya has also been unable to adequately regulate the importation of electronic products into the country. This is partly due to lack of clear laws regulating the same and also due to the bureaucracy involved in the importation of these products. Nairobi river, for example, is currently unusable due to the amount of waste directed to the river. While this is not entirely to be blamed on e-waste as every kind of waste finds its way there, there is significant amount of electronic waste in the water as well (Muniafu & Miya, 2016). With the continued use of electronic products and the careless disposal of the same, the environment is at risk of degrading further unless stringent measures and actions are taken.

#### **2.4. E-waste management practices in developing countries**

Kenya is a developing country with a population of 48 million in the year 2019 (KNBS) and land area of 549,137 km<sup>2</sup> (KNBS, 2019). Waste management in Nairobi County is characterized by poor solid waste management, uncontrolled dumping leading to serious pollution problems, unregulated private sector participation in solid waste management, lack of solid waste management infrastructure, and lack of waste management policies and strong waste recycling and recovery industry (Government of Kenya, 2010).

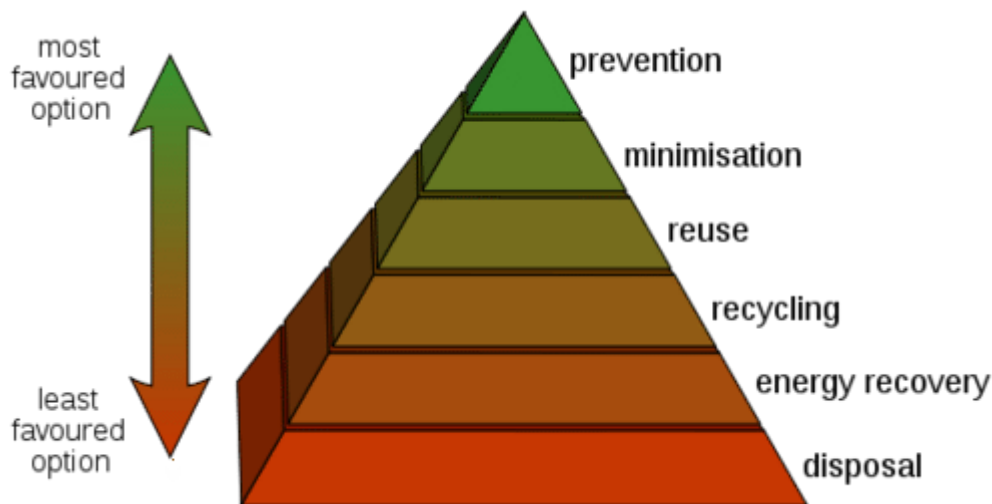
“The per capita waste generation within urban areas ranges between 0.29 and 0.66kg/day (NCC, 2007). Japan International Corporation Agency (JICA, 1997) points out that on average 21% of the waste generated in urban centres emanates from industrial areas while 61% from residential areas, 6% from roads and the rest is not stated. It is estimated that Nairobi generates 1, 5000 tons of solid waste daily and only 25% of this waste is collected and sent to the Dandora dumpsite (Muniafu & Miya, 2016). By the year 2010 the estimates of e-waste generated annually in Kenya were: 11,400tones from refrigerators, 2,800 tonnes from

TVs, 2,500 tonnes from personal computers, 500 tonnes from printers, 150 tonnes from mobile phones (Lucache et al., 2017).

The remaining waste is mostly composed of chemicals (salts, heavy metals, detergents and medical waste) is dumped in undesignated areas or in the rivers and wetlands. There are several illegal dumpsites emerging in Nairobi along the introduction of road, in residential backyards and commercial premises (J. T. Anyango, 2011)”.

## 2.5. Effective e-waste Management

Management of electronic waste is more than just the activities that reduce electronic waste; it is about effective methods and strategies that ensure electronic waste is well managed (Anusree & Balasubramanian, 2019). This entails several things and need for awareness. As per previous research done in the area of e-waste management, effective waste management is something that if done correctly, leads to significant reduction of the adverse effects of e-waste. The following has been identified as an effective e-waste management strategy by different stakeholders. The hierarchy shows the most preferred waste management strategy to the least preferred. In this model, waste prevention is the most preferred strategy with the least preferred being disposal of e-waste.



**FIGURE 1: Waste Management strategies**

*Source: S. O. Anyango & Munyugi, (2018)*

**Waste prevention:** Waste prevention has been identified as the most ideal strategy of ensuring effective e-waste management. The idea behind this is the fact that when there is no e-waste, then there will definitely be no need to manage e-waste in the first place.

**Waste minimization:** It is important to appreciate the fact that it is very difficult to completely eliminate electronic waste. Thus, the second strategy for effective e-waste management is the minimizing of electronic waste. This was the idea behind having smaller electronic products for example computers.

**Waste reuse:** Reuse involves using a given product more than once in order to lengthen its relevance to the organization. Reusing of electronic products is a good way of lengthening their relevance and thereby minimizing the disposal rates of products. The reuse can be for the same purpose or a different purpose that suits the particular product.

**Waste recycling and reuse:** Recycling refers to recovery of useful materials from the waste stream so that they can be incorporated into the fabrication of new products. Most electronic products do not become obsolete in entirety and thus can be recycled with some parts being put into the production chain once they are due for disposal.

**Waste disposal:** This is the least preferred method of e-waste management and involves getting rid of the electronic waste totally. Often times, this leads to increased electronic waste as well as having environmental and health impact.

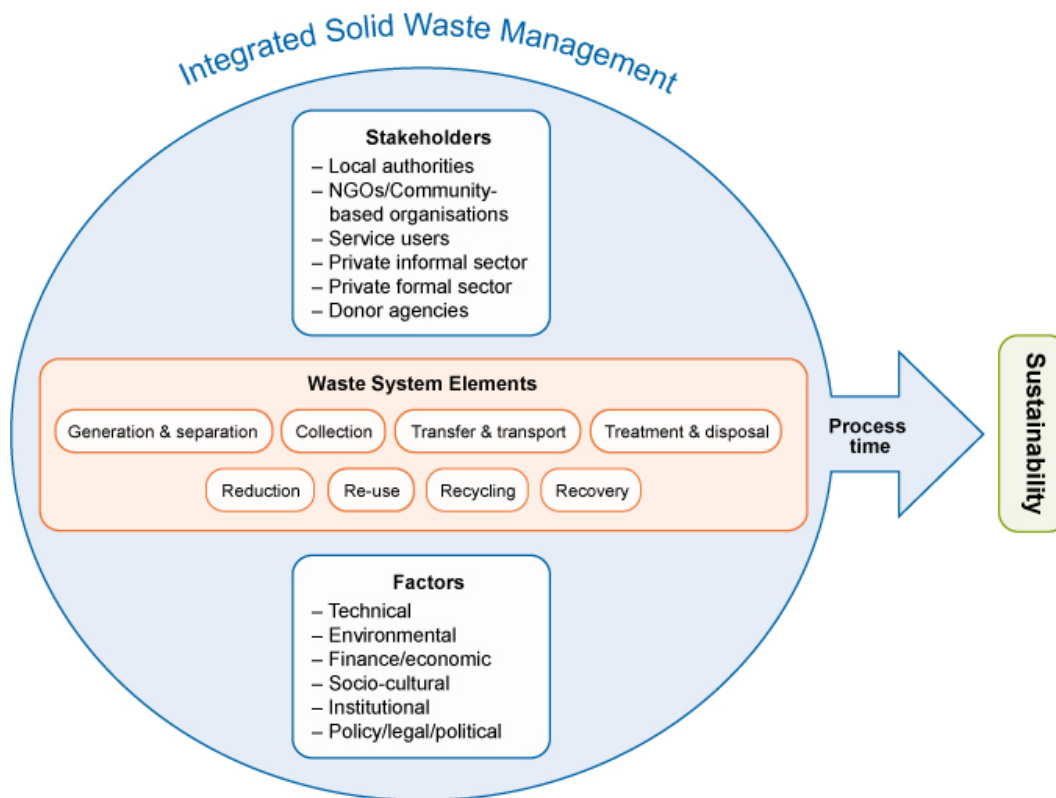
## **2.6. Integrated Solid Waste Management Framework**

Integrated solid waste management (ISWM) can be defined in different ways, but it refers to the strategic approach to sustainable management of solid wastes covering all sources and all aspects such as waste generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency. A plausible solution to waste management would be an integrated approach which would include collective management of all types of wastes and implementation of the 3R (Reduce, Reuse and Recycle) policies and strategies.

Van de Klundert and Anschütz (2001) explain that the ISWM concept is built upon four basic principles:

- **Equity:** the allocation of resources, services and opportunity to all segments of the population according to their needs. In waste management this means that everyone has a right to be served by a waste management system that protects their health and the environment.
- **Effectiveness:** the waste management methods used must meet the overall aims of any waste plan and meet the needs of the people. At the very least, effectiveness means that all the waste is collected and disposed of in a safe way.

- **Efficiency:** in general, efficiency means increasing output for a given input, or minimising input for a given output. An efficient waste management system is one that is equal and effective while making the best use of the resources available (staff effort, use of equipment and cost).
- **Sustainability:** for a project, programme or other activity to be sustainable it must be effective and last a long time.



**FIGURE 2: The ISWM Model**

**Source:** Van de Klundert and Anschütz (2001)

## 2.7. Resource Based Value Theory

The Resource based value (RBV) theory of the firm is the framework which links the success of a firm to resources and skills which are firm specific, rare, and difficult to imitate (Barney 2007, 2008). The RBV focuses on difficult to copy attributes of the firm that are fundamental drivers of performance (Schultze, 2007). In this research, the theory is used to depict the success of e-waste management to the specific resources in the organization. Although the theory generally talks about firm success in terms of profitability, it could be used in this research by taking the various factors necessary for effective e-waste management as the resources input and effectivity in e-waste management as the success.

Wernefelt (2012) offers a contributing angle in his seminal approach in the subject of the theory by alluding to the notion that resource position barriers at times act as a limitation to an organization's success. Similarly, e-waste management resources positioning has a great impact in determining the effectiveness of e-waste management in government. It is the ability of a firm to combine the factors of resources and correct positioning that would eventually lead to effective management of e-waste.

## **2.8. The National ICT Policy**

This policy was designed to realise the potential of the digital economy by creating an enabling environment for all citizens and stakeholders. A review of the 2006 policy was necessitated by the rapid changes and developments in the ICT sector, evolving global trends and the fast-changing public needs. The Fourth Industrial Revolution is driving automation and massive data exchange, impacting our macro and microenvironments and increasing the level of ICT consumption worldwide. It is for this reason that the ministry of ICT set up a policy designed to take advantage of these changes and trends that would enable Kenya to become a more prosperous participant in the global economy. The ICT Policy defines the forward-looking position of the Government on various areas of the evolving ICT sector landscape in Kenya. The focus of the ICT policy were four key areas namely: mobile first, market, skills and innovation and public service delivery. The first area focuses on ensuring that as many Kenyans as possible have access to ICT as possible. This would be achieved through steps like investing in the infrastructure needed, creating an enabling environment for locally assembled devices, growth of e-commerce among others.

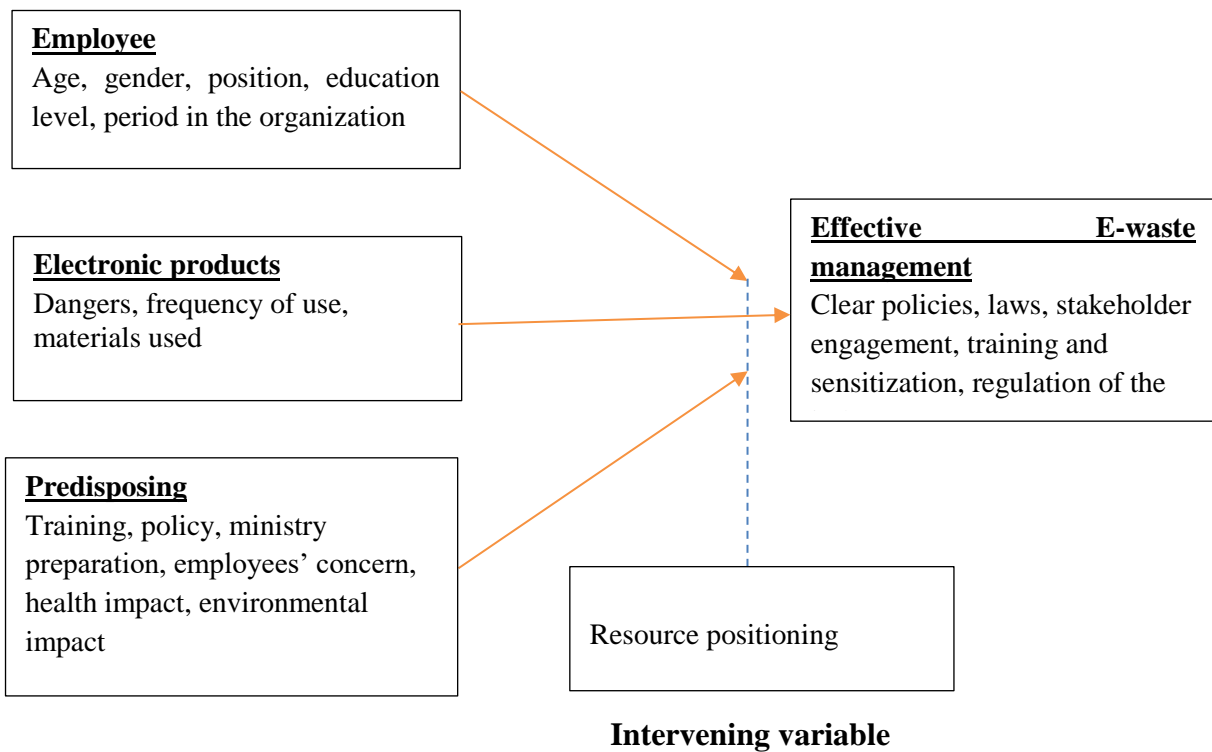
The second area of focus is about gaining market for the electronic products while the third area is focused on ensuring people are equipped with skills and innovative ideas in order to be able to partake of this important change. The fourth area that focuses on public service delivery is aimed at ensuring that the government is able to provide services online to its citizens. This clearly affects the aspect of e-waste management. This is because online service delivery by government is will definitely lead to the rise in electronic products used which in turn will lead to increased electronic waste. Under ICT infrastructure and access, the policy proposes the development of a government ICT registry to prevent the waste of electronic resources while under environmental protection, the policy proposes development of comprehensive policies to govern electronic waste management by involving stakeholders and providing incentives for adoption of best e-waste management practices.

## **2.9. Conceptual Framework**

The research framework was developed from the literature reviewed by the researcher in chapters one and two. The framework was derived from The National ICT policy by the Ministry of ICT, the Resource Based Value Theory and the ISWM model. These were preferred because the national ICT policy governs the acquisition, use and disposal of electronic products which is the main source of electronic waste while the ISWM model has been used over time and covers the elements of stakeholders and factors affecting e-waste management. Below is the proposed conceptual framework for the study.

**Independent variables**

**Dependent variable**



**FIGURE 1: Conceptual Framework**

**2.10. Chapter Summary**

This chapter has looked into the various literature available on the topic of study. This was done in line with the objectives of the study. The aim was to identify what previous authors have said about the topic of discussion. Additionally, the research looked into the theoretical framework which was based on the Integrated Solid Waste Management framework.

## **CHAPTER THREE: RESEARCH METHODOLOGY**

### **3.1. Introduction**

Chapter three explains procedures that were followed when undertaking this study; it describes the various methods put in place by the researcher to collect data for the study. Saravanel (1992), refers to research as a systematic and concentrated analysis of a given topic or area of investigation supported by the gathering, collation, presentation and interpretation of relevant details or data.

### **3.2. Research Approach**

The researcher used mixed methods consisting of both quantitative and qualitative research approaches. Mixed methods research focuses on the collection, analysis, and mixes both qualitative and quantitative data in a single study or even a series of studies (Cresswell, 2018; Demir & Pismek, 2018). Quantitative research purposes to measure the amount or quantity of the object of study and conducts a comparison of the same to past records as it tries to project for forthcoming periods (Cresswell, 2018). Qualitative research on the other hand involves the analysis and interpretation of data through observation of what people do and say (Harnett, 2016). The research was descriptive in nature and sought to describe in details the subject under research. By implementing an exhaustive research design such as this, the researcher was able to provide understandings into the how and why of the research (Lamb, 2015).

### **3.3. Research Design**

The researcher employed Convergent mixed methods design due to the fact that it collates various data from different sources. In this research, the researcher collected the various data concurrently from the various sources and converged them together for analysis. The justification for this design is that one data collection form can be used to covers up for the weaknesses of the other research method, and that a more complete understanding of a research problem is as a result of collecting both quantitative and qualitative data (Cresswell, 2018). Since data was gathered from different sources, this method was effective to converge the various data types and get meaning out of the same.

### **3.4. Area of the study**

The study focused on government ministries within the Republic of Kenya. Specifically, one ministry was selected for the research. This was the ministry of ICT. The purpose of selecting

the Ministry of ICT is because they are the body in charge of the ICT sector, which is the main generator of e-waste in Kenya.

### **3.5. Study Population**

Cooper & Schindler (2006) defined population in research as the total group of people or elements with at least one thing in common; while Saravanel (1992) refers to it as any infinite or infinite collection of individuals. The population for this research were 451 employees in the ministry of ICT.

### **3.6 Target Population**

The target population refers to the complete set of units which data from the research are to be used to make interpretations. It describes those units for which the findings of the research are meant to be generalized by the researcher. Lavrakas (2008) states that defining the target population is the second step in research design. The target population comprised of the users of electronic products and managers of e-waste in the Ministry of ICT (MoICT) and the Ministry of Education (MoE). All the 451 employees were the target population.

### **3.7. Sampling**

Sampling in research is the procedure that a researcher uses to bring together people, places or items to use for a particular study. Sampling as a process entails selecting a number of individuals from a population in a manner that the selected group of individuals contains features that represent the target group (Education Centre, 2006; Kothari, 2004)

#### ***3.7.1. Sampling procedure***

A crucial step in research is selecting a method of obtaining data from the target population. This should be done with sound judgment since no amount of analysis can compensate for poorly collected data.

This research employed two main sampling methods for different samples: simple random sampling and purposive sampling. Simple random sampling was used in sampling the employees within the two ministries. Purposive sampling is a type of non-probability sampling technique where the individuals or objects to study are investigated based on the judgment of the investigator (Cresswell, 2018). This was applied in selecting the ministry i.e. Ministry of ICT. The ministry was purposively selected because the Ministry of ICT is the main regulator of the ICT sector which contributes to a large percentage of electronic waste.

### **3.7.2. Sample Size**

According to Cresswell (2018), a sample representation of at least 10% is acceptable for a research. The researcher selected a sample of 27% of the target population which translates to 121 respondents.

## **3.8. Data Collection Techniques**

Data collection techniques can be grouped into two categories depending on the data being collected (Neuman, 2000). While quantitative data is collected in terms of numbers, qualitative data is collected in the form of words or pictures. This particular research employed both qualitative and quantitative research methods and used two techniques for the data collection. Quantitative data was collected using survey research technique. Survey research uses a written questionnaire or formal interview to gather information on the backgrounds, behaviours, beliefs, or attitudes of a large number of people, usually 100 to 5,000 people (Kothari, 2004; Neuman, 2000).

### **3.8.1. Data Collection Instruments**

Data collection instruments refers to the tools that are used to collect data. According to Keya, Makau, Mani, & Omari (1989), the choice of tools for collecting or gathering data for any study largely depends on their efficiency and accuracy because each of the instruments has its own strengths and weaknesses. Data was collected using semi-structured questionnaires. Online questionnaires were administered to staff at the Ministry of ICT. The questionnaires were set in such a way that all questions had to be responded to before submission. This played a key part in ensuring that all the returned questionnaires were fully filled.

## **3.9. Piloting**

The researcher purposively selected a sample of 10 respondents from the Ministry of Health to whom the tools were administered to test their effectiveness. The results of the pilot study were analysed by the researcher and recommendations and alterations made to the instruments as was deemed fit after the study. The researcher added what was missing and omitted what was not necessary for the research. In this case the actual research was accurate and free from error.

### **3.10. Data Analysis & Modelling Procedures**

These are the techniques the researcher used in analysing the collected data. The collected data was analysed and useful conclusions drawn from it. The data collected was organized, categorized and relationship between the categories established in a form which could easily be understood and from them inherent facts and useful conclusions were derived. There are several methods of analysing data depending on the type of research being conducted, the objectives and the hypothesis to be tested. Statistical Package for Social Sciences (SPSS) was used in analysis of the quantitative data collected through questionnaires. Statistical data was presented in form of tables and pie charts and the researcher employed SPSS to analyse quantitative data.

The data collection method involved extending of data collection process to the population universe (The employees within the ministry of ICT). Well documented and objective google forms were sent as digital questionnaires to the intended audience. This forms clearly captured the variables that would later be used in analysing the required output from the answers provide. Once the researcher got back the responses from the target population, it was exported to CSV format; this would clearly give an insight into what kind of data was collected. Upon updating the CSV format, the researcher conducted data cleaning on the dataset. During data collection, Values such as negative and none column type variables were replaced as well.

WEKA software is an application developed in java and owned by Waikato University in Zealand, It is a data analysis, model training, machine learning and predictive analytics software that is open source and can be used by anyone for any of the prior mentioned purposes. Before using the WEKA application, the researcher had to endure that the dataset is in CSV format, this way, it would be easier to use the WEKA raff viewer to save the dataset in .raff format, which is the confirmed dataset that is recognised by the WEKA application. Decision tree analysis come in handy because top level management in the ministry of ICT and government at large would use the inside and recommendations from this research to improve on current dangers passed by e-waste devices. As will be discuss later in the next chapter, the research used two algorithms in decision tree analysis i.e. J48 and BayesNet to try to realise the closest and closest prediction by output for this data.

The data was split into two categories. 70% as the training set used to develop the model and 30% as the test set, while k-fold cross-validation was used to validate the

developed model.  $k=10$  is the default value in the WEKA tool. It is preferred because it has been shown empirically to yield test error estimates that don't suffer from excessively high bias or variance.

The framework was developed following the review of other frameworks discussed in chapter two, the conceptual framework and the research findings from the study. The various frameworks were reviewed and used by the researcher to come up with an enhanced framework that could be used in the public sector to ensure effective management of e-waste.

### 3.11. Study Variables

From the descriptive analysis done on the data, the following variables were identified and used on WEKA to develop the model for the study. This was used in meeting the third objective of the study. These were captured by the online questionnaires (section A-F)

**TABLE 2: Study Variables**

No.	Variable	Description
	Gender	Male or female
	Age bracket	Divided into 6 categories: below 25 years, 31-35, 36-40, 41-45, 46-50 and above 50 years
	Highest level of education	Highest education achieved in terms of PhD, Masters, Undergraduate Degree, Higher Diploma, Diploma and Certificate
	Position	The position a respondent occupied in the ministry of ICT
	Period in organization	This referred to the length of period a respondent had spent in the ministry of ICT
	Frequency of use	Implied the frequency of usage of electronic products within the office
	Knowledge of materials	How much do the respondents know about the material used in electronic products?
	Danger awareness	Do the respondents know the dangers of electronic waste?
	Involvement	This variable sought to establish how involved the respondents were in matters of electronic waste management.
	Training	If the employees had been trained on electronic waste management
	Health impact	If the respondents thought that electronic waste had a health impact
	Environmental impact	If the respondents thought that electronic waste had an environmental impact
	e-waste concern	How concerned are the employees about e-waste in the ministry

	Ministry preparedness	How prepared is the ministry for managing e-waste?
	Policy	What do employees know regarding presence of an e-waste management policy?

### **3.12. Ethical Considerations**

Ethics are an integral part of conducting any meaningful research and therefore a close attention is being paid to the same (Bailey & Burch, 2016). Ethical consideration forms a crucial part of research as it functions to give it credibility and reliability. Ethical considerations included confidentiality, informed consent, respect and honesty.

### **3.13. Chapter Summary**

Chapter three has delved deeper into the aspect of the research methodology that was employed in conducting the research. The chapter looked at the research design employed as well as the research method. Aspects of the study population and sampling have been discussed at length. Additionally, the chapter looks at the data collection methods and instruments as well as data management and analysis procedures and methods. Also covered are the ethical considerations that the researcher put into consideration while conducting the research. Being a research that entailed different data collection methods and techniques, the chapter presents a research conducted using mixed methods in order to effectively cover the various aspects and data collected. This combination gave a more accurate result that was used to make conclusions and give recommendations for further research.

## CHAPTER FOUR: DATA PRESENTATION AND ANALYSIS

### 4.1 Introduction

This chapter discusses the aspect of data presentation and analysis as collected using the tools identified. Data collection was done through online questionnaires for both the employees and the Heads of Departments (HoDs). The data was were interpreted in line with the objectives of the study which included: to identify electronic products used in government ministries in Kenya, to investigate the impact of e-waste in government ministries in Kenya, to examine the electronic waste management practices in government ministries in Kenya, to identify challenges associated with managing e-waste in government ministries in Kenya and to make recommendations on how the government ministries can effectively manage their e-waste.

To achieve the above objectives, the study used semi-structured questionnaires to collect data from the heads of departments and regular employees. The presentation of the collected data was done using tables, graphs and charts. The software used in the analysis included SPSS and Microsoft Excel while model testing and validation was done using WEKA.

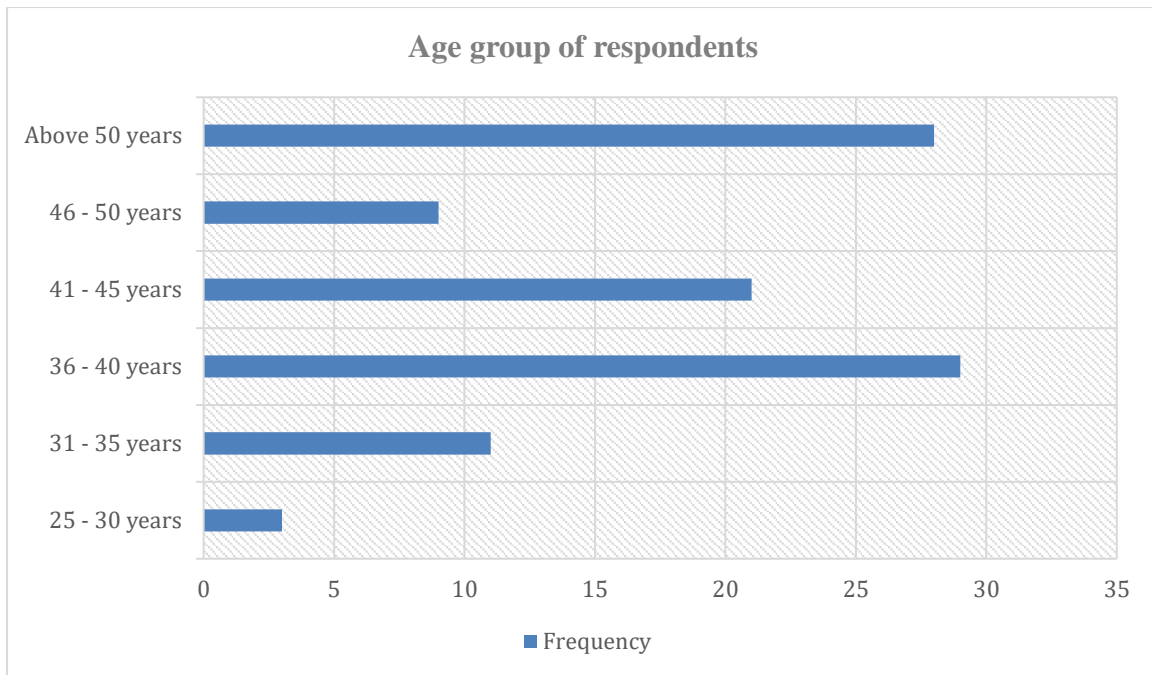
### 4.2 Variable Analysis

**Gender of respondents:** There was a near even distribution of respondents in terms of gender with females accounting for 55(55%) while the male gender had 46(46%) representation. Table 2 presents this data.

**TABLE 3: Gender of respondents**

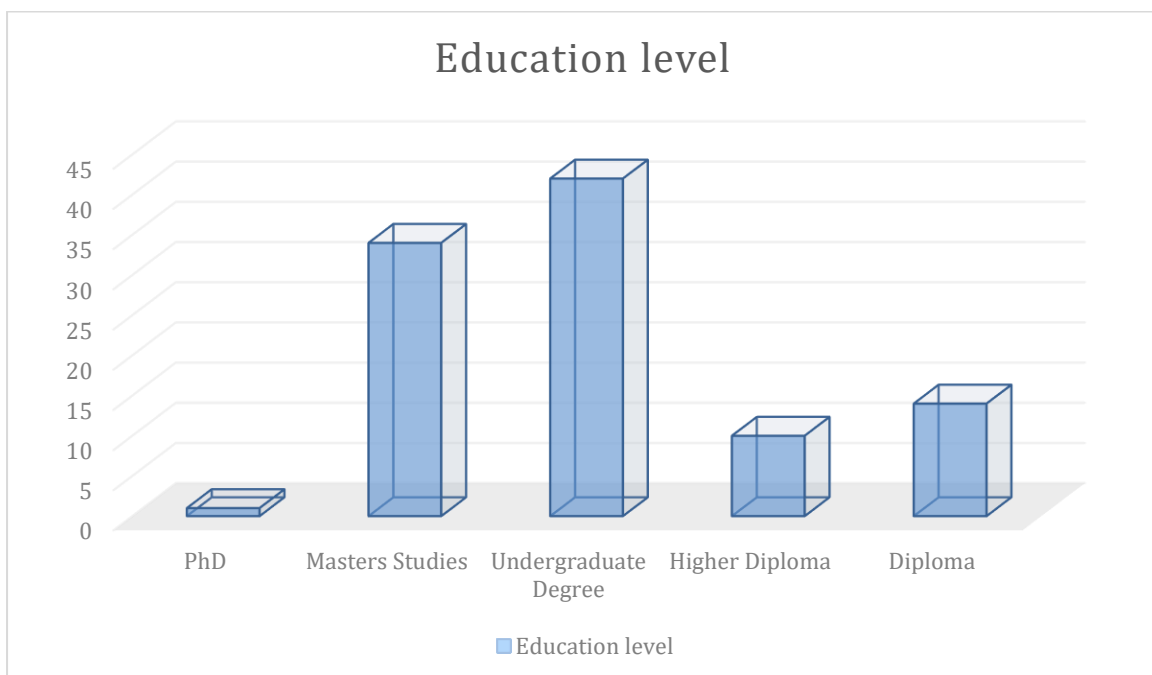
	Frequency	Percent	Cumulative Percent
Male	46	45.5	45.5
Female	55	54.5	100.0
Total	101	100.0	

**Age bracket of respondents:** Data analysed showed that the age group of 36 – 40 years was the most represented with 29 respondents translating to 29% representation. Closely following was the age bracket of above 50 years which had 28(28%) representation. The age bracket of 41 – 45 years had 21(21%) respondents with 11(11%) respondents falling under the age bracket of 31 – 35 years. The age brackets of 46 – 50 years and 25 – 30 years were the least represented with 9(9%) and 3(3%) respectively. The age group of below 25 years did not have any response. This is presented in the figure below.



**FIGURE 4: Age group of respondents**

**Highest Level of Education:** Majority of the respondents 42(42%) have undergraduate degree followed by 34(34%) who have a master’s degree. Those with Diploma and Higher Diploma are 14(14%) and 10(10%) respectively while just 1(1%) of the respondents had a PhD. None of the respondents had a certificate as the highest level of education.



**FIGURE 5: Highest education level**

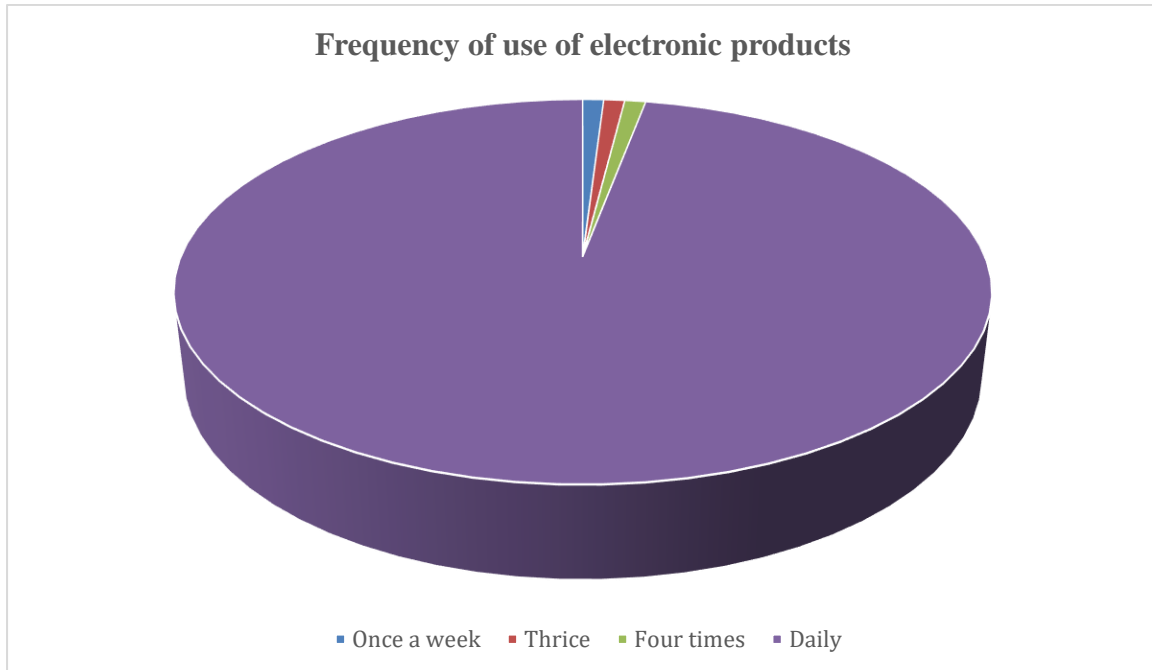
**Position of respondents:** Data showed that majority of the respondents, 21(21%) of the respondents were working as an ICT Officer. 17(17%) were working as a Principal ICT Officer while 14(14%) were Senior ICT Officers. The least represented positions were Public Relations Officer, Senior Accountant, Senior Assistant Office Administrator, Senior Auditor, Senior Clerical Officer, Administrator, Assistant Accountant General and Supply Chain Management Officer. Each of these had 1(1%) representation. The data is shown in the table below.

**TABLE 4: position of respondents**

	<b>Frequency</b>	<b>Percent</b>	<b>Cumulative Percent</b>
Accountant	5	5.0	5.0
Administrator	1	1.0	5.9
Assistant Accountant General	1	1.0	6.9
Assistant Director of ICT	8	7.9	14.9
Clerical Officer	2	2.0	16.8
Deputy Director	3	3.0	19.8
Finance Officer	5	5.0	24.8
Human Resource Management Officer	5	5.0	29.7
ICT Officer	21	20.8	50.5
ICT Officer 1	5	5.0	55.4
Office Administrator	1	1.0	56.4
Principal Accountant	1	1.0	57.4
Principal Assistant Office Administrator	2	2.0	59.4
Principal HRM Assistant	2	2.0	61.4
Principal ICT Officer	17	16.8	78.2
Public Relations Officer	1	1.0	79.2
Senior Accountant	1	1.0	80.2
Senior Assistant Office Administrator	1	1.0	81.2
Senior Auditor	1	1.0	82.2
Senior Clerical Officer	1	1.0	83.2
Senior ICT Officer	14	13.9	97.0
Supply Chain Management Officer	1	1.0	98.0
Support Staff	2	2.0	100.0
Total	101	100.0	

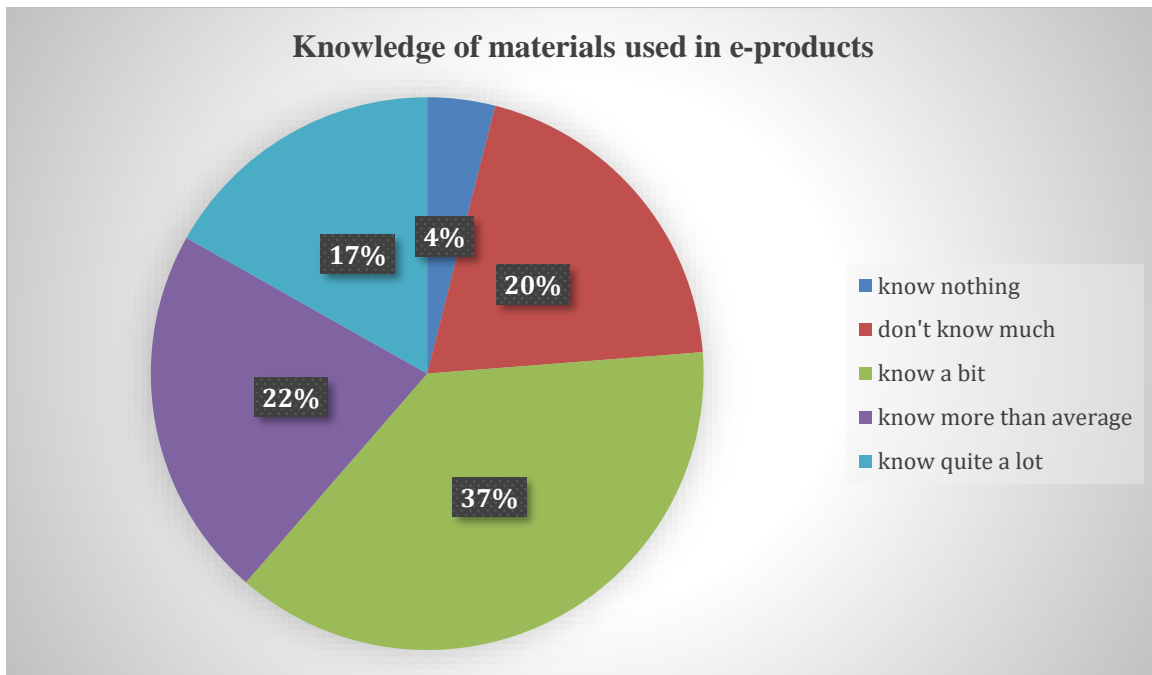
**Period in organization:** Most of the respondents had stayed in the organization for at least 3 years. 39(39%) of the respondents had stayed above 5 years while 19(19%) had been in the organization for a period between 3 – 4 years. 33(33%) of the respondents had been with the ministry for less than a year while 10(10%) of the respondents had been at the ministry for a period between 1 – 2 years.

**Frequency of use of electronic materials:** 98(97%) of the respondents use these electronic products on a daily basis. On the other hand, 1 respondent each (1%) use these electronic products once a week, thrice a week and four times a week. No respondent indicated usage of electronic products twice a week. The figure below shows this data.



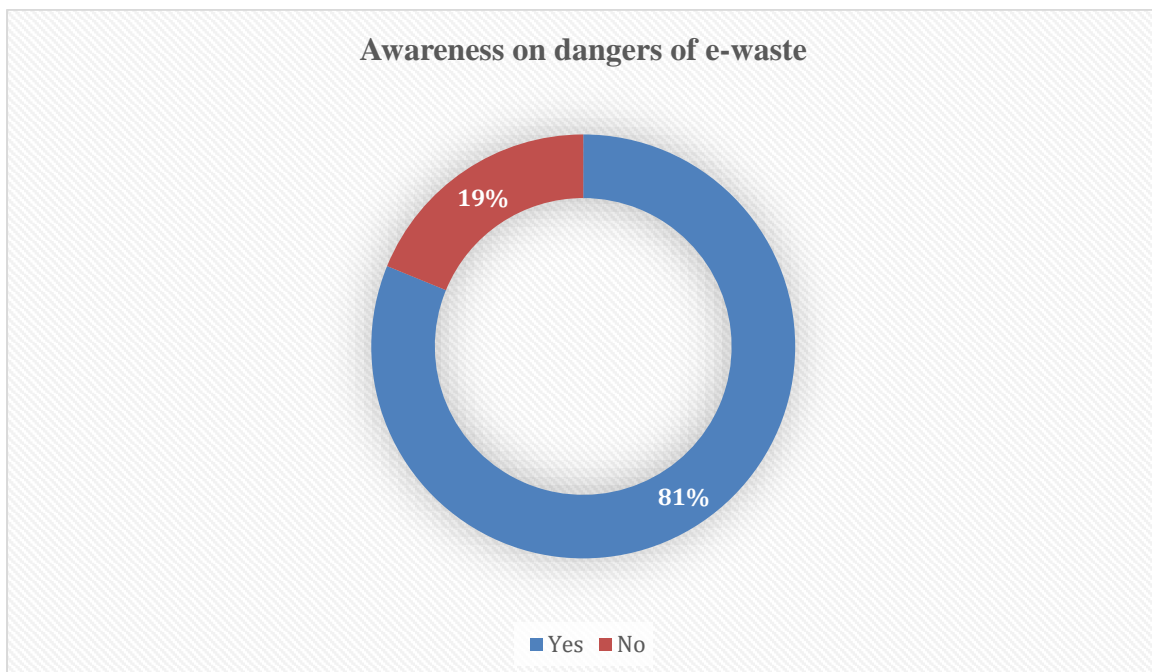
**FIGURE 6: Frequency of use of electronic products**

**Knowledge of material used:** From the analysed data, 38(38%) of the respondents admitted to knowing a bit about the materials used in manufacturing the electronic products used at the ministry. On the other hand, 22(22%) of the respondents indicated that they know more than average regarding the materials used in the manufacturing of the electronic products in use. 20(20%) of the respondents indicated that they do not know much about the materials used while 17(17%) respondents indicated that they know quite a lot regarding the materials. 4(4%) of the respondents admitted to not knowing anything about the materials used in the manufacturing of the electronic products they use. None of the respondents knew everything about the materials used in the manufacturing of the electronic products. The figure below shows this data as collected from the respondents.



**FIGURE 7: Knowledge of materials used in e-products**

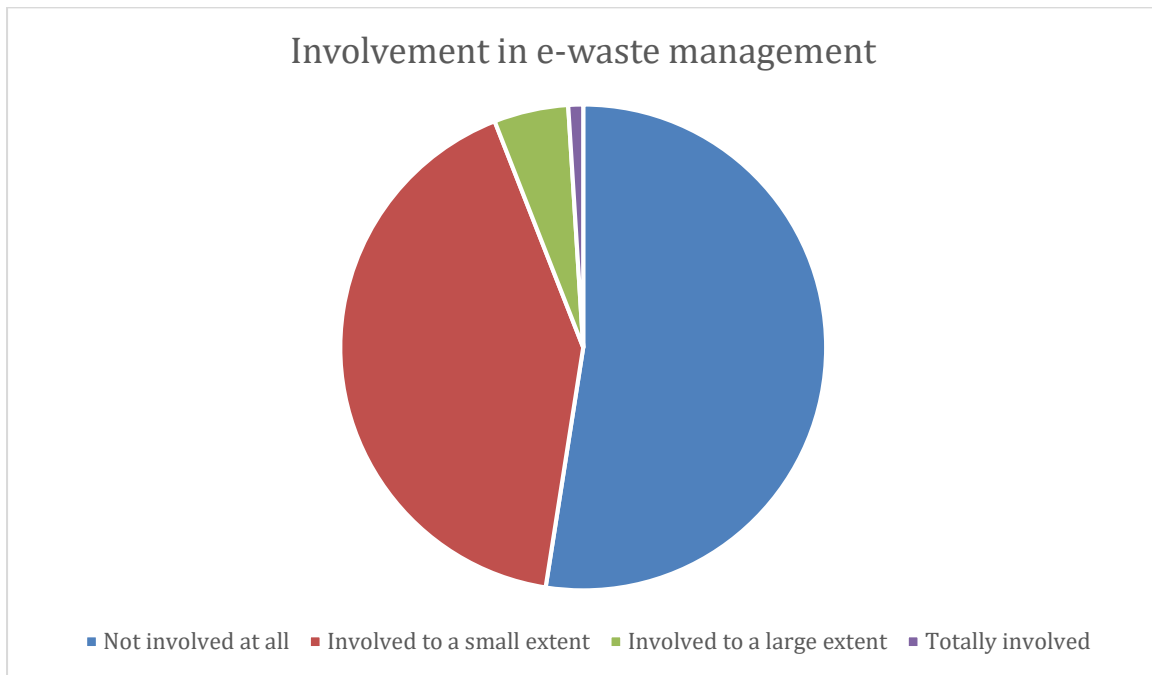
**Danger of e-waste:** Results showed that 82(81%) of the respondents were not aware of the dangers of electronic waste while 19(19%) indicated that they were aware of the dangers of e-waste as shown below.



**FIGURE 8: Awareness on dangers of e-waste**

**Involvement in e-waste management:** From the analysed data, over 90% of the respondents are either not involved at all or involved to a small extent in the management of

electronic waste in the ministry of ICT. 53(53%) of the respondents indicated that they are not involved at all in the management of electronic waste in the ministry while 42(42%) indicated that they are involved to a small extent in the same. 5(5%) of the respondents indicated that they are involved to a large extent in managing e-waste while only 1(1%) indicated that they are totally involved in the management of e-waste in the ministry of ICT. This data was presented in the figure below.



**FIGURE 9: Involvement in e-waste management**

**Training on e-waste:** Majority of the respondents (95) have not been trained on e-waste management. This translates to 94% of the respondents. On the other hand, 6(6%) of the respondents indicated that they have been trained on e-waste management. The table below shows this data.

**TABLE 5: Training on e-waste**

	Frequency	Percent	Cumulative Percent
Yes	6	5.9	5.9
No	95	94.1	100.0
Total	101	100.0	

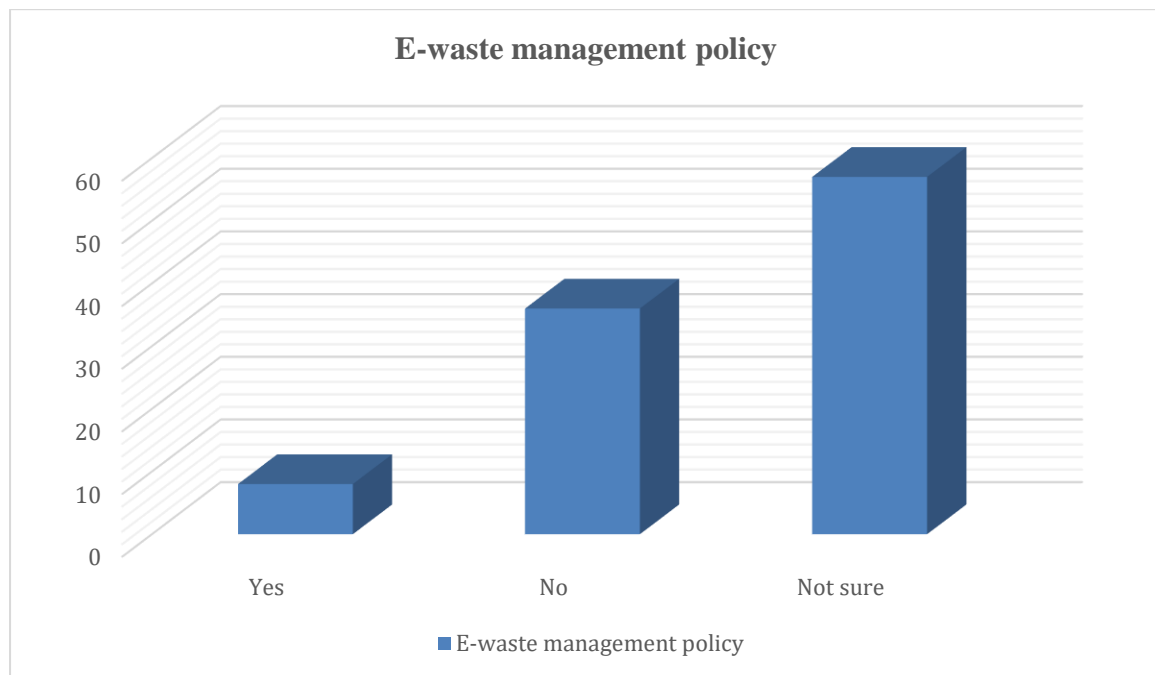
**Health impact:** the analysed data showed that majority of the respondents (90%) were aware that electronic waste had a health impact while another 10% were of a different opinion.

**Environmental impact:** About 82% of the respondents identified environmental impact as an effect of electronic waste while 18% of the respondents said otherwise.

**Ministry concerned:** over 80% of the respondents indicated that they were not concerned with the e-waste management in the organization. Further analysis shows that majority of these people had not been trained on e-waste management.

**Ministry prepared:** Majority of the respondents indicated that the ministry of ICT was not adequately prepared to tackle the issue of e-waste management.

**Policy:** Of the 101 respondents, 57(56%) were unsure whether there is an e-waste management policy in the ministry or not. 36(36%) of the respondents indicated that there was no e-waste management policy in the ministry with only 8(8%) of the respondents indicating that the ministry had an e-waste management policy. The same is presented graphically as shown.



**FIGURE 10: E-waste management policy**

In general, there was a feeling from the employees at the ministry of ICT that the status of e-waste management is wanting at the ministry and poses them to several dangers. The fact that the ministry makes little effort in addressing e-waste management issues like training and policy development means most of the employees are much concerned about the dangers of e-waste to their health and the environment.

### 4.3 E-waste Management Model

The data was subjected to two classification algorithms; J48 and BayesNet, both with a 10-fold cross validation. The BayesNet model has an accuracy of 60.4% while J48 has an accuracy of 55.45%. the J48 has a higher mean absolute error of 0.3302 as compared to BayesNet's 0.2532. The relative absolute error for J48 and BayesNet are 89.63% and 77.34% respectively.

**TABLE 6: Summary of cross validation**

	<b>J48</b>	<b>BayesNet</b>
Correctly classified instances	55.45%	60.40%
Incorrectly classified instances	44.55%	39.60%
Kappa statistics	0.1164	0.2532
Mean absolute error	0.3302	0.2849
Root mean squared error	0.437	0.421
Relative absolute error	89.63%	77.34%
Root relative squared error	102.11%	98.34%
Total number of instances	101	101

The model results are illustrated by the following figures:

## J48 modelling results

Test mode: 10-fold cross-validation

==== Classifier model (full training set) ====

J48 pruned tree

-----

Time taken to build model: 0.05 seconds

==== Stratified cross-validation ====

==== Summary ====

Correctly Classified Instances	56	55.4455 %
Incorrectly Classified Instances	45	44.5545 %
Kappa statistic	0.1164	
Mean absolute error	0.3302	
Root mean squared error	0.437	
Relative absolute error	89.6254 %	
Root relative squared error	102.11 %	
Total Number of Instances	101	

==== Detailed Accuracy By Class ====

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	
Class									
	0.389	0.262	0.452	0.389	0.418	0.132	0.576	0.391	No
	0.737	0.614	0.609	0.737	0.667	0.131	0.619	0.738	Not
sure									
	0.000	0.011	0.000	0.000	0.000	-0.029	0.562	0.112	Yes
Weighted Avg.	0.554		0.440	0.504	0.554	0.525	0.119	0.599	0.565

**Figure 11: J48 Modelling results**

==== Confusion Matrix ====

a b c <-- classified as

14 21 1 | a = No

15 42 0 | b = Not sure

2 6 0 | c = Yes

### BayesNet Modelling results

Test mode: 10-fold cross-validation

==== Stratified cross-validation ====

==== Summary ====

Correctly Classified Instances	61	60.396 %
Incorrectly Classified Instances	40	39.604 %
Kappa statistic	0.2532	
Mean absolute error	0.2849	
Root mean squared error	0.4209	
Relative absolute error	77.3404 %	
Root relative squared error	98.3367 %	
Total Number of Instances	101	

==== Detailed Accuracy By Class ====

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	
Class									
	0.556	0.292	0.513	0.556	0.533	0.259	0.710	0.549	No
	0.719	0.409	0.695	0.719	0.707	0.312	0.739	0.836	Not sure
	0.000	0.032	0.000	0.000	0.000	-0.051	0.719	0.209	Yes
Weighted Avg.	0.604	0.604	0.338	0.575	0.604	0.589	0.264	0.727	0.684

**Figure 12: BayesNet modelling results**

==== Confusion Matrix ====

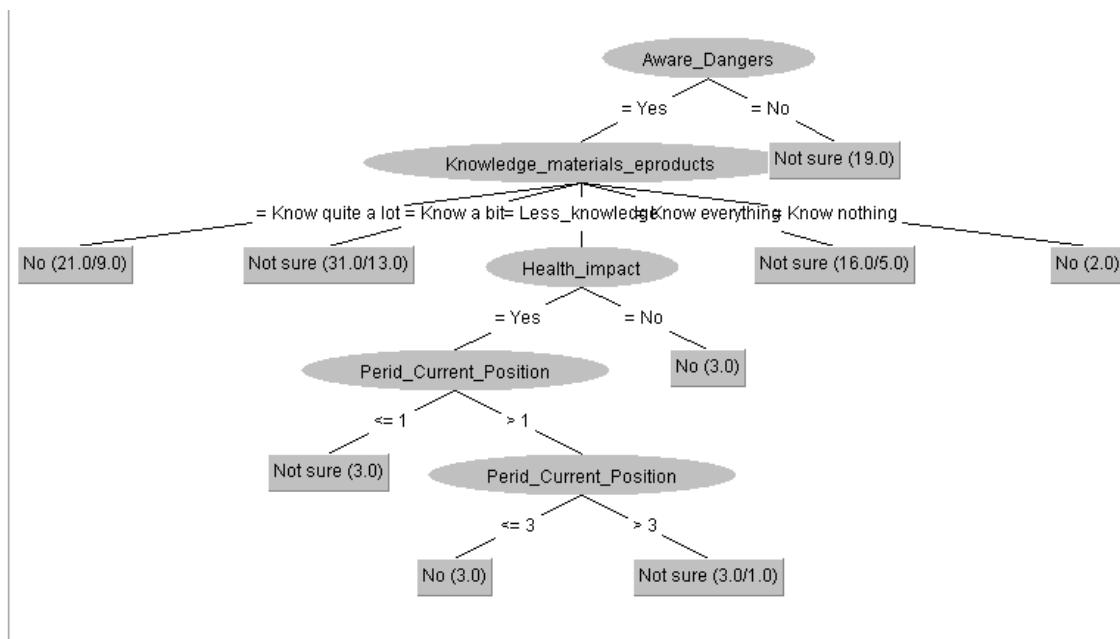
a b c <-- classified as

20 14 2 | a = No

15 41 1 | b = Not sure

4 4 0 | c = Yes

### J48 Decision tree



**Figure 13: J48 tree decision**

Data analyzed using J48 shows that the period in the organization, knowledge on health impact and knowledge of materials used in electronic products greatly contributed to respondents' awareness of the dangers of e-waste. The analyzed data shows that there was no relationship between the ages of the respondents and their awareness on the dangers of electronic waste. The dangers of e-waste were not known to many of the respondents across the board. Similarly, there was a close relationship between the involvement of employees in managing e-waste and their awareness of the dangers of e-waste. For example, the more the employees were engaged in the management of e-waste, the more they were aware of the dangers of e-waste and the less they were engaged in the management of e-waste, the less they were aware of the dangers. There was no relationship between the gender and awareness of the dangers of e-waste.

The two models were tested using the 30% test data set in order to predict the results. The results of the two models were compared whereby the J48 model had an accuracy of 43.3% while BayesNet had an accuracy of 63.3%.

As such, the BayesNet model was chosen as the best model for the research as it produced a more accuracy level as compared to J48.

#### **4.4 Chapter Summary**

This chapter presented the data that was captured using online questionnaire. The two sets of data were analysed using SPSS and Excel while WEKA was used to analyse the variables and test the models. A description of the findings was given for every data set that was collected. The analysis was comprehensive to ensure that correct interpretation can be made from this data by the researcher in the subsequent chapter. The model testing revealed that BayesNet was the preferred model as it had a higher accuracy level.

## **CHAPTER FIVE: DISCUSSION OF FINDINGS**

### **5.1. Introduction**

This chapter discusses the findings as presented in the previous chapter. The discussions are aimed at making meaning out of the collected data and hence drawing amicable conclusions from the same. The data analysis was done in line with the objectives of the study identified in chapter one. Further, conclusions and recommendations were made in the chapter.

### **5.2. General information of the respondents**

The response rate of the research was generally good given that there was an average response rate of 91.5% from the two sets of data collected from the Heads of Departments (HoDs) and the regular employees. This is acceptable given that a response rate of 75% is considered sufficient.

There is generally a fair representation in terms of gender of the respondents. The female gender accounted for 55% of the respondents while the male gender accounted for 46% of the respondents among the regular respondents. This is a contrast with previous research done in government institutions that found the male gender to be higher than their female counterparts in government and especially in the IT sector (J. T. Anyango, 2011; Muniafu & Miya, 2016; Otieno & Omwenga, 2015). That was not the case among the HoDs however, with 80% of them being males with just 20% females. This shows that more males occupy top positions in government as compared to females. This is consistent with the findings by Sharma (2019) who established that most top positions in organizations are occupied by the male gender.

Majority of the regular employees in the Ministry of ICT fall in the 36-45 years age group. These accounted for half of the respondents. There is also a significant number of employees above 50 years of age which accounts to almost 30% of the respondents. On the other hand, there are very few employees in the ministry who are below 30 years. The age groups among the HoDs is quite high with all the HoDs being at least 41 years of age. This shows that most of the top positions in government are occupied with relatively older people as compared to other low cadre positions. This is an issue that has been in the public sector for a while with research consistently establishing a high percentage of older people in government jobs as compared to the younger generation of employees (de Oliveira et al., 2020; Li & Song, 2016).

Undergraduate degree is the most popular education level among the respondents in the Ministry of ICT. This accounts for over 40% of the respondents while a number of them

have a master's degree as well at 34%. Diploma and Higher Diploma are less represented in the ministry with both accounting to about 25% of the employees in the ministry. The least represented education level on the other hand is PhD which only has one respondent. 90% of the HoDs have a master's degree with just one HoD having an undergraduate degree. As compared to the other cadres of employment, there are higher requirements for HoDs as opposed to regular employees who can be employed with all levels of education from Diploma onwards.

Majority of the employees in the ministry occupy the position of ICT Officer. From the research, this accounted to over 20% of the responses. The position of Principal ICT Officer is similarly popular in the ministry with 17% of the respondents while Senior ICT Officers account for 14% of the respondents. These three positions account for over 50% of the employees. While other positions are present and significant, it can be said that the most popular positions in the ministry are ICT related, just like the ministry itself. Each of the departments has one head each who took part in the study except for the department of Accounts. The same is translated into the departments where over 66% of the respondents are in the departments of ICT unit and Directorate of ICT. This is consistent with the role and aim of the ministry.

### **5.3. Electronic products used in the Ministry of ICT**

The most commonly used electronic product in the ministry of ICT is computers (laptops and desktops). From the research, 99% of the respondents use this product in the course of their work. With the advent of digitization in government, it is not surprising to find that majority of the employees in the ministry use electronic products. These findings reveal that electronic products are almost indispensable at the work place, a finding averred by Bhaskar & Turaga (2018 and Bozkurt & Stowell, 2016). Other most used electronic products in the ministry included flash disks and memory cards, phones and tablets as well as cables. Generally speaking, there is a very high usage of electronic products in the ministry of ICT. All the identified products had a user with the least used product having 44% respondents.

There were three sets of electronic products that had a 100% usage among the HoDs. These included computers, phones and tablets and flash disks/memory cards. The two sets of data reveal that there is generally a high usage of electronic products among both cadres of employees in the ministry of ICT. This is further supported by the fact that 98% of the respondents indicated that they use electronic products on a daily basis. On the respondents' knowledge on the materials used in the manufacture of electronic products, majority of them

(38%) admitted to knowing a bit about the same. The distribution was fair among the other responses included those who don't know much, those who know more than average and those who know quite a lot. However, there were four employees who indicated that they know nothing about the materials used. Considering the popularity of electronic products being used in government and elsewhere, this is a worrying trend. Similar research revealed a near similar trend with majority of respondents having some knowledge on the materials used in electronic products (Althaf et al., 2020; Leigh et al., 2012; Osibanjo et al., 2016; Tong et al., 2015). 70% of the HoDs on the other hand know quite a lot about these materials with no employee saying that they know a bit or nothing at all about the materials used in electronic products.

#### **5.4. Impact of e-waste in the Ministry of ICT**

From the research findings, all the respondents, both regular employees and HoDs, had an idea of what e-waste is. Much as there were varying definitions, generally the idea was well captured. The notable observation was that some of the respondents were limiting e-waste to computers only and not mentioning the aspect of electronic products in general. This is not new as previous research have established that people tend to limit the description of electronic waste to the obsolete computer products (Balasubramani et al., 2020; Gao et al., 2011). While computers are part of the sources of electronic waste, the definition of e-waste is much wider and includes literally every electronic product. While a good percentage of the respondents were aware of the dangers of e-waste, there were 19 respondents who did not know any dangers associated with e-waste. This is particularly worrying given that this is the umbrella ministry for such issues as e-waste. Of the 82 respondents who said they are aware of the dangers of e-waste; the most common danger was the issue of health complications. Majority of the respondents recognized health impact as the main danger of e-waste with another significant number of respondents mentioning environmental impact as a danger of e-waste. Most of the responses on the danger of e-waste can be categorized into the two: health and environmental impact. Several previous research have established these two categories of impact as the dangers of e-waste, which is consistent with these findings (Corsini et al., 2015; Hamouda & Adjroudi, 2017; Neyland & Simakova, 2012; Osibanjo et al., 2016).

#### **5.5. E-waste management practices in the Ministry of ICT**

The most common disposal methods for e-waste in the ministry included returning the products to the issuing department or office and putting in the trash. The fact that putting in

the trash got so many responses indicates that most employees in the ministry are actually unaware of the e-waste management processes in the ministry and only return or put the products into the trash. Another worrying number of 12% indicated that they have no idea what happens to electronic products once they become obsolete. This is contrary to research done in the west and Asia where e-waste management responsibilities are more advanced and employees are more proactive in the disposal of obsolete waste (Christensen et al., 2010; Farrelly et al., 2016; Streicher-Porte et al., 2016). Since e-waste management actively begins upon the obsolescence of a product, this ideally means these respondents have no idea on e-waste management in the ministry. The situation was replicated among the HoDs where 70% said that they put the products into the trash and another 30% saying they return the products to the issuing department. Again, 40% of the HoDs asserted that they do not know what happens once electronic products become obsolete. Only one respondent indicate that they recycle the electronic products.

Of the 101 regular employees who participated in the research, only 1% indicated that they are totally involved in the management of e-waste in the ministry. This confirms the challenge of non-involvement of staff in the management of e-waste, as established by Neyland & Simakova (2012). Over half of them indicated that they are not involved at all in the management of e-waste in the ministry. In total, 95% of the respondents indicated that they are either not involved at all or involved to a small extent in the management of e-waste in the ministry. The situation was replicated among the HoDs where 90% responded that they are either not involved at all or involved to a small extent in the management of e-waste. The conclusion is that majority of the Ministry of ICT employees are not involved in the management of e-waste in the ministry.

Further, only 6 respondents out of the 101 regular employees had been trained on e-waste management within the ministry. The remaining 95 had not been trained on management of e-waste. As per the National ICT policy by the Government of Kenya (2019b), training and awareness was identified as the key to ensuring a waste-free environment as far as electronic product is concerned. Employees who have been trained on e-waste management have generally fared better in management of e-waste (Chang & Pires, 2015; Christensen et al., 2010; Mandadi et al., 2020). Probed further, the most identified training topics covered by the training included definition of e-waste, sources of e-waste, types of e-waste and the impact of e-waste. All the HoDs had not been trained on e-waste management.

The employees generally agree that e-waste has a health impact on them with 100 respondents in total disagreeing that e-waste does not have such an impact on them. On environmental impact, 103 respondents agreed that e-waste has an environmental impact with only 9 thinking otherwise. On the other hand, majority of the respondents indicated that they are concerned about e-waste in the ministry. However, it is important to note that there are 19 respondents who are not concerned about e-waste in the ministry. A large percentage of the respondents (87) said that the ministry is not well prepared for e-waste management with only 24 agreeing that the ministry was well prepared for managing e-waste. Previous research on the government's readiness for effective e-waste management have revealed the lack of or poor preparation by governments in ensuring e-waste is effectively managed (Balasubramani et al., 2020; Davis & Garb, 2019; Holmes & Osmani, 2014; Yuan, 2013). None of the 24 respondents strongly agreed that the ministry was well prepared to manage e-waste.

The variety of responses given on whether the ministry has an e-waste policy also points out to lack of clarity on the issue of policy for e-waste. While all the employees work in the same ministry, 57 of the regular employees were not sure whether the ministry has an e-waste management policy. 36 said the ministry does not have one while only 8 said that the ministry has an e-waste management policy. Among the HoDs, half of them said that the ministry does not have an e-waste management policy, 40% were not sure and only one said the ministry has an e-waste management policy. Most of the employees are either not sure or think the ministry does not have an e-waste management policy.

## **5.6. Challenges in managing e-waste**

From the research, most employees at the ministry indicated that the present status of e-waste management at the ministry is wanting. While this was an optional question, there was a general consensus among the responses given that the ministry is not doing enough in as far as ensuring that e-waste management is properly done.

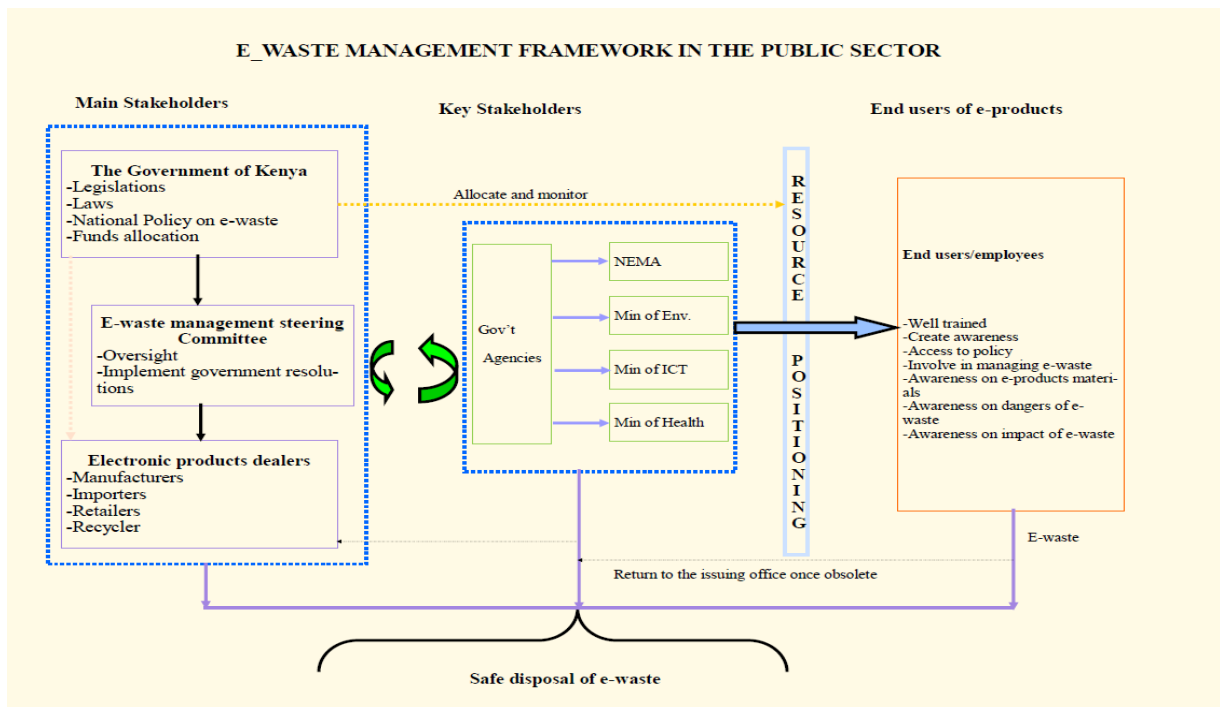
The respondents identified various challenges they are facing with regards to e-waste management in the ministry. Some of these challenges identified included:

- Lack of clear policies governing the management of e-waste in the ministry
- Inadequate funding to oversee e-waste management
- Inadequate knowledge among the employees on the management of e-waste
- Lack of centralized management point for e-waste
- E-waste taking a lot of time before disposal
- Lack of concern for e-waste management

- Insufficient regulations to address the life

### 5.7. Effective E-waste Management Framework

From the research conducted and the different models and frameworks studied, the researcher came up with a framework that could be implemented for effective management of e-waste in the government ministries and beyond. This took into consideration the various data collected and analysed, the empirical review and the models studied. Below is the proposed model for effective e-waste management.



**FIGURE 14: Effective e-waste management framework**

**Source:** researcher (2020)

The proposed model has three stakeholder playing various roles in the management of e-waste in government. The following are the stakeholders.

#### a. Main stakeholders

The main stakeholders refer to the parties actively engaged in the management and generation of electronic products. This is because e-waste is not really manufactured but is a result of electronic products that have outlived their usefulness. The main stakeholders are further grouped into three sub categories.

- The government of Kenya:* The government of is a main stakeholder in the proposed framework. This is because the government will develop legislations, laws and

national policies that govern the management of electronic products and waste. The government also supervises and monitors all the other stakeholders, either directly or indirectly. Additionally, the government allocates funds towards the management of e-waste management and to support such efforts as those.

- ii. E-waste management committee:* The e-waste management steering committee is in charge of the implementation of government policies and laws regarding the e-waste and also does oversight of such government efforts. The steering committee acts as the government wing that deals with management of e-waste and e-products. The other government agencies work hand in hand with the steering committee in order to implement best practices of e-waste management. The steering committee regulates the dealers of electronic waste in terms of what is being manufactured or imported. The government agencies and the electronic products dealers report to the steering committee which in turn reports to government.
- iii. Electronic product dealers:* the third main stakeholders in the framework involves the electronic product dealers who play a very vital role in the management of e-waste in the country. These dealers include manufacturers, recyclers, importers and retailers among others. These stakeholders are responsible for the electronic products used in the country as they act as the link between the producers and the end users. These are being supervised by the steering committee and partially by the government that monitors their activities. The electronic products dealers have a collective responsibility of safely disposing electronic waste, recycling or reusing the electronic products.

#### **b. Key stakeholders**

The main stakeholders refer to the category of government agencies who are directly involved in the management of electronic products and/or electronic waste in the country. These are the people who work directly with the final end users of electronic products and generators of e-waste. The key government agencies here include National Environmental Management Authority (NEMA) whose role is to implement policies passed by the government. It also ensures that the various legislations are adhered to by all the end users of electronic products in the country. The Ministry of Environment is involved due to the fact that environmental impact was identified as one of the main impacts of electronic waste. They will be able to regulate the use and disposal of electronic waste and ensure that the environment is well secure. The Ministry of Health are the other players in the proposed

framework and are involved in ensuring that the health impact of electronic waste is minimised. The ministry will ensure that they monitor the health of all people and identify any negative impact of electronic waste to the human health. The Ministry of ICT on the other hand are key players in the sense that they regulate the ICT space, which is the main contributor of electronic waste in the country as identified by the research. The ministry is also tasked with the role of ensuring that the government implements digital service delivery which in turn affects the number of electronic products used in the government. These government agencies work together with the main stakeholders and act as a link to the end users. Collectively with the other stakeholders, the key stakeholders ensure that electronic waste is well handled by way of returning to the manufacturer, recycling or safely disposing electronic waste generated in the government ministries. Additionally, they ensure that the resources are well positioned in order to be relevant for the various purposes they are serving. In this framework, research positioning has been captured in order to ensure that the right resources are available to the right people at the right time and place. In this way, the end users will have an easy time in ensuring effective management of e-waste.

### **c. End users**

In the proposed framework, the end users are included as their actions, behaviour and awareness of electronic products directly impacts the generation and management of electronic waste in the country. Being the users of these products, it was important to design the framework with them in mind so that they can play a role in ensuring effective e-waste management. In order to effectively contribute to the effective management of e-waste, the end users need to be well trained on what electronic products are and their impact. They also need to be aware on the material used and why they need to be custodian of the government resources allocated at their disposal. These group should also have access to the policy documents governing as well as being actively involved in the management of electronic waste. This way, they will learn to take personal initiative and responsibility to ensure electronic waste is well managed. They will also be made aware of the treatment of electronic products once they become obsolete. This will be achieved by involving them in the disposal of electronic products by way of returning to the dealers through the government agencies or safely disposing the electronic waste they generate.

## **5.8. Conclusion and summary of the findings**

Several conclusions can be drawn from this study after carefully analysing the collected data. Generally, there is a balance in gender among the regular employees in government with the heads of departments positions dominated by males. It can be concluded that majority of the employees in government ministries are between the ages of 36-40 and 41-45 years of age based on this study with very few employees below the age of 30 years. Majority of the government employees have an undergraduate degree as the highest education level. Quite a number also have master's degree especially the heads of department.

Electronic products are widely used in government ministries almost on a daily basis by all. Different products have different frequency of use based on the particular type of product. The most widely used electronic products in government ministries include computers, phones and tablets, flash disks, memory cards and cables.

The research further revealed that more than half of employees in government ministries do not quite understand the materials used in the manufacturing of electronic products. There are also government employees who completely have no idea of what is used in manufacturing electronic products. However, a significant percentage have a good knowledge of what is used in manufacturing electronic products.

Nearly all employees in government ministries have an understanding or idea of what constitutes e-waste. This is based on their responses to the definition of e-waste. This does not translate to knowledge on dangers of e-waste as a majority of government employees do not know about the dangers of e-waste.

Most electronic products in government ministries are disposed through returning to issuing office or putting in the trash. This clearly does not indicate any e-waste management good practice. Options like returning to the manufacturer or recycling are rarely used while a significant percentage on the other hand do not know what happens to electronic products once they become obsolete.

Another conclusion from the study also is the fact that very few employees are involved in the management of e-waste in government ministries. Over 90% of employees in government ministries are not involved in the management of e-waste. Training is not regularly conducted to employees in government ministries as per the study. Over 95% of employees in government ministries have not been trained on management of e-waste.

Despite all the issues of awareness identified, most employees in government ministries acknowledge that e-waste has both health and environmental impact. This is based on their agreement with the statement that indeed e-waste has an impact on health and the environment. There is also a fairly good concern about e-waste among employees in

government ministries while there is a general lack of preparedness for managing e-waste among government ministries.

There is no clarity on the availability of e-waste policies in government ministries. This was as indicated by the responses from this study that found out that there are varied responses from the same employees regarding availability of an e-waste management policy. The researcher further concluded that e-waste management faces a lot of challenges in the government ministries. The most commonly identified challenges revolved around policies, training, funds, disposal of items and storage space.

### **5.9. Study Contributions**

This research has made a great contribution to how the perennial issue of e-waste management in government will be tackled. This is because there has been no previous research on affectivity of e-waste management in government. The most common research undertaken have concentrated on e-waste government in general which ends up covering so little about such a big population. Such a focused research will be instrumental to the specific targeted area i.e., the government ministries.

This research will contribute to the effective management of electronic waste by the government by providing a realistic and simplified way of combining the different aspects of e-waste management into a comprehensive system. With all the stakeholders taken care of and their roles clearly defined, accountability in the management of e-waste will be achieved, something that has been missing for a while. The framework also stipulates the flow of the electronic products from the point of acquisition to the point of safe disposal. As the process is greatly simplified, the various people involved in the process will easily play their part in a bid to reduce careless e-waste disposal. Above all, the greatest contribution of the framework in the effective management of e-waste is the fact that it will provide a clear guideline for the management of e-waste. This, once the parties are sensitized, will greatly enhance e-waste management in the government ministries and beyond.

This research will help the government identify the correct positioning of resources in as far as e-waste management is concerned. From the RVB model, it is clear that correct positioning of resources enhances the success of a firm or project. From the research, the correct positioning was identified and will be helpful in ensuring success of e-waste management in government ministries.

Further, the research will help the government, and specifically the ministry of ICT, in developing an e-waste management policy, something that is missing in Kenya at the

moment. A national e-waste management policy will offer guidelines for both the government and corporate sector in handling the e-waste in the country. It will additionally be helpful in developing relevant legislations and laws that will govern the area of e-waste management.

The framework developed through this research could be adopted and put into use by the relevant stakeholders. This will provide a sense of direction as the country aims to seriously start taking care of the e-waste generated by government ministries and other stakeholders.

The research will also be used as a benchmark to guide on e-waste management in other government ministries. Since there are so many ministries in Kenya, this research can be in e-waste management decision for the other ministries. This is because the operations of government ministries are almost similar, save for a few differences which are relatively minor in nature.

## **5.10. Recommendations**

### ***5.10.1 Recommendation to government***

From the study conducted, the researcher wishes to make the following recommendations to the government of Kenya:

- The government to develop policies & legislations governing the management of e-waste in the country. This can be done through NEMA in collaboration with other key stakeholders in the sector. Currently we only have guidelines which are not exhaustive in scope.
- The government needs to develop guidelines governing the importation of second-hand electronic products into the country. Most of the time these products are brought in when they have reached their usage thus making the country serve as a dumping site for other countries.
- The government should develop tough legislations to protect against poor disposal of e-waste to discourage users from careless disposal of e-waste.
- Government needs to be at the forefront in championing for the proper management of e-waste in the country.
- Where possible, government should allow the use of alternative products which are made from biodegradable materials. This will help in limiting e-waste.
- The government should develop a department to regulate and manage the e-waste issues in the country. A dedicated department will ensure better results in the long run.

- Set aside funds to be used in the management of e-waste in the country
- Offer support to firms that are already involved in the management of e-waste in the country regardless of whether they are public or private firms.

#### ***5.10.2 Recommendation to ministries***

The following are recommendations made for the ministries.

- Ministries to continually conduct awareness on e-waste management to their employees
- Ministries to involve all employees in the management of e-waste. As little as it may be, every employee can certainly contribute to the management of e-waste.
- Ministries to continually train their staff on e-waste management best practices so that employees know what to do regarding e-waste
- Ministries to develop and share an e-waste management policy that governs the management of electronic products from the point of acquisition to the point of disposal
- Ministries to have a dedicated team in charge of handling electronic products from the point of acquisition to disposal.
- Ministries to collaborate with each other in order to identify the best practices in the management of e-waste

#### ***5.10.3 Recommendation to the public***

The following recommendations are made to the members of the public:

- Members should take it as a personal initiative to ensure they properly dispose their e-waste they no longer use.
- Members should take good care of the electronic products in their possession in order to ensure they stay longer to minimize the number of electronic products in use.
- Members should adhere to stipulated guidelines governing the management of e-waste in their respective areas of work.
- Members to support government efforts towards managing of e-waste.

#### ***5.10.4 Recommendation for future research***

The following are recommended for further research.

- Research on the status of e-waste management in other government ministries in Kenya.
- Research on how the public manage their personal electronic products once they become obsolete.
- Research on the public's awareness on e-waste management.

### **5.11. Chapter Summary**

This last chapter presented the discussion of the findings, the summary from the research, the conclusions drawn from the research as well as the recommendations going forward. The proposed framework for effective management of e-waste in government has also been presented and discussed at length. Key areas for consideration have been identified and recommendations made to the various stakeholders.

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## APPENDIXES

### Appendix I: Introduction Letter

Dear respondent,

I am MaryAnn Wambui, a master's student pursuing Master of Science Information Systems Management at KCA University. As a requirement for partial fulfilment of the course, all students are required to carry out a research on a topic relevant to their course of study. My topic is: **E-Waste Management Practices in Government Ministries in Kenya: A case Study of the Ministry of ICT**

I humbly request for your sincere assistance to get the necessary information required in this questionnaire so as to make research a success. Your sincerity in this research will be of great importance and highly appreciated. Any information provided herein shall be used solely for the purposes of this research and will be treated with utmost confidentiality.

If you agree to participate in this project, please answer the questions on the questionnaire as best you can. It should take approximately 20 minutes to complete.

For inquiries, please contact me through 0721681283

Thank you for your assistance in this important endeavour.

Sincerely yours,

MaryAnn Wambui.

## Appendix II: Questionnaire

Please indicate your response by ticking ( ) in the provided boxes. For questions that require suggestions or comments please use the space provided.

### PART A: GENERAL INFORMATION

1. Indicate your gender. (Choose one only).

Male	[ ]
Female	[ ]

2. Indicate your age bracket. (Choose one only).

Below 25 years	[ ]
25-30 years	[ ]
31-35 years	[ ]
36-40 years	[ ]
41-45 years	[ ]
46-50 years	[ ]
Above 50 years	[ ]

3. What is your highest level of education? (Choose one only).

PhD	[ ]
Masters Studies	[ ]
Undergraduate degree	[ ]
Higher Diploma Studies	[ ]
Diploma	[ ]
Certificate	[ ]

4. What is your position in this organization?

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5. For how long have you worked in this ministry? (Choose one only).

Less than 1 year	[ ]
1-2 years	[ ]
3-4 years	[ ]
5 years and above	[ ]

6. In which department do you work? (Choose one only).

Finance	[ ]
Accounts	[ ]
Human Resource	[ ]
Procurement/Supply Chain	[ ]
Administration	[ ]
Communication	[ ]
Legal	[ ]
Directorate of ICT	[ ]
ICT Unit	[ ]
Directorate of Quality Assurance & Standards	[ ]
Central Planning & Project Monitoring Unit	[ ]
Directorate of Audit	[ ]

**PART B: ELECTRONIC PRODUCTS USED IN GOVERNMENT MINISTRIES**

7. Which of the following electronic products do you use in your work? (Tick all that apply)

Computers (Laptops & Desktop)	[ ]
Phones & Tablets	[ ]
Kitchenware (e.g. microwave, electric kettle, fridge etc.)	[ ]
Air conditioning (e.g. fan)	[ ]
Audio devices (Speakers)	[ ]
Flash disks/memory card	[ ]
Lighting devices (e.g. bulbs)	[ ]
Water dispenser	[ ]
Cables	[ ]
Others (specify)..... .....	[ ]

8. On average, how often do you use these electronic products in a week? (Assuming a week has 5 days). (Choose one only).

Once a week	[ ]
Twice	[ ]
Thrice	[ ]
Four times	[ ]
Daily	[ ]

**PART C: IMPACT OF E-WASTE IN GOVERNMENT MINISTRIES**

9. What is electronic waste according to you?

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Are you aware of the dangers posed by electronic waste? (Choose one only).

Yes	[ ]
No	[ ]

10. State some of the dangers of electronic waste

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**PART D: E-WASTE MANAGEMENT PRACTICES IN GOVERNMENT MINISTRIES**

11. What do you do with the electronic products once they become obsolete? (Tick all that apply).

Put in the trash	[ ]
Return to the issuing department	[ ]
Return them to the manufacturer	[ ]
Recycle the product	[ ]
Resell the product	[ ]
I don't know what happens to obsolete electronic products	[ ]

12. To what extent are you involved in the management of e-waste in the ministry? (Choose one only).

Not involved at all	[ ]
Involved to a small extent	[ ]
Involved to a large extent	[ ]
Totally involved	[ ]

13. Have you been trained on e-waste management? (Choose one only).

Yes	[ ]
No	[ ]

14. Which of the following aspects of e-waste management did the training cover? (Tick all that apply).

Definition of e-waste	[ ]
Sources of e-waste	[ ]
Types/classification of e-waste	[ ]
Impact of e-waste	[ ]
Methods of disposing e-waste	[ ]
E-waste management policy	[ ]
Challenges associated with e-waste management	[ ]
E-waste management best practices	[ ]

15. What is your opinion on the status of e-waste management in the ministry?

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16. Indicate your level of agreement with the following statements

Statement	Strongly Disagree	Agree	Disagree	Strongly Disagree
I am well aware of the electronic products that I use	[ ]	[ ]	[ ]	[ ]
Electronic products do not have a health impact on me	[ ]	[ ]	[ ]	[ ]
Electronic products do not have environmental impact	[ ]	[ ]	[ ]	[ ]
I am concerned about e-waste produced by the ministry	[ ]	[ ]	[ ]	[ ]
The ministry is well prepared to manage its e-waste	[ ]	[ ]	[ ]	[ ]

17. Does the ministry have an e-waste management policy? (Choose one only).

Yes	[ ]
No	[ ]
Not sure	[ ]

### **PART E: CHALLENGES ASSOCIATED IN MANAGING E-WASTE**

18. What is your opinion on the status of e-waste management in the ministry?

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19. Which challenges are you facing with the electronic wastes in your department?

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## PART F: RECOMMENDATIONS

20. What recommendations can you give to overcome the challenges identified above?

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21. What is your biggest concern in as far as e-waste is concerned? (Choose one only).

Users' awareness of e-waste	[ ]
The volume of e-waste produced	[ ]
Disposal methods of e-waste	[ ]
The duration which electronic products are used	[ ]
Government efforts in management of e-waste	[ ]

22. Which best practices can the government employ in managing e-waste in ministries?  
(Select all that apply).

Continuous training of employees	[ ]
Creating awareness on e-waste	[ ]
Collaboration and benchmarking between ministries	[ ]
Allocation of more funds towards e-waste management	[ ]
Come up with clear legislations governing e-waste management	[ ]
Develop policies to guide on e-waste management	

### Appendix III: Work Plan

<b>Time</b>	<b>Research</b>
Week 1	Questionnaire designing and websites contacting
Week 2 & Week 3	Completion of questionnaires, Desk research
Week 4	Carrying out personal and in-depth interviews
Week 5	Internet primary research.
Week 6	Collection of competitor information
Week 7	Analysis of data and presentation.
Week 8	Writing of the report.

**Appendix IV: Budget**

<b>S/NO</b>	<b>ACTIVITY</b>	<b>QUANTITY</b>	<b>AMOUNT(Ksh.)</b>
	On-line Questionnaire	(Bundles & Printing)	20,000.00
	Data analysis	(6 Days *Ksh. 10,000)	60,000.00
	Stationery Expenses		7,500.00
	Transport and Contingency		20,000.00
<b>TOTAL</b>			<b>107,500.00</b>