FACTORS INFLUENCING AN ICT FRAMEWORK FOR A CIRCULAR E-WASTE ECONOMY BY HOUSEHOLDS IN NAIROBI, KENYA

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A Project Research Submitted in Partial Fulfilment of the Requirements for the Award of the Degree of Master of Science in Applied Information Technology in The Department of Computer and Information Technology and the School of Science and Technology of Africa Nazarene University

Sep 2020

DECLARATION

I declare that this document and the research it describes are my original work and that they have not been presented in any other university for academic work.

Charles Shabaya Deche

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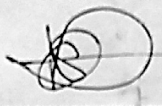

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This research was conducted under our supervision and is submitted with our approval as university supervisors.

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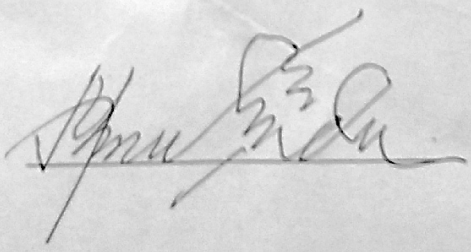

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DEDICATION

I dedicate this research paper to my parents Eng. Japheth and Ruth Mwachiro who enabled me to reach these heights through vast sacrifices and opportunities, my siblings Dr Michael and Dr Elizabeth Mwachiro, Alex and Marian Kimani, Dr James and Mercy Wanjohi, and Aaron and Emily Munzaa for their continuous support.

To my nerd friend Meshack; Kustikāne se rigle. Valar morghūlis, skoros gaomi isse ābrar, echoes isse eternity.

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ABSTRACT

This study sought to assess the existing state of Waste Electrical and Electronic Equipment in Kenya, to improve on the methods of disposal, recycling, and facilitation of a circular economy by households through the use of ICT. The study was driven by the following objectives on how they influence a circular e-waste economy; socio-demographic factors, consumer behaviour, level of access to information and ICT infrastructure. The target population for the study was households within Nairobi County who had the ease of access to small ICT equipment (mobile phones, tablets, iPods, and computers). A descriptive survey study method was employed. A sample size of three hundred and eighty-four (384) households was determined, probability sampling was used in the study; utilizing the stratified sampling technique. An electronic questionnaire was used as the main research instrument. The data was analysed by the use of descriptive statistics (mean, frequency distribution) and inferential statistics (regression analysis). SPSS version 25 tool was used to analyse the data. The study determined that the selected factors had a positive influence on the ICT framework for a circular e-waste economy. The consumer behaviour of respondents (β = .159, p = .001), access to information influence (β = .174, p = .001), ICT infrastructure (β = .604, p = .001) were found to have the most influence on the ICT framework for a circular e-waste economy. Socio-demographic factors influence (β = .036, p = .280) were found to have the least influence on the ICT framework for a circular e-waste economy. The study concluded that the consumers' financial and emotional attachment to their electronic devices influenced how they disposed off their e-waste, affecting the residual value. The study also confirmed that effective and efficient e-waste management needs households to have ease of access to information. Lastly, it also concluded that integration and usage of ICT increase the rate at which the framework will be adopted by the circular e-waste economy. The study recommended that any policy to be formulated should target the tech adverse youth who are the majority. Electronic manufacturers should create and spearhead consumer responsibility to mitigate e-waste menace. Nairobi County Government should create awareness and sensitization programs for households. Technology should be integrated into the e-waste management process. Lastly, the collection of e-waste shouldn't be pegged to the geographic and socio-economic status of the households.

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DEFINITION OF TERMS

Bamako Convention: An African treaty, prohibiting the import of any hazardous waste.

Basel Convention: An international treaty signed so as to reduce the cross-boundary movement of hazardous waste by participating nations, specifically to curb the transfer of hazardous waste from developed to the developing countries.

Circular Economy: Economic system aimed at eliminating waste and the continual use of resources.

Draft E-waste regulations 2013: Policy document that provides the appropriate legal and institutional framework and mechanisms for the management of WEEE handling, collection, transportation, recycling and safe disposal.

Environmental Management and Coordination Act (EMCA 1999): The set of laws and policies enacted in Kenya that offers a framework on environmental management and conservation.

ABBREVIATIONS/ACRONYMS

EEE	Electronic and Electrical Equipment
KEPSA	Kenya Private Sector Alliance
NEMA	National Environmental Management Authority
SME	Small-to-Medium Enterprise
WEEE	Waste Electrical and Electronic Equipment

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

This research set out to find the effect social factors have on an ICT framework designed for a circular e-waste economy. The chapter introduces the research study. It consists of the sub-sections: background of the study, statement of the problem, the purpose of the study, problem statement, research objectives, research questions, the significance of the study, scope, delimitations, limitations, assumptions, theoretical and conceptual frameworks.

1.2 Background of the Study

Over the past few years, devices using either a battery or electricity as a source of power have increased in both developing and developed countries, increasing the amount of electronic waste that is at its end of the life cycle. Rapid growth and development of the Information Communication Technology (ICT) field has fuelled this occurrence (Ibrahim & Elijah, 2015).

Kenya's medium-term Gross Domestic Product (GDP) growth is placed at 5.5% for 2018, translating into a significant increase in the purchasing power of the citizens. The social ranks of the citizens have also absorbed more, especially within the middle class and the rich, who have high spending power in the country (World Bank, 2017). This has changed how the citizens are buying and disposing of their electronic devices. The technological advancement, consumption lifestyle of citizens, and short product life spans render most electronic devices obsolete faster.

With globalization and improved economic growth, ICT devices have become part and parcel of most Kenyan households and are no longer perceived as luxuries. Households lacking these facilities have resorted to seeking access from places like

cyber cafés, workplaces, and through friends. The ownership of these ICT devices such as computers, mobile phones, and internet access are highly determined by the socio-economic status of a household (Anyango, 2011). All these owned Electronic and Electrical Equipment (EEE) devices upon their end of the life cycle will become Waste Electronic and Electrical Equipment (WEEE)/e-waste. Electronic waste is defined by the National Environment Management Authority (NEMA, 2013) as waste resulting from EEE which includes its components and any sub-assemblies of it.

The increasing volume of e-waste globally, and its improper disposal via open-air burning or untreated discarding in dumpsites, pose risks to the ecosystem; hence hampering the chances of achieving the Sustainable Development Goals (SDGs). Estimates place 44.7 million metric tons of WEEE was generated worldwide in 2016, with a projected increase to 52.2 million metric tons by 2021 (Baldé, Forti, Gray, Kuehr, Stegmann, 2017). In Kenya alone, it is estimated that forty-four thousand tons of electronic waste are generated in a single year (Obi, 2018). The Guidelines for E-waste Management in Kenya (NEMA, 2013) categorizes e-waste into 11 categories are shown in Table 2.1, which includes ICT equipment, office electronics, toys, batteries, large household appliances, small household appliances, consumer equipment, lighting, medical equipment, automatic dispensers, and monitoring equipment.

The e-waste sector in Kenya is highly dominated by informal sector collectors and recyclers, due to lack of take-back policies and infrastructure for recycling are nearly non-existent. Also, the government oversight, regulation, and control of the WEEE sector are very minimal and inefficient (Baldé, et al, 2017). The Kenyan government has developed a draft Environmental Management and Co-ordination (E-waste Management) Regulations 2013 that seeks to provide the necessary legal and institutional framework and mechanisms for e-waste management (National

Environment Management Authority (NEMA), 2013). Though the legislation and approval process are still pending till date.

Kenya does not have a fully functional e-waste management system in use, but there are the ever-increasing efforts of individuals and SMEs that are geared towards the reduction, reusing, and recycling of e-waste. Global leaders adopted 17 Sustainable Development Goals (SDGs) commencing January 2016, to improve the social, economic, and political landscape. The efficient and effective e-waste management should be guided by; Goal 3 - Good health and Well-being, Goal 6 - Clean Water and Sanitation, Goal 8 -Decent Work and Economic Growth, Goal 11 - Sustainable Cities and Communities, Goal 12 - Responsible Consumption and Production (UNDP, n.d.). These efforts are starting points to the creation of an ecosystem that will improve e-waste management and increase e-waste awareness to its citizens. A gap has been identified in how households co-exist with other e-waste stakeholders (collectors, recyclers, and government agencies) in the sector. The introduction and use of an ICT framework in the e-waste sector may be able to transform how the sector is managed and the benefits accrued through it can be maximized.

1.3 Problem Statement

In recent years, Kenya has become more reliant on technology, generating waste in the process once the devices reach their end-of-life cycle, aggravating the problem of how electronic waste is disposed and its disastrous effects on the environment. This has been brought about by the increased purchasing power of EEEs by households. Most households employ the linear economy model (take, make, consume, and dispose of) which is not sustainable in economic or environmental terms. This is a challenge being faced both in urban and rural areas, though urban areas have higher levels. E-waste management operations in Nairobi are mostly manual with low ICT use.

Research has been done on e-waste management focusing on its causes, effects, and ICT based solutions; but few local research highlight how ICT can be used to offer sustainable solutions. Closing the loop in the linear model ensures that no waste is generated, hence creating a circular economy that offers sustainability. Meaning that no value is lost from the process, resources used to build products are kept within a cyclic system of reuse, recycling, and repurposing. In the literature on the circular economy, various factors affect the holistic process that needs all sector players to be on the same page. To gain a fuller understanding of how ICT can engage a circular economy, in-depth research is required. Focusing on selected factors to help develop a robust ICT framework, as well as potentially informing future policymakers.

1.4 Purpose of Study

The purpose of this research was to assess the existing state of WEEE in Kenya, with an aim of improving the methods of disposal, recycling, and facilitation of a circular economy by households through the use of ICT. Nairobi as a case study was a good focal point, as having a population of over 3 million citizens living in rural, semi-urban, and urban settings spread across its geographical borders; all fiddling with the common problem of how to collect and deal with e-waste. Furthermore, Nairobi and Kenya as a whole is an economic and ICT powerhouse within East and Central Africa. This study sought to evaluate the social factors and their influence on how ICT can be used to achieve a circular e-waste economy.

1.5 Objectives of Study

This research paper sought to fulfil the following objectives;

i) To assess the influence of socio-demographic (gender, age, education, socio-economic status and ICT competence) factors on an ICT framework for a circular e-waste economy.

ii) To assess the influence of consumer behaviour to an ICT framework for circular e-waste economy.

iii) To evaluate how level of access to information influences an ICT framework for circular e-waste economy.

iv) To determine how an ICT infrastructure influences a circular e-waste economy.

1.6 Research Questions

The study sought to answer the following research questions:

i) What influence does socio-demographic factors have on an ICT framework for circular e-waste economy?

ii) What influence does consumer behaviour have on an ICT framework for circular e-waste economy?

iii) How does the level of access to information influence an ICT framework for circular e-waste economy?

iv) How does an ICT infrastructure influence a circular e-waste economy?

1.7 Significance of Study

The Dutch, have formulated policies and set up structures to handle e-waste as a resource more effectively and return it into the economy. Hence closing the loop and forming a circular economy. This has accrued many benefits for the country and its citizens (Golsteijn & Martinez, 2017). The study is set to promote the implementation of an ICT framework in the e-waste ecosystem so as to facilitate a circular economy in Kenya.

Kenyan cities and towns are currently facing an environmental strain, the landfills are increasing in size and also natural resources are being depleted with the ever-increasing consumer appetite. Hence the reason why businesses are now routing for sustainable business practices. With the success seen in other affiliated waste

management sectors, the researcher agrees that it can be applied and implemented in the Kenyan space. The study ensures economic vitality and enabling a sustainable environment. ICT becomes fundamental to the e-waste management ecosystem due to the high adoption rate experienced in other related fields.

1.8 Scope of Study

The study focused on the selected factors and their influence on e-waste generation and disposal by households. It targeted people living in the city with ease of access to ICT services. The study focused only on ICT and telecommunications equipment and office electronics as per classifications made by NEMA (2010). The selected area of the study was Nairobi County which can be categorized using the socio-economic status of the residents.

1.9 Delimitations

The study focused on Small ICT and Communication devices (such as mobile phones, tablets, laptops, handheld gaming consoles, and music players) and the researcher excluded these other categories of e-waste: Large Household Appliances, Toys, Leisure and Sports equipment, Small Household Appliances, Consumer Equipment, Lighting, Medical equipment, Automatic dispensers, and Monitoring and control instruments. This is because e-waste is wide and the handling process of the various categories is different compared to the others, Small ICT and Communication devices are the major sources of e-waste due to their shorter life span compared to the other categories.

1.10 Limitations

The study was limited to Nairobi County as a representation of how other regions of the country generate e-waste. The researcher faced an uphill task from the respondents who had a lack of electronic access to the questionnaire, especially areas

of lower-income households; this was however mitigated by the researcher providing a tablet for them. Respondents with low ICT competence were assisted in inputting their data into the questionnaire. Anonymity was a major concern for most respondents an assurance was made to inspire confidence and honesty towards the whole process.

1.11 Assumptions

The following were the assumptions made during the study:

i) The approached respondents would agree to partake in the research.

ii) The study assumed the honesty of the respondents will offer data of high accuracy and reliability levels.

iii) The geographical region and its population will represent the overall e-waste situation being faced in the whole country.

1.12 Theoretical Framework

Two theories were used to explain the study; systems theory and the sustainability theory.

1.12.1 Systems Theory

Systems theory tries to focus on the relations that are exhibited between various components or parts within a system, instead of reducing the entity into isolated elements. The entire structure is considered to be a system that has been able to integrate the various parts, which can be harmonized for efficiency and effectiveness (Chikere & Nwoka, 2015).

For an organization or an economic sector to be sustainable, it needs to be dependent on their environment for resources; customers who consume a product or service, suppliers of materials, labour force, investors, and governments for regulations. (Saylor Academy, 2012). Using Systems Theory, ICT offers a value creation process known as cross-impact analysis. It enables an integrated understanding of how the

system's elements used to evaluate and manage the system are interdependent. The elements of a value system being; the driving elements, general outcomes, identity of the system, goals of the system, trends, and its structure; with each having its different implications (Ceric, 2015).

Concerning this study, the various parts of the e-waste management eco-system need to work in harmony to increase the efficiency and effectiveness that it has in the disposal, collection, handling, recycling, and storage of e-waste. For instance, a person discarding his/her old phone should be able to find a local recycler or disposal point with ease. The consumer should discard the phone with a registered e-waste recycler or agent than throwing it in the dustbin. The recycler/or his/her agent should also follow the laid down policies and regulations of how to deal with e-waste and ensure that the phone various components do not become waste, but become a new resource to be used elsewhere.

E-waste management is a sub-set of a larger interdependent system in the waste management system. The outcomes of e-waste management systems have benefits that are felt by the general environmental and economic ecosystems. It follows that a circular economy accruing from e-waste requires careful planning and decision making for an efficient and effective implementation. This means that e-waste management systems are pivoted on strategies that employ a diverse range of activities to facilitate and ensure the successfulness of its objectives.

1.12.2 Sustainability Theory

Sustainable development looks at the management of organizations through a holistic approach by considering the social, economic, and environmental ecosystems in which they operate (Chang, et al., 2017). Sustainability theory arose due to activities

that led to resources being depleted, degraded or damaged for short term gain (Thatcher, 2014).

Figure 1.1: *Diagram:* Sustainability Venn
Source: (Brand, n.d.)

In the three-pillar model (Environment, Social equitable, Economic), sustainability is achieved when all three pillars work together. In recent years we have seen a rise in population in Kenya, especially in urban centres such as Nairobi, this has come with a consumption lifestyle. The economic model/pillar ensures fair distribution and efficient allocation of the available resources. Ensuring a balance in the economic growth of the ecosystem. The social pillar of sustainable development supports social justice, reduction of poverty amongst other social equity initiatives. The resources in our environment aren't unlimited, hence the need for protection against exploitation and neglect. The environmental pillar is rooting in recycling, efficient and effective waste management, sustainable consumption, and the conservation of the ecosystem (Circular Ecology, 2018).

The sustainability theory was adopted to guide the research in a holistic and integrative manner on a circular economy through the use of ICT in e-waste

management. A circular economy is essential in ensuring that the stakeholders do not produce waste or pollution. Instead, the products are used, maintained, repaired, reused, and recycled (Golsteijn & Martinez, 2017).

1.13 Conceptual Framework

Effective and efficient management of e-waste as a resource can be actualized by the use of an ICT framework in the operations. In Figure 1.2, the researcher conceptualised the implementation of an ICT framework for e-waste management as relationships of several variables at play to actualize it.

The circular e-waste economy is affected by the following independent variables in different forms and measures; consumer behaviour affects the disposal norms and collective action that can be undertaken, the access to information also influences it, available ICT infrastructure in place has an influence, and lastly, other socio-demographic norms may also affect the e-waste circular economy with various magnitudes. The ICT framework is expected to have different outcomes once implemented to the eco-system, this may be; improved e-waste levels, an increase in e-waste awareness, or improved resource sustainability.

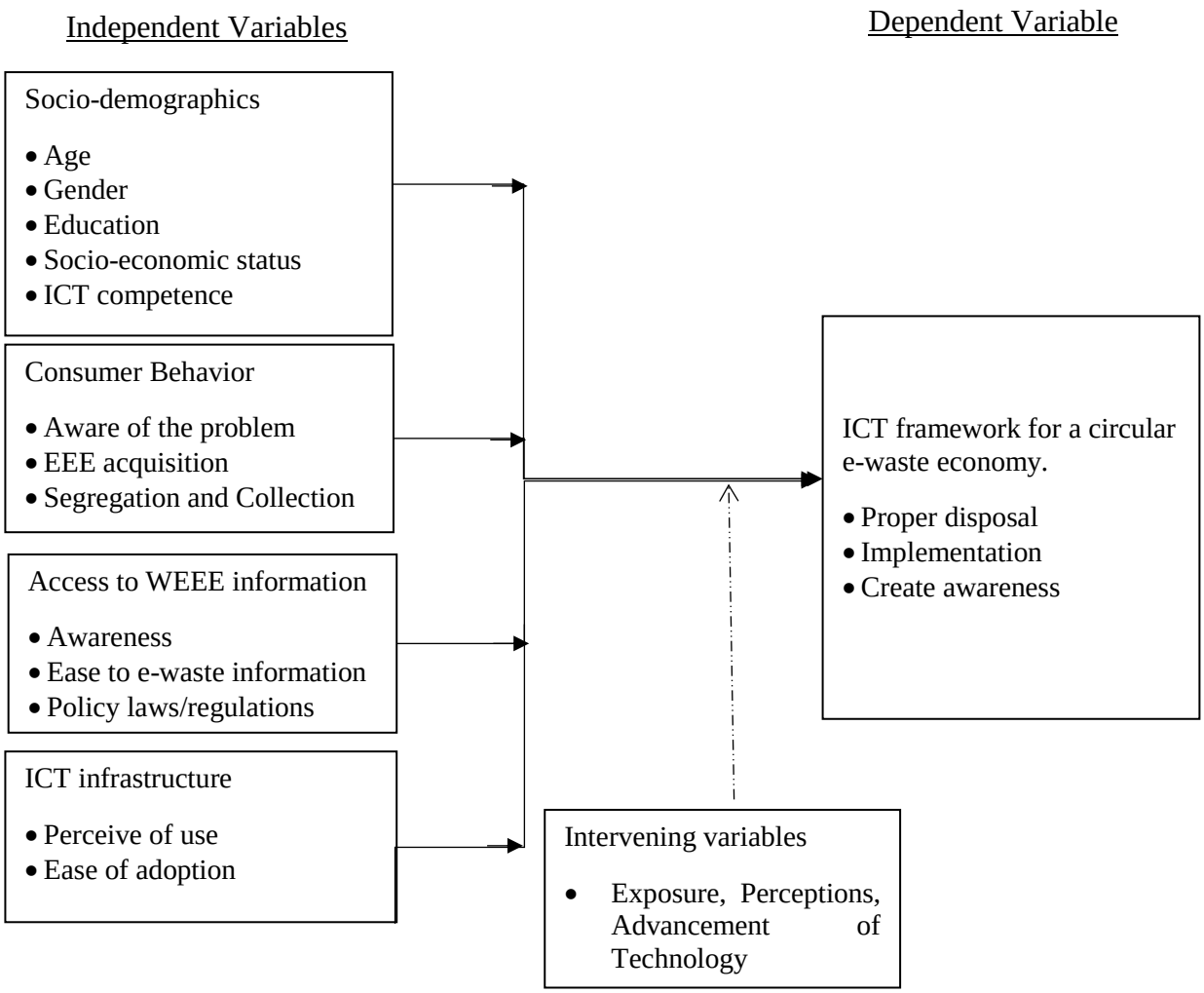

Figure 1.2: *Flow Chart:* Conceptual Framework Showing the Factors Influencing an ICT Framework for a Circular E-Waste Economy

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This study sets out to find the effect of an ICT framework on a circular economy emanates from e-waste management. This chapter presents a review of related literature of what other scholars have written on the research topic to point out existing research gaps.

2.2 Waste Management Theory

Waste Management Theory tries to explain the conceptual analyses, the activity, and a holistic view of waste management. The foundation of the theory looks at waste management as a means of preventing waste to generate or cause harm to the general population's health and the environment (Pongrácz, Phillips, & Keiski, 2004). It is a perfect example of Industrial Ecology.

Defining waste, looking at its ownership structure, and impact to its management, are of high relevance. National E-waste Management Strategy by the Ministry of Environment and Forestry states that E-waste is generalized as part of solid waste. Current legally accepted waste definitions are vague; hence they can be termed as lacking the insight of the concept of waste. Once a product is given the label, it is treated so. Uses of such definitions mean that sustainable waste management systems cannot be developed. Waste management's role is the oversight, control and regulation of all activities that are waste oriented, this is aimed at prevention, minimization and utilization of waste (Pongrácz E., 2002).

African countries currently generate less waste compared to other regions. However, this is changing due to urbanization, population growth, and the shift in consumption patterns. Only 44% of waste generated in sub-Saharan Africa is currently

being collected, mainly in urban areas. This can be attributed to; lack of institutional capacity by waste service providers, an increase in the generated amount of waste which strains the existing waste collection systems, and insufficient finances to run effective and equitable waste management services. SDGs commit countries to waste management targets, though there is insufficient data on waste management services that can be used to assess whether these goals are attainable or the extent of their implementation. Legislative frameworks, allocation of responsibility and financing of waste is often fragmented and inadequate. However, evidence from cities such as Dar es Salaam suggests that when the private sector is brought in, inequality of the waste management services increases as the private company is only interested in delivering good quality services to areas where residents can afford to pay a fee for waste collection (van Niekerk & Weghmann, 2019).

Waste dumping accompanied by open-air burning are the most common forms of waste disposal, creating health and environmental problems for adjacent communities. Recycling efforts have resulted in job creation, and cleaner, safer cities. Informal waste workers play a key role in the recycling of waste, saving local governments huge costs as they divert recyclable waste away from landfills; yet governments are reluctant to acknowledge their role and importance to the waste management system. Egypt for example, experienced accumulation of waste, and a massive reduction in recycling when the informal waste workers were excluded, and the private sector was brought in. If not handled well this might lead to tension, that sometimes escalates to strife (van Niekerk & Weghmann, 2019).

The theory is significant to the study as it will assist in understanding the different policies and procedures available for the e-waste sector. If the generators and recyclers of e-waste have a procedure of managing the waste, they also need to have

partnerships with other agencies to ensure that there is zero waste. It was therefore beneficial to determine if the principles of waste management theory were applied within the research study.

2.3 Circular Economy in Waste Management

The linear model of resource management promotes short term consumption of goods and services leading to unsustainable practices. There are many problems that are associated with the deployment of a linear economy; in EEEs the raw materials are subjected to price volatility in the international markets, scarcity as raw resources are being exhausted at a daily rate. With all this, there arises the need for closing the gap. This is where a circular economy arises.

The circular economy system makes use of the 3R's policy (Reduce, Reuse and Recycle). The first R, "reduce," looks into the eco-efficiency in production and consumption that lead to economic and environmental improvements, saving resources for other purposes. The second R, "reuse," is having a better design of products and business models that allows easy, multiple disassembly and reuse. The last R, "recycle," refers to the process by which waste elements are reprocessed into products or materials for either their original or other purposes (Geisendorf & Pietrulla, 2018).

A circular economy tries to overcome the extract-make-dispose linear production and consumption pattern by replacing it with a circular system. Product, material and resource value is maintained within the economy as long as possible (Merli, Preziosi, & Acampora, 2018).

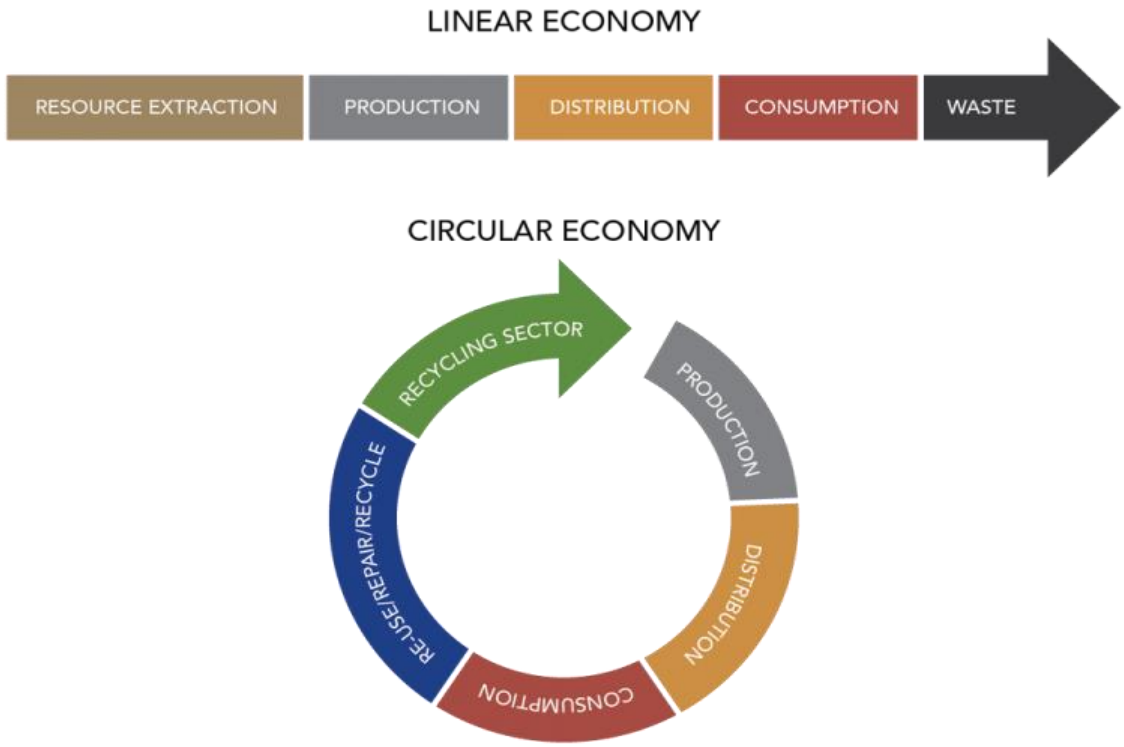

Figure 2.1: *Diagram*: A linear economy and a circular economy
Source**:** (Sydney Environment Institute, 2018)

Residual value can be determined by how much functional value that a product retains over accumulated time and how the users perceive this. The residual value can be affected by factors such as; design of devices, refurbishment technology, the pace of technological development, user perception, and the available quantity of products. Understanding this creates the opportunity to apply a systemic approach towards change, and to reinvent our relationship with EEEs (Ellen MacArthur Foundation, 2017).

In a circular economy, the natural ecosystem is used as a basis point. Toxic items are minimised from the product manufacturing so as to eliminate waste, this is due to the fact that all waste is a resource. For a circular economy to work effectively and efficiently, it needs collective systematic thinking. All actors of the production, usage and recovering process are part of a network in which the actions of one impacts

the rest, hence, decisions being made both short and long term are considered on the basis of the impact they will have on the value chain. This creates a system that is resilient and effective (Ellen MacArthur Foundation, 2015).

In the African continent, Circular Economy was practised however, most of those products were bio-degradable or reusable. The challenge comes with the newly manufactured products which pose a relatively new concept to many. Thus circular economy brings opportunities to the local population to achieve inclusive economic growth through product value addition and employment places. The circular model also allows the population to practise proper and positive environmental practices that are in line with sustainability theory and the African bio-degradable and reuse concept (Stubbs, 2019). This is achieved by integrating innovation into the ecosystem. This will help the continent to close the gap by allowing resources and materials to be reintroduced back into the cycle.

Full adoption and success of a circular economy within the developing countries, especially in the African continent, is critical to strides being made to ensure sustainable growth in the various sectors. Countries such as Kenya that are still developing are increasingly becoming heavy consumers of technology. The challenge is how to embed the circular principles in the development strategies and policies that are being set up, at the same time try and mitigate the rise in primary resource use that are heavy environmental pollutants (Preston, Lehne, & Wellesley, 2019).

The lessons that have been achieved from other successful sectors that have adopted circular economies can be applied to the Kenyan e-waste sector. For example, an EEE consumer can pay for the use of the device and upon attaining the end of life, the device can be repossessed by the seller in return for either a new device with new

subscription rates or an alternative incentive (Desmond, 2015). If this is implemented it will be able to replace the highly consumption-based model being used currently in most EEE sectors.

Governments and other related agencies need to come up with a systematic transition from the linear based model of production and consumption, to the more sustainable circular model; ensuring that materials are kept in use for as long as possible while still maximizing on their economic value. This is not achievable by just one single actor but through collaborative efforts across the whole value chain. Companies need to design and build products with circularity in mind. Consumers need to create demand. The government needs to provide the ecosystem with the necessary infrastructure, formulate policies and regulations that will foster innovation. For example, the Nairobi County government will be able to map resources and collaborate with businesses and residents in the creation of an urban-industrial symbiosis (World Economic Forum, 2018).

2.4 How the E-waste Sector Operates

Nairobi produces approximately 2,400 tons of waste per day; about a third of the waste produced is collected for disposal at Dandora dumpsite, which has already attained its full capacity. The Nairobi County Council doesn't have existing by-laws for hazardous waste (e-waste is currently categorized as hazardous waste), hence lack of efficiency in its management (JICA, 2010). EEE production is one of the fastest manufacturing activities experiencing growth and advancement, thus creating an influx of e-waste being generated as a result. Economic growth, urbanization and consumer demands have rapidly increased both the use of electric and electronic devices which upon disposal generates e-waste, creating risk to the sustainable economic output and growth of the ecosystem (Babu, Basha, & Parande, 2007).

Waste management is a devolved function in Kenya; hence Nairobi County Government is in charge of the collection, disposal and treatment of any waste within the county boundaries. As a guiding policy, the Nairobi County Government enacted the Waste Management Act in 2015. Though with all these policies at the national and county level, Nairobi is still faced with serious challenges in waste management (Makena, 2018). Though waste management is a county government responsibility, private companies are engaged in the business and are the dominant player in the commercial areas, high- and middle-class residential areas, the poor are left to tend for themselves hence the illegal dumping characterized within the social bracket (Omari, 2018). Most of the electronic devices end up in the dumpsites which lack proper e-waste handling infrastructure due to lack of no segregation mechanisms in place (Kalana, 2010).

Kenya lacks a well-established structure of waste management, which can be summarized as the collection, transportation and open-air dumping of the waste; with minimal oversight and enforcement of laid down rules and regulations. Within the dumpsites, there are waste pickers who scavenge for recyclable and sellable items that they take to recycling companies and industries. Governmental agencies have low capacity and means of dealing with the e-waste challenge in Kenya, leaving it to private companies such as the WEEE Centre in Utawala, and the East African Compliance Recycling are currently operating in the highly informal sector (Mbula & Machuka, 2017).

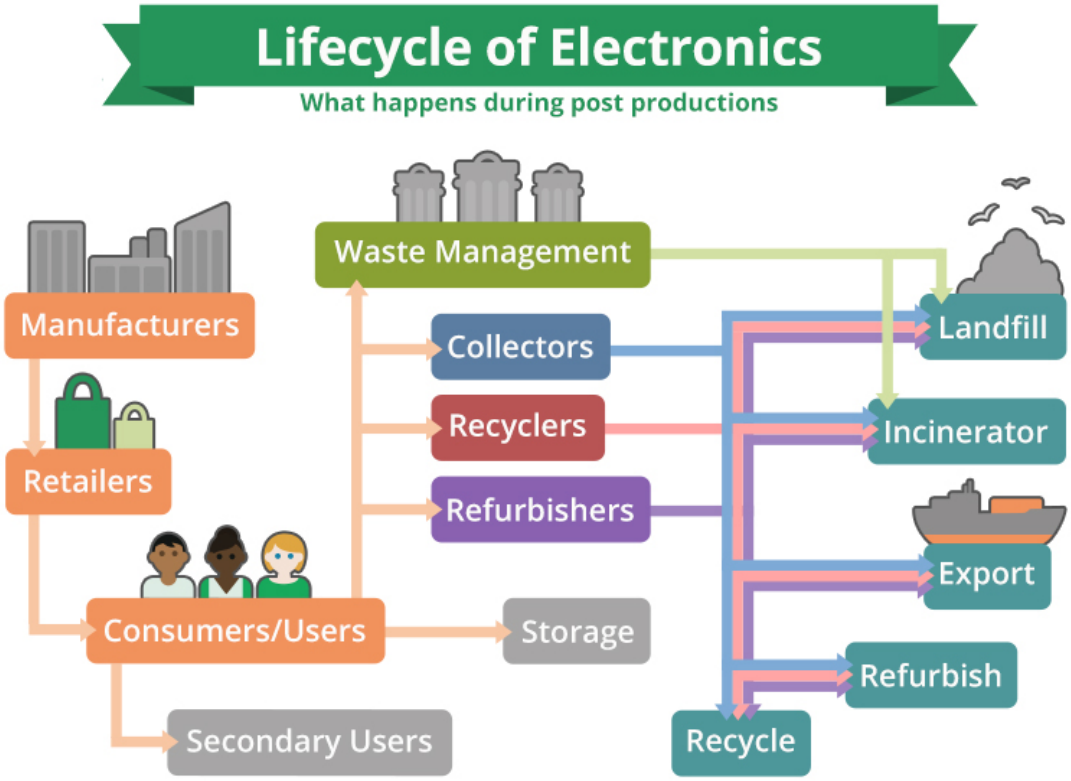

Figure 2.2: *Flow Chart:* Lifecycle of Electronics
Source: (Great Forest, 2018)

The e-waste sector is governed and regulated by the government through the local governments, the Ministry of Environment, governmental agencies such as NEMA and international agencies that Kenya is part of such as the UN and UNEP. Local laws such as the Environmental Management and Coordination Act 1999, and the Draft E-waste regulations 2013 form the legal framework that the e-waste sector operates in. Kenya is also a signatory to the Basel and Bamako Conventions (Omari, 2018). The Maputo protocol governs human and people's rights, guaranteeing the right of women to live in a healthy and sustainable environment. The Agenda 2063; The Africa We Want (2013) backs these two conventions. Agenda 2063 is a socio-economic blueprint and master plan for transforming African states into the future global powerhouse. The key aspirations to borrow from the document are inclusive growth

and sustainable development, and a people driven development (relying on the youth and women).

E-waste management projects that have been formulated to assist in the menace have all been affected by the socio-demographic factors (gender, age and education), all having an influence on the performance levels (Waweru, 2017). Occupation, income levels and education levels of consumers of EEE devices had an influence on the e-waste management in Kisumu Central Business District system (Odera, 2016). Hence they should be factored in designing any e-waste management solution.

Most households throw their e-waste to the waste bin (Arif & Afroz, 2014). They resort to disposal of e-waste with other wastes, due to the lack of know-how on where and how to dispose of WEEE in a hygienically safe and proper manner, hence minimal segregation of waste. Most of the e-waste is stored for a long period of time before it is discarded, highlighting the lack of awareness on e-waste disposal of obsolete technology and the belief that the devices still have physical and emotional value in them. Devices are usually used for a period of 5 years before disposal. Hence, products have a lifespan of 2 to 5 years depending on the socio-economic usage of the user (Kalana, 2010). This hoarding of devices may arise due to: lack of disposal mechanisms of the WEEE, plans for future cannibalization of WEEE for spare parts, the initial purchase cost factor and the belief that the recyclers and e-waste collectors need to purchase the e-waste (Tiep, Kin, Ahmed, & Teck, 2015).

Most EEE consumers prefer acquiring new equipment than buying used products, these products are in service until they cannot be used anymore (Rimantho & Nasution, 2016). WEEE that finds its way into landfills can be termed as a toxic time bomb. This is highly due to the possibility of the waste containing acids and heavy metals such as mercury, nickel, cadmium, zinc and copper to leach into the

environment. This may affect the water sources, animals, plants and humans (Sivaramanan, 2013).

Table 2.1: ***NEMA E-waste Classification***

Category	Examples
ICT and telecommunications equipment	Printers, Computers, Laptops, Mobile phones, Radios, TVs, Cameras and recorders, Audio instruments.
Office electronics	Photocopier, calculators, Fax and Telephones.
Toys, leisure and sports equipment	Electric powered toys, sports or gaming appliances, this includes fitness gears
Batteries	Lead Batteries, Nickel and Cadmium batteries etc.
Large Household Appliances	Refrigerators, Washing machines, Cooking gadgets, Microwaves, Air conditioner appliances.
Small Household Appliances	Vacuum cleaners, Water dispensers, Toasters, Shavers, Appliances used for sewing, knitting and weaving.
Consumer Equipment	Construction equipment such as electric hammer, saw, drill and churner
Lighting	Bulbs, lamps, or any other equipment that might be used to spread or control light with the exception of filament bulbs.
Medical equipment	Scanners, Operating equipment, or any other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability.
Automatic dispensers	Dispensers for drinks, solids, money, or other devices which deliver automatically all kind of products.
Monitoring and control instruments	Measuring, weighing or adjusting appliances used in installations.

Source: (NEMA, 2010)

Safe e-waste disposal methods include: the recycling, refurbishing and reusing of the materials. This is highly strengthened by implementing and enforcing of the laid-out rules and regulations that assist in the efficient and effective management of e-

waste. This ensures that all e-waste collectors and dismantlers operate within the confines of the laws and the adherence of the legal requirements. Various governments should also monitor the transportation of e-wastes within their geographical boundaries (Sivaramanan, 2013).

Kenya faces various challenges in the e-waste management sector: this includes low citizen awareness on e-waste, inefficient legal framework, poor e-waste management infrastructure, high cost of brand new EEE, and the lack of take-back policies (Otieno, 2015). There is a lack of professionally trained labour force in the e-waste sector and also there is the improper design and allocation of dumping sites. The dump-sites being used currently are located near residential areas, posing dangers to the health of nearby residents and overall extended environmental concerns (Koloseni & Shimba, 2012).

Reuse of EEE means the discarded device is still in working condition. With minimal repairs and renovation, it can be donated or sold, so as to lengthen the "life" of the product. Recycling of WEEE is the disassembly of equipment into its various components; glass, plastic or metals. The recovered elements are reintegrated into the manufacturing cycle in the form of new products. Individuals and organizations may either be in the reuse or recycling segments, while others tackle both of them simultaneously (CalRecycle, 2018).

Organizations and individuals have been donating their older EEE to less fortunate parts of the community such as schools in the recent past. Some developed countries have forbidden such practices. These old appliances ought to be recycled so as to extract raw materials. The recyclers acquire the e-waste by paying households a small fee (Wei & Liu, 2012).

The e-waste informal sector offers employment opportunities to thousands of people, creating a profitable environment for entrepreneurs to exploit the business gap. The flip side of this is that the sector lacks the skills, technology and hygienic conditions to be operating within acceptable legal safety standards. They make use of crude techniques of WEEE disassembly, making the pollutants into leach to the environment. Over the past few years, formal recyclers' numbers have started increasing, bringing out the expectation of more professional e-waste management; leading to better ecological conservation and enhanced recycled resource recovery. However, it is still not yet clear how far the informal and formal sectors of e-waste management complement each other (Raghupathy, Krüger, Arora, & Henzler).

As for the public, there is a lack of education on the hazardous elements housed within their old electronics, and where to take their waste for recycling. When a device which has reached its end of life is held onto for a long duration, it loses its reuse potential and at the same time, its value decreases. Obsolete devices tend to be less valuable for recyclers, this is due to the complexity of extruding the components (Szczepanski, 2016).

Current trends and technologies have seen EEE become smaller than their predecessors, complicating the e-waste trade. Reducing the number of valuable materials being used in the devices is complicated by designs that make extraction of the components harder. This hinders the urban mining opportunities available for the recyclers to exploit. The sector is also faced with low commodity prices, making the prices of secondary materials to also drop, hence new incentives need to be put into place so as to ensure the sustainability of recyclers' trade. A change of tact by the recyclers is needed, to secure their role and survival within a circular economy (Egerton, 2016).

2.5 Factors Influencing the Adoption of a Circular Economy for E-Waste Management

The Circular Economy model is described as a regenerative system with the ability to redefine growth. This ensures that there are wide-scale society benefits, based on the following principles: elimination of waste and pollution, ensuring products and materials are in use and regenerate to the natural systems (Brinzea, 2018). The EU, for example, has set rules that ensure the separation of waste materials. This will ensure that the quality and purity of collected waste can still be fed into the circular economy. This enables the achievement of SDG target 11.6, which talks about the identification of waste systems as a means of reducing the city's environmental impacts. This implies the products' designed are simple and modular, ensuring that the materials used are easy to reuse or recycle with minimal effort (Fishman, 2018).

Germany is placing a circular economy as a top priority for its environmental policy. If this is emulated it will transform the waste into a resource, giving developing nations prone to poor waste management systems a learning opportunity. For this to be possible, the developing countries should establish laws that will promote the recovery, recycling and reintegration of waste into the economic system. Waste management in developing countries is a big challenge, and a circular economy is able to try and fix this challenge (Uroko, 2018).

The circular waste management system should try to overcome some barriers for it to be effectively adopted by the general population, the barriers being: meeting consumers expectations, government regulations, lack of proper waste management infrastructure, improvement of the recycling technologies, and the use of the wrong business model. Furthermore, governments policies should be aligned to foster innovation that offers circular solutions (Stanislaus, 2018).

The efficiency of a circular model is affected by the availability and ability to obtain WEEE. The sourcing of this waste as a resource is a concern; this can be solved by the introduction of legislation that supports the model. Informal and illegal disposal of WEEE is also part of the factors that influence the adoption and use of a circular model (SCU, 2013).

The barriers to embracing a circular economy in cities such as Nairobi can be categorized into four major areas: financial, institutional, social and technical. The financial barriers include and are not limited to: the upfront cost of investment needed which the benefits will be realized after a long period of time, the economic viability of recycling, and a high transition cost from the current linear model to the circular model. Institutional barriers can thus be summarized to as: current mindsets have the linear model deeply engraved into them limiting any room for change, the regulatory structures are very inflexible thus is a major hindrance to a circular economy, and there is a lack of proper leadership to spearhead the adoption of the circular economy. Social barriers include; the lack of awareness on the benefits of adopting the model, and the resistance to change that will be faced by all involved parties. Lastly, the major factor is the technical barriers: the producers need to design their products with disposal in mind, moving from the notion of planned obsolescence as characterized by most producers, there is also lack of information exchange, and there is need to set up a metrics to measure the circularity of the progress being made (World Economic Forum, 2018). The social and demographic factors of a person such as age, employment status, education level and the level of wages have an effect on the collection rate of WEEE. Though these factors have an effect at different levels, Age having the most influence while level of wages having the least amount (Corina, Carmen, & Claudiu, 2016).

In Kenya, in Kisumu Central Business District; occupation, income levels and education levels of consumers of EEE devices influence the e-waste management. Hence they should be factored in designing of an e-waste management system (Odera, 2016). Socio-demographic factors (gender, age and education) all have an influence on the performance of e-waste projects that have been formulated (Waweru, 2017).

2.6 ICT Use for E-waste Management

The global economy is currently using up more of its natural resources due to the population boom experienced. This natural resource exploitation has impacts on the inhabitants of the world. It is proposed that an environmentally sustainable economic growth model should be used so as to reduce the number of used resources (Ion & Gheorghe, 2014).

Waste management problems in developing countries arose due to near none existent implementation of both formal and informal environmental awareness programmes being conducted. If the community participates in the exercise, waste management costs will be reduced significantly. ICT can be used to assist in the acquisition and amalgamation of knowledge, increasing awareness of best practices in terms of waste management practices. Application of knowledge management methods is very crucial in creating an attitude change of consumers towards improving waste management. Communication technologies have now become a major factor in how the global economy is shaped, and as a result, it brings about rapid changes within society. Indeed, over the past few decades, ICT tools have changed how people communicate and do their business (Wagh, 2018).

In view of the increase in the generated e-waste amount worldwide and cross-boundary movement, regulations to manage e-waste have been developed by various governments and international agencies. These policies touch on the provisions of the

production of EEEs, collection from source, treatment and export of the discarded WEEE products (United Nations, 2017). Due to this, ICT has earned a place in modern waste management.

The use of ICTs acts as a bridge where technology connects policymakers and implementers. Information and knowledge are readily available for the stakeholders. This should be used for grass root organizations' capacity building, so as to push for change (Global Information Society Watch, 2010). Sustainable development ensures that human, nature, and economy coexist in harmony ensuring future prospects remain intact. The role of ICT in supporting waste management arises through innovative solutions that are developed to help the ecosystem. This has led to research and investments towards fixing the waste management problem using ICT as a tool (Ion & Gheorghe, 2014).

ICT offers innovative solutions towards recycling, ensuring that the process is able to retrieve maximum elements of high value from the devices without degrading the ecosystem. The investment being made in the technologies being used should look at the long-term benefits while offering effectiveness and efficiency (Szczepanski, 2016).

ICT also offers an avenue of convenience on environmental information. This is through; the increased availability of information through the ICT platforms and ICT allows for greater case analysis. The shared data and information on ICT platforms allow users to have ready access to environmental information. The data is stored into the systems can easily be retrieved so as to paint a true picture, creating a chronological comparison of periods (Ministry of Environment, Japan, 2012).

While green ICT was earlier limited only to the direct effects of ICT on the environment, currently, it now includes the use of ICT to improve the efficiency of

industries in relation to their environmental practices. ICT based solutions allow for natural resources to be extended via the reduction of diverse environmental unsustainable resources. This also involves the optimization of the systems in the aim of having an environmental load of diverse systems at their minimal levels (Ahola, Ahlqvist, Ermes, Myllyoja, & Savola, 2010). An e-waste ICT infrastructure will consist of devices capable of sensing different operational data via sensors along the value chain. The gathered data and information are shared across the different stakeholders through a web portal (Asif, et al., 2018).

An ICT e-waste framework employs technological tools so as to assist in the monitoring and management of the waste from point of source, to all the final point either landfill, recyclers or re-furbishers. The framework automates and makes the various processes in the value chain to be transparent. Making the processes and use seamlessly from the various stakeholders. This improves on the effective communication process in the waste management, create employment opportunities and create an organized structure framework to be used in the ecosystem (Faiza, Ishaq, Hussein, & Stella, 2016).

Recent studies have proven that technology can be used in practice under extreme working conditions. In Brazil, the Relix Project made the participating waste pickers to improve their well-being and recognition, strengthening the ties between waste pickers and society. ICT was used to enable contact between recycle waste pickers and the society, bridging the existing gap. An application was developed with the following functions; indicating points of collections, allowing rapid access to available waste pickers, and creating employment opportunities (Coelho, Hino & Vahldick, 2019). These were all achieved by the project.

ICT alone cannot be used to combat all the challenges communities face in e-waste management; as technology is a means not an end. Thus, ICT should not just be available, but it is important and should be harnessed to monitor and transform the information and e-waste management. There was a varying acceptance of technology as people moved away from the urban areas, as there was lack of proper ICT infrastructure and inclination to use ICT; thus, the impact of ICT usage was less significant. Thus in the Relix Project, ICT was able to raise awareness regarding recycling. ICT also enabled social inclusion, job creation, increased visibility and network, easier contact and establishment of well-known companies (Coelho, Hino & Vahldick, 2019).

2.7 Summary of Review of Literature

The above literature has shed light that EEE manufacturing companies ought to develop products that will be able to be managed throughout their life cycle. Therefore manufactures should ensure that all devices are reusable, repairable and recyclable so as to ensure that they have value throughout their life-cycle. The e-waste sector should increase the EEE's consumers' awareness of what to do when a product reaches its end-of-life stage.

A circular economy will be able to foster economic growth via the reuse, recycling and reintegration of finite resource that can be mined from WEEE within the cycle, instead of overexploiting natural resources. Furthermore, ICT is also being used in various capacities currently so as to tackle waste management challenges. The innovative approach that ICT offers allow for a wide range of solutions and mechanisms that can be used in the management of the e-waste sector.

2.8 Research Gap

The Literature Review suggests that many studies have been carried out to study e-waste, with a skewed focus on the management (Arif & Afroz, 2014; Asiimwe, 2010; Ibrahim & Elijah, 2015; JICA, 2010; Kalana, 2010; Kaloki, 2014; Makena, 2018; Tiep, Kin, Ahmed, & Teck, 2015). Moreover, most of these studies have been mainly undertaken to understand the consumers' behaviour and also the environmental impact. Henceforth, the literature reviewed shows a rapid increase in the amount of WEEE being generated around the globe, a comprehensive study on how ICT can foster an e-waste circular economy is therefore necessary.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter describes the research design, the intended study area, target population for the study, study sample, methods to be used in data collection, the data analysis and the legal or ethical considerations that were followed.

3.2 Research Design

The study employed the use of a descriptive survey study method. A descriptive study is defined as an attempt to determine, describe or identify "what is" (Fox & Bayat, 2007). The research attempts to gather quantifiable information, usable to statistically analyse the target audience. Hence, this was able to analyse how the already developed ICT based Waste framework by Faiza, Ishaq, Hussein, & Stella (2016), can be used for e-waste management and if it can create a circular economy from the e-waste.

3.3 Research Site

The study was conducted within the confines of Nairobi County (Appendix D), the capital city of Kenya. The county is made up of 17 constituencies. The research area was favourable because the county hosts the largest dumpsite in Kenya and also it has the largest use of EEEs in the country, hence has the highest e-waste generation potential (Anyango, 2011).

3.4 Target Population

The target population for the study was households within Nairobi County who had the ease of access to small ICT equipment (mobile phones, tablets, iPods and computers). A target population is a group with common attributes that information needs to be derived from and confirmed, which is not limited only to people (Banerjee & Chaudhury, 2010). According to the Kenya National Bureau of Statistics, by 2013

Nairobi County had a population of more than 3.3 million people. They further segment this population into 1.5 million households that had ICT access within Nairobi then. Not being a large geographical area, the researcher was able to capture the views of people from both the urban and semi-urban areas of the county.

3.5 Determination of Study Sample

3.5.1 Sampling Procedure

Probability sampling was used in the study, utilizing the stratified sampling technique. To avoid bias, systematic samples were taken from the random target population. The researcher endeavoured to get respondents from all the sub-counties of Nairobi to attain holistic information from the whole study area. Selected key informants were chosen from both the government and private sector; NEMA, Ministry of Environment, Ministry of ICT, WEEE Centre and KEPSA representatives. Kenya National Bureau of Statistics estimates that Nairobi accounts for 1.5 million households. This being more than six years ago, population growth is expected, as the next census is due in a few months. Henceforth, the current household statistics may be superseded by the time of the completion of the study, and with significant implications on the accuracy of the statistics.

3.5.2 Study Sample Size

Sample size in the study is a representation of all stakeholders identified below. The accuracy of the results dictates the level of generalization be applied to demonstrate as the whole target population (Kothari, 2014). In this study, the sample size was calculated using Krejcie and Morgan (1970) table. This formula was used as recommended in sample calculations in which the target population is more than a million people; the sample size is then calculated as 384 (as shown in Appendix E). This can also be expressed as indicated in the formula;

$$s = \boldsymbol{X^2 NP}(1 - \boldsymbol{P}) \pm \boldsymbol{\partial^2}(\boldsymbol{N} - \mathbf{1}) + \boldsymbol{X^2 P}(\mathbf{1} - \boldsymbol{P})$$

Where,

s = required sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (0.05 = 3.841).

N = the population size.

P = the population proportion (assumed to be 0.50 since this would provide the maximum sample size.

d = the degree of accuracy expressed as proportion (0.05).

The study sample shall be divided to:

Table 3.1: *Strata Segmentation*

Strata	**Number**
Lower Income Households	102
Middle Income Households	232
Upper Income Households	50
TOTAL	**384**

Low-income households were categorized as those earning less than KSh 25,000.00 a month; the sampled households were from Kibera, Kayole, Mathare, Dandora, Kangemi and Kawangware. Mid income households were those earning between KSh 25,001.00 and KSh 150,000.00 a month, the sampled households were from Westlands, Kilimani, Ruaka, Imara Daima and Donholm areas. The upper-income households were those earning above Ksh 150,000.00 a month, and they were residing in Riverside, Runda, Rosslyn and Karen regions.

3.6 Data Collection Measures

3.6.1 Development of Instruments

The research used primary and secondary data as a means of finding answers to the research questions from the respondents. Primary data was collected by electronic

self-administered questionnaires and interviews. Secondary data was attained by collecting data through review of past similar or related research papers, waste management policy documents including the National Sustainable Waste Management Policy and Nairobi Solid Waste Management, Convention Reports including the Basel and Bamako Convention documents and regulatory policy information from the National E-Waste Management Strategy by the Ministry of Environment. Thus, formulating questionnaires and interview schedules that were used as research instruments for data collection in the study was vital.

Questionnaires were administered to the sampled population; based on the objectives that the study sought to achieve. For this purpose e-waste in this context was limited only to small ICT appliances. The questionnaires comprised of two parts: the first part being a general introduction about the researcher, the topic of research, its objectives and instructions on how to input data into the questionnaire, and the second part sought to know the personal details of the respondents and their views on the research questions based on the objectives. The questions were both open and closed-ended.

Interview schedules were also used; for key informants (government bodies were represented by Assistant Secretary for Ministry of Environment, NEMA officials and Nairobi County Council Environment officials and e-waste handlers) on the research topic. These had predetermined questions that were used to probe information from the respondents. The interviews were booked in advance to give ample room for planning and were brief to maximize the efficiency and effectiveness of the instrument.

3.6.2 Pilot Testing of Research Instruments

The research questionnaire was tested for refining the questions before it was administered to the respondents. A pilot test was carried out in Kiambu County to

identify the weaknesses in the design. Kiambu County was chosen because of proximity to Nairobi and the similarities in terms of e-waste management. 5% (accounting for 20 respondents) of the research target respondents were piloted to determine the accuracy of the questionnaire. The study assumed that the rule of thumb at 5% of the sample size consisted of a pilot test (Cooper & Schindler, 2010). The outcome of the pilot test was not applicable in this study but helped in correcting any anomalies such as ambiguity of the questions and time of response.

3.6.3 Instrument Reliability

Reliability refers to the extent to which a study's findings are considered consistent and reliable (Creswell, 2014). To ensure reliability, the instrument was pretested (piloted) in a small sample to determine the soundness, accuracy, clarity, and suitability of the research instruments before the final field survey was carried out. Necessary adjustments were made for the final survey process to further ensure data reliability. Using the Cronbach test of reliability, a score of 0.72 was achieved.

3.6.4 Instrument Validity

Pre-test on the face, content, construct and criterion validity was carried out on a sample population, same as the target population; to confirm the quality of the instruments in use. This gave the researcher an insight into the items that were not appropriate in the measurement of variables, allowing modification of the instruments as necessary. Validity was ascertained through expert judgement. This involved giving the supervisor the questionnaire to peruse and recommend necessary changes.

3.7 Data Processing and Analysis

Collected raw data was analysed using IBM's Statistical Package for Social Sciences (SPSS Version 25). Descriptive and inferential statistics were used for an in-

depth quantitative analysis. The questionnaire had a seven-point ranked scale 1 being the lowest (strongly disagree) and 7 being the highest (strongly agree).

The researcher used frequency, percentages, mean, and standard deviation to analyse the data; which was then presented in the form of tables. Indicators were combined to form an index; a compound measure that aggregates multiple indicators into a variable (Earl, 2012). Linear regression analysis was used to show the existing relationships between independent variables and dependent variables of the study. Interpretation, discussion and comparison of the results with existing related works were also done. This was all guided by the objectives of the study.

3.8 Legal and Ethical Considerations

The research conformed to research tenets and processes. The best practices and ethical standards (including consent and confidentiality) of research were kept throughout the study. Impartiality in the research was maintained throughout, ensuring that there was the independence of personal thoughts, ideas and words. The necessary permits from relevant institutions such as the National Council for Science Technology and Innovation (NACOSTI) and relevant bodies' approvals for conducting research study were sought to be within the legal confines of research.

Table 3.2: ***Summary of the Analytical Procedures***

Research Questions	**Variables Involved**	**Statistical Methods Used**
(i) What influence does socio-demographic factors have on an ICT framework for a circular e-waste economy?	Independent: Socio-demographic factors Dependant: ICT framework for a circular e-waste economy	Descriptive Statistics, Simple Linear regression analysis,
(ii) What influence does consumer behaviour have on an ICT framework for a circular e-waste economy?	Independent: Consumer behaviour Dependant: ICT framework for a circular e-waste economy	Descriptive Statistics, Simple Linear regression analysis,
(iii) How does the level of access to information influence an ICT framework for a circular e-waste economy?	Independent: Access to WEEE information Dependant: ICT framework for a circular e-waste economy	Descriptive Statistics, Simple Linear regression analysis,
(iv) How does an ICT infrastructure influence a circular e-waste economy?	Independent: ICT infrastructure Dependant: ICT framework for a circular e-waste economy	Descriptive Statistics, Simple Linear regression analysis,
(v) What factors should an ideal ICT framework consider for a circular e-waste economy?"	Independent: Socio-demographic factors, Consumer behaviour, Access to WEEE information, ICT infrastructure Dependant: ICT framework for a circular e-waste economy	Multiple regression analysis

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Introduction

This chapter highlights the results of the study and followed by a description of the analysis of data of the research findings. The findings relate to the research questions that guided the study. Data were analysed to identify, describe and explore the relationship between the selected factors (socio-demographic factors, consumer behaviour, access to information and ICT infrastructure) and how they influence an ICT framework for a circular e-waste economy by households in Nairobi. Data was obtained from an online survey based on Google Docs. A Ranked scale of 1-7 was used (1 the lowest being strongly disagreed and 7 the highest being strongly agree).

4.2 Questionnaire Response Rate

The study targeted households' respondents. Due to ample time and efficiency of ICT as the questionnaire was availed electronically (for lower-income areas and people with poor ICT skills a personal approach was used to aid them), the survey yielded a 100% response rate. The questionnaires were examined for errors and omissions and the data then analysed.

4.3 General Responses on WEEE from Respondents

4.3.1 Sources Used by Respondents to Acquire EEE

The source of acquiring electronic gadgets strongly describes the financial ability of the respondent, the love for the gadgets and the use purpose of the electronic devices. Table 4.1 highlights the findings obtained from the respondents.

Table 4.1: ***Sources Used by Respondents to Acquire EEE***

Electronic Source	Frequency	Percentage
Retail Stores	293	76
Online Platform	40	11
Hand Me down	47	12
Street Purchase	4	1
Total	**384**	**100**

This study established that most of the respondents acquired their electronics from retail stores, showing that we are a traditional economic market where people still prefer visiting an actual shop to purchase commodities. Online platforms have been slowly making an increase in the rate of adoption by users. With the ever-advancing of digitization of processes in the country, this is expected to increase with time.

4.3.2 Condition of the Electronics Bought by the Respondents

The condition of the purchased/ received gadget explains how long the electronic gadget will be used before disposal since old electronics have a lower lifespan and increases the frequency of repurchasing to replace the damaged one. Table 4.2 highlights the findings obtained from the respondents.

Table 4.2: ***Condition of the Electronics Bought by the Respondents***

Electronic Source	Frequency	Percentage
New	287	75
Slightly Used	48	12
Refurbished	33	9
Damaged	7	2
Old	9	2
Total	**384**	**100**

Majority (75%) of the respondents acquired new EEE devices, this can be attributed to the affordability of new EEE devices in the market, a basic smartphone retails in the market for KSh 4,500, which comes with the peace of mind that it is a new

product with no strings attached to it (such as crime-related activities). People shun old EEE devices as they have a shorter lifespan with more maintenance costs. Furthermore, most old devices also have obsolete technology which people shun. This aligns with the sources of electronic products used by the respondents, which shows that people are acquiring newer products. This can be attributed to the socio-economic status of most of the respondents.

4.3.3 Average Usage of Electronics by Respondents

Long period of using an electronic gadget means that few e-waste will be released while the short period of use means increased e-waste. Table 4.3 highlights the findings obtained from the respondents.

Table 4.3: ***Average Usage of Electronics by Respondents***

Average usage	**Frequency**	**Percentage**
Less than 2 Years	77	20
3-4 Years	233	61
5-6 Years	46	12
7-8 Years	24	6
Over 9 Years	4	1
Total	**384**	**100**

Majority (61%) of the respondents use their devices between 3-4 years. This conforms to the lifespan that most small ICT products have in the market and also end of support for software in the devices. Users who use their devices for less than 2 years are those who want to keep up with the latest technological trends. The outliers are those who use devices for more than five years, and tend to look for durability and comfort in their products, they also tend to maximize their recoup from the initial cost of investment.

4.3.4 Awareness of E-Waste Management Systems

Awareness of e-waste implies that the respondents are informed on e-waste management systems and are able and willing to comply in order to reduce the e-waste. Table 4.4 highlights the findings obtained from the respondents.

Table 4.4: ***Level of Awareness on E-Waste Management Systems***

E-Waste Awareness	Frequency	Percentage
High Awareness	87	23
Low Awareness	259	67
Partial Awareness	38	10
Total	**384**	**100**

Majority (67%) of the respondents had low awareness on e-waste management. This can be attributed to how the e-waste management system currently works and its challenges. Lack of awareness hampers any strategy that will be employed towards e-waste management practices, as you cannot practice what you do not know.

4.3.5 E-Waste Separation Practice of the Respondents

The practice of sorting e-waste from other household wastes implies that the respondent is informed of e-waste management practices as this improves the chances of maximum residual value. Table 4.5 highlights the findings obtained from the respondents.

Table 4.5: ***E-Waste Separation Practice of the Respondents***

E-waste Separation	Frequency	Percentage
Separates	37	10
Doesn’t Separate	264	69
Partial Separate	83	21
Total	**384**	**100**

This study established that majority (69%) of the respondents do not separate e-waste from other waste streams. Meaning that the e-waste being collected by recyclers at a household level has a higher probability of being contaminated at source, reducing

the residual value of the resources within it. This can be attributed to the low awareness levels from the respondents.

4.4 ICT Framework for a Circular E-Waste Economy

The dependent variable for this study was an ICT framework for a circular e-waste economy which was created as an index. The index was drawn from the respondents self-score on four questions that evaluated the influence an ICT framework has on a circular e-waste economy. The questions tested the e-waste levels reduction, e-waste awareness levels, resource sustainability and impact on the EEE value chain. The respondents rated themselves using a ranked scale. The questions testing the quality of learning and the frequency of the responses are shown in Table 4.6.

Table 4.6: ***Statements Questioning ICT Framework Influence***

Statements		**Strongly Disagree**						**Strongly Agree**
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
It will lead to a reduction in the levels of e-waste within Nairobi	f	0	1	21	31	137	*145*	49
	%	0	.3	5.5	8.1	35.7	*37.8*	12.8
It will improve on the e-waste awareness levels of households in Nairobi.	f	0	0	9	47	117	*176*	35
	%	0	0	2.3	12.2	30.5	*45.8*	9.1
It will have an effect on the available resources sustainability	f	1	1	14	29	116	*182*	41
	%	.3	.3	3.6	7.6	30.2	*47.4*	10.7
It will have an impact on the value chain for electronic products	f	0	0	10	34	97	*186*	57
	%	0	0	2.6	8.9	25.3	*48.4*	14.8

The respondent's scores were added to create the index. Cronbach's alpha was used to measure reliability of the index created for the ICT framework for a circular e-waste economy by checking its internal consistency, and an output of 0.9 was achieved. Indicating that the reliability of the index was high Descriptive statistics of the data was achieved as shown in Table 4.7.

Table 4.7: ***Descriptive Statistics for ICT Framework for a Circular E-Waste Economy***

ICT Framework Statements	Mean	SD
It will lead to a reduction in the levels of e-waste within Nairobi	5.434	1.012
It will improve on the e-waste awareness levels of households in Nairobi.	5.471	0.905
It will have an effect on the available resources sustainability	5.521	0.958
It will have an impact on the value chain for electronic products	5.641	0.929
ICT Framework Index	**5.517**	**0.951**

The study was able to establish that the respondents agreed that the ICT framework will assist in the e-waste level reduction, create e-waste awareness, have an effect on the resources sustainability and have an impact on the EEE value chain. All this summed up together formed the ICT Framework Index.

4.5 Influence of Socio-Demographic Factors on an ICT Framework for a Circular E-Waste Economy

The study sought to find out the demographic characteristics of the respondents namely; gender, age, level of education, social economic status and the level of competence in the use of ICT. An electronic self-administered questionnaire was used to collect data from the respondents.

4.5.1 Distribution of Sample by Sex of the Respondent

In many waste management studies, sex based questions try to address issues around welfare or inequality. This is relevant not only to assess the degree of participation but also to understand better if it has an influence or impact. Respondents were asked on their gender and responded as in Table 4.8.

Table 4.8: ***Sex Distribution Group Statistics***

	Sex	N	Percentage	Mean	Std. Deviation	Std. Error Mean
ICT Circular E-waste Economy	Male	177	46	22.186	3.116	.234
	Female	207	54	21.966	3.288	.229

Table 4.8 shows that majority (54%) of the respondents were female. This implies that females were more receptive to the study. However, this may also be due to the fact that according to general population statistics, females are more than their male counter parts in Kenya.

Table 4.9: ***Sex Distribution Independent Sample Test***

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	*p*	*t*	*df*	*p (2-tailed)*	Mean Difference	Std. Error Difference	Lower	Upper
ICT Circular E-waste Economy	Equal variances assumed	.814	.368	.670	382	0.503	0.220	0.329	-0.426	0.866
	Equal variances not assumed			.673	377.954	0.501	0.220	0.327	-0.423	0.864

Based on Table 4.9, since Levene's *p* (0.368) is > 0.05, equal variances holds. *p (2-tailed)* which is 0.503 is > 0.05, means that the population means are equal. The ICT framework for a Circular e-waste economy scores of the two sexes did not differ, t (382) = 0.670, p = 0.503. This means that e-waste affected both sexes equally.

4.5.2 Age Distribution of the Respondents

The distribution of age among a population helps the policy makers and the government to exercise their duties smoothly and effectively by having helpful data and information. Respondents were asked to include their age bracket and responded as in Table 4.10.

Table 4.10: ***Age Brackets of the Respondents***

Age Bracket	Frequency	Percentage
25 Years and Below	94	24
26-35	149	39
36-45	89	23
46-55	33	9
56 and above	19	5
Total	**384**	**100**

In this study, majority of the respondents were aged 35 years and below. The age distribution of the respondents as shown in Table 4.10 can be attributed to the fact that Nairobi and Kenya overall have a youthful population. Nevertheless, the fact that those who are in the age bracket of 26-36 years are more than those below 26 years can be attributed to their financial abilities. Acquiring these gadgets require financial sacrifices. Furthermore, most of those below 26 years do not have a stable source of income, hence they might find it difficult to afford.

4.5.3 Level of Formal Education attained by the Respondents

Education is considered critical for social economic development, hence understanding the level of education among the respondents offers insight into their knowledge on E-waste. Table 4.11 shows findings from the respondents.

Table 4.11: ***Level of Formal Education attained by the Respondents***

Level of Education	Frequency	Percentage
Informal Learning	5	1
Primary School	11	3
High School	45	12
College	146	38
University	177	46
Total	**384**	**100**

In this study, minority of the respondents had received basic education. This implies that most of the respondents had attained post high school education. Meaning that the respondents were exposed and knowledgeable in their various skills set. The respondents having come from an urban setting may highly also contributed to the above findings.

4.5.4 Social Economic Status of the Household Heads

Social-economic status categorizes the respondents into their financial level/ability to afford their needs and wants. Table 4.12 shows the findings from the respondents.

Table 4.12: ***Social Economic Status of the Respondents***

Social Economic Status	Frequency	Percent
Lower income	108	28
Middle income	245	64
Upper income	31	8
Total	**384**	**100**

The population is majorly composed of middle-income earners, the lower- and upper-income earners are outliers in this case.

4.5.5 Competence in ICT usage by the Respondents

Level of competence determines one’s ability to use electronic gadgets. Table 4.13 highlights the findings obtained from the respondents.

Table 4.13: ***Competence in ICT usage by the Respondents***

ICT Competence Status	Frequency	Percent
Beginner	41	11
Casual	245	64
Expert	98	25
Total	**384**	**100**

This study established that most of the respondents had casual knowledge of ICT and its use, followed by those who were experts. These findings align with the socio-economic status and age distribution of the respondents earlier shown. Kenya has been making progress in terms of ICT adoption and use in its activities, hence the high percentage demonstrated by the findings.

4.5.6 Analysis of the Influence Socio-Demographic Factors Have on an ICT Framework for a Circular E-Waste Economy

The respondents' scores from the five statements were added to create the socio-demographic index from the indicators. This included gender, age, level of education, socio-economic status, and competence of ICT usage. Cronbach test was used to test the reliability, with an output of 0.7 achieved. This meant that the index had a high reliability. Descriptive statistics of the data was achieved as shown in Table 4.14.

Table 4.14: ***Competence in ICT usage by the Respondents***

Socio Demographic Statements	Mean	SD
Demographic		
Age	2.307	0.055
Social		
Level of education	3.188	0.094
Socio-economic status	1.799	0.029
Competence of ICT use	1.148	0.030
Socio Demographic Index	**2.111**	**0.052**

The study used simple linear regression to determine the relationship between the independent variable socio-demographic factors and the dependent variable circular e-waste economy. Table 4.15 shows the model summary.

Table 4.15: ***Model Summary for Socio-Demographic Factors***

R	R Square (R^2)	Adjusted R Square	Std. Error of the Estimate
.166[a]	.028	.025	3.167

a. Predictors: (Constant), Age, Education, ICT Competence, Socio Economic Status

The analysis found $R^2 = 0.028$, indicating that the socio-demographic factors explained 2.8% of the proportion in the circular E-waste economy by Nairobi Households.

Table 4.16: ***ANOVA for Socio-Demographic Factors***

	Sum of Squares	*df*	Mean Square	*f*	*p*
Regression	108.870	1	108.870	10.855	.001[b]
Residual	3831.369	382	10.030		
Total	3940.240	383			

a. Dependent Variable: ICT Based Circular E-Waste Economy
b. Predictors: (Constant), Socio Demographic Factors

The ANOVA findings shows the reliability of the model on the relationship between Socio-Demographic factors of Nairobi households and the ICT based circular e-waste economy. The result shows that there exists a significant relationship F (1,382) f =10.855, p= 0.001, between socio-demographics and the ICT based circular e-waste economy among the Households in Nairobi. Based on the analysis, socio-demographics does influence the circular e-waste economy.

Table 4.17: ***Coefficients for Socio-Demographic Factors***

Model	**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p***
	B	**Std. Error**	***β***		
(Constant)	19.871	.686		28.970	.001
Socio Demographics	.201	.061	.166	3.295	.001

a. Dependent Variable: ICT Based Circular E-Waste Economy

The study found that the linear relationship between socio-demographics and the ICT framework for a circular e-waste economy is positive ($\beta = 0.166$, $t = 3.295$, $p = 0.001$). The study concluded that socio-demographics had a positive impact on the ICT framework for a circular e-waste economy.

4.6 Influence of Consumer Behaviour on an ICT Framework for a Circular E-Waste Economy

The first independent variable for this study was the consumer behaviour which was indexed. This was obtained from the respondents' eight self-administered statements highlighting their behaviour towards EEE products. Both frequency and percentage of the responses are shown in Table 4.18.

Table 4.18: ***Consumer Behaviour Statements' Frequency and Percentage Distribution***

Statements		**Strongly Disagree (1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**Strongly Agree (7)**
E-waste is a major issue in Nairobi	f	3	15	91	*128*	90	28	29
	%	.8	3.9	23.7	*33.3*	23.4	7.3	7.6
Awareness of Personal Duty	f	15	53	*141*	88	56	9	22
	%	3.9	13.8	*36.7*	22.9	14.6	2.3	5.7
Initial Cost affects disposal Method	f	6	11	53	101	*137*	55	21
	%	1.6	2.9	13.8	26.3	*35.7*	14.3	5.5
Emotional Attachment controls the duration of Electronic use	f	5	22	61	74	*134*	57	31
	%	1.3	5.7	15.9	19.3	*34.9*	14.8	8.1
Incentives fosters proper waste disposal	f	1	5	25	50	118	*121*	64
	%	.3	1.3	6.5	13	30.7	*31.5*	16.7
Convenience collection point has an effect on the willingness of an e-waste consumer to partake in a circular economy	f	0	0	24	45	*137*	135	43
	%	0	0	6.3	11.7	*35.7*	35.2	11.2
Availability of home collection point for e-waste boosts household adoption of a circular economy	f	0	3	16	62	*144*	120	39
	%	0	.8	4.2	16.1	*37.5*	32.1	10.2
Segregation of e-waste from other waste at the source improves the chance of maximum value extraction from the disposed product	f	0	1	15	46	120	*143*	59
	%	0	.3	3.9	12	31.3	*37.2*	15.4

The respondents' scores from the eight statements were added to create the consumer behaviour index from the indicators. This included awareness of the problem, how EEE is acquired and how segregation and collection is processed. Cronbach test was used to test the reliability, with an output of 0.8 achieved. This meant that the index had a high reliability. Descriptive statistics of the data was achieved as shown in Table 4.19.

Table 4.19: ***Consumer Behaviour Index Table***

Consumer Behaviour Statements	**Mean**	**SD**
Aware of the Problem		
E-waste is a major issue in Nairobi	4.270	1.266
Awareness of personal duty	3.600	1.369
EEE acquisition		
Initial Cost affects disposal Method	4.570	1.225
Emotional Attachment controls the duration of electronic use	4.580	1.359
Incentives fosters proper waste disposal	5.340	1.192
Segregation and collection		
Convenience collection point has an effect on the willingness of an e-waste consumer to partake in a circular economy	5.330	1.026
Availability of home collection point for e-waste boosts household adoption of a circular economy	5.250	1.029
Segregation of e-waste from other waste at the source improves the chance of maximum value extraction from the disposed product	5.470	1.032
Consumer Behaviour Index	**4.801**	**1.187**

The study established that respondents acknowledged that e-waste was a major issue in Nairobi. However, they were not aware of their duties in having a proper e-waste management system. In regards to whether the initial cost affected the disposal method, the respondents agreed that it did affect. The study also established that the level of emotional attachment controlled the duration of electronic use, incentives fostered proper waste disposal. Convenient collection points affected the willingness of an e-waste consumer to partake in a circular economy. Availability of home collection points for e-waste also boosts household adoption of a circular economy. Segregation

of e-waste from other waste at the source improves the chance of maximum value extraction from the disposed of product.

4.6.1 Consumer Behaviour Influence on an ICT Framework for a Circular E-Waste Economy

The study used simple linear regression to determine the relationship between the independent variable consumer behaviour and the dependent variable circular e-waste economy. The model summary is shown in Table 4.20.

Table 4.20: ***Model Summary for Consumer Behaviour***

R	R Square (R^2)	Adjusted R Square	Std. Error of the Estimate
.538[a]	.289	.287	2.707

a. Predictors: (Constant), Consumer Behaviour Index

The analysis found R^2 = 0.289, indicating that the consumer behaviour explained 28.9% of the proportion in the circular E-waste economy by Nairobi Households.

Table 4.21: ***ANOVA for Consumer Behaviour***

	Sum of Squares	*df*	Mean Square	*f*	*p*
Regression	1140.118	1	1140.118	155.538	.001[b]
Residual	2800.122	382	7.330		
Total	3940.240	383			

a. Dependent Variable: ICT Based Circular E-Waste Economy
b. Predictors: (Constant), Consumer Behaviour

The ANOVA findings indicate the reliability of the model on the relationship between Consumer behaviour of Nairobi households and the ICT based circular e-waste economy. The result shows that there exists a significant relationship F (1,382) *f* =155.538, p= 0.001, between consumer behaviour and the ICT based circular e-waste economy among the Households in Nairobi. Based on this analysis, consumer behaviour does influence the circular e-waste economy.

Table 4.22: ***Coefficients for Consumer Behaviour***

Model	**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p***
	B	**Std. Error**	***β***		
(Constant)	11.100	.890		12.469	.001
Consumer Behavior	.286	.023	.054	12.471	.001

a. Dependent Variable: ICT Based Circular E-Waste Economy

The study found that the linear relationship between consumer behaviour and the ICT framework for a circular e-waste economy to be positive ($\beta = 0.054$, $t = 12.471$, $p = 0.001$). The study concluded that consumer behaviour had a positive impact on the ICT framework for a circular e-waste economy.

4.7 Influence of Access to Information on an ICT Framework for a Circular E-Waste Economy

The second independent variable for this study was the access to information. This was obtained from the respondents' eight self-administered statements highlighting their behaviour towards EEE products. The frequency and percentage of the responses are shown on Table 4.23.

Table 4.23: ***Access to Information Frequency and Percentage Distribution***

Statements		**Strongly Disagree (1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**Strongly Agree (7)**
I am not aware of the existing policies/laws and regulations regarding e-waste disposal	f	6	8	18	38	95	*144*	75
	%	1.6	2.1	4.7	9.9	24.7	*37.5*	19.5
I am not aware of the benefits of using a circular economy for e-waste management	f	11	29	16	54	101	*122*	51
	%	2.9	7.6	4.2	14.1	26.3	*31.8*	13.3
ICT currently is not being used to improve e-waste awareness amongst households	f	5	11	23	51	*117*	116	61
	%	1.3	2.9	6	13.3	*30.5*	30.2.	15.9
It is not easy to gain information on e-waste management best practices	f	8	12	18	81	*110*	108	47
	%	2.1	3.1	4.7	21.1	*28.6*	28.1	12.2
E-waste recycling information will have an effect on the adoption of circular e-waste economy	f	1	15	41	88	*148*	70	23
	%	.3	3.9	10.7	22.9	*38*	18.2	6
Consumer awareness on electronic end-of-life is important for the successfulness of e-waste recycling	f	1	3	20	61	*174*	101	24
	%	.3	.8	5.2	15.9	*45.3*	26.3	6.3
A take back policy introduction on electronic products will reduce the e-waste levels in Nairobi	f	1	2	21	64	*149*	103	44
	%	.3	.5	5.5	16.7	*38.8*	26.8	11.5
Providing feedback on e-waste management is important to facilitate the practice of a circular e-waste economy	f	0	1	14	49	*147*	135	38
	%	0	.3	3.6	12.8	*38.3*	35.2	9.9

The respondents' scores from the eight statements were added to create the access to information index from the indicators; awareness level, ease of e-waste information, and the policies, laws and regulations in place. Cronbach test was used to

test the reliability, and an output of 0.78 was achieved. This meant that the index had a high reliability. Descriptive statistics of the data was achieved as shown in Table 4.24.

Table 4.24: ***Access to Information Index Table***

Access to Information Statements	**Mean**	**SD**
Awareness level		
I am not aware of the existing policies/laws and regulations regarding e-waste disposal	5.415	1.298
I am not aware of the benefits of using a circular economy for e-waste management	5.020	1.517
ICT currently is not being used to improve e-waste awareness amongst households	5.230	1.315
Ease to e-waste information		
It is not easy to gain information on e-waste management best practices	5.040	1.337
E-waste recycling information will have an effect on the adoption of circular e-waste economy	4.730	1.185
Consumer awareness on electronic end-of-life is important for the successfulness of e-waste recycling	5.090	0.993
Policy, laws and regulations		
A take back policy introduction on electronic products will reduce the e-waste levels in Nairobi	5.200	1.080
Providing feedback on e-waste management is important to facilitate the practice of a circular e-waste economy	5.340	0.965
Access to Information Index	**5.133**	**1.211**

The study established that the respondents were not aware of the existing policies/laws and regulations regarding e-waste disposal. They were also not conversant with the benefits of using a circular economy for e-waste management. They did not acknowledge that ICT currently is being used to improve e-waste awareness amongst households. Gaining information on e-waste management best practices seems to be an issue amongst the respondents. On the other hand, the study established that e-waste recycling information affects the adoption of circular e-waste economy. The

respondents agreed that consumer awareness on electronic end-of-life is important for the successfulness of e-waste recycling, and a take-back policy introduction on electronic products will reduce the e-waste levels in Nairobi. Lastly providing feedback on e-waste management was deemed important to facilitate the practice of a circular e-waste economy.

4.7.1 Level of Access to Information Influence on an ICT Framework for a Circular E-Waste Economy

The study used simple linear regression to establish the relationship between the independent variable: access to information and the dependent variable: Circular e-waste Economy. The model summary is shown in Table 4.25, while Table 4.26 shows the ANOVA tests, and the regression coefficients are illustrated in Table 4.27.

Table 4.25: ***Model Summary for Access to Information***

R	R Square	Adjusted R Square	Std. Error of the Estimate
.442[a]	.195	.193	2.882

a. Predictors: (Constant), Access to information

The analysis found R^2 = 0.195, indicating that the access to information explained 19.5% of the proportion in the circular e-waste economy among the Nairobi Households.

Table 4.26: ***ANOVA for Access to Information***

	Sum of Squares	*df*	Mean Square	*f*	*p*
Regression	768.286	1	768.286	92.525	.001[b]
Residual	3171.953	382	8.304		
Total	3940.240	383			

a. Dependent Variable: ICT Based Circular E-Waste Economy
b. Predictors: (Constant), Access to information

The ANOVA findings indicate the reliability of the model on the relationship between access to information and the circular e-waste economy among the households in Nairobi County. The ANOVA result shows that there exists a significant relationship

F (1,382) *f*= 92.525, *p*=0.001) between access to information and the circular e-waste economy. Based on the findings, the access to information does influence the circular e-waste economy by Nairobi Households.

Table 4.27: ***Coefficients for Access to Information***

Model	**Unstandardized Coefficients**		**Standardized Coefficients**	***t***	***p***
	B	**Std. Error**	***β***		
(Constant)	11.083	1.151		9.625	.001
Access to information	0.267	.028	.442	9.619	.001

a. Dependent Variable: ICT Based Circular E-Waste Economy

The study found that the linear relationship between access to information and the ICT framework for a circular e-waste economy was positive (β = 0.442, t = 9.619, p = 0.001). The study concluded that access to information had a positive impact on the ICT framework for a circular e-waste economy.

4.8 Influence of ICT Infrastructure on an ICT Framework for a Circular E-Waste Economy

Finally, the fourth independent variable for this study was the influence of ICT infrastructure. This was obtained from the respondents' six self-administered statements highlighting their behaviour towards EEE products. The frequency and percentage of the responses are shown in Table 4.28.

Table 4.28: ***ICT Infrastructure Frequency and Percentage Distribution***

Statements		**Strongly Disagree**						**Strongly Agree**
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Integrating ICT into e-waste management will increase the rate of adoption of a circular e-waste economy	f	0	3	25	44	*151*	136	25
	%	0	.8	6.5	11.5	*39.3*	35.4	6.5
Convenience of the ICT infrastructure affects the adoption of a circular e-waste economy	f	0	4	19	63	*149*	123	26
	%	0	1	4.9	16.4	*38.8*	32	6.8
Rate of recycling increases when the availability of e-waste drop-off recycling facilities are available via ICT platforms	f	0	2	17	55	*144*	136	30
	%	0	.5	4.4	14.3	*37.5*	35.4	7.8
An e-waste recycling reminder has a positive impact in ensuring the constant practice	f	0	2	16	44	141	*148*	33
	%	0	.5	4.2	11.5	36.7	*38.5*	8.6
ICT infrastructure should be able to sense, collect and process useful information and share that with relevant stakeholders	f	0	2	18	33	109	*185*	37
	%	0	.5	4.7	8.6	28.4	*48.2*	9.6
The presence of ICT training programmes will affect the adoption of ICT based e-waste circular economy	f	0	0	9	43	112	*179*	41
	%	0	0	2.3	11.2	29.2	*46.6*	10.7

The respondents' scores from the six statements were added to create the ICT infrastructure index from the indicators; user perception of ICT usage to waste management and the ease of adoption of ICT usage. Cronbach test was used to test the reliability, and an output of 0.8 was achieved. This meant that the index had a high reliability. Descriptive statistics of the data was achieved as shown in Table 4.29.

Table 4.29: ***ICT Infrastructure Index Table***

ICT Infrastructure Statements	Mean	SD
User perceive of ICT usage in waste management		
Integrating ICT into e-waste management will increase the rate of adoption of a circular e-waste economy	5.220	1.008
Convenience of the ICT infrastructure affects the adoption of a circular e-waste economy	5.160	1.012
Ease of adoption of ICT usage		
Rate of recycling increases when the availability of e-waste drop-off recycling facilities are available via ICT platforms	5.260	0.983
An e-waste recycling reminder has a positive impact on ensuring the constant practice	5.340	0.970
ICT infrastructure should be able to sense, collect and process useful information and share that with relevant stakeholders	5.480	0.980
The presence of ICT training programmes will affect the adoption of ICT based e-waste circular economy	5.520	0.911
ICT Infrastructure Index	**5.330**	**0.977**

The study found out that, integrating ICT into e-waste management will increase the rate of adoption of a circular e-waste economy. Convenience of the ICT infrastructure will affect the adoption of a circular e-waste economy. Rate of recycling increases when the availability of e-waste drop-off recycling facilities are available via ICT platforms. An e-waste recycling reminder has a positive impact on ensuring constant practice. The respondents also suggested that an ICT infrastructure should be able to sense, collect and process useful information and share it with relevant stakeholders. Moreover, the presence of ICT training programmes affects the adoption of ICT based e-waste circular economy.

4.8.1 ICT Infrastructure Influence on an ICT Framework for a Circular E-Waste Economy

The study used simple linear regression to determine the relationship between the independent variable ICT Infrastructure and the dependent variable circular e-waste economy. The model summary is shown in Table 4.30, the ANOVA tests are shown in Table 4.31 and the regression coefficients are illustrated in Table 4.32.

Table 4.30: ***Model Summary for ICT Infrastructure***

R	R Square	Adjusted R Square	Std. Error of the Estimate
.770[a]	.593	.592	2.048

b. Predictors: (Constant), ICT Infrastructure

The analysis found $R^2 = 0.593$, indicating that the ICT Infrastructure explained 59.3% of the proportion in the circular E-waste economy.

Table 4.31: ***ANOVA for ICT Infrastructure***

	Sum of Squares	*df*	Mean Square	*f*	*p*
Regression	2337.829	1	2337.829	557.317	.001[b]
Residual	1602.411	382	4.195		
Total	3940.240	383			

a. Dependent Variable: ICT Based Circular E-Waste Economy
b. Predictors: (Constant), ICT infrastructure

The ANOVA findings indicate the reliability of the model on the relationship between ICT Infrastructure and the circular e-waste Economy among the households in Nairobi County. The ANOVA result shows that there exists a significant relationship F (1,382) f=557.317, p=0.001) between ICT Infrastructure and the circular e-waste economy. Based on this findings, ICT infrastructure does influence the circular e-waste economy by Nairobi Households.

Table 4.32: ***Coefficients for ICT infrastructure***

Model	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	**Std. Error**	***β***		
(Constant)	4.962	.732		6.779	.001
ICT infrastructure	.535	.023	.770	23.608	.001

a. Dependent Variable: ICT Framework for Circular E-Waste Economy

The study found that the linear relationship between ICT infrastructure and the ICT framework for a circular e-waste economy to be positive ($\beta = 0.770$, $t = 23.608$, $p = 0.001$). The study concluded that ICT infrastructure had a positive impact on the ICT framework for a circular e-waste economy.

4.9 Overall Regression Analysis Using the Index

The multiple linear regression analysis was used to model the relationship between the socio-demographic factors, consumer behaviour, access to information and ICT infrastructure, and how they influence an ICT framework for a circular e-waste economy by households in Nairobi. The coefficient of determination (R^2) and correlation coefficient (R), shows the degree of association between the selected factors and circular e-waste economy.

Table 4.33: ***Overall Model Summary***

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.796[a]	.633	.630	1.952

c. Predictors: (Constant), Consumer Behaviour, Access to information, ICT infrastructure, Socio-Demographics

The research findings indicated that there was a positive relationship (R= 0.633) between the variables. The study also revealed that 63.3% of the selected factors influence an ICT framework for circular e-waste economy by households in Nairobi. From this study, the variables produce statistically significant values and can be relied on to validate the effectiveness of ICT framework on circular e-waste economy by

households in Nairobi. Table 4.34 shows the results of ANOVA test which revealed that the combined independent variables have a significant influence on ICT framework for circular e-waste economy by household in Nairobi.

Table 4.34: *Overall ANOVA*

Model	Sum of Squares	*df*	Mean Square	*f*	*p*
Regression	2495.851	4	623.963	163.725	.001[b]
Residual	1444.389	379	3.811		
Total	3940.240	383			

a. Dependent Variable: ICT Based Circular E-Waste Economy
b. Predictors: (Constant), Consumer Behaviour, Access to information, ICT infrastructure, Socio Demographics

According to Table 4.34, the F distribution of the data was given as F (4,379) *f*= 163.725, *p*=0.01. This shows that F-calculated was greater than the F-critical, and hence, there is a linear relationship between the independent variables and the dependent variable. In addition, the p-value was 0.001, which was less than the significance level (0.05); since F is greater than the F critical, this implies that the overall model was significant.

Table 4.35: *Overall Coefficients*

Model	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*
	B	**Std. Error**	***β***		
(Constant)	.617	1.012		.611	.001
ICT Infrastructure	.419	.028	.604	14.774	.001
Consumer Behaviour	.084	.020	.159	4.110	.001
Socio Demographics	.043	.040	.036	1.083	.280
Access to information	.105	.021	.174	4.987	.001

a. Dependent Variable: ICT Based Circular E-Waste Economy

The study found that the ICT infrastructure positively influenced the ICT framework for a circular e-waste economy when combined with other independent variables, β = .604, t = 14.774, p = .001. Consumer behaviour also had a positive influence on the ICT framework for a circular e-waste economy when combined with other independent variables, β = .159, t = 4.110, p = .001, access to information influence was, β = .174, t = 4.987, p = .001. Finally, socio-demographic factors influence was β = .036, t = 1.083, p = .280. Hence, the study concluded that when the selected factors are combined, consumer behaviour, access to information and ICT infrastructure had the most influence on the ICT framework for a circular e-waste economy. Socio-demographic factors were not a significant factor in the framework.

CHAPTER FIVE

DISCUSSION, SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The chapter summarizes the findings of the study, with specific reference to the objectives and research questions, used as units of analysis. Data was collected, interpreted, and the results of the findings were correlated with both empirical and theoretical literature available. The conclusion relates directly to the specific research questions. The recommendations were deduced from discussions and conclusion of the findings.

5.2 Discussions

This section discusses the effectiveness of converting e-waste into economically viable opportunity within the eco-system, through development and implementation of affordable and efficient e-waste management structures in Nairobi. The discussions are guided by the research questions. The discussion on how the study findings were related to existing theory and empirical studies in the study area is also given.

5.2.1 Influence of Socio Demographic Factors Influence on the Circular E-waste ICT Framework

The study was able to establish a relationship between socio-demographic factors and the ICT framework for a circular e-waste economy, though at minimal levels. In terms of respondents' sex distribution in the study, both female and males were represented, even though females were higher compared to male. This implies that in terms of e-waste contributions both male and female contribute, from the analysis it showed that they all had similar views towards the study. On the other hand, most of the respondents who were the users of electronic gadgets were between the ages of 26-35 years followed by those of below 26 years. This implied that most of the e-waste

producers are youths as indicated in Table 4.10. The age distribution of the respondents as shown in Table 4.10 can be attributed to the fact that most of the electronic users are young in age. Therefore, they generate more e-waste.

The study also established that the majority of the respondents had attained post-high school education (college and university level education). In regards to the social-economic status, the study established that the middle-class income earners are majority of e-waste producers, agreeing with Anyango (2011). However, on the level of their competency in ICT, majority had above-average knowledge of ICT. This implied that most ICT users were conversant with the use of ICT products. This affirms Koloseni and Shimba assumptions.

In regards to the sources of acquiring electronic gadgets, the study established that most of the respondents acquired their electronics from retail stores, as new devices. Majority using their electronics between 3-4 years, concurring with Kalana (2010), who argues that most electronics are usually used for a period of up to 5 years. The study also affirmed Rimantho & Nasution (2016) findings that consumers preferred acquisition of the unused devices. Moreover, this study also showed the respondents were not aware of their responsibilities. Besides, most respondents did not separate e-waste from other waste streams. These findings concurred with other earlier studies which indicated that most households throw their e-waste into domestic waste bins (Arif & Afroz, 2014). In their study, they established that e-waste was not sorted before being disposed of, due to the lack of knowledge on how and where to dispose of WEEE in a hygienically safe manner. This corresponds with the information acquired from interviewing the key respondents.

5.2.2 Influence of Consumer Behaviour on the Circular E-waste ICT Framework

As for consumer behaviour, the study established that the respondents acknowledged e-waste was a major issue in Nairobi, backing the findings of Makana (2018); that Nairobi faces a serious challenge in waste management. The study also established that the respondents were not aware of their personal responsibilities. This can be attributed to lack of education of the public on the hazardous elements housed within their old electronics, and where to take their waste for recycling (Szczepanski, 2016).

Concerning the question of whether the initial cost affected the disposal method, the study established that the respondents agreed that it actually contributed to the duration of use, backing Kalana (2010) findings. Furthermore, incentives foster proper waste disposal, supporting the proposal that new incentives should be put in place to ensure the recyclers continue with their trade (Egerton, 2016). Thus, it further cements the sentiments made by the key informants in regards to e-waste consumer behaviour.

The findings showed that convenient collection points had an effect on the willingness of an e-waste consumer to partake in a circular economy. It was also noted that the availability of home collection points for e-waste boost household adoption of a circular economy. In addition, respondents were aware that segregation of e-waste from other waste at source improved the chances of maximum value extraction from the disposed of the product. This backs EU rules that encourage the separation of waste materials at the source. Ensuring that the quality and purity of collected waste can still be fed into the circular economy.

5.2.3 Influence of Access to Information on the Circular E-waste ICT Framework

The study found that access to information does influence the circular e-waste economy of the households in Nairobi. Awareness levels on issues regarding e-waste and a circular economy was established to be low amongst the respondents. Moreover, the respondents were not aware of the existing policies/laws and regulations regarding e-waste disposal. This means they could be caught on the wrong side of the law easily without knowing, affirming the sentiments of Arif & Afroz (2014). Lack of awareness also affects how respondents dispose of their e-waste. In addition, they were not aware of the benefits that can be accrued by the use of a circular economy for e-waste management. This affected the residual value of e-waste being discarded, hence hampering recycling efforts currently available.

The respondents confirmed that there is currently minimal use of ICT within the e-waste sector. This explains low levels of awareness on e-waste management and lack of information by the respondents, affirming Wagh (2018) and the Ministry of Environment of Japan (2012) view that there is a heavy reliance on ICT services for information on various issues. The respondents agreed that consumer awareness of end-of-life of products is vital in the recycling process. They also felt that EEE consumer feedback is vital for the adaptation and maintenance of an e-waste circular economy.

5.2.4 Influence of ICT Infrastructure on the Circular E-waste ICT Framework

It was found out that integrating ICT into e-waste management will increase the rate of adoption of a circular e-waste economy. Likewise, the convenience of ICT infrastructure affects the adoption of a circular e-waste economy. Similarly, the rate of recycling increases when the availability of e-waste drop-off recycling facilities is available via ICT platforms. Furthermore, an e-waste recycling reminder has a positive impact on ensuring constant practice. Thus, ICT Infrastructure should be able to sense,

collect and process useful information and disseminate to relevant stakeholders. It was also noted that the presence of ICT training programmes affects the adoption of ICT based e-waste circular economy. This concurs with Global Information Society Watch (2010) contention that the use of ICT acts as a bridge that connects technology policymakers with implementers, hence ensuring the availability of information and knowledge to stakeholders.

The findings also established that adoption of an ICT framework will lead to a significant reduction in the levels of e-waste within Nairobi. This will enhance e-waste awareness levels of households in Nairobi. Moreover, it will have an effect on resources sustainability and an impact on the value chain for electronic products, backing the arguments by Egerton (2016), Szczepanski (2016), and Faiza, Ishaq, Hussein, and Stella (2016).

5.3 Summary of Main Findings

This study sought to evaluate how the selected factors influenced ICT framework for circular e-waste economy by households in Nairobi. In this regard, an assessment of the influence of socio-demographic factors on an ICT framework for a circular e-waste economy was vital. It was also necessary to examine the influence of consumer behaviour on an ICT based circular e-waste economy. Evaluation of how the level of access to information influences an ICT based circular e-waste economy was also considered. The influence of an ICT infrastructure on a circular e-waste economy was assessed.

The findings revealed that social demographic factors such as age, level of income, education, among others, have an influence on the utilization of electronics. According to the findings, most electronic users were youths (aged 35 years and below), who had attained post-high school education, and were middle-income earners.

Generally, most of this age group bracket tend to have a higher available disposable income which may account for more EEE consumption.

Consumer behaviour was determined as a crucial factor to consider when coming up with an effective framework that tackles e-waste management. Nairobi faces a serious challenge in waste management, this can, however, be improved by EEE manufacturers offering incentives, WEEE collections points and consumers segregating waste at source. The findings also revealed that access to information contributed to the use of ICT products. However, most users were unaware of the laws and regulations in regard to their disposal procedures upon reaching its end-life. On the same note, the findings also revealed that most of the users had an above-average level of competency in the use of ICT products, hence the need to engage them in training programmes. ICT infrastructure is vital for the adoption of an e-waste circular economy. Integrating ICT will help significantly to set up and maintain an effective and efficient e-waste management system.

5.4 Conclusion

The research questions were tested and outcomes confirmed that the selected factors positively influenced the ICT framework for a circular e-waste economy, with the following specific conclusions:

(i.) Socio-demographic factors can influence how Nairobi households are able to adapt to an ICT e-waste circular economy framework.

(ii.) As regards to consumer behaviour, EEE consumers can directly or indirectly shape the ICT framework for a circular e-waste economy.

(iii.) The more information the households have on e-waste, the higher the rates in which they will be able to dispose off their e-waste properly.

(iv.) Integration of ICT into e-waste management has a significantly positive effect, increasing the circular e-waste economy success rate.

5.5 Recommendations

Based on the study's findings, discussions and conclusions, the following recommendations for improvement were made;

In view of the fact that youth (under age of 35) are educated and have access to disposable income due to their socio-economic status, and are the majority EEE consumers, any policy that will be formulated, should in particular target them.

As most consumers have a financial and emotional attachment to the EEE devices that they acquire, manufacturers of the EEE devices should spearhead consumer responsibility through incentive methods such as; take-back policies, developing longer-lasting devices and reward schemes. Such incentives will motivate and assist in the collection and segregation of e-waste; ensuring maximum residual value and enhance unmixed collected waste. With time, this will alter how consumers behave towards e-waste as a whole.

As the access to information is an important prerequisite for a successful ICT based circular e-waste economy, the Nairobi County Government should create awareness programmes in collaboration with households. The main goal should be to continuously improve the rate of adopting best practices that enhance sustainable e-waste management. For a circular economy to be successful, the implementers and users of the system should be aware of the benefits that can be accrued from the whole process.

ICT and other technological advancements should be integrated into the e-waste management process fully, so as to seal all the existing loopholes that are currently there. This will, in turn, increase the adoption rate of a circular e-waste economy by the

ecosystem, and at the same time improve the dissemination of information to the local households, businesses, government and other related bodies.

As Nairobi has minimal e-waste collection points, the county government should establish collection points equally across the county, not pegged on the geographic and socio-economic status of households; as this was found to be a common problem. Furthermore, regulations and policies should be implemented to ensure that the established collection points are used effectively and efficiently. Additionally, the process after the collection should also be monitored to ensure full conformity to best practices.

5.6 Areas of Further Research

This study was only conducted within Nairobi County boundaries, limiting it to the localized area. Even though Nairobi is located near other towns and municipalities, they were excluded and not taken into account. Additionally, other studies should be conducted on the same subject area, in the general Nairobi Metropolitan area which includes the neighbouring counties such as Kiambu, Kajiado, Machakos. Similarly, in-depth studies should also be conducted to investigate ICT usage in Waste Management as a whole.

As this research focused mainly on the consumption and recycling, further research to accommodate the whole circular economy of e-waste management cycle is also necessary. Other categories of e-waste should also be included within the research. Thus, further research on how institutions and organizations use ICT to mitigate the e-waste challenge, looking more into how they are plugged into the whole circular economy and if it is beneficial, is indeed necessary.

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APPENDICES

Appendix A: Household Questionnaire

An evaluation of the selected factors that influences an ICT framework for a circular e-waste economy by households in Nairobi

Dear respondent,

My name is Shabaya Deche, an MSc in Applied IT student at Africa Nazarene University. I am carrying out a research for my thesis titled "An Evaluation of the Selected Factors that Influences an ICT Framework for a Circular E-Waste Economy by Households in Nairobi". I am hereby inviting you to participate in this survey, through completion of this questionnaire. Information collected is purely for academic purposes and will be treated in confidence.

I realize how precious your time is. That's why I made sure this survey will only take a quick 5 minutes to complete.

*Required

Section A: Background Information

1. **What is your gender?** * *Mark only one oval.*
   - ◯ Female
   - ◯ Male

2. **What is your age?** * *Mark only one oval.*
   - ◯ 25 or younger
   - ◯ 26-35
   - ◯ 36-45
   - ◯ 46-55
   - ◯ Over 56

3. **What is your highest level of education?** * *Mark only one oval.*
   - ◯ Did not attend school
   - ◯ Primary school
   - ◯ High school
   - ◯ College
   - ◯ University

4. **What is your socio-economic status?** * What is your monthly household income status? Lower income (less than 25k, middle income between 25k – 150k, upper income more than 150k) *Mark only one oval.*
   - ◯ Lower income
   - ◯ Middle income
   - ◯ Upper income

5 **What is your competence in the use of ICT based services?** * *Mark only one oval.*
   - ◯ Beginner
   - ◯ Casual
   - ◯ Expert

Section B: WEEE Information

6. **Which of the following sources do you use to acquire your electronic products?** * *Tick all that apply.*
   - ☐ Retail stores
   - ☐ Online platforms
   - ☐ Hand me down
   - ☐ Street sale

7. **What was the condition of the electronic product bought?** * *Mark only one oval.*
   - New
   - Slightly used

Refurbished
Damaged
Old

8. **What is the average length of use before discarding or replacing an electronic product (in years)?** * *Mark only one oval.*
   - ◯ Less than 2 years
   - ◯ 3-4
   - ◯ 5-6
   - ◯ 7-8
   - ◯ Over 9 years
9. **Are you aware of electronic waste? Its cause, benefits, challenges and hazard** *

   Electronic waste is any refuse created by discarded electronic devices and components as well as substances involved in their manufacture or use. *Mark only one oval.*
   - ◯ Aware
   - ◯ Not Aware
   - ◯ Maybe Aware
10. **Do you separate E-Waste from other waste streams?** * *Mark only one oval.*
    - ◯ Yes, I do separate
    - ◯ No, I do not separate
    - ◯ Maybe I separate

Section C: How consumer behaviour influences an ICT framework for a circular e-waste economy

Kindly indicate your level of agreement with the statements provided, using a scale of 1-7 (1 being strongly disagree and 7 being strongly agree)

11. **E-waste is a major issue in Nairobi** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

12. **I am aware of the personal duty that is needed in having a proper e-waste management system.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

13. **The initial cost of an electronic product affects the disposal method used.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

14. **The emotional attachment affects how soon a person releases a product as e-waste.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

15. **Offering an incentive fosters motivation for proper e-waste disposal.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

16 **Availability of home collection for household e-waste boosts households' adoption of a circular economy.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

17. **Convenience of the collection point has an effect on the willingness of an e-waste consumer to partake in a circular economy.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

18. **Segregation of e-waste from other waste at source improves the chances of maximum value extraction from the disposed products** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Section D: How access to information influences an ICT framework for a circular e-waste economy

Kindly indicate your level of agreement with the statements provided, using a scale of 1-7 (1 being strongly disagree and 7 being strongly agree)

19. **I am not aware of existing policies / laws and regulations regarding e waste disposal.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

20. **I am not aware of the benefits of using a circular economy for e-waste management.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

21. **ICT currently is not being used to improve e-waste awareness amongst households.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

22 **It is not easy to gain information on e-waste management best practices.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

23. **E-waste recycling information will have an effect on the adoption of a circular e-waste economy.** *
Mark only one oval.

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

24. **Consumer awareness on electronic end-of-life is important for the successfulness of ewaste recycling** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

25. **A take back policy introduction on electronic products will reduce the e-waste levels in Nairobi.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

26. **Providing feedback on e-waste management is important to facilitate the practice of a circular e-waste economy.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Section E: How the ICT infrastructure influences an ICT framework for a circular e-waste economy

Kindly indicate your level of agreement with the statements provided, using a scale of 1-7 (1 being strongly disagree and 7 being strongly agree)

27. **Intergrating ICT into e-waste management will increase the rate of adoption of an ICT based circular e-waste economy.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

28 **Convenience of the ICT infrastructure affects the adoption of a circular e-waste economy.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

29. **Rate of recycling increases when the availability of e-waste drop-off recycling facilities are available via ICT platforms.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

30. **An E-waste recycling reminder has a positive impact in ensuring the constant practice.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

31. **ICT infrastructure should be able to sense, collect, and process useful information and share that to all relevant stakeholders.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

32. **The presence of IT training programs will affect the adoption of an ICT based e-waste circular economy.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Section F: How an ICT framework will influence a circular ewaste economy

Kindly indicate your level of agreement with the statements provided, using a scale of 1-7 (1 being strongly disagree and 7 being strongly agree)

33. **It will lead to a significant reduction in the levels of e-waste within Nairobi.**
* *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

34 **It will improve on the e-waste awareness levels of households in Nairobi.**
* *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

35. **It will have an effect on the available resources sustainability.**
* *Mark only one ov al.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

36. **It will have an impact on the value chain for electonic products.** * *Mark only one oval.*

	1	2	3	4	5	6	7	
Strongly disagree	◯	◯	◯	◯	◯	◯	◯	Strongly agree

Appendix B: Questions for Government Officials and E-Waste Body Officials

1) What are the policies in place for e-waste management in Kenya?
2) Are there flaws to these policies?
3) Have companies and the general population complied to these set policies?
4) What is your perception of public awareness of the policies in place on e-waste management?
5) Which other countries should Kenya look to as models of e-waste management?
6) Do you think it would be viable to support the informal sector's role in waste management (while providing for safer practices)?
7) Is there a role an e-waste circular economy can play to mitigate the current challenge?
8) How can ICT be used in e-waste management?

Appendix C: Questions for Formal and Informal Recyclers

1) From where and from whom do you collect unused electronics?
2) Do you collect unused electronics are repairable or reusable, or are they purely waste?
3) What do you do with unused electronics that are functioning?
4) What do you do with unused electronics that are not functioning?
5) For defective electronics, what components or materials are most valuable to you?
6) Do you interact with electronics producers? If so, please describe your interactions.
7) Do you think the government should do anything to assist you in your work?

Appendix D: Map of Study Area - Nairobi County of Kenya

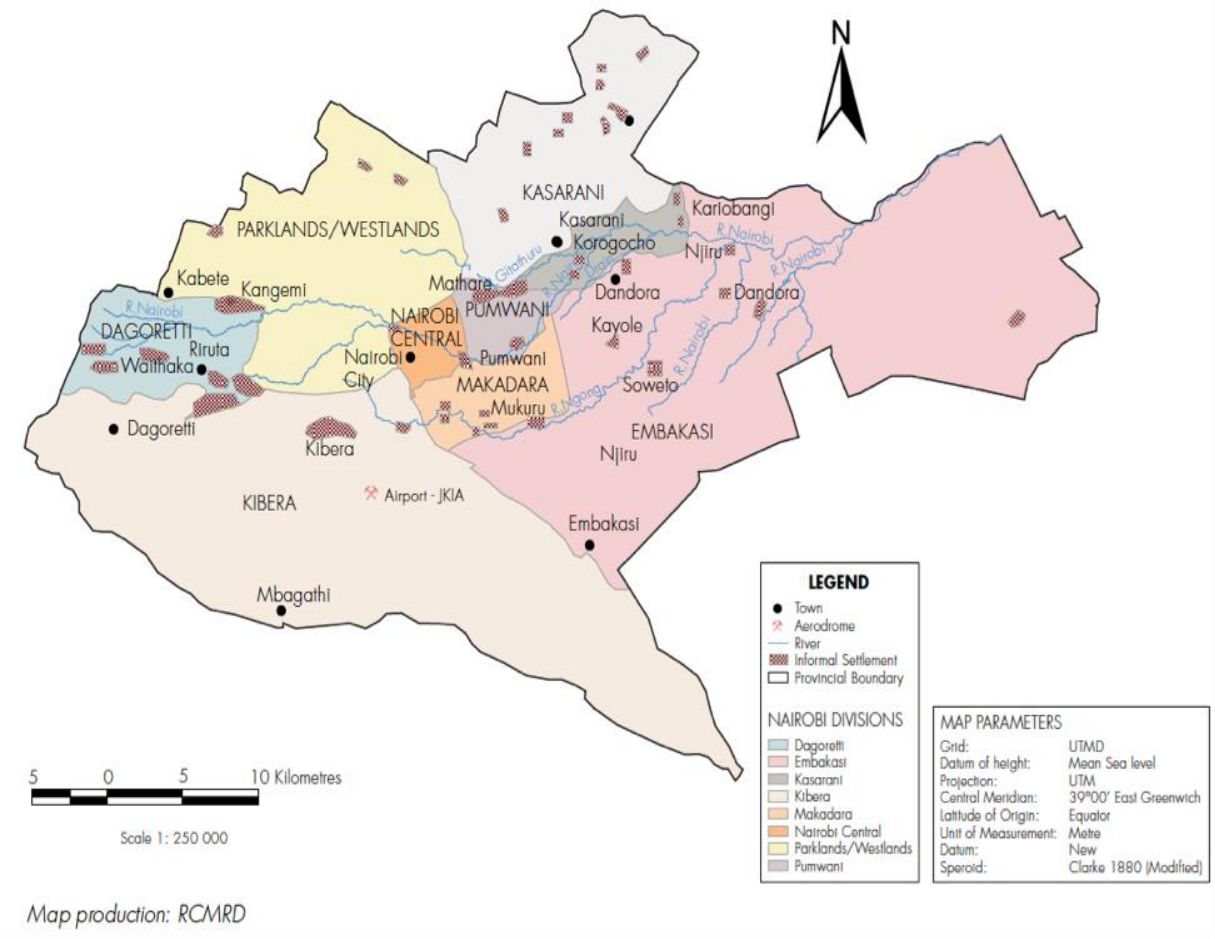


Figure 6.1: ***Map:*** **Nairobi County**

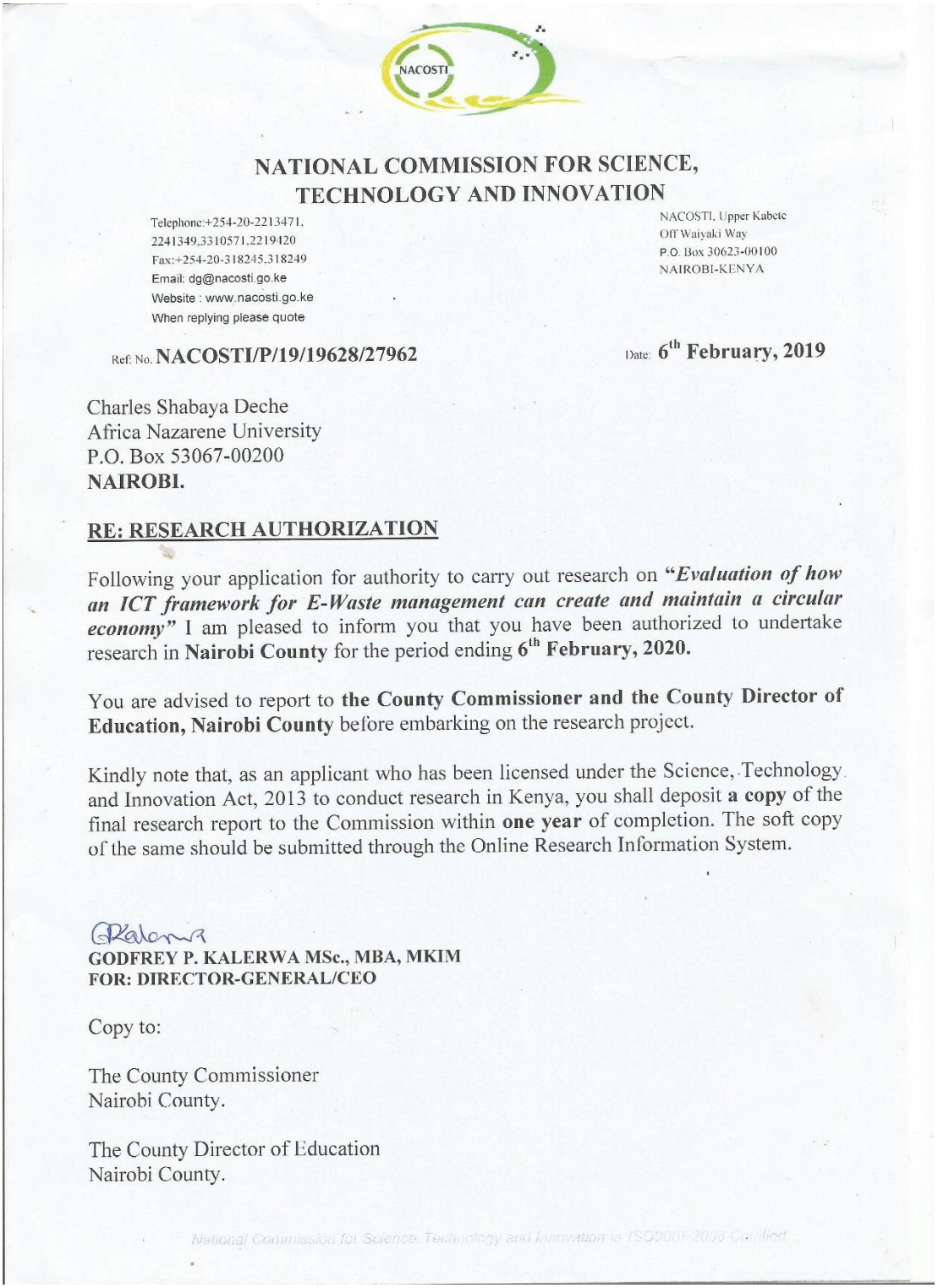
Appendix E: Krejcie and Morgan (1970) Formula

N	*S*	*N*	*S*	*N*	*S*
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

Appendix F: Research Authorization



NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/19628/27962**

Date: **6th February, 2019**

Charles Shabaya Deche
Africa Nazarene University
P.O. Box 53067-00200
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Evaluation of how an ICT framework for E-Waste management can create and maintain a circular economy"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for the period ending **6th February, 2020.**

You are advised to report to **the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

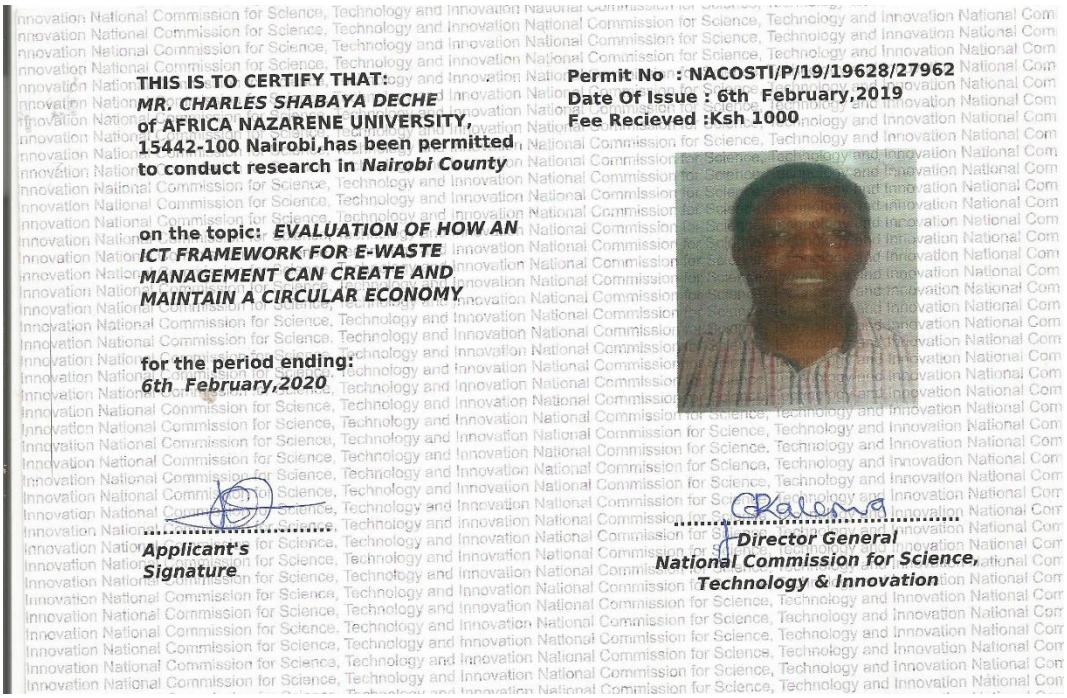
Copy to:

The County Commissioner
Nairobi County.

The County Director of Education
Nairobi County.

National Commission for Science, Technology and Innovation is ISO9001:2008 Certified

Appendix G: Research Permit



THIS IS TO CERTIFY THAT:
MR. CHARLES SHABAYA DECHE
of AFRICA NAZARENE UNIVERSITY,
15442-100 Nairobi,has been permitted
to conduct research in *Nairobi County*

on the topic: *EVALUATION OF HOW AN ICT FRAMEWORK FOR E-WASTE MANAGEMENT CAN CREATE AND MAINTAIN A CIRCULAR ECONOMY*

for the period ending:
6th February,2020

Permit No : NACOSTI/P/19/19628/27962
Date Of Issue : 6th February,2019
Fee Recieved :Ksh 1000