E-WASTE MANAGEMENT IN KENYA: A CASE STUDY OF MOBILE PHONE WASTE IN NAIROBI

BY

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A PROJECT REPORT SUBMITTED IN PARTIAL FUFILMENT OF THE REQUIREMENTS OF MASTER OF ARTS IN ENVIRONMENTAL PLANNING AND MANAGEMENT AT THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES, UNIVERSITY OF NAIROBI.

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DECLARATION

This project report is my original work and it has never been submitted for examination in any other University

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To my wonderful parents, Joseph and Edna, my beloved husband Ken and my siblings who are my inspiration, motivation, encouragement and strength.

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Any errors or omissions in this research paper, if any, are mine.

Eunice Cherutich
University of Nairobi, October 2013

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
ATM	Automatic Teller Machine
AT&T	American Telephone and Telegraph Company
BAN	Basel Action Network
BFR	Brominated Flame Retardants
CCK	Communication Commission of Kenya
CEC	Commission of the European Communities
CFSK	Computers for Schools Kenya
CIVIDEP	Civil Initiatives for Development and Peace
CoP	Conference of Parties
CSR	Corporate Social Responsibility
CRT	Cathode Ray Tube
DEC	Digital Equipment Corporation
DfE	Design for Environment
EACR	East African Computer Recycling Centre
EC	European Commission
EEE	Electrical and Electrical Equipment
EMCA	Environmental Management and Coordination Act
EoL	End of Life
EPR	Extended Producer Responsibility
ESD	Electrostatic Discharge
EU	European Union
GCC	Global Commodity Chain
GDP	Gross Domestic Product
GPN	Global Production Network
GVC	Global Value Chain
HIV	Human Immunodeficiency Virus
HP	Hewlett-Packard
IBM	International Business Machines
ICT	Information and Communication Technology
IT	Information Technology
JICA	Japan International Cooperation Agency

KEBS	Kenya Bureau of Standards
KNBS	Kenya National Bureau of Statistics
KPA	Kenya Ports Authority
KRA	Kenya Revenue Authority
LCD	Liquid Crystal Display
LG	Life's Good
MPPI	Mobile Phone Partnership Initiative
MRC	Medical Research Council
NEC	Nippon Electric Company
NEMA	National Environment Management Authority
NHIF	National Hospital Insurance Fund
NGOs	Non-Governmental Organisations
NSL	Nokia Substance List
PCBs	Printed Circuit Boards
PPEs	Personal Protective Equipment
PRO	Producer Responsibility Organisation
PVC	Polyvinyl Chloride
PWBs	Printed Wiring Boards
RFR	Restricted Flame Retardants
RoHS	Restriction of the use of Certain Hazardous Substances
R&D	Research and Development
SGS	Société Générale de Surveillance
SMS	Short Message Service
SPSS	Statistical Package for Social Scientists
SSA	Sub-Saharan Africa
UNEP	United Nations Environmental Programme
UNICEF	United Nations Children's Fund
UNU	United Nations University
WEEE	Waste Electrical and Electronic Equipment Directive

ABSTRACT

This study focused on the management of mobile phone E-waste in Nairobi, Kenya. The mobile phone sub-sector in Kenya has been recording a phenomenal increase in the number of mobile phone users, which continues to act as a stimulant for growth in other sectors of the economy. Mobile phone users rose from 24.9 million in 2010 to approximately 28 million in 2011, which means that the volume of mobile phone E-waste produced increased by a similar margin. Global production network (GPN), which involves companies outsourcing their production to low-cost countries while retaining their core business has been taking place in Kenya leading to both economic and social upgrading. Economic upgrading is the process where firms and workers move from low-value to high-value activities in GPN while social upgrading is the process of improvement in the rights and entitlement of workers as social players.

This study therefore sought to: (i) map out the mobile phone GPN in Kenya; (ii) investigate the social and economic upgrading that has taken place in the mobile phone GPN in Kenya; (iii) examine the E-waste policy framework on mobile phones in Kenya; and (iv) interrogate the link between Nokia's design for environment (DfE) and the end of life (EoL) practices of mobile phones in Kenya. Both primary and secondary data collection was undertaken. Different methods were utilized to collect primary data. They include key informant interviews, questionnaire surveys and case studies. The study targeted stakeholders in the mobile phone sector who include government agencies, mobile phone manufacturers, mobile phone network operators and owners and workers of repair shops.

The research indicates that the mobile phone GPN in Kenya includes post consumption activities where mobile phone E-waste are recycled and exported. The findings showed that both economic and social upgrading is occurring in Kenya. Social upgrading was evident since the mobile industry has employed many people directly and indirectly. Economic upgrading was also evident since the mobile phone industry in Kenya is the leading source of government revenue through tax. It has also led to the use of several mobile phone applications that include m-agriculture, m-commerce, m-education, m-governance, and m-health.

The research paper emphasizes the need to develop an E-waste management policy and regulations, which will aid in the management of mobile phone E-waste. There is a need for Nokia to design a system that will sensitize users to bring back their EoL phones to the appropriate collection points. The National Environment Management Authority (NEMA) on the other hand should educate the public on the hazardous materials found in E-waste and how it will affect their health, water, environment and overall food chain. Further research on the link between economic and social upgrading and on the operations of exporters of printed circuit boards (PCBs) should be undertaken.

CHAPTER 1: BACKGROUND OF THE STUDY

1.1 Introduction

The mobile phone sub-sector is one of the fastest growing sub-sectors in the telecommunication industry, gradually substituting fixed telecommunication service. Over the last two decades, the mobile phone industry has transformed from a national monopoly system providing a simple voice service to a global industry serving over four billion mobile phone users. Until the early 1990s, mobile phones were a privilege of developed nations and most of the users were clustered in the United States (US), Europe and the affluent parts of Asia. Currently, the majority of mobile phones are produced in China, India and other emerging economies and mobile phone users in least developed countries are growing faster than in any part of the world (Lee and Gereffi, 2010). According to Rao (2011), there were more than 500 million mobile phone users in Africa in March 2011. The biggest mobile phone markets in Africa are Nigeria, Egypt, South Africa, Kenya, and Ghana.

Kenya has not been left behind in the rapid growth in the mobile phone subscription. The mobile phone sub-sector has been recording a phenomenal increase in the number of mobile phone users that continues to act as a stimulant for growth in other sectors of the economy (Communication Commission of Kenya (CCK), 2008). This is because mobile phones are not just tools of communication but have taken a new meaning altogether. They are used as cameras, recorders and computers. Lower rates of communication coupled with the reduced prices of mobile phones have made mobile phone communication accessible to many Kenyans in almost all regions of the country. Another service offered through the mobile phone is the money transfer services. These include Airtel money, M-Pesa, Orange money and Yu cash with M-Pesa being the most popularly used money transfer service in Kenya. Mobile phones are also increasingly being used for internet services and entertainment (e.g. access to radio stations). This improvement in mobile use and easy accessibility has resulted in the increased use of mobile telephones over fixed lines.

Since CCK issued Safaricom and Kencell licenses in 2000, the mobile phone users have increased from 114, 000 to 28,080,771 in December 2011 (CCK, 2011). This means that the volume of E-waste produced from mobile phones increased by a similar margin. The United Nations Environmental Programme (UNEP) estimates the current E-waste generated in Kenya to be 150 tons from mobile phones (UNEP and United Nations University (UNU),

2009). Upon their end of life (EoL), they produce complicated multi-material waste with different proportions of metals, plastics and glass (National Environment Management Authority (NEMA), 2007). With this, the problem of safe disposal of E-waste becomes a difficult task.

The best practice for mobile phone E-waste management involves a combination of proper management practices, legislation and education. Proper management practices include inventory, collection and segregation, product reuse, recycling and disposal. Legal framework on the other hand provides an implementation and management model for E-waste handling and minimization, disposal, setting up of goals and standards, allocation of responsibilities and identification of penalties. E-waste best management practices also consider research and development and awareness and education.

Globalization of production has stimulated changes in most developing and developed countries, creating new opportunities and challenges for their firms and workers. Global production networks (GPNs) are characterised by companies outsourcing their production to inexpensive locations in developing countries, while retaining control over production in the higher value added areas of their core competency. Involvement in GPNs has implications both economically and socially for developing country firms and their workers. It can bring increased knowledge and value addition in production, provide employment opportunities to workers, but may also increase pressure on production and labour costs (Rossi, 2011).

Economic upgrading is defined as the process by which firms and workers move from low-value to relatively high-value activities in GPNs (Gereffi, 2005). Social upgrading is the process of improvement in the rights and entitlements of workers as social actors, and enhances the quality of their employment (Sen, 2000). This includes access to better work, enhanced working conditions, protection and rights. According to Lee and Gereffi (2010), mobile phone GPN generally entails the following key domains:

- raw material sourcing;
- hardware manufacturing;
- software development;
- sales and marketing;
- mobile service provision and use; and
- after-use.

This study explored the economic and social upgrading in the context of GPNs that has occurred in the mobile phone sector in Kenya. The study concentrated on the after-use domain and examined the chain of travel of mobile waste in Nairobi once it reaches its EoL and the actors involved in the chain. The study also developed knowledge on employment and wellbeing of workers operating in mobile phone repair shops in Nairobi.

The most commonly used mobile phone brand is Nokia, which is the world's largest manufacturer of mobile phones. However, its global mobile phone volume market share decreased from 34% in 2009 to 32% in 2010 (Nokia Corporation, 2010). In Kenya, the Nokia handset is used by majority of the people at 88%, followed by Motorola (8%), Samsung (2%), Siemens and others (2%) (Ogembo, 2010). The market share in Kenya has also been declining and stood at 57% in 2012.

Other mobile phone users use second hand mobile phones that are imported from countries like Europe and Asia. According to CCK (2010), there is a growing demand for second hand mobile phones in Kenya. These imports mean that Kenya is prone to dumping. These phones have a short lifespan and need frequent upgrading to the latest models, and in the process contribute to increasing volumes of E-waste. Due to lack of enforcement of legislation regarding E-waste exports, large quantities of used and sometimes obsolete electronics have been sent to developing countries (Li *et al,* 2006). Under the Basel Convention that governs the movement of hazardous substances, this trade in second hand electronics is illegal.

Mobile phones contain heavy metals such as mercury and other toxic elements that make them unsuitable for land filling. Open burning of mobile phones releases dioxins and furans (Hageluken, 2007). If the mobile phones or the information and communications technology (ICT) equipment end up in landfills or dumpsites as is the case in many African countries, they can cause long term pollution of the environment including ground water and soil; and they could also have serious effects on human health. It is therefore crucial to address the EoL management of mobile phones so as to ensure that these products do not end up in landfills and dumpsites.

Kenya in its attempt to address the E-waste problem came up with E-waste management guidelines developed by the Ministry of Environment and Mineral Resources through NEMA. These guidelines point out how to handle the various types of E-waste including their transportation, sorting, treatment, recycling, re-use and disposal. The purpose of these guidelines is to provide a basis for the development of E-waste regulations and an E-waste policy in Kenya (Ministry of Environment and Mineral Resources, 2010).

Nairobi has a thriving electronics repair market. About 75% of EoL electronics received by these electronic repair shops are neither repairable nor usable and are simply dumped and/or burned at dumpsites (NEMA, 2007). Informal mobile phone repair shops in Nairobi buy EoL phones for spare parts. The number of repair shops in Kenya include ten formal repair shops and 2,000 to 4,000 informal repair shops (Rowley, 2009).

In an effort to manage mobile phone E-waste in Kenya, Safaricom a mobile phone network operator and Nokia came up with mobile phone take back schemes. Safaricom's mobile phone take back scheme was put in place to encourage the culture of recycling and reusing of products, gain a competitive edge, effect efficient resource use and practice environmental consciousness. The take back scheme has however not been successful due to poor response from the mobile phone users who did not return the EoL phones as was expected. It was noted that mobile phone users expected to be given incentives to return their EoL phones. Lack of awareness on the part of mobile phone users has also resulted in many EoL phones being kept at homes and repair shops. Other factors include lack of mandatory collection schemes and competition from mobile phone repair shops that use the EoL phones to meet the demand for secondhand phones. To remedy this, in 2007, Safaricom partnered with Computers for Schools Kenya (CFSK), a non-governmental organization to undertake recycling of mobile phones. During the pilot project, Safaricom and CFSK were able to collect 300kgs of EoL mobile phones. Collection points were placed in Safaricom shops and Nakumatt outlets. They got all types of phones, which they dismantled and separated into plastics and printed circuit boards (PCBs) that were later sold to recyclers. Computers for Schools Kenya was established in 2002 with a goal of empowering the youth and communities for life in the information age through establishing ICT infrastructure and capacity building. In 2007, CFSK established a Waste Electrical and Electronic Equipment (WEEE) centre to handle electronic waste especially from computers. Computers for Schools

Kenya collects, refurbishes and redistributes used computers to Kenyan schools. Computers for Schools Kenya have managed to give 50,000 computers to approximately 2500 institutions i.e. primary schools, secondary schools, community centres and universities at a subsidized rate. The centre also provides an opportunity for corporate organizations to dispose off their electronic waste in an environmentally friendly manner. The centre, which was set up at a cost of Kshs 3.8 million, is situated in Nairobi's Embakasi area. The main office is in Nairobi, Embakasi but CFSK has branches in Kakamega, Kisumu, Machakos, Mombasa, Meru, Nakuru and Nyeri.

Nokia East Africa also has a mobile phone take back scheme aimed at convincing mobile phone users to recycle their EoL mobile phones instead of trashing them. This has made it easy for the mobile phone users to return EoL mobile phones and accessories to an authorized service vendor. It was launched in Kenya in 2008 and covers the Eastern African countries of Kenya, Rwanda, Somalia, Tanzania and Uganda. The mobile phone users are required to drop off their EoL mobile phones at designated Nokia collection centers. Nokia has six collection points in Kenya i.e. four in Nairobi and one each in Kisumu and Mombasa respectively. The EoL mobiles and accessories are then sent to Europe for recycling. By 2008, only 3% of mobile phone users were able to recycle their mobile phones despite the fact that most of them had EoL phones in their home that they no longer use. Another 48% did not know that a phone could be recycled and 66% did not know how to recycle them (Nokia, 2010). This is despite the fact that 65% to 80% of a mobile phone can be recycled (Nokia Corporation, 2008). This lack of awareness has hampered Nokia's mobile take back scheme. Nokia is running a major training and awareness program designed to ensure that those working in care centers operated on behalf of Nokia take back EoL mobile phones and can advise mobile phone users on recycling. It is also investing in putting more take back bins and collection points at these care centers.

Nokia is also implementing Design for Environment (DfE) that aims at improving the impact of their products throughout their entire lifecycle. The four objectives of DfE are integrated into the entire process of product development. They include: (i) minimizing material and energy use; (ii) minimizing the use of materials detrimental to the environment; (iii) maximizing reuse and recycling; and (iv) designing equipment to be easily or remotely

maintainable or maintenance free. This Nokia's initiative to reduce the materials used in manufacturing mobile phones hence a reduction of E-waste was thus investigated.

1.2 Statement of the research problem

Kenya is experiencing an ICT evolution as it moves towards becoming part of the global information society. With this, the quantity of ICT equipment continues to grow rapidly with mobile phones becoming an indispensable part of Kenyans daily lives. Approximately 28 million Kenyans' have access to mobile phones and this is now playing a huge role in the development of the Kenyan economy. The growth of mobile phones has also been witnessed in rural areas. This is attributed to the ease of carrying them, availability of cheap mobile phones, reduced calling rates and mobile money transfer services. Mobile phones are also replacing computers as most people use mobile phones to access internet unlike before where people had to go to cyber cafes. Mobile phones have also led to increased consumer choice even for very low income customers through cheap handsets and low denomination top-up cards.

The increase in the mobile phone users depends to a large extent on the secondhand mobile phone market. This has led to importation of secondhand phones into Kenya. With this, Kenya is exposed to dumping of near EoL mobile phones. This is due to the lack of enforcement on existing legislation governing the importation of secondhand electronics (Munyua, 2010). The reality is that even with the Basel Convention prohibiting the transfer of hazardous waste internationally, hundreds of containers filled with near EoL secondhand phones continue to be shipped into Kenya because of the high demand for such low-cost mobile phones. The rapidly changing standards and the rapid evolution of technologies mean that even the best of these shipments are not always useful, and are too often used as an excuse to dump unwanted goods (Munyua, 2010).

Given that the lifespan of mobile phones has been reducing from 3-4 years to around 18 months, the mobile phone users desire to keep up with latest handsets and technological change, the problem of mobile phone E-waste has accelerated. Poorly disposed mobile phones can result in severe health and environmental hazards due to toxins that include heavy metals and poisons such as arsenic, lead, and mercury. They also contain substances that are amongst the ten most dangerous known to human kind i.e. cadmium, rhodium, palladium,

beryllium and lead solder which may end up in landfill sites or water bodies. These toxins are found in the different components of a mobile phone, which include plastics (58%), metals (25%), ceramics (16%), flame retardant (1%) and trace materials. These contents vary from model to model, and as the technology advances there will be changes in their composition (Sahu and Srinivasan, 2008).

In its attempt to manage E-waste effectively, NEMA released E-waste guidelines in 2010. Chapter four of the guidelines categorizes mobile phones as E-waste from ICT and telecommunications equipment. The guidelines include requirements on how to handle the various types of E-waste including transportation, sorting, treatment, recycling, re-use and disposal. The guidelines have been developed with the strategic objective of providing a framework for the development of regulations and policies in Kenya. It is important to note that the guidelines only provide a basis for the development of E-waste regulation and an E-waste policy in Kenya. The National Environment Management Authority has noted that the guidelines have not helped in addressing poor disposal of EoL mobile phones and believes that a policy will help in dealing with the problem.

The repair costs of mobile phones are often too high when compared to the phone's value (Nokia, 2008). This does not give recycling companies incentives to recycle them as they cannot make a profit. This magnifies the problem of recycling keeping in mind that there is lack of a safe recycling infrastructure in the formal sector for recycling mobile phones. This has led to reliance on the informal sector which may pose severe risks to the environment and human health.

Global production networks from developed to developing countries have become a staple of our times. However, the implications that participation in mobile phone GPNs has on Kenya's firms and workers is not well documented. One question that is crucial to address is how participation in mobile phone GPNs impact Kenya's firms and workers. There is no conclusive evidence on whether participation in GPNs in itself is beneficial or detrimental for workers. In order to fully understand the intricacies related to mobile phone GPNs in Kenya, it is critical to analyse the dynamics of working conditions of workers in repair shops in order to understand how to exploit the potential of economic upgrading to bring about social upgrading.

1.3 Research questions

The specific questions that were addressed in this study are:

1. Who are the main actors within the GPN of mobile phones in Kenya?
2. What are the current mobile phone E-waste management practices in Kenya?
3. What are some of the social and economic upgrading taking place in the mobile phone GPN in Kenya?
4. What is the existing E-waste policy framework dealing with mobile phones in Kenya?
5. What is the link between Nokia's DfE and the end of life practices of mobile phones in Kenya?

1.4 Objectives of the study

The overall objective of this study was to examine the mobile phone GPN in Kenya. More specifically the study attempted to achieve the following objectives:

1. To map out the mobile phone GPN in Kenya.
2. To study the current mobile phone E-waste management practices in Kenya.
3. To investigate the social and economic upgrading that has taken place in the mobile phone GPN in Kenya.
4. To examine the E-waste policy framework on mobile phones in Kenya.
5. To interrogate the link between Nokia's Design for Environment (DfE) and the end of life practices of mobile phones in Kenya.

1.5 Assumptions

A number of assumptions are associated with this research. First, the repair shops are concentrated in the downtown areas of Nairobi central business district. Second, Kenya is not managing its mobile phone E-waste properly. Third, GPN is a desirable approach for understanding the production network of mobile phone E-waste. Four, to deal with mobile phone E-waste situation positively, the future direction will be towards repair and recycling of mobile phones. Finally, employing DfE will help in maximizing reuse and recycling of mobile phone E-waste.

1.6 Justification

This study focused on E-waste management regarding mobile phones. The study was informed by the fact the mobile phone industry is the fastest growing sector in the Kenyan economy. In 2011 the contribution of the mobile sector to the Kenyan economy represented over 5.6% of gross domestic product (GDP), and up to a further a 1.9% from intangibles (social benefits) (Deloitte LLP, 2011).

Kenya's ICT evolution has led to increased growth in the mobile phone sector and subsequent increase in the number of mobile phones in the market. However, Kenya has not yet created a policy framework nor has it established environmentally safe disposal methods to keep pace with the ever changing technology. The innovation in most cases is changing must faster than the rate at which regulations are drawn. Subsequently, large amount of mobile phone E-wastes are generated and their negative environmental impacts may undermine any attendant gains if mobile phone E-waste is not well managed.

The study area (Nairobi City) was chosen because it has the highest number of mobile phone users in the country. According to the 2009 census, 88.3% of the households in Nairobi own mobile phones against the country's overall percentage of 63.2% (Kenya National Bureau of Statistics (KNBS), 2010a).

The study focused on Nokia handsets since statistics show that Nokia phones are the most widely used phones in Kenya. Nokia's phone market share in 2012 stood at 57%. The reason for this is that Nokia phones have easy to use features and the cost is reasonable (Ogembo, 2010). This means therefore that Nokia has a similar percentage of E-waste in the Kenyan market. The rationale for focusing on Nokia is also because of the mobile take back scheme initiated by Nokia to encourage mobile phone users to recycle their EoL mobile phones. Further, Nokia's is implementing DfE that aims at minimizing material use and maximizing recycling.

Economic and social upgrading in the mobile phone GPN was studied because of the number of jobs that have been created by the mobile phone GPN in Kenya especially in the service provision and mobile phone applications. The mobile phone contribution to employment in Kenya has grown considerably over time, from just under 60,000 jobs in 2003 to almost

250,000 in 2011 (Deloitte LLP, 2011). There are also a number of repair shops that have been established in Nairobi that helped in developing knowledge on employment and wellbeing of workers operating in mobile phone repair shops in Nairobi.

1.7 Scope and limitations

The scope of this study was limited to mobile phones. This is despite the fact that E-waste includes a broad range of electronic equipment. The choice of the mobile phone was based on the fact that the mobile phone industry is one of the fastest growing industries in Kenya. Ideally, the study should have examined the E-waste from all types of electronic equipment in Kenya. However, given the financial and time resource constraints, this was not possible. The study's geographical boundary was limited to Nairobi City. This is because the problem of E-waste generation is more concentrated in the capital. In order to make general assumptions about mobile phone E-waste, this study focused on Nokia phones instead of all models of mobile phones being used in Kenya. Ideally, this study should examine all the five key domains of mobile phone GPN. However, the study limits itself to investigating the after-use domain.

The researcher experienced some challenges while undertaking this study. First, it was hard to trace the E-waste dealers since they do not have a specific work area. However, a middleman assisted the researcher in locating the E-waste dealers who then helped in locating the rest of the E-waste dealers. Secondly, it was difficult to acquire information on the PCB exporters and the researcher relied on information from a middleman, repair shops and E-waste dealers.

Thirdly, it was difficult to map out the post consumption treatment of E-waste especially the PCBs since most of them are exported. This means therefore that the researcher could not accurately establish what happens to the PCBs which are exported. To remedy this, the researcher visited CFSK which is an established E-waste centre that exports PCBs to Belgium. Finally, some of the owners and workers in the repair shops were either unavailable or unwilling to be interviewed. These repair shops were therefore replaced in order to get the required sample of 60 repair shops.

1.8 Operational definition of terms and concepts

Design for Environment (DfE):	Is defined as systematic consideration of design performance with respect to environmental, health, and safety objectives over the full product and process life cycle (Ray and Guzzo, 1993).
Economic upgrading:	Is the process by which firms and workers move from low-value to relatively high-value activities in mobile phones GPN (Gereffi, 2005)
End-of-Life (EoL) mobile phone:	Is a mobile phone that has reached a lifespan of 18 months or is no longer working.
E-waste:	Is a generic term that denotes various forms of electrical and electronic equipment (EEE) that have reached end-of-life or EEE that have ceased to be of any value to their owner (Orisakwe and Chiara, 2010).
Repair shop:	This is a shop that undertakes mobile phone repair. It can either be formal or informal.
Global production network (GPN):	A set of inter-firm relationships that bind a group of firms into a larger economic unit (Sturgeon, 2001).
Social upgrading:	Is the process of improvement in the rights and entitlements of workers as social actors (Sen, 2000).

CHAPTER 2: LITERATURE REVIEW

This chapter describes the theoretical and conceptual framework employed to analyse the mobile phone E-waste. It maps out the mobile phone GPN and highlights the social and economic upgrading that has taken place in the mobile phone GPN. It looks at the policy framework in management of mobile phone E-waste. It provides an overview of the DfE concept. It also shows the research gaps that this study seeks to bridge together with the contributions to this research.

2.1 E-waste management

The E-waste problem in Kenya was brought to the spotlight during the Eighth Conference of Parties (COP 8) to the Basel convention on Trans-boundary waste management, which was held in Nairobi in September 2006. Before this, E-waste was not considered urgent due to the low consumption of electrical and electrical equipment (EEE) and the general trend by households to store EEE, reuse it or dump it along with other solid waste after their EoL. A study by Mureithi and Waema (2008) suggests that the total E-waste generated each year in Kenya is about 3,000 tonnes. This amount of E-waste is likely to increase as the importation and use of EEE increases in future. The study found that there is high a accumulation of old ICT equipment in homes, offices and repair shops because the owners are not aware of safe disposal options and that information on how to discard E-waste is lacking right from the consumer to the final E-waste handlers. The E-waste management policies are also lacking and there is no legislation to deal properly with the challenge. Mureithi and Waema's study also found that the following have undermined the quest for a policy and legislation framework in Kenya:

- lack of mechanism to implement the policy interventions by the government;
- limited capacity of the important government agencies dealing with E-waste;
- lack of a coordinated approach across the government agencies dealing with E-waste;
- absence of regulatory and policy structures to safeguard health, environmental and social consequences of E-waste have.

Mureithi and Waema's study limited the product scope to IT equipment; specifically personal computers, laptops, cathode ray tube (CRT) and flat panel monitors, printers, and related computer accessories. This study therefore focused on mobile phone E-waste.

Estimates from UNEP and UNU (2009), puts the amount of mobile phone E-waste produced annually in Kenya at 150 tonnes. This is bound to increase as the number of mobile phone users increases. The study considered Kenya as a country with a small scale formal and informal E-waste recycling sector. It stated that the key barrier to sustainable E-waste recycling technologies and E-waste management is lack of a policy framework that this study seeks to examine.

Basiye (2008) undertook a study on extended producer responsibility (EPR) for the management of waste from mobile phones in Kenya. The study was undertaken in Nairobi, Mombasa and Kisumu. Basiye (2008) found that there is no system or government involvement in E-waste management in Kenya. Basiye said that there are plans to develop a strategy on E-waste management. She recommended that comprehensive studies on E-waste status in Kenya should be undertaken including adoption and implementation of EPR. She also recommended stakeholder involvement and awareness and information dissemination. The study helped in the understanding of EPR, which is a component of mobile phone take back schemes.

2.2 The mobile phone global production network

A study by Lee and Gereffi (2010) mapped out the mobile phone GPN. Lee and Gereffi (2010) provided an overall structure of the mobile phone GPN, which include hardware manufacturing, software development, sales and marketing, mobile service and use and after-use. The study recognized that several Sub-Saharan Africa (SSA) countries in the low-income group have received more research attention in the mobile phone industry than others. Lee and Gereffi stated that few studies on mobile GPN have been undertaken in Kenya unlike countries like Ghana and Uganda. This therefore means that, more studies on GPN in Kenya are necessary.

Maree (2011) gave a summary of the mobile phone industry GPN in SSA sketching out its five major domains. Maree (2011) dealt with three domains i.e. software development, sales and marketing, and mobile service provision and use. In hardware manufacturing, Africa is mainly involved in the extraction of the mineral (coltan columbite) tantalite that is used in the manufacture of mobile phones, computers and other electronic equipment. Coltan is used by

manufacturers of capacitors that are integrated into the circuit boards of mobile phones. Maree did not deal with this domain and also the after-use domain. Maree (2011) believed that the after-use domain does not seem to be a prominent aspect of the mobile phone value chain in SSA. However, studies have shown that the after-use domain is an important component of mobile GPN thus the present study.

Nathan and Sarkar (2010) traced the connections between armed factions, poverty and violence in Democratic Republic of Congo (DRC) and mobile phone users worldwide. Nathan and Sarkar concluded that the critical link is coltan as more than 30% of the world's supply of coltan is mined in the eastern part of DRC and the Great Lakes region by tens of thousands of artisanal miners. Nathan and Sarkar concluded that, despite the contribution of coltan in the mobile phone industry, social upgrading, or the concern for the livelihoods of artisanal miners in Congo has not been realized.

2.3 Theoretical framework

The literature on production networks and its role in the international trading system has been analysed using different theoretical frameworks. Hopkins and Wallerstein (1986) defined the production network as 'commodity chains', i.e. "a network of labour and production processes whose end result is a finished commodity". In this approach, the chain links together different productive activities and agents. It particularly puts emphasis on labour as a significant input in commodity chains, highlighting its function as a production factor. The commodity chain approach described by Hopkins and Wallerstein identifies them as being a sign of the emergence of modern capitalism, and not a distinctive feature of the last decades.

Porter (1985) proposed the 'value chain' definition as a practical tool to analyse the relationships between various actors and activities within a specific organisation. Porter's analysis paid attention to the internal functions of the organisation and on how each single element of the production chain could achieve maximum efficiency. This, in turn, would bring about successful management of the organisation. Porter's value chain approach contained an element of international coordination defined as 'value systems'. This means recognising the inter-firm linkages between each individual firm in the chain and its suppliers as well as its distributional channels. Porter did not clearly mention labour as an element of

value chains, but assumed labour as a factor of production that can facilitate the increased efficiency of each activity of the value chain.

Gereffi (1994) introduced the global commodity chain (GCC) concept. From this perspective, actors not only interact with each other but also with world markets, making them the "infrastructure of international trade". According to this approach, GCCs are defined by three dimensions: (i) an input-output structure that characterises the transformation of raw materials into a finished product; (ii) a territoriality aspect that ties them to a particular geographical location; and (iii) a governance structure that defines the power relationships among different firm actors across the chain, as well as the lead firms that control the production process and outcome and capture the highest shares of value. The GCC approach became popular due to its more comprehensive attempt at studying globalisation of production. In the years following this contribution, the definition shifted towards that of global value chains (GVCs) that highlighted the relevance of value creation, value distribution and value capture in the production process. This definition also allowed the analysis to go beyond commodities to high technology products and global services (Barrientos *et al*, 2008). Furthermore, the GVC framework in general refers to a broader intellectual project than GCCs, including more complex forms of governance and an institutional context (Sturgeon 2001). Over the years, most of the studies employing the GVC framework have focused on their input-output structure and/or on their governance structure. Subsequently, the GVC framework has been object of some criticism because of its lack of attention to the spatial and territorial dimension of the chain.

The definition of GPNs goes beyond that of GVCs in that GPNs do not only connect firms functionally and territorially, but also they connect aspects of the social and spatial arrangements in which firms are embedded and which influence their strategies and values, priorities and expectation of managers, workers and communities (Henderson *et al*, 2002). Hence, since the GCC/GVC framework focuses largely on the commercial dynamics between lead firms and suppliers and the value that is created and distributed during production, its analytical scope stops at the factory level, and does not reach workers as social actors. In the GVC framework, labour is not explicitly taken into consideration. Because of the evolution of the concept of production networks, this present study uses the definition of GPNs because it is wider than the previous concepts and because its definition encompasses not only the

economic and commercial actors of the production chain, but also the whole range of actors operating in the social and institutional context that surrounds and influences global production (Bair 2009; Henderson *et al*, 2002).

The involvement of developing countries in GPNs has important implications both in economic and in social terms. Given the dramatic rise of GPNs across countries and sectors, developing country producers face not a question of whether to participate in the global market but rather under which conditions to do so (Kaplinsky 2005). Most attention has been devoted to exploring the economic outcomes of developing country participation in GPNs. Usually, the outcomes for developing country supplier firms have been assessed in terms of their shares of economic profits and value added, and have been connected to their ability to upgrade their production.

2.4 Social and economic upgrading in the mobile phone global production network

A study by Bernhardt and Milberg (2011) focused on economic upgrading and social upgrading in the horticulture, apparel, mobile phones and tourism sectors. The goal of the study was to understand the economic and social upgrading or downgrading in horticulture, apparel, mobile phones and tourism sectors and whether there is a connection between developments in the economic sphere, on one hand, and the social sphere, on the other. The study showed that between 2000 and 2009, Kenya experienced economic upgrading in the mobile phone sector with a growth in market share and unit value. In Africa, the study showed that social downgrading has happened in South Africa where employment went down by 58% and real wages by 57% respectively. However, the study did not analyse if social upgrading has happened in Kenya's mobile phone industry. The present study there tried to bridge this gap.

According to Barrientos *et al* (2008), liberalization, privatization, digital convergence, offshore outsourcing, and increasing specialization have transformed the mobile phone sector. It now creates many opportunities for jobs and entrepreneurship across developing countries. They include assembly operators in Shenzhen, China, coltan miners in DRC, software engineers in Bangalore, India, "village phone" women in Bangladesh and street airtime resellers in Colombia. In most of the GPN studies, there is no reference to labour in its embodiment of workers as social actors. At best, there seem to be an assumption that

economic upgrading will automatically deliver social benefits for workers operating in them by adding value in the production and hence the gains for firms. However, there is no strong evidence to support this relationship (Barrientos *et al*, 2008). Even when workers have been mentioned when referring to upgrading, the impact of such process on workers' wellbeing and livelihoods is not addressed. It is therefore crucial to understand under which circumstances economic upgrading also delivers social upgrading.

A study by Civil Initiatives for Development and Peace (CIVIDEP) (2009) in India found that most of the workers in different stages of mobile phone production had no industrial experience. They are also not members of trade unions and therefore are anxious of losing their jobs if they become part of any organising efforts or if they raise their voice against poor workplace standards. Their findings also suggest that the quality of labour conditions in a firm depends on the position of the firm within the value chain. Working conditions are generally better in the factories run by mobile phone manufacturers than the ones by contract manufacturers (CIVIDEP, 2009). It was of interest therefore for this present study to check whether the same applies to Kenya.

The importance and potential of the economic and social benefits that can be gained by involving the repair shops in E-waste management are also recognized (Medina, 2000). Medina (2000), believes that repair shops are involved in scavenging and as such are an effective means of improving the income, working and living conditions of scavengers in developing economies. Medina (2000) further indicated that repair shops to a great extent participate in recycling of electronics. It has become acceptable, and somewhat fashionable, to regard recycling as a sustainable option to E-waste management. Medina concluded that it is important to integrate the informal sector into E-waste management together with working towards improving efficiency and the living and working conditions of those involved.

2.5 Policy framework in management of mobile phone E-waste

Various strategies and practices have been adopted by a few countries and regions to handle, regulate and prevent mobile phone E-waste as a response to the challenges posed by this waste stream. Most of these have been enacted via legislation specific to E-waste. In response to the large amounts of E-waste disposed within its borders every year, (approximately 6.5 million tonnes), the European Union (EU) enacted the Waste Electrical and Electronic

Equipment Directive (WEEE Directive) (Directive 2002/96/EC) which its member states were to translate into national law in their respective countries. The EU Directive on the Restriction of the use of Certain Hazardous Substances (RoHS Directive) in EEE banned six substances from electrical and electronic devices; including mobile phones that are placed in the EU market after July 2006. These substances are lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ethers. The WEEE Directive requires the prevention, separate collection, appropriate EoL treatment as well as the design-for-recycling of EEE. The Directive sets various annual targets for the collection, reuse and recycling of E-waste. Despite these efforts, the European Commission (EC) reports that only one-third of generated E-waste is collected and treated according to the stipulated procedures with prevalent exports to developing countries (Commission of the European Communities (CEC), 2008 and EU, 2003). The Directive requires that mobile phone batteries, printed wiring boards (PWBs), the button cell on the PWB as well as the liquid crystal display (LCD) be removed. A study by Huisman (2004) measured the environmental performance and integral costs for recycling mobile phones using the quotes for environmentally weighted recyclability and eco-efficiency approach. The study compared two scenarios for treatment of discarded mobile phones i.e. sending handsets to a copper smelter and selective treatment of the PWB following the WEEE Directive; and concluded that, "the direct smelter route is clearly the most eco-efficient processing option for discarded mobile phones."

An international effort such as the Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and their Disposal is a global environmental treaty that strictly regulates the trans-boundary movement of hazardous wastes. Kenya ratified the Basel Convention in 2000. Parties to the Convention are obliged to ensure environmentally sound management of hazardous wastes, particularly in their disposal. The Convention, adopted on 22 March 1989, came into force on 5 May 1992. The ninth meeting of the Conference of the Parties to the Basel Convention considered new guidelines for getting rid of phones and other E-waste in a way that protects both the environment and human health. Successes of this initiative include the adoption of five Technical Guidelines and an overall Guidance document for the environmentally sound management of EoL mobile phones. The technical guidelines focus on awareness raising on design considerations, collection of used and EoL mobile phones, trans-boundary movement for collection of mobile phones, refurbishment of

used mobile phones; material recovery and recycling of EoL mobile phones (Sahu and Srinivasan, 2008).

The Nairobi Declaration on environmentally sound management of electrical and electronic wastes Decision VIII/5 on partnerships and VIII/6 on Mobile Phone Partnership Initiative (MPPI) was adopted during the eighth Conference of Parties to the Basel Convention (Basel Convention, 2007). The MPPI targets environmentally sound management of used and EoL mobile phones. The MPPI comprise of manufacturers like Alcatel, Life's Good (LG), Matsushita (Panasonic), Mitsubishi, Motorola, Nippon Electric Company (NEC), Nokia, Philips, Samsung, Sharp Telecommunications Europe, Siemens, Sony Ericsson and mobile phone network operators like Vodafone, Bell Canada and France Telecom/Orange. It also includes refurbishers, recyclers and non-governmental organisations (NGOs).

Most of the mobile phone E-waste generated from other parts of the world end up in Asian countries, especially in China (receives approximately 90%) (Li *et al*, 2006). To cope with the alarmingly large quantities of EoL products it receives and the attendant spontaneous informal and in some cases potentially harmful handling and treatment of E-waste within the country, China has recently legislated measures to cope with E-waste. Japan has legislation designed to tackle their sources of E-waste especially mobile phone E-waste. Specific recovery targets for reuse and recycling are stipulated by the legislation referred to as the home appliance recycling law.

African countries still lag behind when it comes to enacting legislation to deal with mobile phone E-waste. This is despite well documented evidence showing that certain African countries have been the recipients of near EoL mobile phones which are illegally exported from various affluent nations. It has been observed that informal collection, dismantling and recycling of E-waste is beginning to take shape in several countries such as Ghana, Kenya and Nigeria. In South Africa, there is both formal and informal mobile phone E-waste recycling taking place (BAN, 2005; Nnorom and Osibanjo, 2008).

Kenya is a signatory to the Bamako Convention. It is a treaty of African nations that prohibit the import of any hazardous (including radioactive) waste (Ministry of Environment and Mineral Resources, 2010). It was adopted in Bamako, Mali, on 30 January 1991 and came

into force on 10 March 1999. The objective of the Bamako Convention is to protect human health and the environment from dangers posed by hazardous wastes by reducing their generation to a minimum in terms of quantity and/or hazard potential. According to Basiye (2008), the ICT sector is regulated by different state agencies charged with different responsibilities. They include the Kenya Bureau of Standards (KEBS), Kenya Revenue Authority (KRA), Kenya Ports Authority (KPA), CCK, NEMA and local authorities. The implications of the ICT sector being regulated by different state agencies means that there are overlapping responsibilities between the agencies leading to duplication of functions. This can cause conflicting decisions across sectors, or indeed lack of decisions where overlap between mandates cannot be resolved.

2.6 Design for environment and end of life practices

A study on DfE practices was carried out in 1996, when a team from Massachusetts Institute of Technology studied the pattern of adoption of DfE practices in US manufacturing firms and across industries (Lenox *et al*, 1996). Although DfE practices were widespread, varying from food to chemicals to machine tools, there was no consensus on what constituted good DfE practice. Few companies looked at the entire product life cycle; the majority focused only on manufacturing. Government regulations seemed to play a less significant role in promoting DfE prompting Lenox et al (1996) to deduce that the key to the adoption of DfE is the management of innovation and organisational change. Lenox *et al* (1996) study was followed by another survey of four leading US electronics firms, which revealed that many firms still struggled to promote DfE practices across their product development teams. The study focused on American Telephone and Telegraph Company (AT&T), Digital Equipment Corporation (DEC), International Business Machines (IBM) and Xerox Corporation (Lenox et al, 2000). In all the four firms, corporate managers expressed a desire to spread DfE among the organization's various design teams. However, only two firms, IBM and Xerox appeared to have a set of procedures for analysing environmental issues in design which were incorporated into a majority of their product-development efforts. All four firms reported global pressure to improve environmental performance. Lenox *et al* (2000) concluded that, the intricacies of environmental issues require an approach that will continually generate new information in response to ever-changing needs.

Rose (2010) in her study on DfE developed software for formulating product EoL strategies. The software, the End-of-Life Design Advisor, guides product developers to specify appropriate EoL strategies. The products that Rose studied included small electric appliances, such as cellular phones, larger consumer products, e.g. cars and domestic appliances, and large industrial products, such as medical systems or aircraft engines. Rose (2010) concluded that End-of-Life Design Advisor software should be applied in early stages of design when changes to the design are still possible. Rose also recommended that future researchers should develop product EoL tools through active participation of relevant industry stakeholders.

In 1996, the Microelectronics and Computer Technology Corporation surveyed US electronics companies to ascertain the level of maturity of DfE implementation, the tools used and needs of the industry (Mizuki *et al*, 1996). The results of the survey pointed to two critical obstacles to the adoption of DfE practices in electronics companies: the lack of current, accurate data on materials and energy use and lack of a system to monitor and track the movement and storage of materials across a facility.

Jarvinen *et al* (1998) studied the implementation of DfE by Nokia that aimed at integrating DfE into Nokia's product process. The integration was achieved with the help of check lists called "working assistants". Tailored DfE training was arranged for the designers and communicated to the employees to help them understand the concept and to start using the "working assistants". The integrated DfE system was measured with two groups of metrics: product related metrics and DfE system related metrics. The research and development management team set targets for the metrics. Through this, the 'Plan, Do, Check, Act' cycle was successfully used as a framework for the implementation process.

The literature on DfE shows that this concept has been evolving over the years. However, many firms struggle to diffuse DfE practices across their product development teams. This study therefore examined Nokia's DfE efforts to see whether there is a consideration of the environment during their products design and processes.

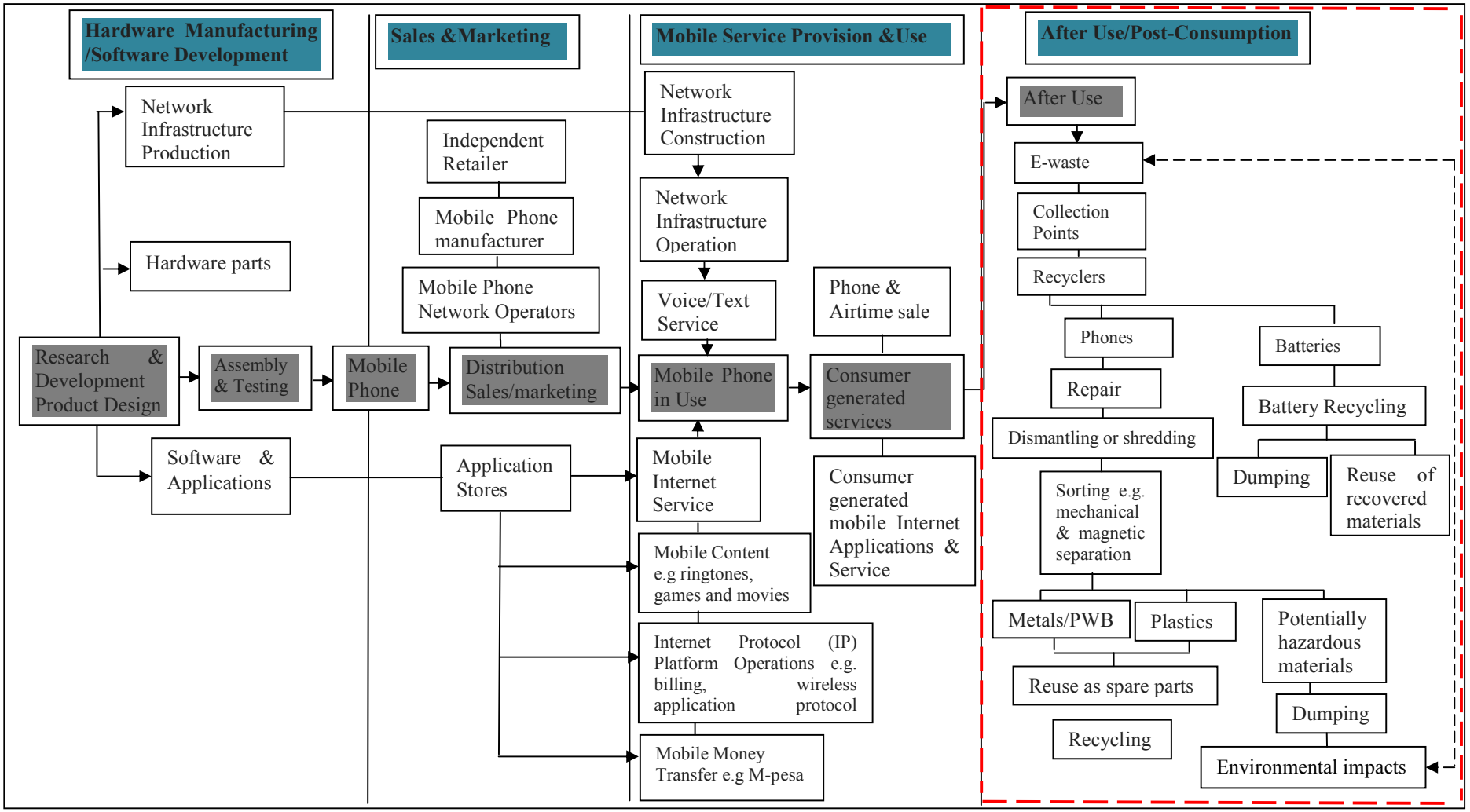
2.7 Conceptual Framework

The global production network (GPN) approach was adopted as the conceptual framework for this study. This is because the concept of GPN is capable of grasping the global, regional and local economic and social dimensions involved in the globalization of production networks. With the GPN of mobile phones entailing five key domains i.e. hardware manufacturing, software development, sales and marketing, mobile service provision and use and after-use (Figure 2.1), this study concentrated on the after-use domain. Lee and Gereffi (2010) stated the major domains of the mobile phone value chain often overlap but each of them has its own key actors that are distinct from each other.

Overall, a mobile phone GPN entails multiple activities encompassing production and consumption. Different roles of actors who play a role in the management of EoL mobile phones were also examined. They include mobile phone network operators, Nokia, CCK and NEMA. These actors play a major role in the policy formulation and implementation and cuts across all the domains of the adopted conceptual framework.

Post consumption component of mobile phone GPN that is the basis of this study occurs when mobile phones reach EoL. These EoL mobile phones contain many hazardous materials that should be properly handled to minimize adverse impacts on the environment. Given the fact that the lifespan of a mobile phone has reduced from 3–4 years to less than 2 years i.e. 18 months (Fishbein, 2002), the disposal and recycling of EoL phones and components has become a serious environmental issue. E-waste management practices involve selecting the most environmentally desired methods for managing E-waste stream, which involves reuse, recycling and finally, disposal of materials. The activities of the formal and informal repair shops were therefore investigated for a better understanding of the post consumption activities of mobile phone GPN in Kenya.

Economic and social upgrading that has occurred in mobile phone GPN falls in the after-use domain. This was looked at by examining the condition of the workers in the repair shops. The formal and informal repair shops are involved in the repair of EoL mobile phones. Nokia's DfE also fits into the conceptual framework as its objective of minimizing material use falls within the hardware domain while the objective of maximizing reuse and recycling; falls within the after-use domain. This has positive impacts both environmentally and economically.



Key: = key domain
= key actor
= focus of the study

Figure 2.1: Conceptual framework

Adapted from: Lee and Gereffi (2010) and Zhang (2002)

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Study site

The study was undertaken in Nairobi which is the capital city of Kenya (Figure 3.1). It is the most populated city in East Africa with an estimated population of 3,138,369 (KNBS, 2010b). The projection for 2012 was 3.4 million people. As the capital of Kenya, Nairobi is a centre of industry, education and culture occupying an area of 696.1 km^2 and hosting about 25% of Kenya's urban population. Mobile phone usage in Nairobi is widespread with 88.3% of all households having mobile phones against the country's overall percentage of 63.2%. Nairobi is followed by Central province (75%), Coast province (65.1%), Eastern province (59%), Rift Valley (58.8%), Nyanza province (57.7%), Western province (53.5%) and finally North Eastern province at 28.8% (KNBS, 2010a).

As a result of the rapid increase in population, the generation rate of solid waste in Nairobi was estimated to be approximately 3,000 tonnes per day. Half of this solid waste is left uncollected or illegally dumped inside the city and the remaining is carried to a final disposal site. The final disposal site in Dandora is however an open dumping type landfill and this therefore has a detrimental effect on the surrounding environment. Since this situation is creating problems in hygienic, environmental as well as aesthetic conditions for the people of Nairobi City, the government of Kenya through the City Council of Nairobi commissioned the Japan International Cooperation Agency (JICA) to undertake a preparatory survey on integrated solid waste management in Nairobi City in 2009. The types of solid waste surveyed were limited to household waste, market waste, commercial waste, street sweeping waste and office waste. In 2011, JICA commenced the feasibility studies and detailed designs for decommissioning of Dandora dumpsite and construction of a sanitary landfill in Ruai.

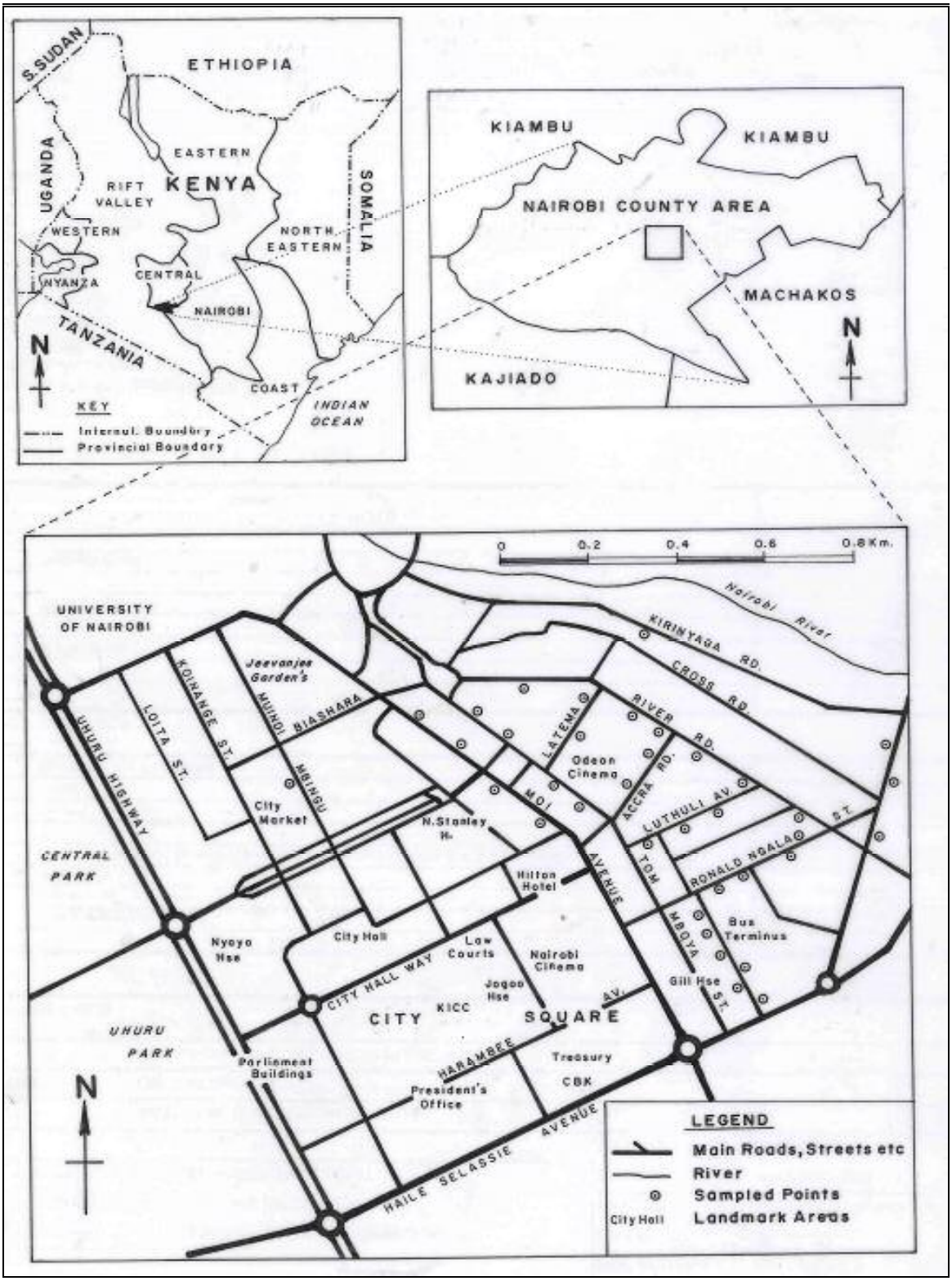


Figure3.1: Study area and distribution of informal repair shops within Nairobi

Source: Survey of Kenya

3.2 Study design

This study employed a number of techniques and approaches which included field survey, case study and statistical analysis. The study targeted stakeholders in the mobile phone sector who included government agencies, mobile phone manufacturers, mobile phone network operators and repair shops.

3.2.1 Data collection

Both primary and secondary data was collected. Secondary data collection was carried out at the beginning of this research through literature review. Different methods were utilized to collect primary data. They include key informant interviews, questionnaire surveys and case studies.

3.2.2 Sampling procedure

In-depth interviews were used with key stakeholders. The key stakeholders that were interviewed include CCK, NEMA, Nokia Corporation, Orange Kenya and Safaricom. A pilot survey revealed that there are four formal repair shops in Nairobi that are authorized by Nokia to undertake mobile repair on their behalf. They include FoneXpress, Midcom, Nokia care centre and Technoservice. A complete survey of these formal repair shops was thus undertaken. Computers for Schools Kenya, which is undertaking E-waste, reuse and recycling was also examined.

According to figures from City Council of Nairobi, there are approximately 300 informal repair shops in Nairobi Central Business District. Most of them are concentrated in the downtown areas of the Nairobi Central Business District. These areas include Moi Avenue, Luthuli, Mfangano and Ronald Ngala Streets. The sampling frame therefore consisted of informal mobile phone repair shops working within the downtown areas of Nairobi Central Business District. Simple random sampling was used to obtain a sample for informal repair shops. Simple random sampling is a probabilistic sampling technique that ensures each subject has an equal chance of representation. It is used where the population is homogeneous. A random sample of 60 informal repair shops was thus selected for detailed investigation. The researcher wrote the name and physical address of each of the 300 repair shops and used the table of random numbers to randomly select 60 names, which formed the research sample. Both the owners and workers in

these repair shops were interviewed. This formed about 20% of the total population of informal repair shops.

Since little is known about the E-waste dealers (people who buy PCBs from repair shops), snowball sampling was employed to recruit potential respondents. Snowball sampling is a non-probability sampling technique that is used when members of the population to be studied are difficult to locate and much information is not know about the potential sample. Starting with a known middleman, the researcher was led to E-waste dealers. The process was repeated until the saturation point in terms of information being sought was reached. A total of ten E-waste dealers were thus interviewed. The aim of this was to have a basic understanding of the profile of the E-waste dealers and to get a complete picture of the mobile phone E-waste chain.

Exporters of PCBs were not easy to contact and to convince them to take time for an interview; therefore their activities were inferred from interviews with a middleman who has direct contact with the exporters. Only one middleman supplying PCBs to the exporters was interviewed, as no other middlemen were available in the area of the field survey. In order to establish the production network of mobile phone plastic panels, a visit to a plastic recycling site in Babadogo was undertaken. An overview of the sample sizes of the different groups and other key persons is given in Table 3.1.

Table 3.1: Interviewed persons

No.	Interviewees	Sample
1	Repair shops	
	Formal	4
	Informal	60
2	Mobile phone network operators	2
3	Government agencies	2
4	Recyclers	1
5	Middlemen	1
6	E-waste dealers	10

Source: Author

3.3 Data analysis

Data editing and reconciliation was undertaken before data analysis was done. This was necessary to avoid using inconsistent data, which would normally lead to making wrong conclusions and drawing wrong inferences. Statistical Package for Social Scientists (SPSS) version 17 was used for quantitative data analysis. The statistical technique that was utilized in data analysis was descriptive statistics. Descriptive statistics helps in quantitatively describing the main features of the data collected. It provides simple summaries about the sample and about the observations that have been made. Descriptive statistics presents some of the most exemplary ways of summarizing and displaying data by using data presentation tools such as tables, pie charts and graphs. Measures of central tendency and variance were used as descriptive data analysis tools. The use of descriptive statistics was particularly useful in screening the data to determine its reliability and consistency. Another statistical technique used in this study was cross-tabulation. Cross-tabulation was undertaken in order to examine the relationships between the variables. It is useful in representing values of two or more variables at the same time.

CHAPTER 4: RESEARCH FINDINGS AND DISCUSSIONS

5.1 Repair shops

This section presents the general characteristics of both the formal and informal repair shops. Four formal repair shops, CFSK and 60 informal repair shops were interviewed. This helped in the mapping of the mobile phone GPN and in understanding of the economic and social upgrading in mobile phone GPN.

4.1.1 General characteristics of repair shops

a) Period in operation

Over half (56.7%) of the informal repair shops have been in operation for less than six years and about a third (28.3%) have been in operation for between six and eight year (Table 4.1). Very few repair shops have been in operation for over ten years. This is also the same period that the mobile phones have been in use in Kenya.

Table 4.1: Years in operation of informal repair shops

Period of operation	Frequency	Per cent
2 years or less	12	20.0
3 - 5	22	36.7
6 - 8	17	28.3
9 - 11	8	13.3
Over 11	1	1.7
Total	**60**	**100.0**

Source: Research data, 2012

It is noted from Figure 4.1 that nearly all (97%) of the informal repair shops have business permits which are from the City Council of Nairobi while only 3% do not have. They pay annual licensing fee of Kshs 7,000. Most of them complained that the annual fee for this kind of business is too high due to high rent rates, the fact that they have to pay salaries and high cost of living. Formal repair shops on the other hand are registered with both KRA and City Council of Nairobi.

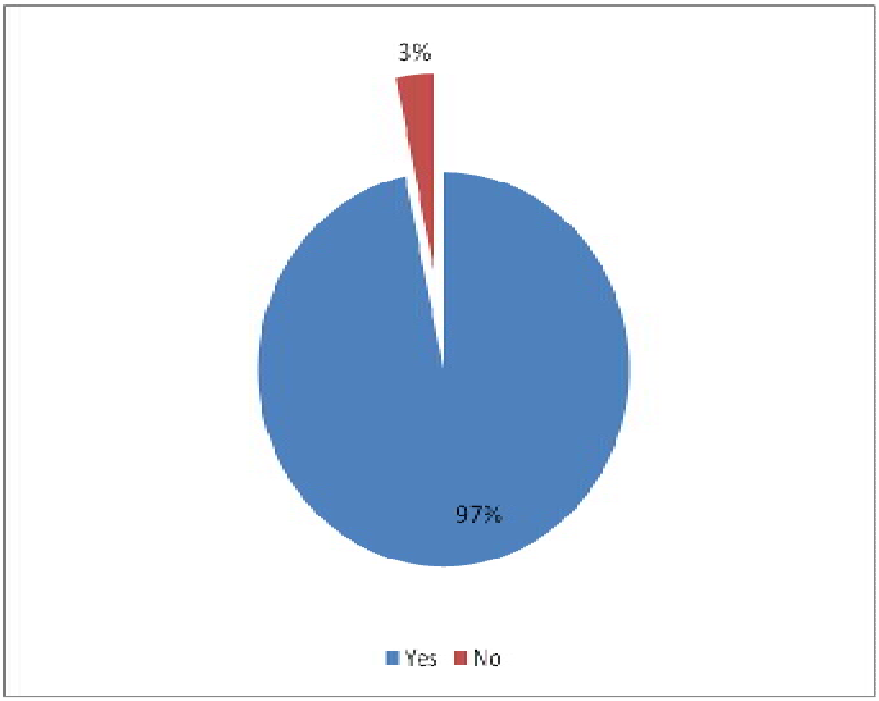


Figure 4.1: Ownership of business permits

Source: Research data, 2012

b) Worker profiles

Majority of the workforce in the informal repair shops are between 20-34 (Table 4.2) years (46.9%), which means that the workforce in the informal repair shops is composed of the youth. For permanent and temporary employees, most of them fall within the 20-24 age groups. All the trainees in these repair shops are of ages 15-19 years. In general most of the staff in this sector are young people who seem to get their experience through on the job training and apprenticeship.

Table 4.2: Employment status by age

Age group	Division of workforce				Total
	Permanent	Temporary	Apprentice/ Trainee	Others	
15-19	7.3	1.3	100.0	0.0	5.2
20-24	43.9	53.4	0.0	100.0	46.9
25-34	29.3	39.2	0.0	0.0	35.4
35-44	14.6	4.1	0.0	0.0	10.4
45-54	4.9	1	0.0	0.0	2.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Research data, 2012

The study revealed that 95% of the workers in informal repair shops are male while 5% are females. This means that males dominate the mobile phone repair business. Majority (68.3%) of the respondents have secondary level of education with nearly a fifth (25%) having attained their primary level of education (Table 4.3). All the workers between the age of 45 and 54 have secondary education. This is because they only made 2.1% of the sampled population. In the formal repair shops, most of the employees are male. About 90.9% (22 workers) were male and 9.1% (2 workers) were female and are of the ages of between 24 to 34 years. All of them are permanent employees. Computers for Schools Kenya employees were between the ages of 19 to 65 years. Computers for Schools Kenya employ both technical and non-technical staff. The technical staff work in the refurbishment section while most non technical staff work in the recycling section. Of the three workers interviewed at CFSK, two were male and one female. Two of them were between 20-24 years and the other was between 35-44 years. The workers had been with CFSK for between six months and two years.

Table 4.3: Age group and education level

	Level of education			
Age group	**Primary**	**Secondary**	**Other**	**Total**
15 - 19	66.7%	33.3%	0.0%	100.0%
20 – 24	13.0%	87.0%	0.0%	100.0%
25– 34	20.0%	64.0%	16.0%	100.0%
35-44	60.0%	40.0%	0.0%	100.0%
45-54	0.0%	100.0%	0.0%	100.0%
Total	25.0%	68.3%	6.7%	100.0%

Source: Research data, 2012

Nearly all the workers in informal repair shops (96.8%) had some kind of training on mobile phone repair (Figure 4.2). Of this, 46.7% received training from the employer while 53.3% received training from other sources, which includes friends and relatives in the repair business. Most of the workers attributed this to lack of established institutions offering training on mobile phone repair. This means therefore that there is an opportunity for government or private institutions to introduce courses on mobile phone repair. Since CFSK has a have a training department that offers training and examination they can take advantage on this and offer courses on mobile phone repair. Computers for Schools Kenya have a one week curriculum on E-waste management. They developed their curriculum in partnership with Masinde Muliro University where they offer diploma courses. Most of the technicians working in the formal repair shops have formal training on mobile phone repair and Nokia trains them twice a year. Nokia trains them on repair of new mobile phone models. All workers at CFSK had university education. This was because the workers sampled comprised of departmental heads. All did not have any form of training on mobile phone repair. Two had received some in-house training on computer maintenance, occupational hazards, materials handling, WEEE dangers and awareness and fire protection and prevention.

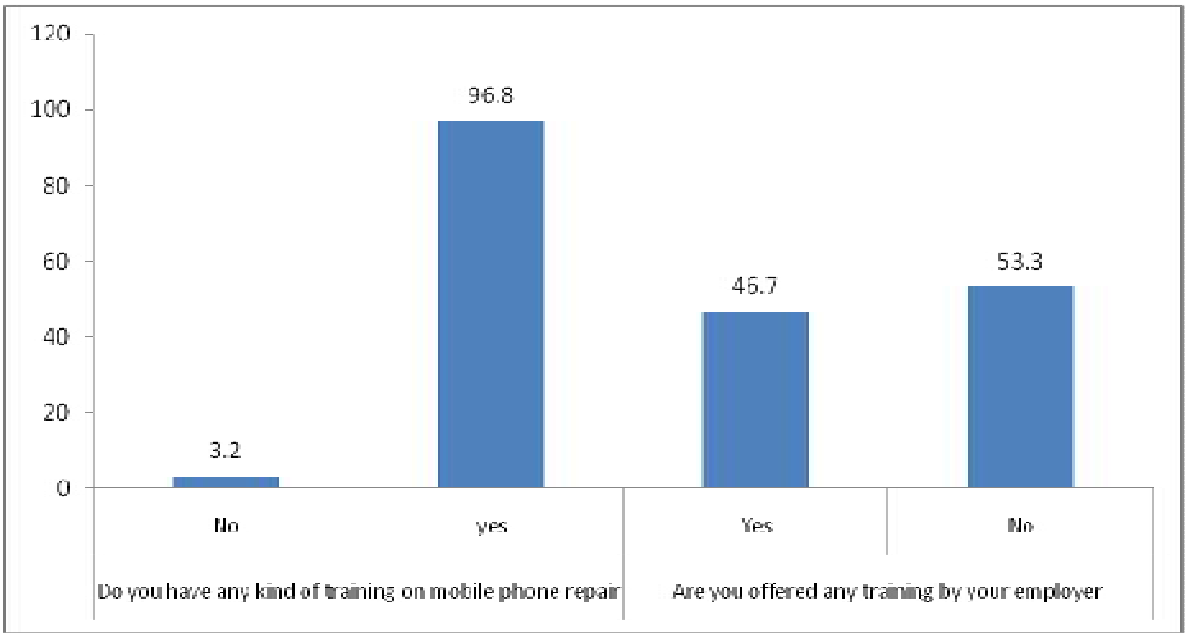


Figure 4.2: Training in mobile phone repair

Source: Research data, 2012

The workers on an average have been working in the informal repair shops between one to five years (64.5%), with a lower range of one month and upper range of 12 years. This shows that most of the workers change their employers quite often. Their recruitment and employment is based on an understanding between them and the employer. Their employment is not based on written contracts, which mean that they can be easily dismissed.

c) Remuneration and working hours

About 64.5% of workers in the informal repair shops have been in the mobile phone repair business for a period of one to five years. Only 8.1% have worked for six months or less and another 24.2% have worked for over six years (Table 4.4). This reflects the period in which the repair shops have been in operation.

Table 4.4: Employment period

Years	Frequency	Percent
0.1 - 0.5	5	8.1
1 - 5 years	40	64.5
6 Years +	15	24.2
Total	**60**	**100.0**

Source: Research data, 2012

Most of the workers in the informal repair shops work between six to twelve hours with an average of eight hours. Some indicated that they do not have a limit on the number of hours they work as it depends on the amount of work they have on one particular day. Majority of them (61.7%) worked for 6 days in a week (Table 4.5). This is in line with the section 37 (2) of the Employment Act Chapter 226 (2010) which states that in calculating wages and the continuous working days, an employee shall be deemed to be entitled to one paid rest day after a continuous six days working period. Their counterparts in the formal repair shops work from 8.30 am to 6.00 pm on Monday to Friday and from 8.30 am to 1.00 pm on Saturday. Those at CFSK work for eight hours five days a week with no overtime. This is in line with the employment act of 2007.

Table 4.5: Workings days per week

Days	Frequency	Percent
5	2	3.3
6	37	61.7
6 to 7	13	21.7
7	8	13.3
Total	**60**	**100**

Source: Research data, 2012

About 48.8% of the workers in the informal repair shops worked overtime and are paid followed closely by those who do not work overtime at 43.3%. Another 8% work overtime but are not

paid. Those in the formal repair shops sometimes work overtime depending on the workload and are paid.

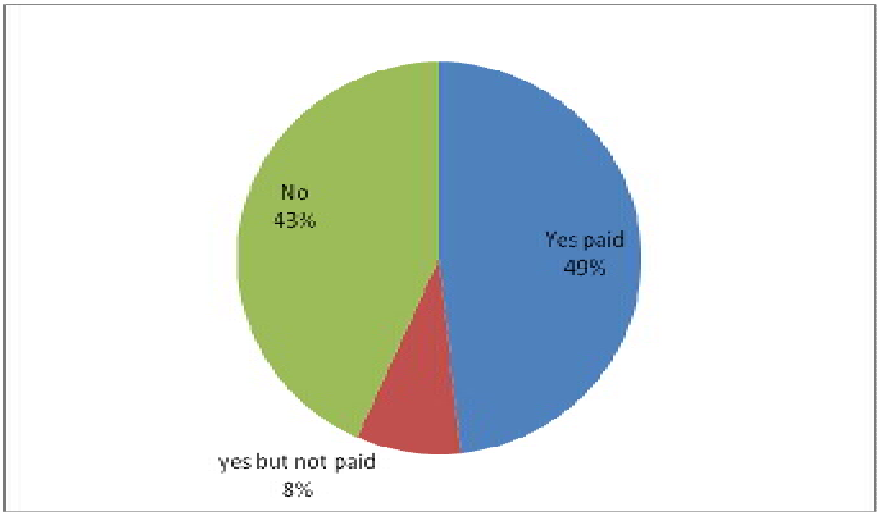


Figure 4.3: Overtime work and payment

Source: Research data, 2012

About 53.2% of the workers in the informal repair shops earn a monthly income of Kshs 10,500 – 20,000. The range of earnings of the workers is Kshs 6,000-25,000 (Table 4.6). Overall, the income was seen as inadequate. Those in the formal repair shops earn an average of Kshs 20,000 per month. Workers at CFSK earn between Kshs 10,000-50,000 per month. The government minimum wage for ungraded artisans is Kshs 11,580.

Table 4.6: Monthly earnings of workers

Earnings in Kshs	Frequency	Percent
6000 -10000	23	37.1
10500 - 20000	33	53.2
More than 20000	4	6.5
Total	**60**	**100.0**

Source: Research data, 2012

d) Social protection and social security

Only one worker (1.7%) in the informal repair shops was a member of a trade union. This is similar to those in the formal repair shops where a few were members of trade unions. Workers at CFSK do not belong to any trade union. Only one worker reported that the employer pays their medical bills when they fall sick. Another three said that they have an insurance policy with National Hospital Insurance Fund (NHIF) (Table 4.7). Those in the formal repair shops also pay for their own medical costs. Two of CFSK employees had medical insurance cover paid by CFSK while one pays his own medical bills. The Employment Act stipulates that every employer shall, with the consent of the employee, cause to be provided to such employee medical treatment at the cost of the employer unless provided free by the Government.

Table 4.7: Medical bills settlement

	Frequency	Percent
Employer	1	1.7
NHIF	3	5
Self	56	93.3
Total	**60**	**100**

Source: Research data, 2012

All the three female workers in the informal repair shops were entitled to maternity leave but male workers reported that they were not entitled to paternity leave. The maternity leave is for one month and is not paid for. This is against section 29 (1) of the Employment Act that recommends that a female employee shall be entitled to three months maternity leave with full pay. Section 29 (8) states that a male employee shall be entitled to two weeks paternity leave with full pay. About 46.7% of the workers said that they are entitled to sick leave against 53.3% who are not entitled to sick leave. Of the 46.7% who are entitled to sick leave, 53.6% said that this leave is paid for while 46.4% are not paid. The duration of the leave depends on the duration of the sickness. Section 30 of the Employment Act states that after two consecutive months of service with an employer, an employee shall be entitled to sick leave of not less than seven days with full pay and thereafter to sick leave of seven days with half pay, in twelve consecutive months of service, subject to production by the employee of a certificate of incapacity to work

signed by a duly qualified medical practitioner. Only two workers were entitled to annual leave of five days and three weeks respectively which is paid. This means that nearly all the employers disregard section 28 of the Employment Act which states that after every 12 consecutive months of service, an employee shall be entitled to not less than 21 working days of leave with full pay. Those in the formal repair shops are entitled to maternity leave, sick leave and annual leave of 21 days. The female employee at CFSK is entitled to three months maternity leave, 36 days of sick leave and 21 days of annual leave, which is paid. The male employees are entitled to annual and sick leave but no paternity leave.

e) Health and safety

About 10% of workers in the informal repair shops use personal protective equipment against 90% who do not use personal protective equipment. The most commonly used personal protective equipment are gloves, boots and overalls. The study findings indicate that 61.7% of the workers had suffered from accidents at their workplace or work related health problems (Figure 4.4). Some of the accidents reported by the workers include burns by soldering gun, burns from battery acids, cuts from plastics and metals, hits by screws, pricks from pins and screws and shock when charging phones. At least 58.3% of the workers are aware that mobile phones have hazardous materials. They indicated that they were aware that batteries have chemicals, which can be dangerous. Workers in the formal repair shops and CFSK do wear personal protective equipment, which includes gloves, earmuffs, dustcoats, goggles, gas masks, electrostatic discharge (ESD) band, ESD coats, ESD shoes and helmets. None of them reported to have suffered from accidents at the work place or health related problems. They are aware that mobile phones have hazardous materials such as lead. According to CFSK, E-waste has hazardous compounds that include mercury, lead, cadmium, chemicals that affect the kidneys, nervous system etc. Most of these compounds are found in the circuit boards

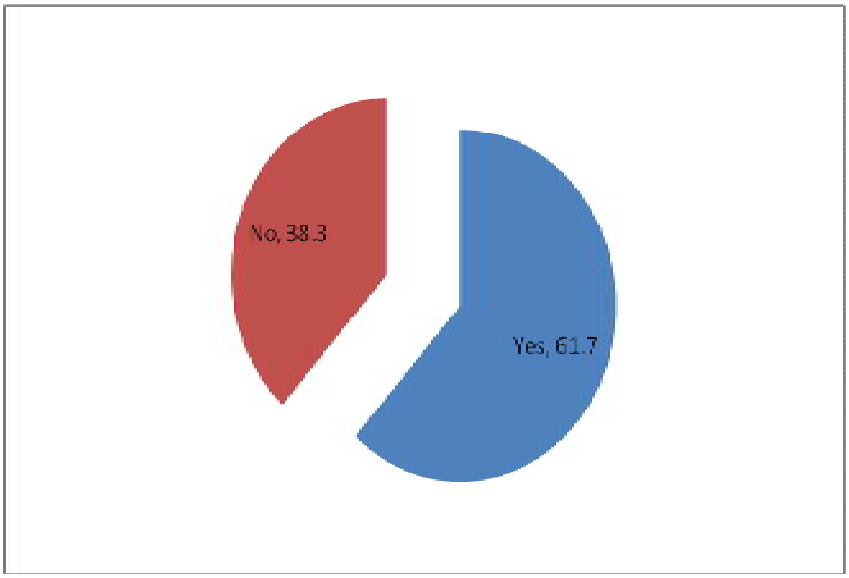


Figure 4.4: Worker related health problems and accidents

Source: Research data, 2012

4.1.2 Repair and recycling of mobile phones

Approximately 68% of the respondents in the informal repair shops said that they procure EoL phones while 32% do not (Figure 4.5). Those who do not source EoL phones buy spare parts from accessories shops within the city. They said that they prefer buying the spare parts from the accessories shops instead of buying EoL mobile phones since some of them are stolen. It emerged that some of the repair shop owners have been arrested by the police for handling allegedly stolen phones. Of the shops that procure EoL phones, 100% source them from mobile phone users while none source them from Nokia care centres or formal repair shops. This is due to the fact that, Nokia and formal repair shops ships all the EoL phones they receive to China for recycling. About 81% of the EoL phones that are sourced are always in working condition while only 19.5% are no longer working. About 70.7% of the EoL phones that are sourced while in working condition are resold to the mobile phone users and a small percentage (29.3%) end up as spare parts (Figure 4.6).

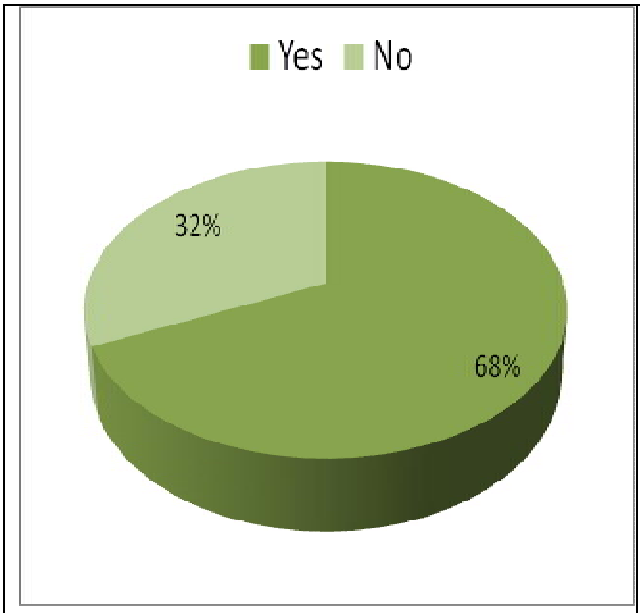


Figure 4.5: Sourcing of end of life phones

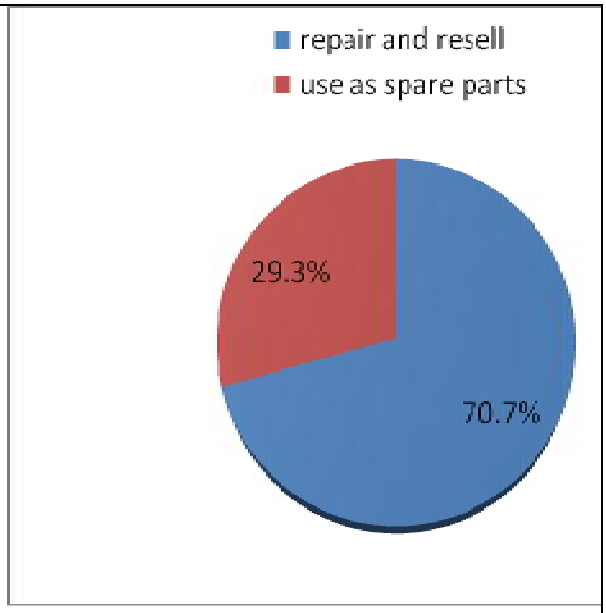


Figure 4.6: Uses of end of life phones

Source: Research data, 2012

The study showed that the mobile phones that were in no longer working were dismantled and the parts used as spare parts for mobile phone repair. The most reused part were speakers at 96.7% followed by sim card trays (93.3%), charging jack and network integrated chip (88.3%), LCD and display/keyboard light chip (85%), flash integrated chip (80%), multimedia chip and camera (73.3%) and others (5%). Other parts include keypads, earpiece, mouth piece and screens. This shows that most components of a mobile phone can be reused.

The most common parts sold to recyclers are Printed Circuit Boards (PCBs) at 58.3% (Table 4.8). Informal repair shops sell the PCBs to E-waste dealers for between Kshs 200 to Kshs 400 per kilogram. Some of the E-waste dealers in turn sell them to middlemen while others sell them directly to exporters. According to a middleman, the PCBs are sold to two exporters from Asia who are based in Ngara. They then ship the PCBs to China after attaining the required quantities i.e. enough to fill a two tonne lorry. The PCBs are transported by trucks to the port of Mombasa then shipped to China.

Most of the informal repair shops (98.3%) reported that they discard the hazardous compound in the municipal bins. It was evident that most of the owners of the repair shops are not aware that

mobile phones have potentially hazardous materials such as beryllium, brominated flame retardants (BFR), cadmium lead and mercury. Plastics are discarded in the municipal bins (56.7%), 40.0% are sold to recyclers while 3.3% are used as spare parts (Table 4.8). Owners of the repair shops stated that when phones are sold to them, the plastic casings do not have much value and that is the reason why they discard them. A few can be modified and used as spare parts when repairing phones. A recycler in Babadogo buys these plastics and recycles them. The recycler utilises plastic waste to manufacture fencing posts. The price ranges from Kshs 450 for 6ft to Kshs 2,500 for 10ft. They buy the plastics at Kshs 10 per kilogram. The recycling plant was established in 2009 and produces 30 to 100 posts a day depending on the sizes.

Table 4.8: Disposal and recycling of mobile phone parts

Mobile Phone part	Discard into municipal bins	Store	Sell to recyclers	Use as spare parts
Metals/PCB	41.7	0.0	58.3	0.0
Plastics	56.7	0.0	40.0	3.3
Potentially hazardous materials	98.3	0.0	1.7	0.0

Source: Research data, 2012

Formal repair shops undertake general service and repair of phones brought in by mobile phone users whether they are on warranty or not. When a phone is on warranty and cannot be repaired, they exchange with a new one and the faulty one is sent back to Nokia offices in Hungary. When it's not on warranty, they give it back to the customer. All of them deal with Nokia phones only except one that deals with all mobile phone models. They only deal with original mobile phones and not counterfeits. Some of the major parts that they repair include the LCD, PCB, network integrated chip, display, keyboard light, vibration chip, speakers, simcard tray, charging jack, and cameras. They use new spare parts, which are imported from Finland and Hungary. They have recycling bins where mobile phone users can drop off their EoL mobile phones. They also use the bin to keep replaced spare parts, which Nokia collects them from time to time. However, they hardly receive any EoL mobile phones for recycling. They do not keep statistics of the number of phones brought in by mobile phone users.

Computers for Schools Kenya has a WEEE centre (recycling department) located in Embakasi, Nairobi, which sources computers that are not working and dismantle them. Other equipment that they deal with includes UPS, mobile phones, printers, photocopiers, desk printers, walky-talkies, batteries and large household equipment. They are then separated into plastics, metals, circuit boards and screens. Plastics are sold to recyclers who make fencing poles. Metals are sold to metal smelters who make building materials (twisted bars). For cables, they have a cable stripper that separates the cables and are then sold to recyclers. Soft and hard aluminium is also sold to recyclers and are used for making decorations. The CRT cutter is used for separating the glass from the plastic in CRT monitors. The glasses from the CRT monitors are currently being stored by CFSK as they do not have a buyer. They are looking for a recycler who can buy them. The circuit boards are shipped to Europe. Computers for Schools Kenya have partnered with a company in Belgium that undertakes precious metal recovery including gold and silver. They do not have any partnership with Nokia or Nokia authorized repair shops to take back their EoL phones but CFSK is undertaking a pilot project in Nairobi, which aims at collecting EoL mobile phones from informal repair shops.

With the changing design of mobile phones, informal repair shops reported that it has become easier to repair mobile phones. This is because 80% reported that it has become easier, 13.3% said it has become harder while 4% said that there is no change (Table 4.9). This is due to the fact that only the faulty parts are replaced e.g. the integrated chips. This was also reported by the formal repair shops who said that the changing design of mobile phones have made them easier for repair. Their major challenge however is that they have to keep up to date with new phone models which keep changing very fast. This means that they will have problems of spare parts and the employees have to undergo regular trainings on repair of the new phone models.

Table 4.9: Ease of mobile phone repair

	Frequency	**Percent**
Easier	48	80.0
Harder	8	13.3
No change	4	6.7
Total	**60**	**100.0**

Source: Research data, 2012

4.1.3 E-waste dealers

Six of the ten E-waste dealers who were interviewed were male and four female with most of them falling within the age bracket of 20-34 years. Eight of them have secondary education while two were in college. They have been collecting the PCBs for a period of between 1 to 7 years. The E-waste dealers do not have a specific area of operation. They buy the PCBs from the repair shops within Nairobi and sell them immediately to the middlemen and exporters. They do not therefore see a need to have offices or storage areas. When they are unable to sell the PCBs, they store them at their homes. The PCBs are then shipped to Europe for recycling. They said that they sell the PCBs to two exporters in Babadogo area and at times, they sell them to middlemen. They are given a commission of Kshs 150 per kilogram. On average, their income ranges from Kshs 8,000 to Kshs 15,000 per month. The E-waste dealers were not aware that PCBs have hazardous materials but were of the opinion that metals such as copper, gold and silver are recovered from these PCBs. It was not possible to trace the GPN beyond the E-waste dealers because none of the exporters were willing to be interviewed.

4.1.4 Reuse and recycling of batteries

Only 5% of the informal repair shops carry out recycling and reuse of mobile phone, 85% do not while 10% dispose them (Table 4.10). This is because most of the repair shops are not interested with the batteries and are given back to the owners. Those who reuse them modify the batteries to fit other phones. Those batteries that cannot be reused or recycled are discarded at the municipal bins (90%), given back to the customers (1.7%) or stored (1.7%). A few said they do not deal with batteries at all (6.7%) (Table 4.11).

Table 4.10: Recycling and reuse of batteries

Battery recycling	Frequency	Percent
Yes	3	5.0
No	51	85.0
Dispose	6	10.0
Total	**60**	**100.0**

Source: Research data, 2012

Table 4.11: Disposal of batteries

	Frequency	Percent
Dispose	54	90.0
Don't deal with batteries	4	6.7
Give back to customer	1	1.7
Store	1	1.7
Total	**60**	**100.0**

Source: Research data, 2012

4.1.5 Income

On average most repair shops (58.8%) make between Kshs 20001-50,000 per month from mobile phone repair. This is followed by those who make between Kshs 10,001-20,000 (28.3%), then those who make less than Kshs 10,000 at 10% and finally those who make between Kshs 50,001-100,000 (Figure 4.7).

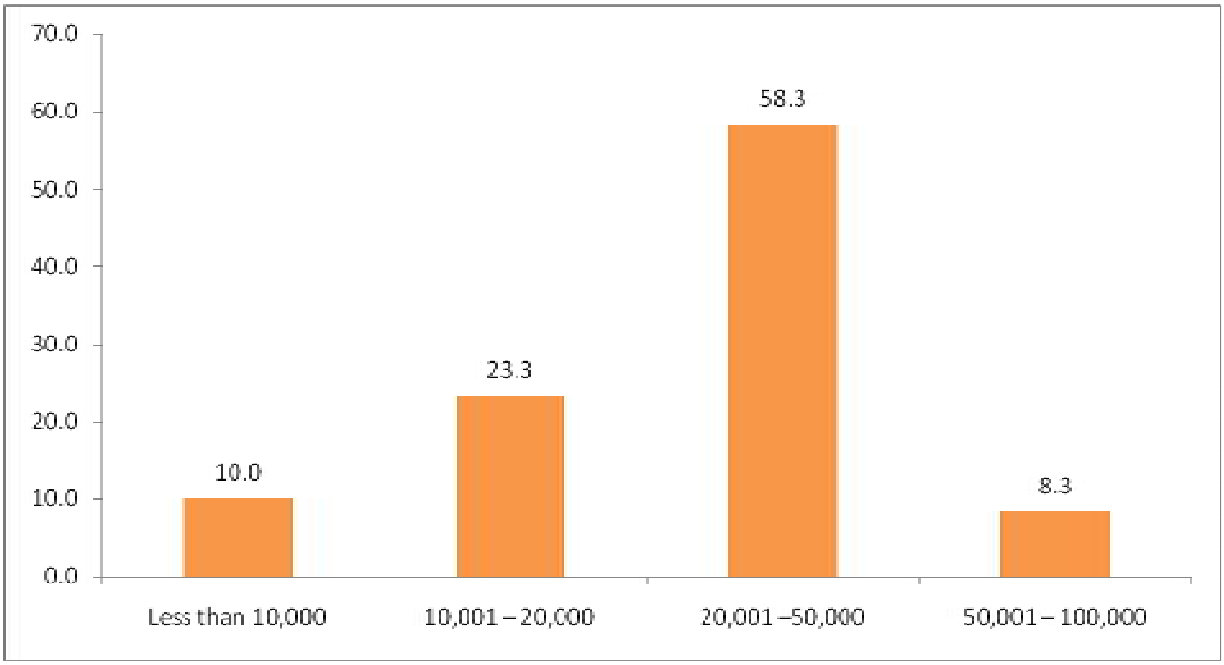


Figure 4.7: Average income of repair shops per month

Source: Research data, 2012

4.1.6 Summary

Findings from discussions with repair shops indicate that, there are two valuable components in a mobile phone - plastic panels and PCBs. The plastic panels enter the larger plastic recycling market where they are used to make products such as fencing posts. The precious metals in PCBs are bought by exporters (four were identified in this research) and exported to China and Europe for recovery and recycling. These exporters buy the PCBs from middlemen or from E-waste dealers. Established recyclers such as CFSK also ship the PCBs to Belgium for recycling, as they do not have the capacity to recover the precious metals from PCBs. It was difficult to acquire information on the exporters and the researcher relied on information from a middleman, repair shops and E-waste dealers. It emerged that the battery recycling is not well established and much information on this was not available. The GPN of mobile phone waste in Nairobi can therefore be summarised in Figure 4.8.

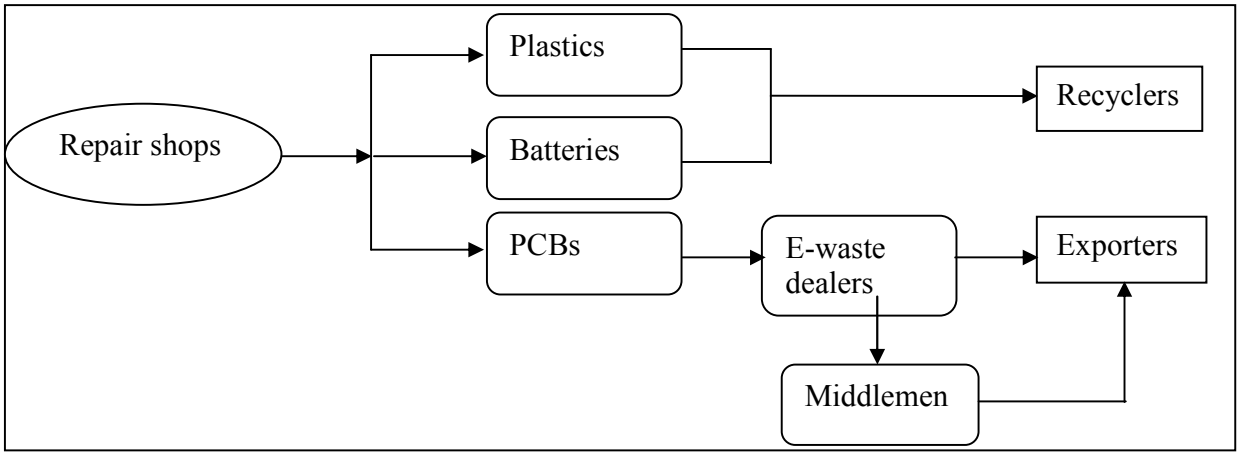


Figure 4.8: Flow of mobile phone waste in Nairobi

4.1.7 Challenges facing the mobile repair business

The major challenges facing repair and recycling of EoL mobile phones in Kenya include inadequate training on mobile phone repair leading to more damage to client's phones, harassment by City Council of Nairobi due to delays in payment of annual licensing fees and lack of spare parts. Other challenges include customers selling them allegedly stolen phones leading to arrests by police officers, difficulty in repairing some phones e.g. phones originating from China, lack of government support and financing, unavailability of equipment for repair in

the market, lack of recycling centres, high competition, high licensing fees, high electricity and rent charges and lack of training institutions thus most of the workers depend on on-the job training. They also gave what they think should be done to. The major recommendations given to overcome these obstacles include introduction of affordable training colleges to keep pace with changing technology, increasing awareness on mobile recycling and encouraging local recycling of mobile phone E-waste. Others include enhancing customer knowledge on repair business and initiation of research and development programs by government to enhance technology transfer.

According to CFSK, the major challenge facing in their operations and repair and recycling business in general is the lack of an E-waste policy in Kenya. Another obstacle is public awareness including the generators of E-waste who do not know how to dispose them. Computers for Schools Kenya further said that the Government offices do not have a clear mechanism for disposal of E-waste despite the fact that they are the biggest generators of E-waste. They also mentioned that the lack of government support for institutions who have taken the initiative of managing E-waste is hindering the E-waste recycling business. Computers for Schools Kenya supposes that a conducive environment for dealing with E-waste and provision of incentives will help in building capacity for dealing with the E-waste. Sensitization through press have been done by CFSK i.e. both the print media and television. They have also held breakfast shows but acknowledge that these breakfast shows are very expensive.

4.2. Mobile phone network operators

Safaricom launched its E-waste management program on 17 February 2011. This is due to the fact that the advances in information technology during the last century which has led to pollution of the environment and posed a new challenge in the management of E-waste. According to Safaricom, mobile phones and computers contain certain components, which are highly toxic, such as toxic gases, toxic metals, biologically active materials, acids, plastics and plastic additives. These hazardous materials poses an environmental and health threat. The lead found in E-waste can seep into the groundwater from landfills thereby contaminating it. Safaricom therefore advocate for proper ways of disposing them or recycling E-waste. Some of the goals and objectives of the take back scheme include: (i) to manage the impacts of its electronic gadgets from cradle to grave; and (ii) to ensure efficient and safe disposal of electronic

waste. Safaricom collection centres are found in all Safaricom retail shops and Safaricom facilities within Nairobi. Safaricom seeks to minimize the impact of its operations on the environment and endeavours to apply a set of mitigation measures to protect and safeguard the environment.

Safaricom has no data on the EoL mobile phones collected over the years. The take back scheme at the moment has been stopped and is to be re-launched soon. Safaricom Foundation partnered with CFSK to offer environmentally safe disposal of E-waste. Safaricom Foundation donated an E-waste grinder valued at KSh 4 million to CFSK. The purpose of the machine is to ensure that every plastic emanating from the ICT hardware equipment is safely recycled and disposed off. Some of the opportunities of the take back scheme include employment opportunities (collection and recycling) and establishment of producer responsibility organisations. The challenges faced by the take back scheme include lack of coordinated approach across the government ministries dealing with E-waste, lack of awareness on the need for the E-waste management, lack of collection systems leading to E-waste being kept at homes, office and repair shops and lack of a national E-waste policy in Kenya.

Orange, another mobile phone network operator does not have a mobile take back scheme or a system to take back EoL mobile phones purchased by their customers. According to Orange, mobile phone repair shops can be set up which can repair and recycle EoL mobile phones. This will reduce the scenario where EoL mobile phones are kept in the house or disposed in the dustbins. By doing so, it pollutes/degrades the environment with all types of materials like batteries. Toxic materials mix with soil and eventually carried away by water to the river then onwards to the sea/oceans where they are absorbed by fish and ultimately the human body.

4.3 Economic upgrading in the mobile phone industry in Kenya

Economic upgrading in the mobile phone sector in Kenya has been experienced in different dimensions. In terms of employment mobile phone repair business has led to employment of many people who work in different categories in both formal and informal repair shops. Formal repair shops employ people who include technicians, managers and customer care staff. Informal repair shops on the other hand have few employees who range from one to five and are mostly

technicians. Other than direct employment in the repair shops, the sector had led to the increase in the mobile phone accessories shops, which sells different spare parts for mobile phone repair. This in itself has created more employment opportunities. E-waste dealers and middlemen have also had a source of income through buying and selling of PCBs. Exporters have also been able to generate some income through the shipping of PCBs. Some E-waste recycling firms such as CFSK have also come up which offer various employment opportunities.

The mobile phone E-waste industry is also a source of government revenue. The study showed that the repair shops pay annual licensing fees of Kshs 7,000 to City Council of Nairobi. The formal repair shops are registered with KRA. This means therefore that they remit taxes to the exchequer.

4.4 E-waste policy framework

Waste management in Kenya is under the jurisdiction of the local authorities (in Nairobi, it is under the jurisdiction of the City Council of Nairobi) as mandated under the Local Government Act (CAP 265) and Public Health Act (CAP 242). These pieces of legislation make the local authorities responsible for the management of municipal waste. The main shortcoming the of the Local Government Act and Public Health Act is that they are silent on management of E-waste. To address this shortcoming, the Ministry of Local Government is developing a solid waste management policy while the City Council of Nairobi is developing an integrated solid waste management strategy in conjunction with UNEP (Ministry of Environment and Mineral Resources, 2010).

The enactment of the Environmental Management and Coordination Act (EMCA, 1999) provides a channel to address the waste management problems in Kenya as there are provisions in the manner in which waste should be handled. The Act sets out the institutional framework for environmental management in Kenya. The National Environment Management Authority is mandated to exercise general supervision and co-ordination over all matters relating to the environment and to be the principal Government agency that deals with the implementation of all policies relating to the environment (NEMA, 2008). This Act also mandates NEMA to develop regulation on waste management including hazardous waste.

In 2006, NEMA developed the waste management regulation. The Environmental Management and Co-ordination (Waste Management) Regulations 2006 is described in Legal Notice No. 121 of the Kenya Gazette Supplement No. 69 of September 2006. It applies to all categories of waste as provided in the regulation. These include industrial wastes, hazardous and toxic wastes, pesticides, biomedical wastes, and radioactive substances. In the regulation, hazardous waste is defined as having five distinct characteristics i.e. explosive, flammable, oxidative, toxic and corrosive This regulation deals with hazardous waste in totality i.e. it provides the activities, administrative and operational procedures that are used in handling, packaging, treatment, conditioning, reducing, recycling, reusing, storage and disposal of waste. The regulation applies to E-waste by virtue of their composition, which includes several of the substances listed as hazardous waste. Other subsidiary legislation of EMCA includes the Environment Management and Coordination (Controlled Substances) Regulations 2007. It deals with management and control of substances that deplete the Ozone. However, the regulations comprise little more than a list of the hazardous substances.

In 2010, NEMA came up with the E-waste management guidelines whose purpose is to help in the establishment of E-waste regulations in Kenya. The National Environment Management Authority introduced the E-waste guidelines because it realised that Kenya as a country had not anticipated the problem of E-waste. The development of the E-waste guidelines was also influenced by the fact that the technology is constantly changing making some of the electronic products such as televisions, computers, fridges and mobile phones obsolete much faster. The guidelines include measures to ensure environmental protection. The E-waste from mobile phones under the guidelines are categorised as waste from ICT and telecommunications equipment. The National Environment Management Authority is in the process of amending the current Environmental Management and Co-ordination (Waste Management) Regulations 2006 to incorporate E-waste since it is considered as a hazardous waste. A draft has already been produced and it has borrowed a lot from the E-waste management guidelines. The regulation will have the different categories of E-waste whether from institutions, homes or from consumers. However, NEMA believes that E-waste from mobile phones will form a large percentage of E-waste.

The National Environment Management Authority came up with the concept of producer responsibility organisation (PRO) group where some of the players in the electronic industry were required to set up collection centres where consumers are able to drop off their EoL electronic products under the take back schemes. However, this is done on a voluntary basis because there is no law governing the sector. These companies include Dell, HP, Microsoft, Nokia and Safaricom. The PROs have partnered with CFSK and East African Computer Recycling Centre (EACR) in Mombasa in a pilot project where they take their E-waste for recycling.

According to NEMA, the major challenge they are facing in the implementation of the guidelines is the fact that guidelines are not enforceable and stakeholders are only involved on voluntary basis. However, their biggest challenge in the management of E-waste is consumer awareness. They said that mobile phones have toxic compounds that can find their way into dumpsites such as Dandora. Burning of these wastes at the dumpsites has the potential of releasing toxic fumes, which may lead to diseases such as cancer. The consumers are also not aware of the various collection points where they can drop off their EoL electronics. The National Environment Management Authority, in an effort to increase public awareness normally holds public meetings and does advertisements in the print media but the cost is prohibitive. It means therefore that they have to look for funds in order to be able to do massive campaigns. This will ensure that the public is educated and well informed.

The National Environment Management Authority said that they are in-charge of drafting the relevant regulations and ensuring its implementation. They are also responsible for educating the public on the hazardous compounds found in mobile phones and how it will affect their health, water, environment and overall food chain. On the other hand, the PROs should be responsible for making sure that the consumers are aware of their take back schemes, the important of taking back their phones for recycling and providing information on the location of the collection centres. They should also ensure that they put up more collection centres for easy access by consumers. The National Environment Management Authority together with PROs are discussing ways of giving people incentives to take back EoL electronics. One of NEMA's

recommendations in the draft waste regulation is that, no one should be allowed to operate within the country without being a member of a PRO. This will make sure that manufacturers, importers, distributors and assemblers are responsible for the E-waste generated by their products.

The National Environment Management Authority believes that both the informal and formal repair shops should be incorporated into the management of mobile phone E-waste. The informal repair shops should be linked up with the formal repair shops and collection centres. Those people who are willing to drop off their mobile phones at the informal repair shops can do that and the repair can then send them to the collection centres. However, it will be important to discourage the burning of E-waste for the extraction of E-waste components such as copper. Export of E-waste without a licence is also prohibited because it's against the Basel Convention, which prohibits transboundary movement of hazardous waste. They said that recyclers should not fear going to NEMA to seek licenses for dealing with mobile phone E-waste because they will be given expert advice on how to handle all types of E-waste.

According to the Kenya Communications (Amendment Bill) 2008, CCK acknowledges that E-waste is at the very core of the relationship between ICT and environmental sustainability. The bill states that E-waste is a growing problem in today's society and poses many health and environmental problems if they are improperly disposed. The Communication Commission of Kenya was established in February 1999 by the Kenya Communications Act of 1998. Its role in ensuring proper management of the E-waste from mobile phones stems from the fact that they are the regulatory authority in the communications sector. They understand what is harmful in a mobile phone such as mercury. The Communication Commission of Kenya suggested that one way of managing E-waste is through making the public aware of their hazardous nature and giving proper education on the hazardous compounds found in mobile phones. According to CCK, disposal of mobile phone batteries is more important because it contains corrosive materials that can which can injure people or damage property.

The Communication Commission of Kenya estimated the number of mobile phone users in Kenya to be 28 million. A quarter of the mobile phones are therefore disposed off annually,

which is about 7 million mobile phones. Mobile phone manufacturers such as Nokia do not give incentives for recycling. Therefore, CCK suggested that mobile phone manufacturing companies like Nokia should give incentives to mobile phone users in order for them to take back their EoL mobile phones for recycling. The Communication Commission of Kenya also recommended public awareness on mobile phone recycling. They do not have a policy specific to mobile phone waste management and CCK believes that this is the work of NEMA. They organised an E-waste workshop in 2010 for sensitisation purposes. They recommended that NEMA should come up with an E-waste policy, which will encompass not only the mobile phone E-waste but also other ICT equipment and batteries. This will ensure a holistic approach to the management of E-waste.

The Communication Commission of Kenya works in collaboration with KEBS in developing standards for the ICT sector. The mobile phones are inspected by the CCK and KEBS based on standards developed by KEBS. The main challenge facing KEBS is the safe disposal of the rejected hazardous goods as the country lacks the necessary infrastructure to destroy these goods although it is stipulated in the law that the importer of the rejected good is to meet the disposal cost. The KRA's role regarding the management of E-waste includes the control of Kenya's exit and entry points to ensure that prohibited and illegal goods do not pass through the Kenyan borders. Hazardous wastes and their disposal as provided for under the Basel Convention are listed as part of the restricted goods that are controlled by the customs services department of KRA. Over and above the fiscal responsibilities of the custom services department, KRA is responsible for the facilitation of legitimate trade and protection of society from illegal entry and exit of prohibited goods. The Kenya Revenue Authority also complements the work of KEBS.

Safaricom and Orange are of the view that the E-waste guidelines are good since they assist the government, private sector, learning institutions and other stakeholders to manage E-waste effectively in order to enhance environmental conservation. Safaricom and Orange recommended that NEMA should have clear enforcement mechanism for the guidelines since at the moment they are only on paper and that NEMA only acts upon receiving complaints. For the guidelines to become more effective, they believes that they should made into law whereby they shall be gazetted by the minister of environment in the Kenya gazette including the penalties in the event of non-compliance. This can help in the management of mobile phone E-waste.

Computers for Schools Kenya echoed the sentiments of Safaricom and Orange. They noted that since they took part in the drafting of the E-waste guideline, they believe that the guidelines are good but should be enacted into law so that it can be easily enforceable. Computers for Schools Kenya recommends that the policy should be inculcated with sensitization of the public to appreciate the problem of E-waste. This will help in segregation of E-waste from other household waste.

4.5 Nokia's design for environment and end of life practices

Nokia's DfE works to improve the impact of a product throughout its entire lifecycle as well as consider the interdependence of all environmental impacts throughout different phases. The four objectives of Nokia's DfE which include: (i) minimizing material and energy use; (ii) minimizing the use of materials detrimental to the environment; (iii) maximizing reuse and recycling; and (iv) designing equipment to be easily or remotely maintainable or maintenance free are integrated into the entire process of product development. The DfE aims at ensuring that there are guidelines for all designs, parts, products, modules, batteries, components and all packaging materials. According to Nokia (2011), Nokia designs their mobile phones with the environment in mind. According to Zhang (2008), the mobile phone size has been reducing from 10kg in 1983 to 79g in 1999 (Figure 4.9). This is due to Nokia's initiative to reduce the materials used in manufacturing mobile phones hence a reduction of E-waste.

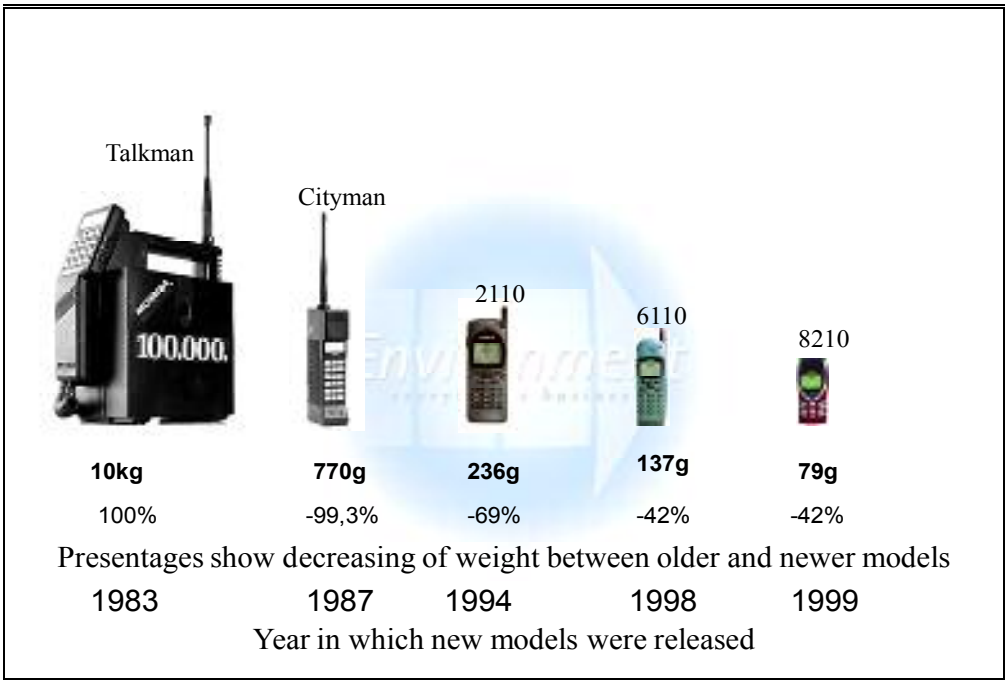


Figure 4.9: Reduction of mobile phone weight: 1983-1999

Source: Adapted from Zhang, 2002

During product creation, Nokia focuses on energy efficiency, avoiding substances that are restricted, use renewable materials, smart packaging and environmental awareness initiatives which encourage people to adopt more sustainable lifestyles. Nokia has dedicated DfE specialists in all their new products who supports product development project. They verify the implementation of the legal environmental requirements, promote the implementation of most sustainable alternatives for material choices and energy efficiency and provide sustainability reporting (Nokia, 2011). Nokia product creation is guided by life cycle thinking to minimize the environmental impacts across the life cycle of a product. During the last decade, the greenhouse gas footprint of Nokia phones has been reduced by up to 50%. Nokia uses an externally audited life cycle assessment methodology to calculate the environmental impact of the products and processes. Life cycle assessments help them to identify and focus on the areas where Nokia can make the biggest reductions (Nokia, 2011).

Annually, Nokia publishes, the Nokia substance list (NSL) in which both legislative and voluntary material restrictions are shown. The NSL introduction dates back to 2000, and in 2001

the first public version of NLS was introduced. All their mobile devices and accessories, worldwide, are fully compliant with the EU Directive on the Restriction of the use of certain hazardous substances in electrical and electronic equipment. From 2001 to 2011, Nokia has been able to voluntarily phase out various substances of concern from mobile phones. They include restricted flame retardants (RFR), Polyvinyl chloride (PVC), brominated flame retardants (BFR), beryllium compounds, phthalates, perfluorooctane sulfonates (PFOSS), perfluorooctane acid (PFOA) and organic tin compounds.

Nokia's focus, in the past, on reducing the packaging materials has resulted in a real chain reaction of benefits. Packaging materials used during 2011 for retail packages included 23,032 tonnes of paper (60% recycled) and 683 tonnes of plastic (90% recycled). Transport packages included 9,948 tonnes of paper (78% recycled). For retail and transport packages combined, it included 32,980 tonnes of paper (66% recycled and 683 tonnes of plastic (90% recycled) (Nokia, 2011). They got smaller, lighter and more efficient chargers. They also made smaller and shorter user guides with fewer language variants per package, less content in the box, tighter wrapping of cabled accessories and fewer and lighter packaging parts. This optimization has been on going for years and they believe that there is nothing much that can be done to reduce the use of materials in packaging. The current focus of the Nokia packaging design team is therefore the use of sustainable materials. In 2011 Nokia saw their first Forest Stewardship Council (FSC)[1] certified packages for the Nokia N9 and the Nokia Lumia 800 packages. Their vision is that they will use only 100% certified renewable or recycled packaging materials with ISO standard recycle markings. Nokia confirmed that their user manual and the packaging have messages on recycling. However they are facing challenges such as influx of counterfeit mobile phones in Kenya and the fact that some component parts such as batteries are not manufactured by Nokia. This makes it harder to enforce some laws.

In order to meet their objective of maximizing reuse and recycling, Nokia authorized four repair shops in Nairobi namely Nokia care centre, Midcom, Technoservice and FoneXpress to undertake mobile phone repairs. All the four repair shops are level 1 and level 2 repair shops.

[1] FSC is an independent, non-governmental, not for profit organization established to promote the responsible management of the world's forests. Its main tools for achieving this are standard setting, independent certification and labeling of forest products.

Level 1 repair shops undertake software repairs while level 2 shops deals with mechanical and electrical repairs. Level 3 shops are not available in Kenya and these are repair factories. This is because they are expensive to establish and Nokia has not found the need to establish one. The authorized repair shops undertake service and repair of mobile phones that are on warranty.

Nokia launched its take back and recycling campaign in Kenya in February 2008. The launch was motivated by the fact that there is too much E-waste accumulation that needs to be properly disposed off as they have a potential of contaminating the environment e.g. acids in batteries. Recycling boxes were placed in authorised care centres. The government does not charge them any duty for shipment. Some parts such as plastics have been used to make bags. As an incentive to encourage mobile phone users to bring in their EoL mobile phones for recycling, Nokia tried giving out tokens such as key rings and pens to mobile phone users. However, this did not increase the number of phones collected. Nokia does not keep statistics of the mobile phones that they sent to China for recycling. This is because according to Nokia, few people bring their EoL mobile phones for recycling. This is due to the fact that most people keep their phones for their sentimental value. Nokia have a corporate social responsibility (CSR) that seeks to safeguard the environment. Nokia tries to create public awareness on recycling through their webpage, Facebook page, care centres and malls. Nokia confirmed that 100% of mobile phone components are sent to China for recycling. However, if a customer insists on being given the faulty parts that were replaced, they do so. They do not persuade the customers to leave them for recycling.

CHAPTER 5: SUMMARY OF FINDINGS CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of key findings

It is clear that there are four forms of management of EoL mobile phones. One is the repair of mobile phones, second is repair and sale of mobile phones in the second hand markets, third is recovery of important components for use as spare parts and fourth is the recycling of plastics and batteries in Kenya and export of PCBs to China and Europe for recycling. The network of mobile phone E-waste starts from the repair shops where repair is done. What cannot be repaired are used as spare parts and the rest enters the recycling market where E-waste dealers and the middlemen are the critical link with the recyclers. Some recyclers do recycle these materials while others export them.

The composition and conditions of employment in repair shops in Nairobi showed that male dominate work force and most of the workers were permanent. Majority of them were between 20 – 24 years. Majority of the workers (53.2%) earn between Kshs 10,500-20,000. However, most workers were of the opinion that the earnings were inadequate. About 61.7% of workers interviewed mentioned that they had suffered from accidents at their place of work or work related health problems. Some of the accidents reported by the workers include burns by soldering gun, burns from battery acids, cuts from plastics and metals, hits by screws, pricks from pins and screws and shock when charging phones.

It is evident that economic upgrading has occurred in the mobile industry in Kenya. This is because mobile phones have led to economic development. The sector has emerged as a source of government revenue through payment of taxes and licensing fees. It has employed many people directly and indirectly. They include workers at repair shops, middlemen, E-waste dealers, exporters and mobile phone accessories shops.

In terms of policy, it is clear that Kenya does not have a policy that deals with mobile phone E-waste. The National Environment Management Authority is in the process of amending the current Environmental Management and Co-ordination (Waste Management) Regulations 2006

to incorporate E-waste since it is considered as a hazardous waste. The link between Nokia's DfE and the end of life practices of mobile phones in Kenya was established. Nokia undertakes DfE through reduction of packaging materials, substance and materials management, sustainable sourcing and maximizing reuse and recycling through their repair shops and shipping of EoL mobile phones to China for recycling.

5.2 Conclusion

This research paper focused on mobile phone E-waste in Kenya using the GPN as the conceptual framework. This research concludes that there are numerous activities that take place when a mobile phone reaches its EoL as indicated in Figure 4.8. This includes use as spare parts to repair other phones, export of PCBs for recovery of precious metals and use of plastic waste to manufacture fencing posts. The research concludes that both social and economic upgrading has occurred in Kenya. The number of repair shops and consequently workers has been growing over the years. Accessories shops have also been increasing creating employment opportunities for many people. The mobile phone GPN has also helped the government increase their government revenue base through licenses and taxes.

The status of E-waste policy that addresses mobile phone waste management in the country is inadequate. The lack of explicit and detailed mention on E-waste in most legislation has created loopholes in the regulation as the actors in the mobile phone E-waste and NEMA is trying to address this through incorporation of E-waste in the waste management regulations. Also the innovation in the mobile phone sector in most cases is changing must faster than the rate at which regulations are enacted. This means therefore that NEMA, in association with other government agencies should come up with a legislation that governs mobile phone E-waste and should be able to keep pace with the changing technology.

Nokia's DfE is firmly life-cycle thinking approach which aims at satisfying the needs of customers and other stakeholders in a way that has less environmental impacts. It involves design procedures that minimise material and energy consumption while maximising the possibilities of reuse and recycling.

5.3 Policy recommendation

There is a need for Nokia to design a system that will sensitise users to bring back their EoL phones to the appropriate collection points. The National Environment Management Authority should be in charge of educating the public on the hazardous materials found in (E-waste) mobile phones and how it will affect their health, water, environment and overall food chain. There is also an urgent need for NEMA to move forward and ensure that the current E-waste guidelines are enacted into law. The government and possibly the private sector should establish a training institution for mobile phone repair. This will ensure that the workers at the repair shop have the required knowledge and that they will be able to keep up with the ever changing technology. The informal repair shops should be linked up with the formal repair shops for proper management of mobile phone E-waste. As it currently stands, they both work in isolation. It will also enhance knowledge transfer.

5.4 Areas for further research

Further investigation on the link between economic and social upgrading is needed. This can be done through primary data collection. Information on economic upgrading was based on literature review. This will ensure that all GPN actors including developing countries as a whole, as well as manufacturers, suppliers, workers and households are fully understood. An attempt to investigate the operations of exporters of PCBs should be made. This was not achieved in this study. This will shed some light on their mode of operation and the exact final destination of the products. Information provided in this research is based on interviews with E-waste dealers and middlemen. This will ensure that the mobile phone E-waste GPN is fully completed.

REFERENCES

Bair, J. (2009). Global commodity chains: genealogy and review. *Frontiers of Commodity Chain Research*. Stanford, CA: Stanford University Press.

Basel Action Network, (2005). *The Digital Dump: Exporting Re-use and Abuse to Africa.* Basel Action Network. <http://www.ban.org/library/TheDigitalDump.pdf> [Accessed on 03/08/2011]

Barrientos, S., Gereffi, G. and Rossi, A. (2008). What are the challenges and opportunities for economic and social upgrading? *Presented to Capturing the Gains Manchester Workshop*, Manchester, UK, December 8-9, 2008. < www.capturingthegains.org/pdf/ctg-wp-2010-03.pdf> [Accessed on 12/06/2012]

Basiye, K.K. (2008). Extended producer responsibility for the management of waste from mobile phone. Institute for Industrial Environmental Economics at Lund University. :80.

Bernhardt, T. and Milberg, W. (2011). Economic and social upgrading in global value chains: analysis of horticulture, apparel, tourism and mobile telephones. *Capturing the Gains Working Paper 2011/6*, Brooks World Poverty Institute, University of Manchester. < http://www.capturingthegains.org/pdf/ctg-wp-2011-06.pdf> [Accessed on 12/06/2012]

Brugger, F. (2011). Mobile applications in agriculture. Syngenta Foundation, mAgriculture. <www.syngentafoundation.org/view/element_href.cfm?src=1/1067.pdf> [Accessed on 05/07/2012].

Communication Commission of Kenya, (2011). *Quarterly sector statistics report 2nd Quarter,* October-December 2010/2011. <http://www.cck.go.ke/resc/statistics/sector_statistics_ report_q2_201011_x2x_x3x_x2x.pdf> [Accessed on 12/05/2011]

Communication Commission of Kenya, (2010). E-waste: impacts, challenges and the role of government, service providers and the consumers workshop. In: *Proceedings of the CCK workshop* Held at Ole Sereni Hotel on 9th -10th June 2010, Nairobi, Kenya. <www.cck.go.ke/consumers/other.../E-Waste_Workshop_Report.pdf> [Accessed on 29/04/2011]

Communication Commission of Kenya, (2008). *Communications statistics report*, CCK, Nairobi. <http://www.cck.go.ke/resc/statistics/Communications_Statistics_Report_2008.pdf> [Accessed on 12/05/2011]

Commission of the European Communities, (2008). *Commission staff working paper accompanying the proposal for a directive of the European Parliament and of the Council on waste electrical and electronic equipment (WEEE) (recast) - Summary of the impact assessment, SEC 2934*. CEC, Brussels, Belgium. <http://eurlex.europa.eu> [Accessed on 12/01/2011].

Civil Initiatives for Development and Peace, (2009). *Corporate Geography, Labour Conditions and Environmental Standards in the Mobile Phone Manufacturing Industry in India*. Centre for Research on Multinational Corporations. Amsterdam, the Netherland.

Deloitte LLP, (2011). Global mobile tax review 2011. GSMA. <http://www.gsma.com/publicpolicy/wpcontent/uploads/2012/03/gsmaglobaltaxreviewnovember2011.pdf> [Accessed on 01/07/2012].

European Union, (2003). EU WEEE Directive 2002/96/EC. <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0096:EN:HTML> [Accessed on 4/05/2011].

Fishbein, B.K. (2002). *End-of-life management of electronics abroad. In: Waste in the Wireless World: the Challenge of Cell Phones*. INFORM Inc. New York. <www.informinc.org> [Accessed on 21/07/2011]

Gereffi, G. (2005). The global economy: organization, governance and development, in: Smelser, N. J. and R. Swedberg (eds.), *Handbook of Economic Sociology*. Princeton, NJ: Princeton University Press and Russell Sage Foundation.

Gereffi, G. and Korzeniewicz, M. (1994). *Commodity Chains and Global Capitalism.* Westport, Praeger.

Hageluken, C. (2007). Eco-efficient metals recovery from mobile phones: technical capabilities, challenges and experiences gained, paper presented in *a WEEE workshop organized by the European Union Commission in collaboration with Basel convention regional centre,* Bratislava 22-26 June 2007. <http://www.basel.int/industry/sideevent030907/umicore.pdf> [Accessed on 25/05/2011]

Henderson, J., Peter., Martin H., Heil C. and Henry, Y. (2002). Global production networks and the analysis of economic development. *Review of International Political Economy* 9 (3): 436-464.

Hopkins, T. and Wallerstein, I. (1986). Commodity chains in the world economy prior to 1800, *Review,* 10(1): 157-70.

Huisman, J. (2004). *QWERTY and Eco-Efficiency analysis on cellular phone treatment in Sweden: The eco-efficiency of the direct smelter route versus mandatory disassembly of Printed Circuit Boards.* <http://www.basel.int/industry/qwerty-sweeden.pdf> [Accessed on 14/08/2011]

Jarvinen, J., Perklen, E., Kaila-Stenberg, S., Hyvarinen, E., Hyytiainen, S. and Tornqvist, J. (1998). PDCAcycle in implementing design for environment in an R&D unit of Nokia Telecommunications. *Proc IEEE International Symposium on Electronics and the Environment*, Oak Brook, USA, 237-242.

Kaplinsky, R. (2005). Globalisation, Poverty and Inequality: Between a Rock and a Hard Place: Cambridge: Polity Press.

Kenya National Bureau of Statistics, (2010a). *2009 Kenya population and housing census volume II: population and household distribution by socio-economic characteristics.* KNBS, Nairobi, Kenya.

Kenya National Bureau of Statistics, (2010b). *2009 Kenya population and housing census volume 1 A: population distribution by administrative units*. KNBS, Nairobi, Kenya.

Lee, J. and Gereffi, G. (2010). Capturing the Gains – Mobile telecommunications scoping study. Capturing the Gains Research Network, Brooks World Poverty Institute, University of

Manchester. <http://www.capturingthegains.org/pdf/ apparel-scoping_pape-pt-1-3.pdf> [Accessed on 24/04/2011]

Lenox, M., Jordan, B. and Ehrenfeld, J. (1996) The diffusion of design for environment: a survey of current practice VO, in *Electronics and the Environment, ISEE-1996., Proceedings of the 1996 IEEE International Symposium on, 1996*. Dallas, TX, USA.

Lenox, M., King, A. and Ehrenfeld, J. (2000). An assessment of design-for-environment practices in leading US electronics firms, *Interfaces*, 30 (3): 83–94.

Li, Y., Richardson, J.B., Walker, A.K. and Youn, P.C. (2006). TCLP heavy metal leaching of personal computer components. *Journal of Environmental Engineering* 132 (4): 497–504.

Maree, J. (2011). Mobile Telecommunications Industry Scoping Study: Sub-Saharan Africa. The Mobile Telecommunication Production Network in Africa. *Paper prepared for Sub-Saharan Africa Regional Workshop Cape Town* 31 January – 4 February 2011. *<http://www.ilo.org/public/english/iira/documents/congresses/regional/lagos2011/3rdparallel/session3b/globalmobiletelecom.pdf>* [Accessed on 02/07/2011].

Medina, M. (2000). Scavenger cooperatives in Asia and Latin America. *Resources Conservation and Recycling* 31(1): 51–69

Ministry of Environment and Mineral Resources, (2010). *Draft guidelines for E-waste management in Kenya, 2009*. <http://www.nema.go.ke/index2.php?option=com_ docman&task=doc_view&gid=531&Itemid=35> [Accessed on 24/04/2011]

Mizuki, C., Sandborn, P.A. and Pitts, G. (1996) Design for environment a survey of current practices and tools VO, in *Electronics and the Environment, 1996. ISEE-1996., Proceedings of the 1996 IEEE International Symposium on*, Dallas, TX , USA.

Munyua, A. (2010). *2010 - ICTs and environmental sustainability report*. Kenya ICT Action Network (KICTANet), Kenya. <http://www.kictanet.or.ke> [Accessed on 22/07/2011]

Mureithi, M. and Waema, T. (2008). *E-waste management in Kenya*. Kenya ICT Action Network (KICTANet), Kenya. <http://ewasteguide.info/Waema_2008_ KICTANet> [Accessed 9/09/20011]

Nathan, D. and Sarkar, S. (2010). Blood on your mobile phones? Capturing the gains for artisanal miners, poor workers and women. *Capturing the Gains Briefing Note No. 2*, February. <http://www.capturingthegains.org/pdf/ctg_briefing_note_2.pdf> [Accessed on 25/06/2012]

National Environment Management Authority, (2007). Provincial environmental action plan 2007-2011, Nairobi Province. Kenya: NEMA.<http://www.nema.go.ke/index2.php? option=com_docman&task=doc_view&gid=236&Itemid=35> [Accessed on 25/02/2011]

Nnorom, I.C. and Osibanjo, O. (2008). Electronic waste (e-waste): Material flows and management practices in Nigeria. *Waste Management*, 28 (8): 1472-1479.

Nokia Corporation, (2010). *Interim report, January 27, 2011*. Nokia. <www.nokia.com/results/ Nokia_results2010Q4e.pdf> [Accessed on 27/05/2011]

Nokia Corporation, (2008). *Nokia corporate responsibility review*. Nokia. <www.nokia.com/ NOKIA.../Corporate_Responsibility/...2008/nokia_cr_report_2008.pdf> [Accessed on 18/05/2011]

Ogembo, J.G. (2010). M-Pesa: A Case study of the critical early adopters' role in the rapid adoption of mobile money banking in Kenya. Thesis submitted to Harvard Medical School/Beth Israel Deaconess Medical Center. <http://www.ejisdc.org> [Accessed on 27/05/2011]

Orisakwe, O. E. and Chiara, F. (2010). Electronic revolution and electronic wasteland: The West/waste Africa experience, *Journal of Natural and Environmental Sciences*, 1: 43-47

Porter, M. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance.* London, Macmillan.

Rao, M. (2011). *Regional hubs of excellence and innovation. Mobile Africa report 2011*. Mobile Monday. <www.mobilemonday.net/reports/MobileAfrica_2011.pdf> [Accessed on 07/06/2011]

Ray, D. L. and Guzzo, L. (1993). *Environmental Overkill; Whatever Happened to Common Sense?* Harper Collins, New York

Rossi, A. (2011). Economic and social upgrading in global production networks: the case of the garment industry in Morocco. Doctoral thesis, University of Sussex.

Rose, C.M. (2010). Design for environment: a method for formulating product end-of-life strategies. Ph.D. dissertation. Department of Mechanical Engineering, Stanford University <http://www.seas.columbia.edu/earth/RRC/documents/2000.dfe.diss.rose.pdf > [Accessed on 04/07/2012]

Rowley, J. (2009). Used and end-of-life mobile phones E-waste management In: GSM Association, *Forum for circulating success*. Cairo, Egypt 9-10 February 2009. <http://ewasteforum.cedare.int/Presentations/Session_IV/JRowley.pdf> [Accessed on 24/05/1011]

Sahu, S. and Srinivasan, N. (2008). *Mobile phone waste: Current initiatives in Asia and the Pacific.* <http://www.techmonitor.net/tm/images/2/24/08jul_aug_sf3.pdf > [Accessed on 25/07/1011]

Sen, A. (2000). Work and rights. *International Labour Review*, 139(2): 119-128.

Sturgeon, T. (2001) How Do We Define Value Chains and Production Networks? IDS Bulletin, Vol. 32, No. 3, July.

United Nations Environmental Programme and UN University, (2009). *Recycling from e-waste to resources: sustainable innovation and technology transfer industrial sector studies.* <http://www.iges.or.jp/en/ltp/activity09.html#01>[Accessed on 08/01/2011]

Waburi, N. (2009). The Contribution of mobile phones to the Kenyan Economy. Market & Social Research Association. <http://www.msra.or.ke/documents/conference/2009/the% 20impact%20of%20mobile%20telephony%20.pdf> [Accessed on 12/06/2012].

Zhang, D.W. (2002). Nokia's takeback scheme in APAC. <http://www.sc.bcrc.cn/download .minyoo?pathfile=/atm/7/20100120161937493.pdf> [Accessed on 12/06/2012].

APPENDICES

Appendix I: Questionnaire for Owners of Repair Shops

Date: _____Name of repair shop: _____

Name of Interviewee: _____Position: _____

1. In which year was this repair shop established?_____

2. How many employees do you have?

Male		Female	
Age	**Number**	**Age**	**Number**
15-19 years		15-19 years	
20-24 years		20-24 years	
25-34 years		25-34 years	
35-44 years		35-44 years	
45-54 years		45-54 years	
55-64 years		55-64 years	
TOTAL			

3. What is the division of your workforce into:

a) Permanent ☐

b) Contract ☐

c) Apprentice/Trainee ☐

d) Casual ☐

e) Other (please specify)_____

4. Do you have a business permit or license (s) to operate this kind of business? If yes, please indicate from which organization (Tick where appropriate).

   a) City Council of Nairobi ☐

   b) National Environment Management Authority (NEMA) ☐

   ☐

c) Kenya Revenue Authority (KRA)

d) Other government agencies(please specify)_____

5. Do you carry out mobile phone repairs brought in by mobile phone users?

   Yes ☐ No ☐

6. Do you source secondhand phones to use for repair?

   Yes ☐ No ☐

7. If yes, please indicate where you source the mobile phones from (Tick where appropriate)

   a) Mobile phone users ☐

   b) Other repair shops ☐

   c) Nokia care centers or Midcom (Nokia priority dealer) ☐

   d) Other (s) (please specify)_____

8. Are these phones that you source in working or non-working condition?

   a) Working ☐ b) Non-working ☐

9. What do you with phones that are repairable?

   a) Repair and resell in the secondhand market ☐

   b) Sell them to other repair shops who service and resell them ☐ (Thank & End)

   c) Use as spare parts ☐

   d) Other (s) (please specify)_____

10. Do you dismantle and use as replacement parts the mobile phones that are in non-working condition?

    Yes ☐ No ☐

11. If yes, please indicate which parts you use for replacement (Tick where appropriate)

    a) Liquid crystal display (LCD) ☐ b) Network integrated chip ☐

    c) Flash integrated chip ☐ d) Display/keyboard light chip ☐

e) Multimedia chip ☐ f) Vibration chip ☐

g) Simcard tray ☐ h) Speakers ☐

i) Charging jack ☐ j) Camera ☐

k) Other (s) (please specify) _____

12. What else do you do with the parts listed above apart from using them for replacement?

_____

_____

_____

13. Please explain what you do with the following parts:

a) Metals/printed circuit board (PCBs)

_____

_____

_____

b) Plastics

_____

_____

_____

c) Potentially hazardous materials such as beryllium, brominated flame retardants (BFR), cadmium, lead and mercury

_____

_____

_____

14. What do you do with mobile phone parts that are no longer useful to you/for you?

a) Sell them to recyclers ☐

b) Discard them into the municipal bins ☐

c) Other (s) (please specify)_____

15. With the rapidly changing design of mobile phones, has it become easier or harder to recover the mobile phone parts listed in question 11? Please explain.

_____

_____

_____

16. Do you recycle mobile phone batteries? If you do, please explain how?

_____

_____

_____

17. Do you recover and reuse materials from mobile phone batteries? If, yes, please indicate the materials that are reused and their uses.

_____

_____

_____

18. What do you do with batteries that cannot be reused or recycled?

_____

_____

_____

19. On average, how much money do you make per month from mobile phone repair?

a). Less than 10,000 ☐ b).10,001 – 20,000 ☐

c). 20,001 –50,000 ☐ d). 50,001 – 100,000 ☐

e). Over 100,000 ☐

20. In your opinion, what are the major obstacles facing repair and recycling of mobile phones in Kenya?

_____

_____

_____

21. What do you think should be done to overcome these obstacles?

_____

_____

_____

Appendix II: Questionnaire for Workers in Repair Shops

Date: _____Name of repair shop: _____

Name of Interviewee: _____

1. Gender

a) Male ☐ b) Female ☐

2. What is your age?

a) 15 - 19 years ☐ b) 20 – 24 years ☐

c) 25– 34 years ☐ d) 35-44 years ☐

e) 45-54 years and above ☐ f) 55-64 years ☐

3. What is your level of education?

   a) None ☐

   b) Primary ☐

   c) Secondary ☐

   d) University ☐

   e) Other (please specify)?_____

4. Do you have any kind of training in repairing mobile phones?

_____

_____

_____

5. Have you received any training from your employer? If yes, please explain the kind of training that you received.

_____

_____

_____

6. How long have you been working in this repair shop?_____

Remuneration and working hours

7. What is your gross income per month?_____

8. On average, how many hours do you work in a day? _____

9. How many days do you work in a week?_____

10. Do you work overtime? Is it paid for?

_____

_____

Social protection and social security

11. Are you a member of a trade union?_____

Yes ☐ No ☐

12. If yes, which one?_____

13. When you fall sick who pays for the medical cost?

_____

_____

14. Are you entitled to:

	Yes	No	Paid	Not paid	Duration
a) Maternity/paternity leave	☐	☐	☐	☐	☐
b) Sick leave	☐	☐	☐	☐	☐
c) Annual leave	☐	☐	☐	☐	☐

Health and Safety

15. Do you have personal protective equipment (PPEs)?

Yes ☐ No ☐

16. If yes, please indicate which one (s).

a) Gloves ☐
b) Face masks ☐
c) Boots ☐
d) Overalls ☐
e) Goggles ☐
f) Ear muffs/plugs ☐
g) Other (s)(please specify)_____

17. Have you suffered from accidents at your place of work or work related health problems? If yes, please explain?

_____

_____

_____

18. Are you aware that mobile phones have hazardous materials? If yes, which ones?

_____

_____

_____

Appendix III: Questionnaire for E-waste dealers

Date: _____Name of Interviewee: _____

1. Gender

b) Male ☐ b) Female ☐

2. What is your age?

b) 15 - 19 years ☐ b) 20 – 24 years ☐

d) 25– 34 years ☐ d) 35-44 years ☐

f) 45-54 years and above ☐ f) 55-64 years ☐

3. What is your level of education?

f) None ☐

g) Primary ☐

h) Secondary ☐

i) University ☐

j) Other (please specify)?_____

4. How long have you been collecting the printed circuit boards (PCBs) from repair shop?_____

_____

5. Do you have a specific area of operation? If yes where?_____

6. How much is the cost of a kg of PCBs_____

7. What is your average income per month_____

8. Are you aware that PCBs have hazardous materials? If yes, which ones?

_____

_____

_____

Appendix IV: Interview Schedule for Nokia

- What is the difference between Nokia level 1, 2 and 3 care centers? Which activities are cared out in these centers?
- Nokia established a take back scheme in 2008. What motivated Nokia to start the take back scheme?
- What are the goals and objectives of the take back scheme?
- How was the scheme rolled out? Who was involved?
- How many collection centers do you have in Nairobi and where are they located?
- What are some of the opportunities and challenges of the take back scheme?
- Are you creating awareness to your customers on the Nokia mobile take back scheme?
- Has this translated to an increased number of mobile phones collected over the years? Please provide statistics of mobile phones collected since 2008 to date.
- What do you do with mobile phones that have reached EoL?
- Are you aware of NEMA's draft E-waste guidelines of 2010?
- What is your view towards the draft E-waste guidelines and other waste management legislations such as the Environmental Management and Co-ordination (Waste Management) Regulations 2006 and why?
- Do you think these E-waste guidelines can help in the management of mobile phone E-waste? Please explain why or why not?
- Do you think the implementation of E-waste policy can lead to a culture of reusing, repairing and recycling of mobile phones?

Appendix V: Interview Schedule for National Environment Management Authority

- NEMA introduced the draft E-waste guidelines in 2010, what do these guidelines seek to achieve?
- What are the key factors that led to the drafting of the E-waste guidelines?
- Have the guidelines helped in the management of E-waste in Kenya?
- What challenges are you facing in the implementation of the guidelines?
- Are there any plans for formulating a national E-waste policy?

- What should the national E-waste policy take into consideration?
- What role does NEMA play in the management of E-waste from mobile phones?
- Does NEMA have a policy for management of E-waste from mobile phones?
- Who (in your opinion) should be responsible for policy development and implementation?
- What role should be played by other stakeholders such as manufacturers, mobile phone operators, distributors, repair shops, NGOs and mobile phone users in the management of E-waste from mobile phones?
- Do you think the informal repair shops should be incorporated into the management of mobile phone waste or are you in favor of formalized recycling sector? Why?
- What should be done to increase the level of consumer awareness on proper management of mobile phone waste i.e. importance or reuse and recycling. Who should be in charge of raising consumer awareness?

Appendix VI: Interview Schedule for Communication Commission of Kenya

- What role is CCK playing to ensure the proper management of the E-waste from mobile phones?
- Which policy does CCK have on mobile phone E-waste?
- Do you think we need an E-waste policy framework in Kenya specific to mobile phones?
- Who should be responsible for the policy development and implementation of E-waste management in Kenya?

Appendix VII: Interview Guide for Safaricom

- How was M-Pesa development and implemented (i.e. a brief history)?
- Why in your opinion has there been such a rapid growth of M-Pesa?
- When did Safaricom establish the mobile phone take back scheme? What motivated Safaricom to start the take back scheme?
- What are the goals and objectives of the take back scheme?
- How was the scheme rolled out? Who was involved?
- How many collection centers does Safaricom have in Nairobi and where are they located?

- What are some of the opportunities and challenges of the take back scheme?
- Is Safaricom educating its customers on the mobile take back scheme? Has this translated to an increased number of mobile phones collected over the years? Please provide statistics of mobile phones collected since the start of the scheme to date.
- What does Safaricom do with the mobile phones that are collected?
- Is Safaricom aware of NEMA's draft E-waste guidelines released in 2010?
- Has the E-waste draft guidelines had any effect on the way Safaricom implements its take back scheme? If so, how?
- What is Safaricom's view towards the draft E-waste guidelines and other waste management legislations such as the Environmental Management and Co-ordination (Waste Management) Regulations 2006 and why?
- Do you think these E-waste guidelines can help in the management of mobile phone E-waste? Please explain why or why not?
- Do you think the implementation of E-waste policy can lead to a culture of reusing, repairing and recycling of mobile phones?

Appendix VIII: Interview Guide for Airtel, Orange and Yu

- When did you start you mobile money transfer service?
- How many customers are registered with your money transfer service and how many agent outlets do you have?
- Do you have a mobile take back scheme or a place where customers who purchase mobile phones from your shops take them for repair? If so, where are they located?
- Are you aware of NEMA's draft E-waste management guidelines released in 2010?
- What is your view towards the draft E-waste guidelines and other waste management legislations such as the Environmental Management and Co-ordination (Waste Management) Regulations 2006 and why?
- Do you think these E-waste guidelines can help in the management of mobile phone E-waste? Please explain why or why not?
- Do you think the implementation of E-waste policy can lead to a culture of reusing, repairing and recycling of mobile phones?

Appendix IX: Interview Schedule for Computers for Schools Kenya

- In which year was CFSK established?
- Which type (s) of E-waste do you recycle?
- Where do you get the E-waste that you recycle?
- What do you do to the E-waste after recycling?
- Do you also recycle mobile phones?
- What type(s) of phones do you usually recycle?
- Where do you get the mobile phones that you recycle?
- Do you get any mobile phones from the Nokia care centers, such as Midcom (Nokia priority dealer) or repair shops?
- Do you dismantle and reuse component parts of a mobile phone? If you do, please indicate which parts you reuse.
- What do you do with mobile phone parts that are no longer useful to you/for you?
- In your opinion, what are the major obstacles facing repair and recycling of mobile phones in Kenya?
- What do you think should be done to overcome these obstacles?
- What has CSFK done to increase awareness among consumers on E-waste management?
- Are you aware of NEMA's draft E-waste guidelines released in 2010?
- What is your view towards the draft E-waste guidelines and other waste management legislations such as the Environmental Management and Co-ordination (Waste Management) Regulations 2006 and why?
- Do you think these E-waste guidelines can help in the management of mobile phone E-waste? Please explain why or why not?
- Do you think the implementation of E-waste policy can lead to a culture of reusing, repairing and recycling of mobile phones?