

**AN ASSESSMENT OF ENVIRONMENTAL AWARENESS AND MANAGEMENT
STRATEGIES, REGARDING ELECTRICAL AND ELECTRONIC EQUIPMENT
WASTE AMONGST ENVIRONMENTAL REGULATORS IN KIGALI, RWANDA**

By

ROBERT RUBONA MUGABE

210545773

**A dissertation submitted in partial fulfilment of the academic requirements for the
degree of Masters of Environmental Sciences in the School of Environmental Sciences,**

University of KwaZulu-Natal

Supervisor: Dr F Ahmed

May 2011

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LIST OF ACRONYMS

| | |
|-----------------|---|
| ADF | Advance Disposal Fee |
| ARF | Advance Recycling Fee |
| ATMs | Automatic Teller Machines |
| BFRs | Brominated Flame Retardants |
| CBOs | Community Based Organizations |
| CFC | Chlorofluorocarbon |
| CH ₄ | Methane |
| CIA | Central Intelligence Agency |
| CO ₂ | Carbon Dioxide |
| CRT | Cathode Ray Tube |
| CSU | Colorado State University |
| DDT | Dichloro Diphenyl Trichloroethane |
| DNA | Deoxyribonucleic Acid |
| DVD | Digital Versatile Disc |
| E-commerce | Electronic Commerce |
| EDPRS | Economic Development and Poverty Reduction Strategy |
| EEE | Electrical and Electronic Equipment |
| EIA | Environmental Impact Assessment |
| E-learning | Electronic Learning |
| E-mail | Electronic Mail |
| EMT | Ecological Modernization Theory |
| EMPA | Eidgenössische Materialprüfungs und Forschungsanstalt/Swiss Federal Laboratories for Materials Testing and Research |
| EPA | Environmental Protection Agency |
| EPR | Extended Producer Responsibility |

| | |
|-----------|---|
| EU | European Union |
| EWASA | Electronic Waste of South Africa |
| E-waste | Electronic Waste |
| GHGs | Greenhouse Gases |
| GIS | Geographic Information Systems |
| GoR | Government of Rwanda |
| ICT | Information and Communication Technology |
| IT | Information Technology |
| ITU | International Telecommunication Union |
| KCC | Kigali City Council |
| LCD | Liquid Crystal Display |
| MDGs | Millennium Development Goals |
| MINECOFIN | Ministry of Finance and Economic Planning |
| MINELA | Ministry of Environment and Land |
| NGO | Non-Governmental Organization |
| NICI | National Information Communication Infrastructure |
| NISR | National Institute of Statistics of Rwanda |
| NUR | National University of Rwanda |
| ODS | Ozone Depleting Substance |
| OEDC | Organization for Economic and Cooperative Development |
| OLPC | One Laptop per Child |
| PC | Personal Computer |
| PCB | PolyChlorinated Biphenyls |
| POPs | Persistent Organic Pollutants |
| PRO | Producer Responsibility Organization |
| RBS | Rwanda Bureau of Standards |
| RDB | Rwanda Development Board |

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| REMA | Rwanda Environment Management Agency |
| RITA | Rwanda Information and Technology Agency |
| RURA | Rwanda Utilities Regulatory Agency |
| SEA | Strategic Environmental Assessment |
| SPSS | Statistical Package for Social Sciences |
| TVs | Television set |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environmental Program |
| USA | United States of America |
| VAT | Value Added Tax |
| VCR | Video Cassette Recorder |
| WEEE | Waste Electrical and Electronic Equipment |
| WHO | World Health Organization |

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ABSTRACT

Information and Communication Technology (ICT), constitutes one of the development sectors that have expanded significantly in Rwanda. With very limited natural resources and a sector of the industry at its early stage of development, ICT provides Rwanda with opportunities to achieve its vision to become a middle-income country by the year 2020. However, old and discarded ICT equipment constitutes a source of hazardous waste, namely waste electrical and electronic equipment (WEEE) or e-waste which, if not appropriately managed, could have serious impacts on human and environmental health. This study aimed at assessing the level of awareness regarding e-waste and management strategies amongst environmental regulators in Kigali, Rwanda. The study was guided by the Ecological Modernization Theory (EMT), which advocates the integration of environmental concerns in all economic and development sectors, such as ICT, in order to achieve environmental sustainability. This research employed a mixed-method approach to scientific enquiry, using a combination of quantitative and desktop research methods. The desktop research method was used to study the current waste management practices in Kigali and the legal and institutional framework relevant to e-waste management. The quantitative approach, conducted through a questionnaire survey, was used to collect data regarding e-waste awareness amongst environmental regulators, current extent of e-waste, e-waste management in Kigali and challenges experienced. Using a purposive sampling method, 32 environmental regulators from different government institutions having vested interest in environmental protection and waste management from central to the district level were selected. Questionnaires were dispatched to the respondents *via* e-mail. The responses comprised 87.5% (28) of the target environmental regulators. Data was coded and analysed using the Software Package for Social Sciences (SPSS) template and Microsoft Excel. In addition, qualitative information was used to support the quantitative data, in the analysis and discussion. The findings of this research revealed that the level of awareness amongst environmental regulators with regard to the hazardous nature of e-waste remains low. In addition, e-waste managerial strategies remain largely unknown amongst environmental regulators. Regarding an e-waste management framework, Kigali does not have any formal e-waste management, while the legal framework remains at the draft level. In addition, the city lacks adequate infrastructure and financial capacity for environmentally sound e-waste management. E-waste is currently managed through various informal structures such as storing discarded equipment, selling and donating it, or disposing obsolete electrical and electronic equipment with other household waste. The study recommends that in order to progress towards sustainable development, an e-waste managerial framework, including clear institutional and legal frameworks must be established. In addition, professional capacity building on environmentally sound e-waste management should be offered to environmental regulators. Finally, the study proposes that programs to raise awareness of e-waste hazards amongst the different population strata should also be initiated.

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| CIA | Central Intelligence Agency |
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| CRT | Cathode Ray Tube |
| CSU | Colorado State University |
| DDT | Dichloro Diphenyl Trichloroethane |
| DNA | Deoxyribonucleic Acid |
| DVD | Digital Versatile Disc |
| E-commerce | Electronic Commerce |
| EDPRS | Economic Development and Poverty Reduction Strategy |
| EEE | Electrical and Electronic Equipment |
| EIA | Environmental Impact Assessment |

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| E-learning | Electronic Learning |
| E-mail | Electronic Mail |
| EMT | Ecological Modernization Theory |
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| EPR | Extended Producer Responsibility |
| EU | European Union |
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| GoR | Government of Rwanda |
| ICT | Information and Communication Technology |
| IT | Information Technology |
| ITU | International Telecommunication Union |
| KCC | Kigali City Council |
| LCD | Liquid Crystal Display |
| MDGs | Millennium Development Goals |
| MINECOFIN | Ministry of Finance and Economic Planning |

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| MINELA | Ministry of Environment and Land |
| NGO | Non-Governmental Organization |
| NICI | National Information Communication Infrastructure |
| NISR | National Institute of Statistics of Rwanda |
| NUR | National University of Rwanda |
| ODS | Ozone Depleting Substance |
| OECD | Organization for Economic and Cooperative Development |
| OLPC | One Laptop per Child |
| PC | Personal Computer |
| PCB | PolyChlorinated Biphenyls |
| POPs | Persistent Organic Pollutants |
| PRO | Producer Responsibility Organization |
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| RDB | Rwanda Development Board |
| REMA | Rwanda Environment Management Agency |
| RITA | Rwanda Information and Technology Agency |
| RURA | Rwanda Utilities Regulatory Agency |
| SEA | Strategic Environmental Assessment |
| SPSS | Statistical Package for Social Sciences |

| | |
|------|---|
| TVs | Television set |
| UNDP | United Nations Development Program |
| UNEP | United Nations Environmental Program |
| USA | United States of America |
| VAT | Value Added Tax |
| VCR | Video Cassette Recorder |
| WEEE | Waste Electrical and Electronic Equipment |
| WHO | World Health Organization |

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CHAPTER ONE

INTRODUCTION

1.1 Preamble

Rwanda, as other developing countries, has embraced Information and Communications Technology (ICT) as a tool to accelerate its economic development. With limited natural resources and an industrial sector that remains heavily aligned with the primary sector, Rwanda views the ICT sector having a great potential for its wider socio-economic development. ICT tools are also source of electrical and electronic equipment waste that has been found to be hazard to the environment and human health. This research was undertaken to assess the level of awareness amongst environmental regulators on electrical and electronic equipment waste in Kigali, Rwanda. This chapter provides a brief background to the study and motivation for undertaking the study. Furthermore, it presents the fundamental aspects of the study namely the aim, objectives and study area as well as research methodology employed in the study. Finally, the chapter outlines the structure of the dissertation through a chapter sequence.

1.2 Background

The United Nations Environmental Program (UNEP) (2003), notes that human activities are depleting resources and producing waste faster than nature can regenerate and process them. In addition, Hamza (1983 cited in Yhdego, 1995: 143) asserts that industrial development through imported technology and concentration of locally based industries in the developing countries has led to the introduction of uncontrolled and unknown waste into the environment in liquid, solid and gaseous forms. Furthermore, Chaaban (2001: 336) reveals that many developing countries are required to accelerate their development activities, which necessitate rapid industrialization, intensive agriculture, and more exploitation of natural resources; however the results are the increases in industrial and agricultural waste and pollution. Most of these wastes contain toxic substances which are harmful for the environment and human well-being.

In the bid to accelerate development, many developing countries have introduced ICT as one of main pillars to achieve their development. According to Rao (2009: 129), ICT offers enormous

opportunities to narrow social and economic inequalities and to support sustainable local wealth creation by overcoming obstacles of geographic isolation, and lack of access to information and communication. In addition, it is estimated that ICT can effectively contribute to the achievement of the Millennium Development Goals (MDGs) as demonstrated by a growing number of examples showing that ICT-based services, such as electronic commerce (e-commerce), distance education (e-learning) and telemedicine are improving the quality of life, reducing poverty and empowering people by facilitating access to the expensive health services; reducing the transaction costs and facilitating the integration to the global and local markets (Rao, 2009: 129).

However, Karamagioli (2005: 2) asserts that while the net effect of ICT is generally perceived as positive they can also have negative impacts on human health and the environment. Similarly, Elliot (2007: 2) indicates that ICT is becoming a major contributor to environmental contamination. According to Oh *et al.* (2003 cited in Osibanjo and Nnorom, 2007: 489), the rapid growth in ICT has led to an improvement in the capacity of electrical and electronic products but simultaneously to a decrease in the products lifetime as a result of which increasingly large quantities of waste electrical and electronic equipment (WEEE) or e-waste are generated annually. In addition, the useful life of electrical and electronic products is relatively short and decreasing as the result of rapid changes in equipment features and capabilities (Kang and Schoenung, 2005: 368). This creates a large hazardous waste stream of obsolete electrical and electronic equipment because of their hazardous material contents (Nnorom and Osibanjo, 2008a: 1473).

The UNEP (2007: 12) portrays that the composition of electrical and electronic equipment (EEE) is very diverse and differs in products across different categories. It contains more than a thousand different substances, which fall under “hazardous” and “non-hazardous” categories. The presence of elements like lead, mercury, arsenic, cadmium, selenium, hexavalent chromium and flame retardants beyond threshold quantities classifies them as hazardous waste (UNEP, 2007: 12). In addition, Nnorom and Osibanjo (2008a: 1473) show that when obsolete EEE are not managed properly at the end of their life, these toxins can present problems to the environment with a great effect on humans and animals. These associated effects include severe

sickness such as cancers, nerve system damage, genetic mutations, sterility, foetal damage and infant deaths (Puckett *et al.*, 2002: 8-9). Significantly, Saphores *et al.* (2009: 3323) reveal that electronic waste is a relative newcomer on the list of environmental concerns.

Globally, WEEE and/ or e-waste are most commonly used terms for electrical and electronic waste; however, there is no standard definition of e-waste, as a number of countries use their own definitions, interpretations and usage of the term “e-waste” (UNEP, 2007: 12). For most definitions, e-waste refers to discarded electronic products which include consumer items such as computers, wireless devices, fax and copy machines, cellular telephones, video game consoles, Television sets (TVs), videocassette recorders (VCRs), Digital Versatile Disc (DVD) players, radios and audio equipment, as well as commercial apparatus such as medical, technical and scientific equipment (Pinto, 2008: 65; UNEP, 2007: 13). Nevertheless, the Toxics Link (2003 cited in Nischalke, 2008: 12) argues that “even if these electronic goods are classified as waste, they are secondary resources due to their potential for being re-used and become a source of livelihood for the rural or urban poor in developing counties”.

The extent of e-waste varies from one country to other. However, Robinson (2009: 183-185) postulates that the current global production of e-waste is estimated to be between 20–25 million tons per year, with most e-waste being produced in developed countries mainly in Europe and the United States of America (USA). For instance, e-waste constitutes one percent of municipal waste in the USA and four percent in the European Union (EU) countries (Nnorom and Osibanjo, 2008a: 1747). In addition, the UNEP (2007: 12) reveals that discarded EEE are now the fastest growing component of the municipal solid waste and it is expected that the amount of e-waste will increase 16% – 28% yearly.

On the other hand, Saphores *et al.* (2009: 3323) indicate that developing countries receive large volumes of obsolete EEE from developed countries which become a major source of domestic e-waste, particularly in India and China. Recently, attention has also turned to e-waste in Africa with a focus on Nigeria and Ghana, where most of EEE brought by international trade is considered as “garbage” without proper disposal facilities in place to handle this waste (Puckett *et al.*, 2005: 2; Saphores *et al.*, 2009: 3323). In addition, the UNEP (2007:12) reports that in

developing countries, e-waste will increase from 0.01% to 1% of the total municipal solid waste.

In the bid to solve the e-waste problem, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was adopted in 1989 not only as a response to concerns about toxic waste from industrialized countries which are being dumped in developing countries but also for the development of criteria for environmentally soundly management of hazardous waste and minimization of hazardous waste generation (UNEP, 2003). In addition, Nnorom and Osibanjo (2008b: 850) assert that the EU has adopted different directives with regard to e-waste with objectives to incite electronic industries to design for the environment, to increase electronics re-use and their environmentally soundly recycling.

Nischalke (2008: 26) cautions that most developing and industrializing countries do not have any management systems concerning e-waste. In addition, Nnorom and Osibanjo (2008a: 1475) note that Africa is characterized by the absence of legislation dealing specifically with e-waste, ineffective or lax implementation of existing regulation on the transboundary movement, and lack of capacity for e-waste management. Furthermore, the majority of African countries have neither adequate infrastructure to deal with waste problem nor the institutional capacity to enforce e-waste bans (Saphores *et al.*, 2009: 3323). Consequently, e-waste is growing at a rapid and uncontrollable rate. In addition, Bailey (2002 cited in Nnorom and Osibanjo, 2008a: 844) argues that the approach toward environmental problems as a result, has been one of “command and control” largely addressing the “end-of-pipe” pollution problem.

1.3 Motivation of this study

Rwanda is one of the poorest nations in the world and with more than ten million inhabitants, is also the most densely populated country in Africa (Central Intelligence Agency-CIA, 2010). However, the Government of Rwanda (GoR) seeks to create, by the year 2020, a middle-income country by transforming it from a predominantly agricultural economy to a predominantly information and knowledge-based economy (GoR, 2000: 4). In addition, this Vision 2020 will be realized around six “Pillars” and will be interwoven with three cross-cutting issues, of which is includes ICT (GoR, 2000: 4-5).

As a result, Rwanda has invested significantly in ICT development. For instance, Farrell (2007: 9) reveals that several projects were initiated, such as the introduction of computers into secondary schools, with the target to distribute 300 computers per month or to establish community ICT telecenters across the country. Furthermore, the Rwandan Information and Technology Authority (RITA) (2010) indicates that a one laptop per child distribution project and construction of optic fiber network that will link 36 main nodes in Kigali is currently underway. Furthermore, the “*eSoko*” project was initiated, through which farmers will use ordinary cellular telephones to query up-to-date prices on markets for agricultural goods (RITA, 2010). More projects are expected in the near future.

However, Osibanjo and Nnorom (2007: 489) reveal that ICT in most developing countries particularly in Africa depends more on secondhand or refurbished electrical and electronic products most of which are imported without confirmatory testing for functionality and as result large quantities of e-waste is being mismanaged in these countries. In addition, Kang and Schoenung (2005: 378) contend that there is a high environmental price to pay for the rapid changes in technology because a significant portion of the stock of obsolete electronics, mainly computers, ends up in developing countries.

As a result, there is a significant quantity of obsolete EEE imported or donated to developing countries as secondhand, which is later found to be hazardous wastes. In addition, most of developing countries are facing challenges in e-waste management due to economic, infrastructural and human resources constraints as well as a lack of e-waste management strategies. Furthermore, the fervency for information technology, as well as Rwanda’s ambitious vision for achieving by 2020 a middle income country status by investing in ICT, raises crucial questions on e-waste generation and the government’s awareness and capacity to manage these wastes.

This study seeks to assess the level of awareness and management strategies regarding e-waste, amongst environmental regulators. In addition, it explores the legislative framework on e-waste and assesses different solid waste management options in Kigali, especially for electrical and electronic waste, in order to provide recommendations on their best implementation to achieve environmental sustainability. Moreover, the study seeks to identify the challenges and needs

encountered in e-waste management. The identified needs of government provide a platform from which to draw recommendations for improvement as well as on the sustainable management of e-waste within the city of Kigali as well as in Rwanda.

Since waste strategies are seen as a tool of government, this study focuses specifically on the government institutions from the district to national level. In addition, it is limited to Kigali, the capital of Rwanda, where most economic and administrative activities as well as environmental regulators are based.

1.4 Aim

The aim of this study is to assess the level of environmental awareness and management strategies regarding e-waste amongst environmental regulators in Kigali, Rwanda.

1.5 Objectives and research questions

To meet the aim of this study, this research is centered on the following objectives, outlined below:

1. To assess the level of awareness amongst Rwanda's environmental regulators toward e-waste;
2. To examine the roles of different environmental laws and regulations in place on e-waste management; and
3. To assess different methods for solid e-waste disposal in Kigali.

The key research questions used in this study are:

1. Are environmental regulators aware of e-waste?
2. Is the environmental legal framework adequately addressing e-waste management in Rwanda?
3. What are the roles and responsibilities of all stakeholders in e-waste management?
4. Do tools exist to assess the extent of e-waste management? Are they being used? Are they efficient and sustainable?

5. Is there capacity within the regulatory bodies in Kigali to implement and monitor e-waste generation?
6. In which ways are e-waste currently being managed in Rwanda and what are the challenges experienced?

1.6 Brief summary of research methodology

To carry out this study, different research methodologies were used. The desktop research method was used to study the current waste management practices in Kigali, the roles and responsibilities of stakeholders as well as the legal framework relevant to e-waste management. Additionally, a quantitative approach through a questionnaire was used to collect data about awareness amongst environmental regulators, e-waste management in Kigali and challenges experienced.

1.7 Chapter sequence

Chapter one, the introductory chapter, provides the background to the research, the motivation for pursuing this research, study area, aim, objectives and a brief outline of the methodology used in this study. Chapter two encompasses a literature review on the main issues relating to the topic of this study and which later serves as a basis to discuss the findings of research. It discusses the definitions of e-waste and its potential hazardous nature, including its impact on human and environmental health. The chapter also reviews e-waste management frameworks at different scales, including global, developed, developing countries and the African perspective. Finally, it covers e-waste sources as well as the environment management framework in Rwanda. Chapter three presents the background of the study area and describes the research methodologies used to assess the awareness and management strategies regarding e-waste in Kigali. Chapter four covers the description of data and discussion of the results obtained from the application of methods described in chapter three. Chapter five presents the key findings of this study, the general conclusions of the dissertation and provides the recommendations to improve e-waste awareness and management strategies in Kigali, Rwanda.

1.8 Conclusion

The chapter presented an introduction to the environmental problems associated with e-waste generation, use and management (all of which are elaborated on in chapter two) and the potential for e-waste production in Kigali, Rwanda. While e-waste management is a serious and growing problem worldwide, their environmental impacts are just beginning to be felt on the African continent, which is both rapidly industrializing and one of the major recipients of secondhand EEE. This chapter demonstrated the need for management preparedness to effectively manage e-waste. To this end, this study investigates the level of awareness amongst environmental regulators about e-waste in Kigali, Rwanda.

CHAPTER TWO

THE THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Introduction

We are increasingly living in a society with a tendency toward high consumption where the disposal of obsolete items is sometimes the most convenient and cheapest way to get rid of objects that could still be of use somewhere else. This has given rise to large quantities of waste which have to be treated, and constitutes one of the problems many countries are facing, often exacerbated by rapid urbanization and industrialization.

In the twenty first century, economic development in different areas of world has brought with it a significant change in the quantity and composition of solid waste. Since the 1990s, the world has experienced a boom in the electronic industry which is becoming the world's largest and fastest growing manufacturing industry. However, it has introduced a new form of waste, namely electrical and electronic waste that requires a new managerial system strengthened by clear and rigorous legislature; as it is more complex than household solid waste for municipal waste systems because of its high concentration of toxic compounds.

This chapter reviews relevant and related literature pertaining to electrical and electronic waste. It describes the nature of the hazards of electrical and electronic wastes. In addition, it provides the historical background and procedures of electrical and electronic waste management in developed as well as in developing countries. Furthermore, it discusses e-waste in the Rwandan context with regard to environmental policy, law and regulations and at the same time examines the state of ICT in Rwanda. The chapter begins by discussing the theoretical framework. In this regard, the theory that guides this study, namely the Ecological Modernization Theory, is discussed with regard to its interpretation and importance to this study.

2.2 Theoretical framework: Ecological Modernization Theory

The Ecological Modernization Theory (EMT) has become one of the dominant theories that attempts to understand and interpret how modern societies are dealing with environmental problems (Mol, 2000: 45). In addition, Van Khoa (2006: 31) asserts that within the growing industrializing and globalizing world, ecological modernization suggests that “all economic activities are to be considered, criticized and designed not only from an economic perspective, but also from an ecological one”. As such, ecological modernization departs from the old standpoint which encouraged a necessary trade-off between economic development and environmental protection as it comes in line with the ideas of sustainable development (Van Khoa, 2006: 31).

The concept of ecological modernization was developed against the background of the environmental crisis in the 1970s and 1980s, considering the mode of production and consumption in a capitalist system as both the cause of and the obstacle to overcome environmental degradation (Mol, 2003: 49). For many environmentalists, the emphasis was on the fundamental reorganization of a modernized society into an ecologically sound society (Hajer, 1996 cited in Berger *et al.*, 2001: 56). However, most of the proposed reorganization or reforms were based on dematerialization and the drastic reduction of manufacturing and resource-intensive consumption (Mol, 2003: 52). In contrast, the EMT advocates that environmental problems can be addressed through continued industrial development while adopting more environmentally friendly technology and integrating environmental concerns in all economic sectors (Murphy, 2000: 1-2; Murphy and Gouldson, 2000: 35).

2.2.1 Historical background to Ecological Modernization Theory

The concept of ecological modernization was first developed and adopted in the early 1980s by a small community of Berlin social scientists. Initially, Huber (considered as one of fathers of EMT) emphasized the role of technological innovations, mainly in the sphere of industrial production, criticized the bureaucratic state and, favored market dynamics instruments and actors in environmental protection (Mol and Sonnenfeld, 2000: 4; Murphy, 2000: 2). The second phase, from the late 1980s to the mid-1990s, showed less emphasis on technological

innovation as the key driver of ecological modernization. The institutional and cultural dynamics of ecological modernization processes were given a more and central attention (Van Khoa, 2006: 30). In both phases, however, the emphasis and empirical background held a northern approach and was criticized for not being appropriately applicable to southern contexts. However, from the mid-1990s onward, EMT was broadened to include studies on ecological modernization in non-European countries; and at the same time the emphasis on the production sectors was completed by studying transformations in the consumption sphere (Mol and Sonnenfeld, 2000: 5). Moreover, Mol (2003: 58) reveals that recently a shift towards the international and global dynamics of ecological modernization is being witnessed.

According to Mol and Sonnenfeld (2000: 4), although Huber's contributions constitute the beginning of ecological modernization, it lacked a critical stance toward the nation-state (considered as being unsuccessful in environment protection) and also a naïve and very optimistic attitude toward market actors without taking into consideration human society. For Mol (2003: 59), the necessity is on the transformation of modern institutions and societies in the field of science and technology, industry, global market, civil society and the nation-state, which reorganize themselves in order to achieve environmental reform as a way to address environmental risks.

2.2.2 Core aspects of ecological modernization theory

At the core of ecological modernization are social and institutional changes, as advocated by Mol (2003: 61-62) and Mol and Sonnenfeld (2000: 6) who identify five core aspects of possible transformation: firstly, the role of technology changes to cure and prevent environmental problems instead of creating them so that environmental considerations take place from the design stage (Mol and Sonnenfeld, 2000: 6; Mol, 2003: 61). Secondly, the role of market dynamics and economic agents (such as manufacturers, consumers and credit institutions) in ecological reforms and innovation is increased as social carriers of ecological ideas and practices by internalizing environmental concerns in the production and consumption systems (Mol, 2003: 61; Mol and Sonnenfeld, 2000: 6). Thirdly, the central role of the government changes from command-and-control or a reactive approach to a preventive mode (Mol, 2003: 61; Mol and Sonnenfeld, 2000: 6). In addition, new non-state actors such as environmental

based non-governmental organizations (NGOs), industries, and international organizations take over activities such as administration, regulation or the management of the environment, thereby abetting the government role (Mol, 2003: 62). However, the state provides institutional support and regulatory mechanisms for the effective functioning of the market and consumers (Mol, 2003: 62). Fourthly, the role and ideology of social movements change from outsider criticizer towards a more active participation in decision-making with regard to environmental reforms (Mol, 2003: 62; Mol and Sonnenfeld, 2000: 6). Lastly, the discursive practices and emerging ideologies change as the neglect of environment and counter-positioning of economy and environment are no longer seen as tenable positions (Mol and Sonnenfeld, 2000:6).

2.2.3 Perspectives on ecological modernization

In line with above core aspects, Gibbs (1998: 4) and Mol (2003: 62) postulate that ecological modernization as a framework may be used in two perspectives, the analytical and prescriptive perspectives. As such, it can be used either as a theoretical concept to analyze transformations to the central institutions in modern society that is deemed necessary to solve the ecological crisis, or to describe a more practical political program that directs environmental policy-making (Gibbs, 1998: 4).

Within the ecological modernization framework, Fisher and Freudenburg (2005: 702) argue that ecological problems become economically and politically feasible. Sciences and technology innovation in this approach are considered as the central institutions to ‘ecologize’ the economy as they shift from the perpetuating to the preventer, through environmental innovation, thus bringing about a win-win situation between economic activities and environmental protection (Jänicke, 2008: 558; von Malmborg and Strachan, 2005: 152-153).

In this regard, Jänicke (2000: 2-3) reveals that technological innovation aims at the prevention and minimization of pollution, waste production as well as other environmental degradation at source. According to Jänicke (2000: 3), innovation can take two perspectives, incremental improvement (cleaner technology) or radical innovation (clean technology) which include actions such as substitution of hazardous materials in products, use of renewable material, reduction in material and energy use as well as product redesign. On the other hand, Chavalparit

(2006: 18) argues that for inevitable environmental problems or where advanced technologies are not available, curative measures or clean-up technology substitute for preventive measures. This involves the mitigation of pollution, waste and other environmental degradation using end-of-pipe treatment technologies as well as disposal in an environmentally friendly manner (Chavalparit, 2006: 18).

Fisher and Freudenburg (2001: 702) further assert that the entrepreneur sphere is seen to play the leading role in bringing about much needed environmental innovation. Similarly, Mol (2002: 103) note that “the market actors have a strong role to play in articulating, communicating, strengthening, institutionalizing and extending in time and place the environmental innovation across the globe”. On the other hand, as argued further by Mol (2002: 103), “leaving the few win-win situations aside, the self-regulating economic actors have to be put under pressure first before they contribute to environmental improvements thus political decisions, civil pressure, and citizen-consumer demand are decisive”. In this regard, the concerns rise with regard to the trigger agent that will lead to these environmental innovations.

The argument as advanced by Murphy and Gouldson (2000: 34) highlights that environmental policy, regulations and standards are considered to be the precursor to the environmental innovation. In addition, contrary to Huber’s view that suggests that the state should play no role in adaptation of ecological modernization as it will only hinder the development and diffusion of clean technologies. Jänicke (1995 cited in Choy, 2007: 12) argues that the steering capacity of the nation-state or government becomes essential as the steering potential of market and market actors in the field of environmental protection is weak.

In this regard, Murphy (2000: 3) states that environmental policy using the lens of ecological modernization, takes into account two key elements. Firstly, environmental concerns are integrated into all policy areas of national development sectors, as ecological modernization recognizes that effective environmental protection can only be achieved through the rearrangement of broader policy goals relating to areas such as economics, telecommunication, energy, transport and trade (Murphy, 2000: 3). Secondly, market-based instruments are introduced in environmental policy so that economic value is placed on nature, with the general aim of encouraging economic actors to take the environment into consideration (Murphy, 2000:

3). According to Nischalke (2008: 39), these include principles such as the precautionary principle, the polluter pays principle, integrated pollution control, life-cycle assessment, assessments of environmental impact of products such as product pollution, energy and raw material consumption and as well as waste management. Carter (2001 cited in Van Khoa, 2006: 38) contends that the growing interest in market-based instruments in environmental policy is one indicator of a general shift from a conventional command-and-control approach towards ecological modernization.

According to Mol (2003: 58) and Van Khoa (2006: 34-39), in addition to the change in environmental policy, the aspect of steering government involves a high level of transformation of the role of the government which implies a more decentralized governance and new relationships between state and other environmental actors such as environmentally-based NGOs and international organizations, with more flexible and consensus-oriented governance styles. As mentioned previously, the role of the state is transformed from reactive governance into the formulation of favorable conditions for environmental improvement activities or environmental technology transfer. Thus, the government deviates from prescription of the means to improve environmental performance of polluters to the establishment of goals, standards and norms while leaving the selection of measures and strategies to the polluters (Van Khoa, 2006: 40). In addition, the increase in different actors in multi-level governance causes higher degree of pressure to polluters to innovate, as the polluter wants to move away from a dirty image (Jänicke, 2008: 559).

However, as prerequisites, Jänicke and Weidner (1995 cited in Gouldson *et al.*, 2008: 321) note that these environmental reforms depend on, amongst other factors, local conditions, the levels of awareness and concern on an environmental issue, the presence of suitable institutions and the absence of inertia within these institutions, and the availability of solutions that are technically, politically and economically viable. Further, Jänicke (1995 cited in Gouldson *et al.*, 2008: 321) points out that without knowledge about environmental issues, there is no perceived environmental problem and consequently no policy process.

Although, ecological modernization provides a framework to overcome the conflict between economic development and the environmental conservation, the theory along its maturation has

been criticized for its Eurocentric bases as more empirical studies have been developed in North-West European countries. Thus, Frijns *et al.* (2000 cited in Choy, 2007: 27) recommend that “if EMT is to be used to outline a feasible path of environmental reform, it has to be refined to fit the specific local conditions and institutional development of developing countries”.

Given this background, the GoR has positioned itself to move from reconstruction to wider socio-economic development that is based on sustainable development principles. In the bid to achieve this development, the GoR has put more emphasis on the applications of ICTs. Unfortunately, ICT tools have been found to be a major contributor to environmental contamination (Elliot, 2007: 2). In this regard, the EMT constitutes a substantial theory that will guide the framework of this study as it provides a basis on which economic growth takes into consideration the protection and conservation of the environment. Hence, the EMT is used as a lens through which to examine environmental reform aimed at reconciling the country’s growing ICT sector and its environmental impact but also as a way to investigate the environmental policy and regulation as well as the environmental practice toward e-waste in Kigali Rwanda’s capital.

2.3 Electrical and Electronic waste

According to Hilty (2005: 431), electronic equipment has become a very important part of human life; various types of ICTs are spreading out rapidly and penetrating our everyday lives across traditional categories of basic commodities. This growing importance of ICT to the world has brought about a rise in demand for electronic equipment (Nnorom and Osibanjo, 2008b: 844). In addition, as technology advances, people purchase increasingly more electrical and electronic products even though they may not be necessary (Kahhat *et al.*, 2008: 956). Consequently, the number of electrical and electronic equipment used at the global scale is increasing (Hilty, 2005: 431; Hilty *et al.*, 2004: 853).

Ladou and Lovegrove (2008: 1) observe that while the demand for electrical and electronic products continues to accelerate, the lifespan of the products shorten, resulting in “an alarming increase of discarded electrical and electronic equipment”. Hilty (2005: 433) and Widmer *et al.* (2005: 444) further reveal that when obsolete electrical and electronic equipment are disposed

of and/ or recycled without any control, there are negative consequences for the environment and for human health. Puckett *et al.* (2002: 5) and Widmer *et al.* (2005: 444), for instance, contend that obsolete electrical and electronic equipment contains more than 1 000 different substances, many of which are toxic. Nevertheless, Widmer *et al.* (2005: 444) assert that the obsolete EEE also contain considerable quantities of valuable materials such as gold and copper. According to Sinha-Kethriwal *et al.* (2009: 154), while electrical and electronic waste is receiving increasing attention due to its rapid growth and toxicity, it is relatively recent to the waste stream and is often misunderstood as comprising only computers and related IT equipment, or worse, mistaken for electronic mail (e-mail) spam or electronic trading of waste.

2.3.1 Definition of electrical and electronic waste

Widmer *et al.* (2005: 438) define “electronic waste” or “waste electrical and electronic equipment” (WEEE) or “e-waste” as generic terms embracing various forms of EEE that have ceased to be of any value to their owners. For Robinson (2009: 184), e-waste refers to waste electronic equipment, such as computers, TVs and cell phones while WEEE also includes traditionally non-electronic goods such as refrigerators or ovens. However, Sinha (2004: 5) states that there is considerable ambiguity on what constitutes e-waste as it is often restricted to old electronic products like computers and TVs (brown goods), while excluding products such as washing machines or refrigerators (white goods). In fact, Widmer *et al.* (2005: 438) reveal that there is, as yet, no standard definition of e-waste. In addition, several authors argue that the distinction between e-waste and WEEE is becoming blurred due to the advent of pervasive computing and programmable microprocessors that are increasingly incorporated into electrical equipment or non-ICT items (Hilty, 2005: 431; Hilty *et al.*, 2004: 853; Köhler and Erdmann, 2004: 832).

Williams (2005: 63) considers that waste must have a strict legal definition to comply with law and to enable the accurate formulation of local, regional and national waste management planning and to appoint the right regulatory and enforcement authority. In this regard, the UNEP (2007: 12) indicates that a number of countries, mainly in developed countries such as Switzerland and the EU member states, have attempted their own definition, interpretation and

usage of the term WEEE and/ or e-waste. The most widely accepted definition of WEEE and/ or e-waste is as per the EU Commission (UNEP, 2007: 12).

According to the EU Commission (2003), “waste electrical and electronic equipment or WEEE and/ or e-waste refer to electrical or electronic equipment which the holder disposes of or is required to dispose of in respect of the provisions in national law enforcement”. ‘Electrical and electronic equipment’ or ‘EEE’ refer to equipment which is dependent on electric currents or electromagnetic fields in order to work properly, and equipment for the generation, transfer and measurement of such currents, designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current; and falling under the categories set out in Annex IA to Directive 2002/96/EC (WEEE) (EU Commission, 2003). The Annex IA to Directive 2002/96/EC listed ten categories of electrical and electronic appliances that should fall under e-waste (EU Commission, 2003), which are listed in Table 2.1.

In addition, Kalana (2010: 132) identifies five types of e-waste based on their source. These are:

- Residue or leftover materials from electrical and electronic products during the manufacturing process;
- Leftover parts or materials, or discarded electrical and electronic equipment generated from a repair shop;
- Obsolete electrical and electronic equipment coming from governments, companies, and other facilities;
- Obsolete electrical or electronic products mainly from households; and
- Obsolete electrical or electronic products brought in illegally without a country’s notification.

Although more definitions of e-waste exist, the difficulty to provide a legal definition resides on how to draw the line between e-waste and commodities (Abela and Campbell, 2010: 2; Juan, 2009: 5). For instance, through the life cycle of EEE, discarded EEE might be a commodity, waste or both depending on the EEE uses (Abela and Campbell, 2010: 2; Nischalke, 2008: 12).

In this study, WEEE and e-waste are used synonymously to reflect different categories of electrical and electronic appliances as listed below (Table 2.1).

Table 2. 1: Categories of e-waste and examples of electrical and electronic products (EU Commission, 2003)

| Categories | Electrical and electronic products (examples) |
|------------------------------------|--|
| Large Household Appliances | Washing machines; dryers, refrigerators; and air conditioners. |
| Small Household Appliances | Vacuum cleaners, coffee machines, and iron toasters. |
| IT and telecommunication equipment | Personal computer (PC), laptops, mobile telephones, fax machines, copiers and printers. |
| Consumer equipment | Radio sets; TVs; video cameras; video recorders; audio recorders and amplifiers; and musical instruments. |
| Lighting equipment | Fluorescent lamps, high intensity or low sodium lamps, and metal halide lamps. |
| Electrical and electronic tools | Drills, saws machines, sewing machines, equipment for spraying, spreading and dispersing. |
| Toys, leisure and sports equipment | Electric trains or car racing sets, hand-held video game consoles, sports equipment with electrical or electronic components and coin slot machines. |
| Medical instruments and equipment | Radiotherapy equipment, cardiology, dialysis, nuclear medicine, laboratory equipment for <i>in-vitro</i> diagnosis; analyzers and freezers. |
| Surveillance and Control equipment | Smoke detector; heating regulators and thermostats. |
| Automatic dispensers | Automatic dispensers for hot drinks, bottles or cans and money. |

2.3.2 Composition of e-waste

E-waste contains both valuable and hazardous materials that require special handling and recycling methods to avoid environmental contamination and negative effects on human health (Robinson, 2009: 184; Widmer *et al.*, 2005: 445). However, Widmer *et al.* (2005: 445) contend that given the diverse range of materials found in e-waste, it is difficult to give a generalized material composition for the entire waste. In addition, the chemical composition of e-waste is changing with age and type of the discarded item (Robinson, 2009: 185). For example, Cathode Ray Tube (CRT) screens in computers and TVs containing lead are now being replaced by Liquid Crystal Display (LCD) screens containing Mercury (Nordbrand, 2009: 14; Robinson, 2009: 185). Furthermore, some naturally occurring substances, such as Chromium which are relatively harmless in nature, changes to Chromium VI (highly toxic) when used in the manufacture of electronic equipment (Ewasteguide, 2010).

The UNEP (2007: 12) portrays that e-waste is made up of components that can broadly be grouped into ferrous and non-ferrous metals, plastics, glass, wood, printed circuit boards, concrete, ceramics, rubber and other items. Printed circuit boards constitute the major components found almost in all electronic products (Ladou and Lovegrove 2008: 1). In weight, iron and steel account for almost half of the total weight of WEEE (Widmer *et al.*, 2005: 445). Plastics are the second largest component by weight representing approximately 21% of WEEE while non-ferrous metals, including precious metals, represent approximately 13% of the total weight of WEEE, with copper accounting for seven percent (Eidgenössische Materialprüfungs und Forschungsanstalt-EMPA, 2005 cited in Widmer *et al.*, 2005: 446).

In addition to copper, e-waste contains considerable quantities of valuable materials such as silver, gold, platinum and palladium (UNEP, 2007: 12). Bleiwas and Kelly (2001: 1) for instance, illustrate that one metric ton of computer circuit board contains between 40 and 800 times the concentration of gold contained in gold ore, and between 30 to 40 times the concentration of copper. Betts (2008: 6782) reveals that the precious metal concentration in printed circuit boards is more than tenfold higher than commercially mined minerals. Thus, the presence of valuable metals makes e-waste attractive. Ladou and Lovegrove (2008: 2) postulate

that through state of the art recycling technology more than 95% extraction of gold, silver, copper, iron, zinc, nickel, aluminum and, other usable and marketable material are possible.

Although there are these valuable materials, e-waste also contains hazardous materials such as antimony, arsenic, cadmium, chromium, cobalt, gallium, lead, mercury, selenium, Chlorofluorocarbon (CFC), beryllium and brominated flame retardants (BFRs) that create dioxin and furan when burned; hence, classifying them as hazardous waste (Ladou and Lovegrove, 2008: 2; Pinto, 2008: 67; Puckett *et al.*, 2002: 5; Robinson, 2009: 186). Thus, when WEEE is treated without proper procedures, environmental harm and human health risks arise particularly from the release of these heavy metals into the environment.

However, Puckett *et al.* (2002: 17-25) and Robinson (2009: 184) report that that due to the high labor costs and compliance with stringent environmental standards, rich countries tend not to recycle e-waste. This leads to the exportation of e-waste to developing countries where inadequate disposal and poor recycling practices to recover valuable and marketable metals contribute to potential harmful impacts on the environment and pose health risks to exposed individuals (Puckett *et al.*, 2002: 17-25; Sepúlveda *et al.*, 2010: 29).

2.4 Global generation and dissemination of e-waste

The consumption of EEE, mainly ICT related, is increasing worldwide, for example, the mobile telephone market has grown from about one billion to five billion from 2003 to 2010 while computers estimated to stand at one billion units, are expected to increase to two billion units by 2015 (Cobbing, 2008: 30; International Telecommunication Union-ITU, 2010; Kenny and Keremane, 2007: 156; Yate, 2007: 2). At the same time, the lifespan of EEE is continuously decreasing where, for example, the lifespan of computers estimated at four years in 2005 has dropped to two years (Robinson, 2009: 185). Moreover, many items are entering the waste stream early as many discarded electrical and electronic products are not discarded because they are broken but simply because new technology has left them obsolete or undesirable to the owners (Puckett *et al.*, 2002: 6; Sepúlveda *et al.*, 2010: 29). Hence, the high consumptive, short lifespan associated with the premature disposal of electrical and electronic products due to the

rapid change in technology are resulting in the spectacular growth of e-waste worldwide (Sepúlveda *et al.*, 2010: 29).

According to Cobbing (2008: 5), the world's production of e-waste is estimated at some 20 to 50 million metric tons generated worldwide per annum, comprising between five percent and eight percent of all municipal solid waste. At present, e-waste is mainly generated by developed countries that already have a high amount of EEE (Widmer *et al.*, 2005: 440). For instance, Cobbing (2008: 53) indicates that in the EU, for all e-waste, it is estimated that the total amount 8.3 to 9.1 million metric tons are produced each year, and it is projected that by the year 2020 e-waste production will increase up to 12 million metric tons for the EU only.

It is anticipated that in future developing countries also will produce a large quantity of e-waste, despite the illegal transboundary movement of obsolete EEE (Schwarzer *et al.*, 2005: 2). For example in 2003, it was estimated that China had discarded 55 million units of electrical and electronic appliances mainly TVs, PCs, refrigerators, washing machines and air conditioners that were estimated to have generated about 1.76 million metric tons of e-waste while for India it has been estimated to have discarded 660 000 metric tons of e-waste in 2007 and South Africa between 60 000 to 100 000 metric tons of e-waste per year (Cobbing, 2008: 32; Liu *et al.*, 2006: 95; UNEP, 2009: 44).

Cobbing (2008: 5) believes that the quantities of e-waste generated are predicted to grow substantially in the future for developed countries. For developing countries, however, e-waste generation is expected to triple by 2010. Widmer *et al.* (2005: 440) reveal that developing countries are showing the fastest growing consumption rates of EEE compared to developed countries. For example, Figure 2.1 shows the rapid growth of PCs in developing countries compared to developed countries. This growth may be associated with the consumption of electronic devices related to the advancement of ICT in developing countries, which will later increase the production of e-waste to the quantity received from developed countries.

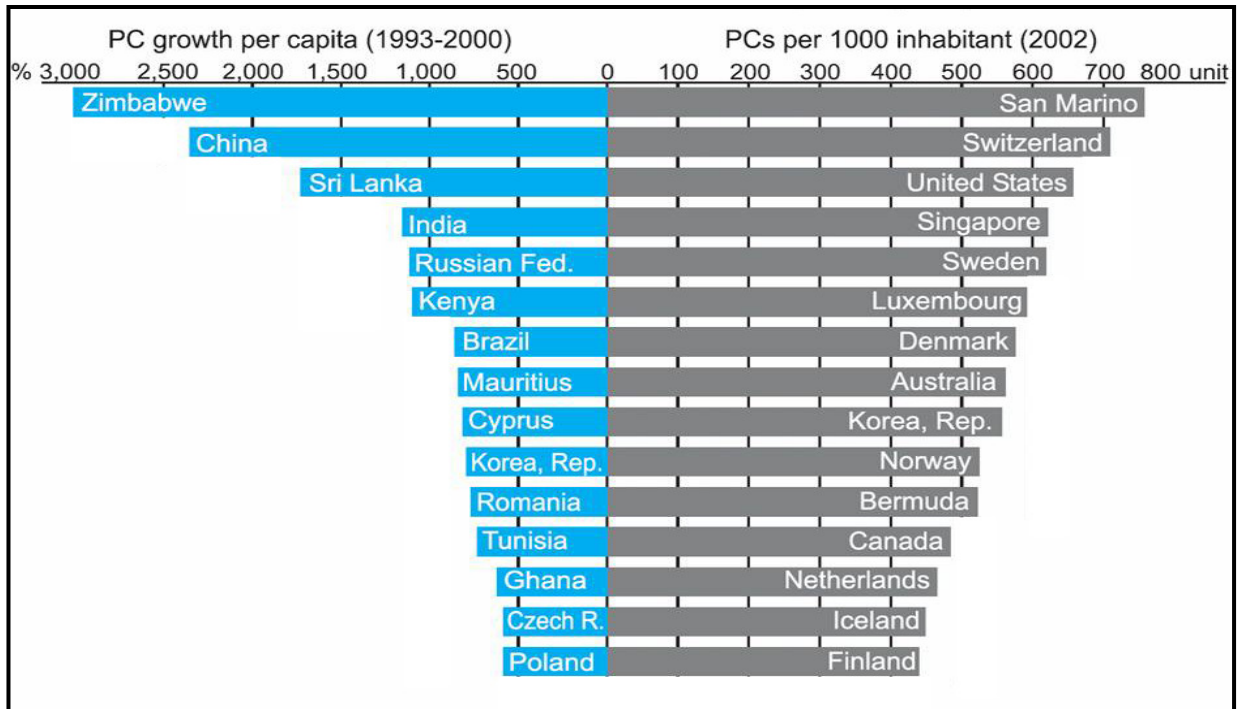


Figure 2. 1: The growth in percentage and number of PCs (World Bank, 2004 cited in Schwarzer et al., 2005: 2)

The current concerns regarding e-waste are issues raised by the use of hazardous substances, their management at the end of their lifespan, the shipment of massive quantities of the substance from developed to developing countries and, the ensuing negative human and environmental impacts in the recipient countries (Cobbing, 2008: 11; Nordbrand, 2009: 11; Puckett *et al.*, 2002: 17-25; Robinson, 2009: 184).

According to Cobbing (2008: 9), much of the e-waste collected in most developed countries is exported to developing countries. Puckett *et al.* (2002: 4), for example, report that an estimated 80% of the e-waste initially collected for recycling purposes in the USA is being exported to developing countries which are subject to informal recycling procedures. To reiterate the point, in 2005, the USA discarded 2.36 to 2.72 million metric tons of e-waste but only 0.31 to 0.34 million metric tons were recycled (USA Environmental Protection Agency-EPA, 2007 cited in Kahhat *et al.*, 2008: 956). Cobbing (2008: 9) asserts that the remains, that is, the non-recycled material enter the “hidden flow”, which consists mainly of shipping e-waste to developing countries either through smuggling or as legal donations.

Currently, there is no system for tracking legal or illegal e-waste shipment, which makes it difficult to find the true final destination of dumping as well as the true sender (Juan, 2009: 12). However, most of the e-waste is exported mainly from the USA, followed by the EU countries, Japan and Australia (Cobbing, 2008: 9; Juan, 2009: 12). In addition, Asia constitutes the largest receiver of e-waste with India and China as the major recipients while Nigeria and Ghana constitute the principal destination of exported e-waste in Africa (Nordbrand, 2009: 27) (Figure 2.2).

Shinkuma and Huong (2009: 27-29), further show that an interflow of e-waste between developing countries is also taking place. For example, a significant quantity of secondhand equipment is rebuilt in China and then re-exported to other countries in Asia and Africa (Shinkuma and Huong, 2009: 27). On the other hand, China also receives electrical and electronic scraps from countries in Asia, Central America and Africa (Nordbrand, 2009: 28).



Figure 2. 2: Known and suspected routes of e-waste dumping (Juan, 2009: 10)

2.5 Environmental and health risk of e-waste

Electrical and electronic equipment are not hazardous *per se*. However, at the end of their lifespan when they are not well managed in terms of disposal and material recovery mainly in informal recycling, environmental pollution may occur (Liu *et al.*, 2006: 96-97). For instance, Puckett *et al.* (2002: 15-20) and Sepúlveda *et al.* (2010: 33-36) indicate that through various crude methods such as dismantling CRT, melting printed boards, open burning for recovering valuable material as well as dumping non-usable material; various toxic substances contained in EEE are released into natural resources such as soils, crops, drinking water, livestock and aquatic wildlife through leaching, ashes, particulate matter and fumes (Figure 2.3).

Liu *et al.* (2006: 96-97) and Sepúlveda *et al.* (2010: 33) further report that in Guiyu, China, sediments and soil from rivers, residential areas and dumpsites indicated quantities of dioxin that are 10 to 60 times higher than any reported in other contaminated locations in world, while the groundwater in Guiyu presented lead levels that were 2,400 times higher than the World Health Organization (WHO) guidelines for lead threshold level in drinking water. In addition, Leung *et al.* (2008 cited in Sepúlveda *et al.*, 2010: 36) indicate that heavy metals that included copper, nickel, lead and zinc were found in a school yard and in an open air market. In the former, the concentrations were 6 to 13 times beyond the threshold value, while in the latter the concentrations were 16 times greater than the standards set by Canadian residential and/ or park guidelines (Leung *et al.*, 2008 cited in Sepúlveda *et al.*, 2010: 36). Sepúlveda *et al.* (2010: 36-37) assume that such high levels of contaminants in other areas imply that the problem is even more widespread beyond the recycling workplace. In this regard, Leung *et al.* (2006: 31) stress that most of the toxic substances in e-waste have the ability to extend long distances across even international boundaries through atmospheric; aquatic and biological media.

Furthermore, Wu *et al.* (2008: 1110) and Zhao *et al.* (2009: 2566) reveal that most of these substances, once in the environment, are persistent and can accumulate in living organisms. Wu *et al.* (2008: 1110), Zhao *et al.* (2009: 2572-3) and Sepúlveda *et al.* (2010: 37) for instance report that large quantities of toxins such as dioxin, mercury and lead were found in a range of both aquatic and terrestrial organisms in different e-waste recycling areas in India and China. According to Zhao *et al.* (2009: 2573), most of these organisms are contaminated through

ingestion of soil, ingestion of other organisms such as annelids, inhalation of dust, and skin contact.

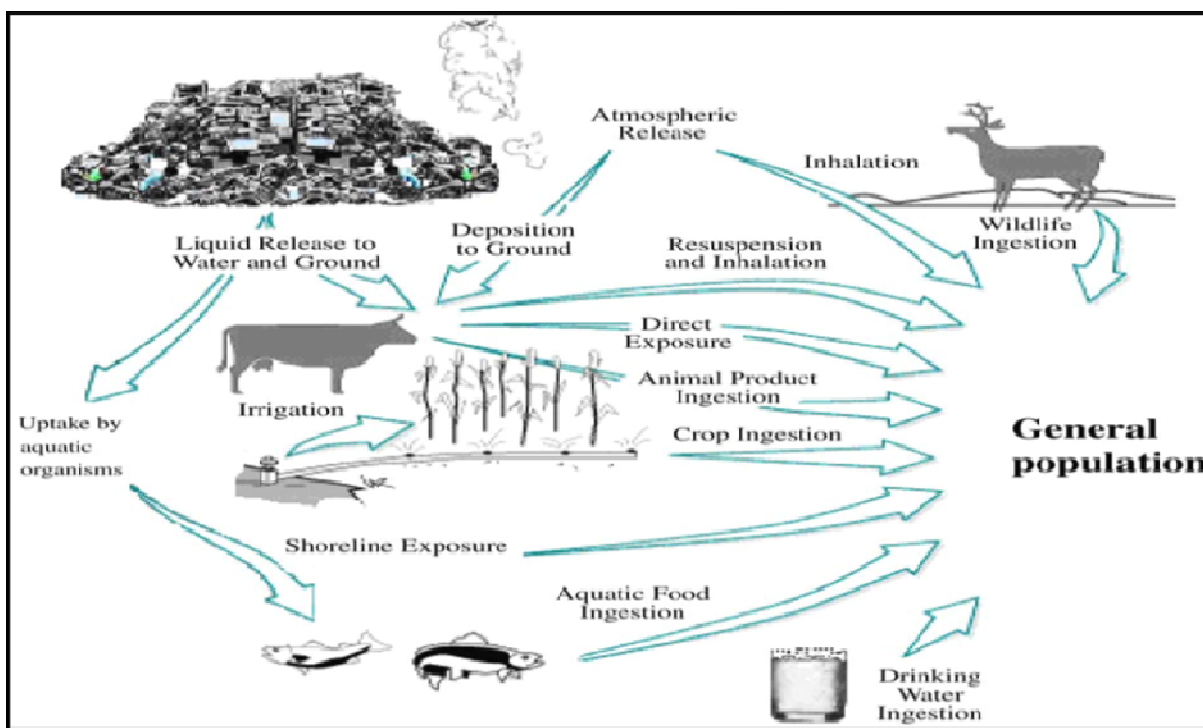


Figure 2. 3: Environmental impacts from the dispersal of e-waste (Frazzoli et al., 2010: 6)

Similarly, the exposure of human to e-waste containing toxic substances through contaminated drinking water, food chain, inhalation and dermal exposure in contaminated environment may cause various health risks and often severe sickness such as various forms of cancers, nervous system abnormality and disturbance, fetus malfunction and even death (Puckett *et al.*, 2002: 8-9; Sepúlveda *et al.*, 2010: 38). Table 2.2 indicates some examples of heavy metals present in e-waste as well as the resultant health risks that they can cause when human are exposed to them.

In addition to the health risks associated with e-waste, Zhao *et al.* (2011:555-556), indicate that e-waste also contributes to the climate change situation, by way of the high concentrations of CFCs (used largely in cooling systems of refrigerators and air conditioners). CFCs are ozone depleting substances which add to the greenhouse effect (Kim *et al.*, 2011: 1369). Thus, the improper end of life treatment of CFC containing equipment increases the quantity of CFCs

being released into the atmosphere, with subsequent effects including ozone deterioration, warming of the earth's surface and the atmosphere with significant implications for the climate system (Zhao *et al.*, 2011: 555-558). In addition, this scenario might intensify as hazardous CFCs are being released with other Greenhouse gases (GHGs) such as Carbon Dioxide (CO₂) from waste open burning and Methane (CH₄) released from non-sanitary landfills and/ or open dumpsites that are common in most developing countries (Guendehou *et al.*, 2006: 5).

Table 2. 2: Health risks from toxic substances in e-waste (adapted from Ewasteguide, 2010; Pinto, 2007: 67; Puckett *et al.*, 2002: 8-9)

| Toxic Substances (Occurrence in EEE) | Associated Health Risks |
|---|--|
| PCB (polychlorinated biphenyls) (Condensers and transformers) | PCBs cause cancer in animals and have effects on the immune system, reproductive system, nervous system and endocrine system. |
| Selenium (Older photocopying-machines) | Selenium causes Selenosis. The major sign are hair loss and nail brittleness. Also it causes neurological abnormalities such as numbness and other odd sensations. |
| Dioxins and Furans (By products when BFRs are burned) | Malformations of the fetus, decreased reproduction and growth rates and impairment of the immune system. |
| Beryllium (Power supply boxes x-ray lenses) | Beryllium causes lung cancer. Workers who are constantly exposed to beryllium, even in small amounts, and who become sensitized to it can develop chronic beryllium disease, the beryllicosis. |
| Cadmium (Fluorescent layer in CRT, printer inks and toners batteries) | The primary health risks of exposure to Cadmium are lung cancer and kidney damage. |
| Chromium VI (Data tapes, floppy-disks) | Chronic exposure can cause permanent eye injury and may cause DNA damage. |
| Lead (CRT screens, batteries, printed wiring boards) | Short-term exposure to lead causes vomiting, diarrhea, convulsions, coma or even death. Long-term exposure affects the kidneys and causes brain and blood disorders mainly in children. |

| | |
|--|--|
| Mercury (Fluorescent lamps in LCDs, batteries and mercury wetted switches) | Accumulate in organisms and causes brain and liver damage when ingested or inhaled. |
|--|--|

2.6 Global e-waste management and regulation

Due to the growing production and dumping of e-waste in developing countries, the international community and regional bodies, as well as some national authorities have realized the importance and the urgency to regulate, monitor and, to control the disposal and movement of e-waste (Puckett *et al.*, 2002: 11, UNEP, 2003).

On the global level, a multilateral agreement has been adopted under the UNEP known as the Basel Convention. The Basel Convention on the Control of Transboundary Movement of Hazardous Waste and their Disposal, has been adopted in 1989 and came into force in May 1992. It was created initially to prevent the economically motivated dumping of hazardous wastes from rich to poorer countries (Puckett *et al.*, 2002: 11).

The Basel convention requires that signatory countries reduce their transboundary movement of hazardous waste, minimize the production of hazardous waste in terms of both quantity and hazardousness, and ensure environmentally sound waste management (Basel convention, 2010). Environmentally sound management of hazardous waste (including other types of waste) is defined as “taking all practicable steps to ensure that waste is managed in a manner which will protect human health and the environment against the adverse effects which may result from such waste” (Basel convention, 2010). According to the Basel convention (2010), Afghanistan, Haiti and USA are the only countries that have not ratified the treaty.

Under the Basel convention, e-waste is considered as hazardous waste that is banned for export and/ or import for any reason including recycling. On the other hand, the Basel convention accepts the trade of hazardous including e-waste between countries with prior notification of the recipient country. In addition, products intended for re-use, are exempt from the Convention. However, according to Williams *et al.* (2008: 6451), the Basel convention does not provide criteria to establish the reusability of items in trade, resulting in e-waste export and/ or import mislabeled as equipment for re-use.

To close the loophole, the Basel convention was amended to include the ban on export from the Organization for Economic and Cooperation Development (OECD) countries, EU and Liechtenstein to non-OECD countries of all the materials categorized by the Convention as hazardous intended for recycling, recovering or final disposal (Basel Convention, 2010). The amendment is known as the Basel Ban. Unfortunately, the Basel Ban has not as yet entered into force as many signatories have not yet ratified the amendment (Widmer *et al.*, 2005: 450; Williams *et al.*, 2008: 6452; Yu *et al.*, 2010: 3232).

In addition to the Basel Convention, other international agreements are now effectively in place to ban or limit the movement of certain toxic substances contained in e-waste; such as the Stockholm Convention on Persistent Organic Pollutants (effective as at May 2004) and the Rotterdam Convention on the Prior Informed Consent Procedure for certain Hazardous Chemicals and Pesticides in International Trade (effective as at February 2004). Moreover, many regional bodies such as the EU and OECD, and local governments are setting regulations to counter the growing production of hazardous e-waste and its export and/ or import (GoR, 2008a: 6; Widmer *et al.*, 2005: 447-449).

2.7 E-waste management in OECD countries

According to Widmer *et al.* (2005: 447-449), in many OECD countries, e-waste management systems are characterized by the presence of an e-waste legal framework that provide a clear definition of e-waste and a categorization of different EEE that must be handled as hazardous waste at the end of their life; producer responsibility; system financing as well as ensuring compliance procedure. Ladou and Lovegrove (2008: 3) and Widmer *et al.* (2005: 446) further assert that in many OECD countries, legislation is shifting the responsibility to manage e-waste from the municipalities to the producers and manufactures.

This new approach to waste management, mainly with regard to e-waste, referred to as extended producer responsibility (EPR), makes the producers, manufactures, importers and/ or retailers responsible for financing, organizing take-back and recycling of their electronic products (Widmer *et al.*, 2005: 446). Thus, as explained by Ladou and Lovegrove (2008: 7), “when e-waste management is shifted to manufacturers and producers, it creates a powerful market

incentive to improve product design and reduce the use of toxic material which makes recycling cheap and easier and therefore reduce mass of landfilled and exported e-waste”.

To meet their responsibility, the producers often form a producer responsibility organization (PRO) that ensures that every member company is meeting his EPR obligations (Widmer *et al.*, 2005: 447). In addition to securing the financing system, an advanced recycling fee (ARF) or advance disposal fee (ADF) is included in the product price is charged at the purchase of new appliances which is then used to pay for the collection, the transport and the recycling of the disposed product (Sinha-Khetriwal *et al.*, 2005: 497).

While the EPR approach provides an end-of pipe solution, some countries mainly in the EU have introduced additional e-waste directives requiring that EEE manufactures phase out hazardous substances such as lead and mercury, thus reducing the level of toxicity at the designing stage (Ladou and Lovegrove, 2008: 4). In contrast to other OECD countries, Herat (2007: 308) notes that in USA, EPR based legislation has received resistance from the electrical and electronic industry as they advocate that the responsibility for e-waste should be spread across the life cycle of the product between the manufacturers, retailers, consumers and the governments instead of being supported by manufactures only. Abela and Campbell (2010: 3) contend that the USA manufacturers prefer a less regulated system in order to keep costs of production minimal, as the voluntary methods of regulation are likely to be less costly than those mandated.

Puckett *et al.* (2002: 1) maintain that in the USA e-waste management fails even before the electrical and electronic products enter the marketplace. The USA is characterized by a lack of federal legislation regarding e-waste (Ladou and Lovegrove, 2008: 4). In addition, contrary to other OECD countries, the USA does not define e-waste as hazardous waste; instead it is defined as special waste (Ladou and Lovegrove, 2008: 4). As explained by Abela and Campbell (2010: 10), “under the existing hazardous waste directives, used electronics determined to have reusable components are classified as tradable commodity, rather than waste. Thus, many of the most common electronic parts (precious metals, scrap metals, circuit boards) which otherwise meet the toxicity levels requiring classification as hazardous waste are either exempt or excluded from the category if they are destined for re-use or recycling rather than disposal”.

According to Puckett *et al.* (2002: 38), CRT monitors are the only items defined as hazardous waste and therefore banned in landfill. Furthermore, Amankweh (2007: 26) reports that manufacturers, producers and retailers do not bear the responsibility to collect discarded CRT as well as other EEE in the USA and it is up to consumers to take their items to the recyclers. Regrettably, as revealed by Puckett *et al.* (2002: 37), within the existing USA's e-waste recyclers more of them have been found to be e-waste exporters to developing countries than recyclers as they can export without fear of any liability.

2.8 E-waste in developing countries

According to Baskaran and Muchie (2006: 29), ICT is being perceived by many developing countries as a vehicle for not only economic growth, but also as a means to achieve wider socio-economic development which would benefit all of society. In addition, ICT may be applied probably to every problem in all sectors, and the highest expectation of ICT application is poverty reduction (Baskaran and Muchie, 2006: 29). Thus, the uses of ICT tools provide developing countries with an opportunity not only to achieve the poverty reduction and other MDGs but also to leapfrog them well into an increasingly globalized world.

The MDGs adopted by many countries, set eight goals to improve people's lives by 2015, including poverty reduction, education accessibility, health care and environmental sustainability, and it is asserted that ICTs are important tools to achieve the overall goals as they can help in poverty reduction by creating jobs and opening markets, improve the education learning process and make improvements in health care (Rao, 2009: 130). However, Baskaran and Muchie (2006: 143) and Kahhat and Williams (2010: 502) observe that the challenge to achieve these goals is to make available the technologies to poor people as the high cost of ICT goods and infrastructure constitutes the main obstacle that many developing countries are facing.

In this regard, Kahhat and Williams (2009: 6010) advocate that the export of secondhand EEE from developed countries constitutes a way for developing countries to overcome the problem of access to ICT tools and to bridge the digital divide between them and rich nations since non-used equipment from rich countries can be donated or sold at an affordable price in developing

countries. For example, projects such as computers donated to schools have proven how refurbished computers can provide access to information and technology in developing countries (Boeni *et al.*, 2008: 5).

On the other hand, in some Asian countries, the import of secondhand EEE is not associated only with the secondhand market for ICT promotion but also as a way to supply raw materials to the electrical and electronic industry (Iles, 2004: 82). Shinkuma and Huong (2009: 27), for instance indicate that China and India, for a long period have encouraged the import of secondhand EEE by reducing the value-added tax (VAT) on secondhand EEE products as raw material, while in Vietnam, the import of secondhand EEE is accepted for the refurbishment industry where the imported obsolete TVs and computers are refurbished for further re-export.

Williams *et al.* (2008: 6447-6450) postulate that these re-use, refurbishment and recycling activities not only constitute an advantage from an environmental point of view, but also provides one of the solutions for poverty reduction in poor communities. With regard to the environmental point of view, the refurbishment, recycling and re-use of EEE constitutes an extension of the lifespan of electrical and electronic products that prevents the extraction of new raw material and energy consumption in manufacture of the new equipment (Williams *et al.* 2008: 6447- 6450). From an economic advantage, the recycling, repairing and refurbishment constitutes considerable revenue for people that are employed in the recycling and refurbished industry (Boeni *et al.*, 2008: 5; Williams *et al.*, 2008: 6450). For example, Boeni *et al.* (2008: 5) report that the project ‘Computer for education’, that refurbishes and distributes computers in Colombian schools, have created 390 low and/ or semi-skilled and about 50 highly skilled jobs with the refurbishment of 46 000 computers annually. In addition, Hicks *et al.* (2005: 463) emphasize that the e-waste trade also provides income-generating opportunities for individuals involved in the e-waste trade chain as obsolete EEE are traded amongst collectors, processors, secondhand dealers and consumers.

However, Puckett *et al.* (2002: 11) argue that even though e-waste or secondhand equipment may provide income for poor communities or facilitate accessibility to technology; with limited disposed technology “the e-waste trade leaves the poorer peoples with an untenable choice between poverty and e-waste’s hazard”. In addition, Osibanjo and Nnorom (2007: 494)

maintain that “exposure to the hazardous chemicals for workers in recycling facilities can mean the difference between making a living and remaining unemployed”. Furthermore, Hicks *et al.* (2005: 462) indicate that only disadvantaged peoples are the ones that work in the hazardous recycling activities such as poorly paid migrant workers and marginalized communities as observed in China and India.

Moreover, these circumstances are exacerbated by the fact that with the change in technology in developed countries, more electrical and electronic products containing hazardous substances are likely to be imported into developing countries (DanWatch, 2008: 2). In addition, more imported secondhand equipment which are intended for re-use are sent without pre-testing for functionality, resulting in more e-waste dumping than promoting ICT use in developing countries (Puckett *et al.*, 2005: 13; Writers, 2007: 2). For example, Puckett *et al.* (2005: 6) and Writers (2007: 2) report that in Nigeria and Kenya, respectively, between 25 to 75% and 10 to 20% of imported secondhand EEE, mainly IT equipment, are neither reusable, economically repairable or may be out-dated, which translates into more secondhand EEE directly entering the waste stream instead of being re-used.

According to Osibanjo and Nnorom (2007: 494), only a minority of the population in developing countries is covered by a well established e-waste management system or an e-waste policy measured to hinder the anticipated side effects of WEEE. Thus, even the advantages that could be obtained from recycling and re-use would become an environmental and human health threat with subsequent clean-up which will become an economic burden for developing countries (European Environment Agency, 2009: 11). To support this view, Osibanjo (2009: 5) states that “recognizing the nexus between environmentally sound management of wastes and chemicals and sustainable development, the uninterrupted increasing of e-waste is a risk factor towards achievement of sustainable development and the attainment of the millennium development goals in developing countries”.

2.8.1 EEE end-of-life treatment in developing countries

Sinha-Khetriwal *et al.* (2005: 500) and Osibanjo and Nnorom (2007: 490) assert that in developing countries, e-waste management activities which range from the collection to the

end- of- life treatment of obsolete EEE are mostly done in an informal manner. In addition, Osibanjo and Nnorom (2007: 490) and Osibanjo (2009: 3) reveal that the e-waste end-of-life treatment include various low-end waste management alternatives such as storage, disposal in landfill, open burning and crude backyard recycling, or simply thrown away in the general waste (Figure 2.4).

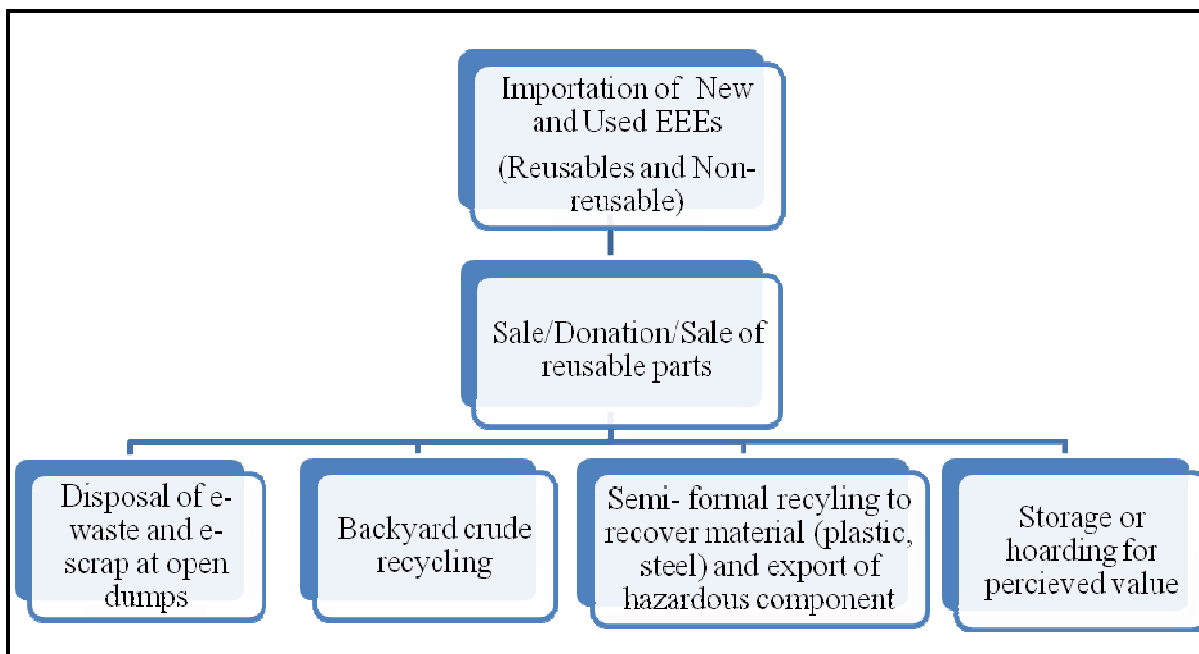


Figure 2. 4: E-waste end-of-life treatment in developing countries (Osibanjo, 2009: 3)

According to Wasswa and Schluep (2008: 3), in a large number of developing countries, e-waste stock, mainly ICT equipment, is believed to be in storage where most of them are held by the government and/ or private institutions. For example, it is reported that in South Africa (Finlay, 2005: 7) and Uganda (Wasswa and Schluep, 2008: 3), it is estimated 70% and 90%, respectively, of unusable ICT equipment are stockpiled within institutions’ storerooms. The main reasons for this are the apparent difficulties in writing off equipment from registers (Finlay, 2005: 6), because of the belief that discarded EEE have certain value (Kalana, 2010: 141), as well as issues with data theft (Finlay, 2005: 6; Puckett *et al.*, 2005: 20). In addition, Kalana (2010: 141) remarks that the absence of a systematic e-waste collection in many developing countries constitutes one of the main reasons for storage options.

The collection of e-waste in almost all developing countries is done informally by private individuals where waste collectors, scavengers or peddlers buy the product from the last owner (Liu *et al.*, 2006: 95; Terazano *et al.*, 2006: 6). According to Sinha-Khetriwal *et al.* (2005: 500), informal recyclers mainly in Asian countries is a well-established network of public-private relationships amongst waste pickers, dealers, wholesalers and recyclers. Sinha-Khetriwal *et al.* (2005: 500) further note that the main incentive for informal e-waste recycling remains economic profit, and reflects little to no strategic environmental management as well as occupational health protection.

Several authors highlight cases from China (Hicks *et al.*, 2005: 462; Liu *et al.*, 2006: 95; Puckett *et al.*, 2002: 15-25; Yoshida and Terazano, 2010: 1069), Pakistan (Puckett *et al.*, 2002: 23) and India (Nischalke, 2008: 23; Puckett *et al.*, 2002: 25; Sinha-Kethriwal *et al.*, 2005: 500) where e-waste handling has impacted on workers health in terms of resulting in the respiratory tract and kidney infections. In addition, they highlight that an already dangerous situation is made worse by the fact that e-waste recycling is often performed by these unorganized sectors, in backyard workshops, in a rudimentary manner, and without critical knowledge about the serious implications of the e-waste handling and disposal on both the environment and human beings. Studies further indicate that women and children are frequent participants in the informal waste handling sector (Pinto, 2008: 66; Puckett *et al.*, 2002: 15-25). According to Pinto (2008: 66) and Sepúlveda *et al.* (2010: 38), they are more vulnerable to the health hazard caused by e-waste.

Puckett *et al.* (2005: 20) and the UNEP (2009: 55) further report that large scale burning to recover steel, manual dismantling and dumping unusable materials in open dumpsites or on water surfaces are the only rudimentary activities that have been observed in Africa. With regard to the dumping problem, Ecoignard (2005 cited in Finlay 2005: 3) indicates that very few developing countries, mainly in Africa, have controlled landfills. Furthermore, the problem of e-waste comes as an addition to the already growing problem associated with municipal solid waste management that many countries are facing as a result of rapid urbanization. Thus, Ecoignard (2005 cited in Finlay 2005: 3) cautions that most countries have to manage the

problems of waste in general, before they can go to the levels of looking at different kinds of wastes, such as e-waste.

Despite the persistence of contaminant crude recycling, Widmer *et al.* (2005: 454) and Finlay (2005: 9) assert that a formal recycling industry is also taking place in developing countries. In Africa, formal recycling facilities for e-waste exist but only in South Africa. In this regard, Widmer *et al.* (2005: 454) explain that the establishment of formal e-waste recycling in South Africa has been facilitated by the presence of state of the art metal recycling facilities in the mining industry which has no difficulty in incorporating the recycling of discarded electronics. Although, the e-waste recycling process in South Africa is described as advanced, it is still at the semi-formal recycling level as it not able to extract or separate some materials (Finlay, 2005: 9). Bondolfi (2007: 46-47) and **Finlay and Liechti (2008: 47)**, for instance, reveal that only plastic processing and steel recovery activities are taking place, while more hazardous electronic scrap such as printed circuit board and CRT are landfilled, stockpiled or exported to Asia and Europe. **The main destinations are China and Singapore in Asia and; Belgium and Netherlands in Europe (Finlay and Liechti, 2008: 47; Finlay, 2005:9)**. Bandolfi (2007: 43-45) **further** observes that with a lack of a recycling financing system, the price offered abroad is more advantageous than investing in more environmental sound and financial feasible recycling processes. **In addition**, the profits within e-waste recycling are low because of an insufficient supply of materials for processing, due to the lack of a collection system for e-waste (Bandolfi, 2007: 43-45). This corroborates with similar barriers that the formal recycling industry are facing in China (Liu *et al.*, 2006: 100) and India (Nischalke, 2008: 81).

2.8.2 E-waste legislation and barriers in developing countries

According to Osibanjo and Nnorom (2007: 498), the prevalent situation with regard to e-waste management in developing countries is exacerbated by the absence of a legislative framework that adequately regulates e-waste management. In addition, Dittke (2007: 1) and the UNEP (2010: 36-37) observe that in the majority of developing countries, e-waste falls under various legislative and regulatory frameworks governing other sectors such as water, municipal waste, industrial waste and other toxic substances. Thus, each sector examines the e-waste issue from a different perspective, thereby resulting in jurisdictional conflicts, duplication of information and

lack of clarity of responsibilities in managing e-waste. Similarly, the UNEP (2010: 37) shows that “e-waste is not mentioned in most of developing countries’ legislations and regulations and clarity concerns e-waste definition; classification of hazardous and non-hazardous chemicals; differentiation between waste and non-waste are not identified; and thus do not specify either its management nor its handling within the country”.

In this regard, Allam and Inauen (2009: 3) and Osibanjo and Nnorom (2007: 498) argue that the low level of awareness at government as well as at institutional levels of the potential negative effect on the environment and human health of e-waste constitutes one of the fundamental issues that hinder the establishment of e-waste legislation as well as a proper management of obsolete EEE in many developing countries. For example, in a survey on e-waste management practices conducted in 23 countries of the Arab region, Allam and Inauen (2009: 3) report that governments, NGOs and private institutions did not recognize e-waste as a key issue in their environmental program or strategy and therefore did not implement any activity regarding e-waste. Allam and Inauen (2009: 3) further reveal that the problem also resides in the fact that many countries do not know the real extent of their e-waste stock (either imported or generated domestically) and consequently, an ‘out of sight out of mind or no news is good news’ situation is the one that is likely to be applied or to prevail.

Schmidt (2004: 103) and Puckett *et al.* (2002: 32) contend that in countries where the problem of e-waste has been documented up to the international level, the absence of e-waste legislation and management is due to a lack of political will amongst legislatives and governments to advance legislation toward e-waste management and the failure to domesticate other multi-international agreements such as the ban of transboundary movement of hazardous wastes perpetuates many developing countries. According to the UNEP (2010: 43), in many **developing countries**, the general tendency is for governments to focus more on those environmental policies and regulations that protect the environment and contribute significantly to government revenue such as the protection of natural resources. Thus, hazardous wastes such as e-waste as a new topic in relation to environmental concerns in many developing countries is relegated at low levels in environmental priorities as it competes with other environmental issues such as

management of natural resources, provision of adequate sanitary infrastructure, clean water, soil conservation and so forth (UNEP, 2010: 43).

However, according to many authors, the situation regarding e-waste legislative and regulatory frameworks in some **developing countries such as Costa Rica (Boeni *et al.*, 2008: 4), Thailand, and Vietnam (Shinkuma and Huong, 2009: 26; Yoshida and Terazano, 2010: 1604)**, is promising even though they are still at the early stages of development. A step to establish an e-waste regulatory framework is on its way in different countries however, the situation differs from country to country. While in some countries there is a total absence of e-waste management policy or any other kind of regulatory framework as discussed previously, countries like China, Thailand, Vietnam and Cambodia have introduced regulations to hinder the e-waste import and/ or to regulate growing domestic e-waste production (Hicks *et al.*, 2005: 465; Liu *et al.*, 2006: 99; Shinkuma and Huong, 2009: 26; Yoshida and Terazano, 2010: 1604).

According to Yoshida and Terazano (2010: 1064), while recognizing the need for secondhand equipment, a standard of quality is imposed on the imported secondhand equipment entering some countries. For example, Hong Kong does not allow the import of any unit that is more than five years from the date of manufacture while Thailand restricts the import of secondhand EEE that is over three years from the date of manufacture (Yoshida and Terazano, 2010: 1064). In countries like Cambodia, Vietnam and China the import of e-waste including the reusable secondhand equipment is prohibited (Shinkuma and Huong, 2009: 26). China, has further introduced other laws and regulations governing the e-waste management process from collection to disposal as well the reduction of other environmentally adverse impacts of e-waste. Aspects in the latter include measures put in place for the prevention of pollution from electrical and electronic products that require Chinese EEE manufacturers to phase out hazardous substances such as lead and mercury in their products (Liu *et al.*, 2006: 99; Hicks *et al.*, 2005: 465).

Nevertheless, Hicks *et al.* (2005: 466) assert that the enforcement of existing legislation is a controversial issue in developing countries. This view is supported by Ni and Zeng (2009: 3993) who indicate that very often in developing countries, laws or regulations are enacted without adequate resources allocated for enforcement within government institutions, and

limited capacity and capability for monitoring and evaluation regarding e-waste, thereby resulting in either lax implementation or total absence of actions. Ni and Zeng (2009: 3992-3993), for instance observe that despite the numerous regulations and laws that China has enacted, it has been reported that the e-waste import persists as well as its environmental unsound management. Similarly, Puckett *et al.* (2005: 12) report that despite Nigeria being a signatory to the Basel convention and require EEE importers to apply for import permits, each month approximately 500 containers of secondhand electrical and electronic products, mostly in unusable condition enters Nigeria through the port of Lagos. Puckett *et al.* (2005: 12) further reveal that although the Nigerian government is aware of the prevailing situation, with limited funds and inadequate infrastructure as well as lack of managerial system, the even existing regulations are not implemented thus the e-waste import continues to take place with the likelihood of the problem spreading within neighboring African countries.

2.9 E-waste in the Rwandan context

To understand e-waste in Rwanda, the background of the evolution of environmental awareness in Rwanda is presented. Aspects of Rwanda's environmental management in terms of policy as well as the ICT policy in Rwanda are further discussed in the following sections.

2.9.1 Evolution of environmental awareness in Rwanda

Rwanda's environmental history has been dominated by concerns for nature conservation and environmental protection, through the creation of parks and protected areas in the early 1930s. Soil conservation also received a major focus of environmental concern (GoR, 2003a: 5).

After independence and particularly in the mid-1980s, the first environment protection authority was created as a division in charge of the hygiene and environment under the Ministry of Health and Social Affairs (GoR, 2003a: 6). Later in 1991, a National Environment Strategy was adopted and the Ministry in charge of Environment and Tourism entrusted to coordinate all environment related activities, carried out by different ministries, was established (GoR, 2003a: 6). In the following year, the first drafting of the law on the environment was developed but the 1994 Tutsi genocide and war stopped the initiatives that had been launched.

However, the GoR (2003a: 6) reveals that since 1996, different initiatives were revived, where the national Environment Strategy and Action Plan was updated and the environment moved from the background to the forefront of concern, and one of the prominent pillars for the development of Rwanda. In this regard, the GoR plans to build a nation where pressure on natural resources as well as environmental pollution and degradation will be reduced to ensure sustainable development as embedded in Vision 2020 and the Economic Development Poverty Reduction Strategy (EDPRS).

In addition, the environment protection authority was reestablished and successively placed between 2001 and 2008 under different Ministries to become a separate Ministry of Environment and Land (MINELA) in 2009. This situation currently prevails. The principal mission of this Ministry is to formulate the policy and laws relating to the protection of the environment (MINELA, 2010).

2.9.2 Rwandan Vision 2020

The Vision 2020 is a document which spells the countries' development agenda and policies. According to the GoR (2000: 4), it provides clear objectives which are based on how Rwandans envision transforming their country from an agriculturally-based economy into a middle-income nation with a more prosperous population within a 20 years target as at the year 2020. In view of these aspirations, the GoR (2000: 4-5) indicates that the vision 2020 recognizes the following development pillars: good governance and a capable state, human resource development and a knowledge based economy, as well as regional and international economic integration. These pillars will be interwoven by three cross-cutting issues namely gender equality, environmental sustainability and ICT (GoR, 2000: 11). The Vision 2020 constitutes the main document on which all of Rwanda's development sectors rest.

The vision 2020 recognizes the need to provide the country with an adequate waste management system. In this regard by 2020, the GoR plans to equip each urban area with at least one adequate infrastructure for treating and compressing solid waste as well as for their disposal (GoR, 2000: 17). Similarly, as the Vision 2020 promotes the protection and

conservation of the environment, it recognizes that ICT as not only a cross-cutting issue but also as a main stake in transformation of the Rwandan economy.

2.9.3 Economic Development and Poverty Reduction Strategy (EDPRS)

According to the Ministry of Finance and Economic Planning (MINECOFIN) (2007: 1), the EDPRS document and plan provides a medium-term framework which forms the basis for all the long-term strategies aimed at developing the country in accordance with the Vision 2020 and MDGs. The Strategy, formulated in 2006, is expected to reach its targets by the year 2012. As an operational tool, the EDPRS promotes three flagship programs that help the prioritization of the GoR actions to achieve the MDGs and Rwanda Vision 2020, which include amongst others the creation of jobs and sustainable growth (MINECOFIN, 2007: 1). Thus, the document recognizes that while placing emphasis on promoting economic growth in Rwanda, targets for effective environmental management must be incorporated into the development activities.

However, contrary to other sectors such as sanitation and resource management where targets to be achieved under EDPRS are set, there are no strategies or indicators to be achieved for waste management by 2012. The document indicates only that the collection and processing of solid waste will be extended to more households and institutions.

2.9.4 ICT sector policy in Rwanda

Rwanda is a landlocked country with limited natural resources and an industrial sector that remains heavily aligned with the primary sector. In addition, Rwanda is densely populated and all arable land is being used for growing crops, with limited technology. This leads to soil exhaustion and the land becomes less productive. Hence, the GoR is viewing a 'knowledge-based' economy based on ICTs to be a way to provide economic diversity and to achieve a great wider socio-economic development.

In this regard, the Rwandan government had adopted an ICT for socio-economic development through a policy known as the National Information Communication Infrastructure (NICI) Plan. The NICI Plans in accordance with the Vision 2020 and MDGs, is made up by programs and projects to incorporate ICT at every level and in every sector of society based on ten pillars,

amongst which are: education, infrastructure equipment, economic development, social development, and rural and community access (GoR, 2006a: 37).

According to Nsengiyumva and Baingana (2007: 10), to make the Rwandan ICT vision operational; the ICT sector was transformed from a centralized and government-based sector to a liberalized and privatized sector from the end-1990s onwards. Within this liberalization, the ICT sector has made major progress. The Rwanda Development Board (RDB) (2010) for instance reports that ICT has attracted US\$500 million in investment over the last three years by both private and public sector and, had created more than 2000 jobs directly and 5000 jobs indirectly. In addition, Nsengiyumva and Habumuremyi (2009: 6) note that the ICT sector is largely import oriented, which have provided enormous opportunities for import substitution through local assembly, creates a market for a wide range of EEE as well as offers new business opportunities to the population. Furthermore, the country has experienced a spectacular growth mainly in the area of cellular telephone and internet with the number of mobile phone subscribers and internet users rising from three to 200 mobile phone users per 1 000 people between 2001 and 2009, and from 2.5 in 2001 to 45 in 2009 internet users per 1 000 people (National Institute of Statistics of Rwanda - NISR, 2007: 60; ITU, 2010).

The GoR in collaboration with the private sector has invested heavily in infrastructure including, amongst others, a 2 500km optic fiber that covers Kigali and the entire country with a total of seven regional links to the neighboring countries and Kigali wireless broadband (RDB, 2010). In addition, different reforms were undertaken, including fiscal reform toward the ICT sector such as the removal of taxes and import duties on ICT products mainly IT equipment, and the creation of Kigali ICT parks providing spaces and other services at minimal cost for ICT-related production and service provision activities (GoR, 2005: 37). Moreover, ICT has been introduced as a compulsory subject in the secondary school and higher learning institutions curriculum as a way to provide the country with qualified human resources (Rubagiza *et al.*, 2010: 2).

Hence, the GoR in partnership with different donors have initiated various projects to disseminate the use of ICT tools, mainly computer and cellular telephones, in different sectors such as educational, health and public institutions. Farrell (2007: 9), for instance, reveals that in

the education sector, more than 5 000 secondhand computers have been distributed to secondary schools with the target to distribute at least 300 computers per month. The target is to reach a ratio of one computer to 10 students by 2010. In addition, the RITA (2010) and Farrell (2007: 9) report that in 2008, the GoR launched the one laptop per child (OLPC) project with the objective to provide 110 000 PCs to primary school pupils. According to the RITA (2010), more than 12 000 computers have been distributed around the country.

Although the aforementioned projects and different ICT initiatives provide a snapshot of the potential growth in electronic equipment in the country, there is no existence of institutions registering the number of computers, TV sets and radios or other electrical and electronic appliances entering the country either being new or secondhand (NISR, 2008: 9). Thus, the exact figure of EEE stock in the country remains unknown. Similarly, the amount of discarded waste and the management capability to assimilate this waste remain unknown in Rwanda. However, according to Kamuzinzi (2010) and Utkucan *et al.* (2010: 38), some institutions like the National University of Rwanda are facing a problem of managing the increasing amount of electronic scrap or obsolete electronic equipment, mainly computers. Thus, the same situation might occur in more institutions around the country.

In addition, although economy liberalization and privatization have provided different developing countries, including Rwanda, with many benefits such as improved economic performance, capacity-building and good services such as ICT facilities; they have also led to environmental degradation (Van Khoa, 2006: 57). This includes new forms of pollution and unknown types of waste such as e-waste. Mete (2006: 40) contends that this environmental degradation results in policy failure to regulate and to integrate the environmental concerns in economic activities. Mete (2006: 40) further notes that the competitive pressure that accompanies the economic liberalization and attraction of more foreign investments has led to many developing countries lowering their environmental protection standards. Hence, the prospective gap in knowledge regarding the environmental impacts of e-waste in Rwanda, despite its pursuit by government, presents a unique opportunity to investigate management issues related to e-waste, as this study seeks to do.

Regarding e-waste, the ICT policy does not provide any management strategy for obsolete EEE. It, however, incorporates the principle of waste re-use and refurbishing. For instance, in order to increase access to computers in educational institutions, the ICT policy mentions that the computers discarded by finance and governmental institutions should be collected and redistributed to schools and universities. However, without any formal system to collect and to test their functionality might result in e-waste dissemination within the country mainly in rural areas. For instance, some of these domestic discarded electronics equipment might be at the end of their life thus quickly degenerating into e-waste and becoming a burden for education institutions.

2.9.5 Policy and Legal framework for environmental management in Rwanda

In this section, the existing laws, policies as well as regulations related to the environment and waste as well as hazardous substances are discussed. These legal frameworks are discussed with regard to their impact on e-waste management or simply on solid waste management.

2.9.5.1 Constitution of Rwanda

The supreme law of Rwanda is its Constitution. The Constitution of Rwanda, as amended in 2003, provides all citizens with the right to a healthy and satisfying environment (Article 49), (GoR, 2003b). The same article obligates everyone to protect, maintain and promote the environment. The state, by law ensures environmental protection as well as a clean and safe environment. In addition, Article 191 of the constitution prohibits any agreements authorizing the storage on Rwandan territory, of toxic waste and other substances that may damage the environment. It states: “It is prohibited to make international agreements permitting the transit or dumping of toxic waste and other hazardous materials capable of endangering public health and the environment” (GoR, 2003b: Article 191).

In pursuance of these constitutional provisions, a number of policy, laws and regulations exist in Rwanda relating to different aspect of the environment management within the country. These are discussed below.

2.9.5.2 National Environmental Policy

The environmental policy in Rwanda instituted in 2004, was the first environment national policy adopted by the GoR. The National Environment Policy contains strategic options with regard to management and utilization of natural resources and other socio-economic sectors, as well as the necessary arrangements for the implementation of the policy (GoR, 2003a: 4).

Amongst the principles that the environment policy is based on are the adoption of environmentally friendly technologies, introduction of the principle of prevention, introduction of the principle of polluter-pays as well as the establishment of a favorable social and economic environment for the utilization of natural resources (GoR, 2003a: 29). In addition, the policy calls for the adoption of strategic actions for environmental protection. The following are also included (GoR, 2003a: 30-37):

- To control the quality of local and imported products;
- To establish a system for collection, transportation, repository and disposal of waste;
- To formulate a national strategy for specific management of chemical products and biomedical and industrial waste; and
- To develop and strengthen institutional and technical capacities for the management, control and monitoring of unsuitable products.

To enforce this vision, the policy sets out institutional and legal reforms for coordination of sectoral and cross-cutting policies. In this regard, the organic law for environmental protection was enacted, followed by the establishment of the Rwanda Environment Management Authority (REMA). The National Environmental Policy is in direct relation with other policies in areas such as policy on water and sanitation, and environmental health.

2.9.5.3 Environmental Health Policy and Water and Sanitation Policy

The Water and Sanitation, and Environmental Health Policies spell out the Rwandan vision with regard to sanitation and environmental health. Both policies address a broad range of issues related to hygiene, water, sanitation and environmental protection, including water resources

management, rural and urban hygiene and the provision of sanitation infrastructure to the country. The latter includes providing the country with adequate waste treatment infrastructure (GoR, 2004; 2008c).

In addition, the National Environmental Health Policy also sets out other priority program interventions to ensure a safe environment that can address impacts on e-waste management. These include promoting environmental health education, the promotion of health education, the promotion of food and water safety; control of pollution and occupational health and safety (GoR, 2008c: 22-28). With regard to waste, the policy recognizes only medical waste as hazardous waste that must be treated separately from other waste; thus not addressing other types of hazardous waste such as e-waste (GoR, 2008: 19). Similarly, the Water and Sanitation Policy largely addresses water aspects with little regard to sanitation. The policy provides the objectives to attain the Vision 2020 framework in the water sector, however there are no clear set goals for the sanitation sector within the country (GoR, 2004: 18).

2.9.5.4 Environment Organic Law

The Environment Organic Law No 04/2005 enacted in 2005 determines the modalities of protection, conservation and promotion of the environment in Rwanda. Regarding waste, the law provides a legal definition of waste, hazardous waste and pollutants under the jurisdiction of the Republic of Rwanda.

According to the GoR (2005: Articles 4), hazardous waste is defined as “any substances whether solid, liquid or gaseous that cause a serious harm to human health, security and other biodiversity together with the quality of the environment” while pollutants are referred to as “any waste disposal whether solid, liquid or gaseous, all wastes, smell, heat, excessive automobile noise, unbearable music noise, echo, radiation or combination of all that are likely to be destructive”. Since e-waste contains hazardous and toxic substances, the closest definition would fall under hazardous waste or pollutants within this law.

In addition, the environment law provides prevention and punitive measures against polluter based on polluter pays principle that can be in form of imprisonment or a fine. The law prohibits:

- Dumping in wetlands any hazardous waste before its treatment or disposal of any solid, liquid waste or hazardous gaseous substances in a stream, river, lake and in their surroundings;
- Release into the atmosphere poisonous gases, smoke, waste, soot, dust and any other chemical substances in an illegal manner; and
- Sale, import, export, transit, store and pile chemicals, diversity of chemicals and other polluting or dangerous substances and as well as import of any kind of waste in the country.

(GoR, 2005: Articles 88-93)

Furthermore, the law requires that every project including programs and policies be subject to an Environmental Impact Assessment (EIA), before obtaining authorization for its implementation (GoR, 2005: Article 6). EIA is considered as an essential tool for environmental management and, according to the REMA (2006: 4), EIA can be used to inform the process of decision-making by identifying potential environmental effects and risks of development projects. In addition, the REMA (2006: 4) asserts that EIA can be an instrument to promote sustainable development by ensuring that development does not undermine critical resources and ecological functions on the well-being and livelihoods of communities and people in general. Furthermore, Barrett (2005: 112) contends that EIA as well as other tools such as Strategic Impact Assessment (SEA) can bring environmental changes advocated by ecological modernization by opening up decision-making processes through public participation and integration of environmental consideration within policy formulation and/ or project development processes.

2.9.5.4 Environmental management regulation and standards

In relation to the chemicals and other polluting substances, two ministerial orders determining categories of chemicals and other polluting substances that are prohibited from import and/ or export have been released. The first is the ministerial order regulating the importation and exportation of ozone layer depleting substances products and containing equipment (GoR, 2008a) which provides a list of prohibited ozone depleting substances such as CFC and containing equipment such as fridges that are banned for import within the country. In addition,

the GoR (2008a: 6) indicates that the ministerial order requires the Rwanda Bureau of Standards (RBS) to ensure the control of imported and/ or exported ozone layer depleting substances based on the listed substances products and equipment within the order. Furthermore, the order requires that the REMA determines the methods of recovery and recycling of ozone depleting substances (GoR, 2008a: 7). However, such guidelines have not as yet been released.

The second, the ministerial order determines the list of chemicals and other prohibited pollutants. It lists different categories of pollutants and products prohibited for import or export within the boundary of the country (GoR, 2008b). It includes hazardous substances such as PCBs, dioxins, furans. The order does not, however, list any specific equipment containing such substances (GoR, 2008b: 9-10).

The GoR (2003a: 7) in addition, reveals that the GoR has also ratified different international conventions prohibiting hazard substances such as:

- Stockholm Convention on persistent organic pollutants;
- Rotterdam International Convention on commercial transactions of agricultural pesticides and other poisonous;
- International Convention on Substances that Deplete the Ozone Layer; and
- The Basel Convention on the Control of Transboundary Movements of Hazardous wastes and their disposal.

Furthermore, in order to establish the appropriate standards for landfill sites, the Rwanda Utility and Regulation Agency (RURA) has released a document detailing standards for waste disposal sites as well as guidelines for waste collection and transport in urban areas in Rwanda. Although, the document provides a definition of solid waste which mentions home and industry appliances, the document does not provide standards, techniques or disposal guidelines for e-waste and other hazardous waste (RURA, 2009: 2). Solid waste under the RURA standards, is defined as “all putrescible and nonputrescible solid and semisolid wastes, including garbage, ... industrial wastes, demolition and construction wastes, abandoned vehicles and parts thereof, discarded home and industrial appliances, ... and other discarded solid and semi-solid wastes or animal solid and semi-solid wastes” (RURA, 2009: 3).

2.10 Conclusion

To conclude, after discussing the definition and the hazard of e-waste as well as their environmental contamination and health risks potential, the chapter has examined relevant literature and discussed the state of e-waste, practical solutions and regulatory frameworks regarding e-waste in both OECD countries and developing countries. Furthermore, environmental management in Rwanda was discussed with regard to the existing policies, laws and regulations related to the environment in general, waste as well as hazardous substances. Finally, the ICT sector policy in Rwanda was discussed.

E-waste is increasing significantly in different areas of the globe in both developed and developing countries. In addition, e-waste is a complex type of waste that contains valuable material and at the same time hazardous substances, classified as hazardous waste. Thus, without any managerial framework, environmental contamination and human health risks might occur.

While an established e-waste management, from the collection to recycling, backed up by clear regulatory and legal frameworks is gaining momentum in most developed countries, many developing countries are still found wanting in terms of establishing e-waste management systems. In addition, where the e-waste management has been introduced in developing countries, e-waste legislation as well as e-waste management systems are primarily at the initial stage and focus more on e-waste import ban than managing domestically generated e-waste. In addition, e-waste management is facing many challenges, including lack of awareness of the hazards of e-waste amongst the environmental regulators and decision-makers, lack of infrastructure to properly manage e-waste, lack of political will as well as lack of regulatory frameworks or its lax implementation to hinder the transboundary movement of e-waste. Nevertheless, the inability to prevent the transboundary movements of e-waste might be regarded as an international failure, as in both developed and developing countries e-waste export and import continues to take place.

The fact that most developing countries have not introduced e-waste management policies into their ICT sector development strategies indicates that planning may be taking place without

taking into account the effects of economic activities on the environment. This could subsequently undermine sustainable development and efforts to attain the MDGs amongst various developing countries.

CHAPTER THREE

BACKGROUND TO STUDY AREA AND RESEARCH METHODOLOGY

3.1 Introduction

This study investigates the awareness amongst environment regulatory authorities on e-waste and management strategies in Kigali, Rwanda. In this regard, this chapter discusses the methodology that was adopted to conduct the study. The chapter begins by contextualizing the background to the study area which includes the geographic as well as the socio-economic aspects pertaining to Kigali. In addition, waste management practices within the city are described with regard to solid waste management and related sanitation aspects. The chapter further discusses the research methodology as well as the design aspect of the data collection and research tools used to collect them. Finally, the chapter concludes by explaining the methods used to analyze the data.

3.2 Background to the Study Area

3.2.1 Geographical profile

Kigali, the capital of the Republic of Rwanda, and the study area, is situated almost in the center of the country. Kigali is built on natural landscape dominated by interlocking hills varying in heights between 1450 and 1850 m and which are separated from each other by large valleys (City of Kigali, 2002: 15; Karamira, 2006: 51). Its climate is temperate with two dry seasons (February to April and June to September) and two rainy seasons (April to June and September

to January). Figure 3.1 shows the administrative boundary of Rwanda and different provinces that constitute the country including Kigali in the center.

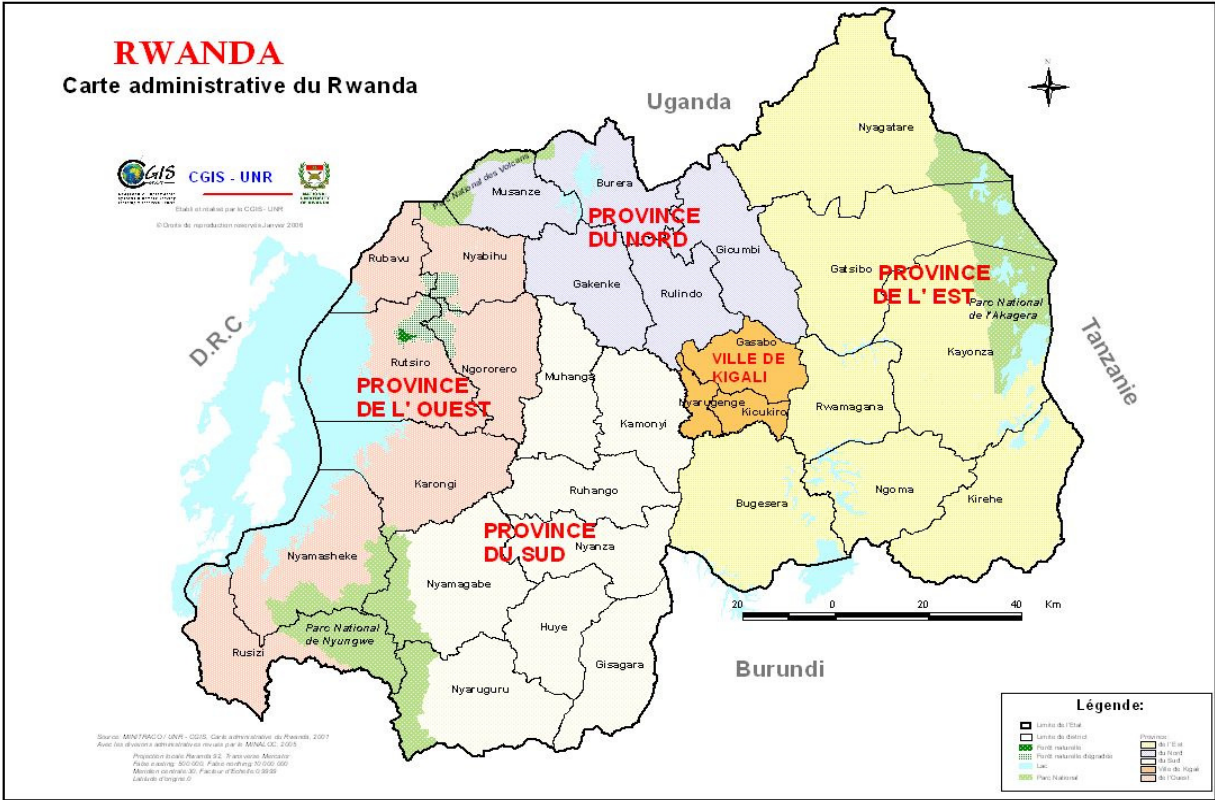


Figure 3. 1: Administrative map of Rwanda (National University of Rwanda, 2010)

3.2.2 Socio-economic profile

3.2.2.1 Population

Compared to other African countries, with one million of inhabitants, the population growth of Kigali has remained small (City of Kigali, 2002: 1; City of Kigali, 2011). This has been, in part due to the 1994 Tutsi genocide which claimed the lives of approximately one million victims countrywide. However, after the 1994 genocide and war, the city experienced a spectacular rise in the population, caused mainly by the return of Rwandan refugees from various parts of the

World (City of Kigali, 2002: 11). This rise in the population has continued, and is estimated to have reached about **one million people**, with an average annual growth rate of 10% (City of Kigali, 2002: 12; 2010). Rural-urban migration is a large contributing factor to this rising trend, as people seek better employment and business opportunities in cities (City of Kigali, 2002: 11).

Furthermore, a socio-economic survey carried out in 2000 reveals that women constitute about 52% of the city's population while about 56% of the entire city's population comprises the youth, aged between 14 and 25 years (City of Kigali, 2002: 11-12). The same survey further reveals that 10% of Kigali's population aged seven years and above has never had any formal education, 54% have primary education and five percent have post-secondary education.

3.2.2.2 Economic development

Kigali constitutes an economic powerhouse for the country, including important sectors such as manufacturing, services and telecommunications. As the capital city, it also constitutes a powerful political and/ or administrative base, accommodating most of the national administrative departments.

In the bid to accelerate its development, Kigali has embraced the National Vision 2020 and the EDPRs. Thus, according to the City of Kigali (2002: 9), a strategic development plan was adopted in 2002, with regard to building a foundation to compete in the global economy and expand job opportunities. In this regard five priority sectors of development having the greatest potential to achieve economic growth were identified. In order of importance with regard to their annual contribution to the economy of Kigali, these include industry, tourism and hospitality, financial services, infrastructure and construction, as well as ICT.

The RDB (2010) observes that due to the economic position of Kigali and because of the availability of infrastructure such as electricity compared to other parts of the country, the use of ICT tools has spread rapidly in Kigali. Hence, it is hard to divorce the ICT sector and national ICT development in Kigali. For instance, more than 80% of mobile subscribers across the country and 65% of the estimated 800 cybercafé to be operational through the country are located in the city (NISR, 2008: 9). In addition, more than 61% of households in Kigali are equipped with radio and TVs (NISR, 2008: 9). Furthermore, with the creation of the Kigali ICT

Park, most of the ICT enterprises are established within the city and amongst others, include A-link, a Chinese enterprise that assembles different kinds of low cost Rwandan-branded mobile telephones with a capacity to produce more than 600 mobile phones per day (Nsengiyumva and Habumuremyi, 2009: 15-16)

As the ICT infrastructure has improved in the city, the use of ICT has spread in all activities from the provision of services to citizens by public institutions, to the use of ICT in education, banking and health sectors. For instance, most of the institutions are connected to the internet and possess computers as well as other electronic equipment such as printers that are used on a daily basis. Thus, various administrative services are provided online to the general public while other services such as banking cards, automatic teller machines (ATMs) and electronic national identity have been introduced (NISR, 2008: 9). In the education sector, as ICT has been introduced as a compulsory subject in the secondary school curriculum as well as in the higher learning institutions, many institutions have been equipped with a computer laboratory. Rubagiza *et al.* (2010: 2), for instance, report that in addition to the computers distributed by the government, many schools have benefited from acquiring secondhand computers from NGOs such as Worldlink, Computer for Africa and Camara Rwanda. According to Rubagiza *et al.* (2010: 4), some schools, mainly in Kigali and other urban areas, received about 200 computers each. In higher learning institutions the figure is likely to be more as many higher institutions in Kigali have introduced computer science faculties. Hence, the increase of electronic equipment waste burden is likely to be more within Kigali than other localities in the country. In addition, Nakkazi and Musoke (2010: 1) consider that Kigali as a major commercial city of Rwanda will soon be the destination of many secondhand electronics as different neighboring countries such as Uganda and Kenya have established various restrictions to hinder the importation of secondhand electronics while taxes and import duties on ICT products have been removed in Rwanda.

Although there are no statistics of generated e-waste within the city of Kigali, the city is likely to generate huge volume of e-waste as the result of different investments in the ICT sector as well as the stock of EEE, mainly computers and cellular phones, which have increased at an astonishing rate in the past years. In addition, as aforementioned, the city accommodates most

national and international institutions and various educational institutions with access to ICT tools. Yet, it has been reported that the lifespan of most of electronics such as computers and cellular phones has dropped considerably. In addition, much of the equipment that is imported as aforementioned are secondhand thus their lifespan is very short. This raises concerns about what is happening to the obsolete electronic equipment or other types of e-waste such as fridge batteries and so forth within the city, and if there are any regulations or standards for these imported secondhand EEE and other components used in these electronic assembly enterprises.

3.2.2.3 Environment

Kigali as many other urban neighborhoods in developing countries, is growing rapidly. However, with increasing urban migration and lack of any town master plan; unplanned settlements including habitation, industries or other economic activities have proliferated rapidly within the city on land considered unsuitable for development such as on the slopes of the hills, valleys and wetlands without taking into consideration the environmental aspects (REMA, 2009: 20). In addition, the city lacks basic urban environmental and sanitary infrastructure such as rain water drainage, sewer systems, treatment and disposal of domestic as well as industrial waste (Kalimba and De Langen, 2007: 2; Sano, 2007: 55-66). Thus, the city is facing many environmental challenges such as soil erosion due to poor drainage systems exacerbated by the hilly landscapes characterizing the city; uncontrolled solid and waste water dumping; industrial pollution as well as health hazard problems (Kalimba and De Langen, 2007: 2; REMA, 2009: 21-23).

3.2.3 Waste management in Kigali

According to Kalimba and De Langen (2007: 4), although the city largely lacks appropriate waste management infrastructure, the city has the capacity to organize itself in terms of solid waste collection to make the city free of solid waste. Thus, the city is gaining the reputation of being one of the cleanest cities in Africa.

Kalimba and De Langen (2007: 8) and Sano (2007: 66) reveal that the city council in collaboration with the private sector and a well organized Community Based Organizations (CBOs) made mostly by women collect garbage from households or from different institutions

and enterprises within the city. In addition, Sano (2007: 65) reports that under the directives of Kigali and all districts it is prohibited to discharge any garbage out of one's plots, thus most of the city's inhabitants have been forced to register for solid waste collection to CBOs or to private collectors mainly composed by cooperatives. However, there is no regulation in the city targeting particularly e-waste or any other hazardous waste stream. Thus, e-waste might be disposed together with other waste by the household or institutions and further collected and treated as regular municipal solid waste.

Kalimba and De Langen (2007: 8) and Sano (2007: 66) further assert that the CBOs collect household garbage mainly in poor neighborhoods while in wealthy areas and big institutions private companies ensure the collection and transport of generated solid waste. The waste collected by CBOs and cooperatives in most of the cases is composed of organic material that is recycled for compost production or fabrication of energy briquette (United Nation Development Program (UNDP) and GoR, 2008: 1).

Although the city in partnership with private sectors has been able to provide waste collection services, the city lacks adequate facilities for waste disposal. According to the UNDP and GoR (2008: 1), the non recycled waste by CBOs and cooperatives estimated to be about 500 tons per day is disposed of in the only facility that deals with collected solid waste within Kigali, the Nyanza landfill. In addition, the UNDP and GoR (2008: 25) portray that the landfill is simply an open dumpsite without any kind of control or environmental and safety standards which constitutes a hazard risk not only for the environment but also for surrounding households. Furthermore, the UNDP and GoR (2008: 25) state that waste is disposed of without any pretreatment or segregation and is frequently burnt by waste pickers and scavengers. Thus, any kind of hazardous waste such as e-waste is likely to end up in the city landfill without any kind of treatment.

Furthermore, the REMA (2009: 23,45) reveals that in other cases waste composed of chemicals including heavy metals from garages, workshops and industry is dumped in unsuitable areas or disposed of in rivers that cross the urban area and other wetlands. Kalimba and De Langen (2007: 8) argue that with limited accessibility in a large part of many poor neighborhoods only limited quantities of waste is collected. Thus, the remains as reported by Sano (2007: 66), is

likely to be dumped in water drains mainly in poor neighborhoods or in public areas contrary to the aforementioned city directives. On other hand, the REMA (2009: 23) postulates that some institutions, mainly health entities such as hospitals and medical centers, possess incinerators for on-site incineration of waste.

To sum up, the solid waste management practices within the city are multifaceted and lack a systematic framework. In addition, the city lacks appropriate infrastructure for waste treatment and their final disposal. Regarding e-waste, Kigali lacks a regulatory framework as well as managerial system. Hence, obsolete electronics are likely to end up either in storerooms within different institutions thus even the chances to re-use them is missed up or in the worst case scenario; e-waste might be dumped in landfills or in public open areas, exposing the city to environmental and risk hazards. This raises the concern about the awareness of environmental hazards associated with e-waste among different institutions in charge of environment protection within the city of Kigali.

3.2.4 Environmental institutional framework

Under the decentralization policy, the state level is in charge of policy and guideline formulation while the decentralization entities namely the district, sector and the cell implement them. With regard to the environment and particularly waste management, the district is in charge to determine the modality of waste management under its jurisdiction, to set up pollution control mechanisms, warn competent authorities in case of violation of environment related regulations and disasters that constitute a threat to environmental quality and check up whether recommendations from studies on environmental impacts are respected during the execution.

Regarding the centralized institutions, in the line with discussed policies, regulations and standards; institutional responsibility with regard to environmental management falls under several institutions. The common institutional cluster that has a direct or indirect relationship with solid waste management and hazardous substances are portrayed in the table below (Table 3.1). Although most of the described institutions are national entities, all of them are based in

Kigali and as such they can provide valuable information on the prevailing situation on e-waste in Kigali.

Table 3.1: Government institutions with links to solid waste and hazardous substances

| Institution | Responsibilities or links to solid waste or hazardous substances |
|-----------------------------------|--|
| MINILENA | Is responsible for the environmental policies formulation and the formulation of legislations regarding various environmental aspects. |
| REMA | REMA acts as the overall agency responsible for overseeing the implementation of the environmental organic law and related policies and laws. |
| RBS | RBS regulates importation, manufacturing or dumping of environmentally hazardous materials. |
| RDB | Under the unit of environment analyst, the RDB assists REMA to call out EIA and compliance monitoring for any investment projects. |
| RURA | As the regulatory agency, the RURA provides standards and directives for waste collection, transport and disposal; and also ensures that services are provided in compliance with the environmental standards. |
| Kigali City Council and Provinces | Responsible for policy formulation with regard to solid waste disposal within the City, responsible for decisions and instruction for treatments, collection and transport of waste within the City. |

3.3 Research Methodology

According to Burns and Groves (2005: 221), the research methodology is closely associated with the conceptual framework of the study and guides arrangements for implementation of the study. It involves the type/s of data to be collected, data collection technique/s, the sampling methodology and so forth. Siddiqui (2008: 121), however, notes that research methodology is more than simply gathering data; it aims also at accessing the phenomena under observation rather than data itself. Bryman (2008: 8) further indicates that the research methodology also depends on whether data to be collected are to test or to build a theory, that is, to make a link between the conceptual framework and the research methodology. According to Bryman (2008: 8), there are two ways to do so, either by the deductive approach or by the inductive approach.

Bryman (2008: 9-12) explains that the deductive approach represents the most common view of the nature of the relationship between theory and research methodology. Within this approach, theory and hypotheses deduced come first and drive the process of gathering data. In contrast, within the inductive approach, according to Bryman (2008: 9-12), theory is the outcome of research, that is, the process involves drawing generalizable inferences out of observations. Bryman (2008: 13) further asserts that “in much the same way that the deductive strategy is associated with a quantitative research approach, an inductive strategy of linking data and theory is typically associated with qualitative research”.

Rubin and Babbie (2005: 63) postulate that despite these philosophical differences, the qualitative and quantitative methods are not inherently incompatible. As in the view of many scholars the qualitative and quantitative methods play equally important and complementary roles in knowledge building (Rubin and Babbie, 2005: 63). In addition, Kumar (2005: 17) argues that through the research process quantitative and qualitative research methodologies are broadly the same in both, however, the two methods are different in terms of the methods of data collection, the procedures adopted for data processing and analyzing, and the style of communication of the findings. Further, Rubin and Babbie (2005: 64) advise that what a researcher needs is to match the tools used with the research question and conditions faced, whether using qualitative or quantitative method or both methods in combination.

Bearing in mind these different points of view, the research methods that are used in this study are oriented towards the deductive approach. In addition, quantitative methodologies will be used in data collection and their further analysis.

3.3.1 Research Design

A research design is a strategic framework for action that the researcher can use as a bridge between the research question and the implementation of the research (Terre Blanche *et al.*, 2006: 34). In addition, a research design is referred to as the plans that guide “the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose within economic resources disposed” (Sellitz *et al.*, 1965 cited in Terre Blanche *et al.*, 2006: 34).

According to Rubin and Babbie (2005: 123), in research, four of the most common and useful purposes are exploration, description, explanation and evaluation, however, a study can have more than one purpose and most do. In addition Cohen *et al.* (2007: 205) assert that many research methods are descriptive as they set out to describe and to interpret what is. For instance, Best (1970 cited in Cohen *et al.*, 2007: 205) states that descriptive methods is concerned with:

Conditions or relationship that exist; practices that prevail; beliefs, point of view, or attitude that are held; process that are going on; effect that are being felt; or trends that are developing. At times, descriptive research is concerned with ‘how what is’ or ‘what exist is’ related to some preceding event that has influenced or affected a present condition or event.

Furthermore, Rubin and Babbie (2005: 123) and Jackson (2009: 100) reveal that description refers to the characteristics of a population, and is based on quantitative data obtained from a sample of people through observational, case study, archival and survey methods. Rubin and Babbie (2005: 123) suggest that the best way to assess the characteristic and perceived problem and needs of a group is to survey its members. In addition, Cohen *et al.* (2007: 205) reveal that a survey has several characteristics and several claimed attractions, typically used to scan a wide

field of issues, population, programs, and so forth, in order to measure or to describe any generalized features.

For Rubin and Babbie (2005: 283), in a typical survey, the researcher selects a sample of respondents and administers a standardized questionnaire to them. In addition, Jackson (2009: 16) adds that the survey method consists of questioning individuals on a topic or topics and then describing their responses. For instance, a questionnaire offers an objective means of collecting information about people's behaviors, beliefs, attitudes and knowledge (Boynton and Greenhalgh, 2004: 1312).

The research design for this study is primarily descriptive in nature, within the context of describing the levels of awareness amongst the environmental regulators toward e-waste as well as strategic management of e-waste in Rwanda. However, the study also has elements of being evaluative. According to Rubin and Babbie (2005: 125), evaluative study asks whether policies, programs or services are affective in achieving their stated goals. For instance, it seems to be evaluative in terms of reviewing the legislative and technical management of e-waste in Rwanda. But, the study will limit itself primarily as descriptive research, explained by De Vaus (2002: 18) as that dealing with questions such as “what” things are like, not “why” they are.

Rubin and Babbie (2005: 207) indicate that the most common way that researchers gather data for analysis and interpretation is by asking people questions, and sometimes the instrument designated to gather data may be by communicating with people (interview) or in writing (with questionnaires). Sometimes questions are either asked by the interviewer and the list of questions is referred to as an ‘interview schedule’ or written down and given to a respondent for completion, in which case the sets of questions are referred to as ‘questionnaires’, ‘self-completion questionnaire’ or sometimes as ‘self-administered questionnaires’ (Bryman, 2008: 216; Rubin and Babbie, 2005: 207).

The self-completion questionnaires present various disadvantages that include a greater risk of missing data, lower response rates, limiting the use of too many questions and sometimes the researcher does not know who answers (Sarantakos, 2005: 263). The self-completion questionnaires, however, present many advantages over the interview such as providing high

quality usable data, and providing anonymity which may encourage more honest and frank answers than in interview, in addition, they are cheaper to administer and are less time-consuming than interviews (Marshall, 2005: 132; Sarantakos, 2005: 263).

The data collection method for this study used a quantitative approach through survey methods. In addition, the self-administered questionnaire was selected as the appropriate tool to collect data regarding levels of awareness on e-waste amongst environmental regulators and e-waste management in Rwanda as it allows the respondents to provide frank answers, and is cheaper and less-time consuming.

3.3.2 Research instrument design

The questionnaire is defined as a method of data collection which is completed by respondent in written format (Politt, 1999 cited in Marshall, 2005: 131). In addition, Franklin and Osborne (1971 cited in Murray, 1999: 148) define a questionnaire as an instrument consisting of a series of questions and/ or attitude/ opinion statements designed to elicit responses, which can be converted into measures of the variables under investigation. Furthermore, Bryman (2008: 242) reveals that the aim of the questionnaire is to obtain information that meets the requirements of the research project. Moreover, Murray (1999: 148) stresses that the first requirement of the questionnaire is that it is suitable to collect data that can be used to test the research question or hypothesis. Thus, Maree and Pietersen (2008: 160) suggest that the questions should be carefully structured and designed to obtain the needed information without any ambiguity or bias as every respondent answers the same questions, which is worded in the same way and in the same sequence.

The questionnaire (Appendix I) was constructed on the basis of the information gathered on the following three aspects: the hazardous nature of e-waste, the legal framework on e-waste and e-waste management disposal and challenges. In addition, the questionnaire was designed with thirty six questions comprising open-ended and close-ended questionnaires that assessed the levels of awareness on e-waste amongst the environmental regulators as well as to assess the e-waste management strategies and challenges faced within Kigali. Furthermore, these questions

were grouped under four sections according to the research questions with each section associated with questions assessing the environmental regulators' awareness on specific aspects.

3.3.2.1 Open-ended questions

The open-ended questions are those questions where the research seeks narrative, qualitative information (Polit, 1999 cited in Marshall, 2005: 132). In addition, Murray (1999: 150) and Kumar (2005: 17) contend that open-ended questions allow the respondents to formulate their own responses in their own words and are extremely useful for seeking opinions, attitudes and perceptions. Singleton and Straits (1999: 281) indicate that open-ended questions allow respondents to include more information, including feelings and understanding of the subject and this allows researchers to better access the respondents' true opinion on an issue contrary to closed-ended questions which do not allow the respondents to explain issues which they do not understand or do not have an opinion on. Furthermore, Cohen *et al.* (2007: 322) state that open-ended questions are useful if the possible answers are unknown. Moreover, the Colorado State University (CSU) (2010) asserts that the open-ended questions reduce monotony and error as they do not allow respondents to disregard reading the questions and just "fill in" the questionnaire with all the same answers, such as filling in the "do not know" space on every question, as in close-ended questions.

However, open-ended questions may require more time from respondents to enter a response thereby leading to refusal to complete the item and to lower response rates (Murray, 1999: 133; Cohen *et al.*, 2007: 322). Secondly, open-ended questions can lead to irrelevant and redundant information; they may be too open-ended for respondents to know what kind of information is being sought (Cohen *et al.*, 2007: 322). Thirdly, if open-ended questions are analyzed quantitatively, the collected information is coded and answers tend to lose some of their initial meaning as they allow respondents to use their own words (CSU, 2010). Fourthly, the analysis of open-ended questions is time-consuming (Singleton and Straits, 1999: 281).

The open-ended questionnaires were used in relation to two objectives in this study. The first objective was to assess the respondent's knowledge on the hazards of e-waste and the second

objective was to allow respondents to provide any additional information regarding e-waste environmental problems and/ or management in Kigali.

3.3.2.2 Close-ended questions

According to Marshall (2005: 132), the close-ended questions are referred to questions where a respondent is offered a choice of alternative replies. In addition, the format of the question is drafted in a way that people need to tick the correct answer or give details where necessary (Nzimande, 2004: 60). Furthermore, Humoud (2010: 164) asserts that the closed-ended questions limit respondents' answers to the survey as the participants are allowed to choose from either a pre-existing set of dichotomous answers, such as yes/ no, true/ false, or multiple choices or ranking scale response options. However, like other methods of enquiring people's knowledge, opinion or perceptions; the closed-ended questions have advantages and disadvantages. According to De Vaus (2002: 99), the close-ended questionnaires can be disadvantageous because on some issues they can create false opinions either by giving an insufficient range of alternatives from which to choose or by prompting people with acceptable answers. In addition, Bryman (2008: 235) stresses that with the use of close-ended questions, there is a loss of spontaneity in respondent answers, as responses are fixed.

Nevertheless, Rubin and Babbie (2005: 207) argue that for many researchers the close-ended questions are more preferred to the open-ended questions. Firstly, with the closed questions, the answers are easy to process, and they enhance the comparability of answers and may clarify the meaning of questions for respondents as there is availability of answers (Bryman, 2008: 231). Secondly, they are extremely useful for eliciting factual information (Kumar, 2005: 17). Thirdly, despite being difficult to construct, the closed-ended questions are easy to administer, answer and analyze (Murray, 1999: 150). Lastly, Parahoo (1997 cited in Murray, 1999: 150) reveals that the greater number of closed questions included in a questionnaire, the more highly structured the questionnaire becomes.

The close-ended questions were designed in two types, namely, "list" close-ended question and "likert scale" close-ended questions. According to Marshall (2005: 133), the "list" close-ended questions are referred to questions where the respondent can select more than one response, as

the responses are not mutually exclusive while scale close-ended questions are referred to the questions where the respondent chooses a ranked option from a list indicated.

In addition, the questionnaire (Appendix I) used dichotomous questions “Yes” or “No” associated to a list of proposed answers, however, an additional “Don’t know” was added to every dichotomous question. According to Marshall (2005: 134), the questions should ideally not challenge the respondent’s knowledge, but if this is essential this must be done in a non-threatening manner and must include a “Don’t know” response. In addition, Rubin *et al.* (1995: 824) indicate that the “Don’t know” is a valid response in the sense that it is of interest to estimate the proportion that does not have a strong enough feeling on or enough knowledge of a particular issue to answer “Yes” or “No”. Furthermore, Converse and Presser (1986 cited in Bryman, 2008: 244) strongly advocate that survey respondents be offered a “Don’t know” option but argues that it should be implemented by using a filter question to filter out those who do not hold an opinion on a topic. This study uses the “Don’t know” response in a way to estimate the knowledge of environmental regulators on e-waste. Therefore, it will allow to separate the “Don’t knows” to the “Knows” represented either by “Yes” or “No” as it is assumed that those who responded by “Yes” and “No” have some knowledge on the issue.

The likert scale questions consists of questions which measured respondent opinions on scale rating either from one to four point or from one to five point (Maree and Pietersen, 2008: 167). The responses were ranged from “Strongly agree” to “Strongly disagree” on some questions which followed a filter questions and, on the other hand, from “Strongly agree” to “Don’t know” for those not preceded by a filter question. Sometimes, the respondents were presented with a statement and asked to indicate the extent of their agreement.

3.3.2.3 Questionnaire format

Rubin and Babbie (2005: 214) assert that the format of a questionnaire is important as the nature and the wording of the questions asked can influence response rates. For instance, an improperly laid out questionnaire can lead respondents to miss questions, confuse them about the nature of data desired, and in the worst case, lead to throwing the questionnaire away. According to Bryman (2008: 222), to avoid such cases the researcher should use one style for

general instructions, one for heading, perhaps one for instructions and one for questions. In addition, Bryman (2008: 222) observes that for closed-ended questions, vertical alignment has the advantage of avoiding confusion, being easier to code and clearly distinguish questions from answers; however, when there is to be a series of questions with identical answers, formats such as the likert scale, a vertical format will take up a too much space.

Bearing that in mind, the questionnaire was designed with closed-ended questions in vertical format except for questions with likert scale answers that are in horizontal format. In addition, different styles were used for different questions and answers. For instance, questions were in bold font while the answers were in normal font. It was done in a way to make questions more visible as respondents will scroll to move from one question to other. In addition, the questionnaire is divided into four sections under which different questions that are related are grouped. Similar, Murray (1999: 151) advises that questions on a similar theme should be grouped together for cohesion as questions flow smoothly from one topic to another.

3.3.3 Recruitment of participants

Davies (2006: 31) reveals that sampling is linked with the external validity or generalizability of research findings. High probability samples allow results to be generalized from the sample of the population. However, Bryman (2008: 179) argues that in most cases it is a compromise between constraints of time and cost, the need for precision and variety, and further considerations such as the non-response probability and the representativeness of the sample. In addition, Rubin and Babbie (2005: 247) advise that given meager resources and timeframe, one option would be to select a purposive sample of community leaders, experts and professionals known for their work with and expertise on the problem in locality. Consequently, a purposive sampling method was used for this study where time and monetary resources are limited.

According to Rubin and Babbie (2005: 247), purposive sampling is referred to as choosing a sample by regarding a population who may represent best the general opinion. In addition, Bowling (2002 cited in Davies, 2006: 32) states that purposive sampling is a deliberately non-random method of selecting participants for research, which allows individuals to be selected because they have knowledge relevant to the research. However, Sverke (2007: 31) notes that

the non-representative sample or non-probability sample cannot be generalized to the population and can therefore only be used to make inferences about the group of individuals participating in the study. The sample was selected based on individuals with some insight into current practices and policies for environmental management in the city of Kigali as well as in the country of Rwanda. In addition, environmental regulators from different government organizations and at different level of administrations were selected assuming that they will provide different opinions and relevant information with regard to e-waste in Kigali, based on their experience in environmental management in Kigali.

Rubin and Babbie (2005: 417) explain that these individuals considered as those being particularly knowledgeable about the topic of interest constitutes key informants. According to Timmreck (2003: 95), key informants are a select group of people who are especially knowledgeable or experienced about certain issues or problems and are willing to share their knowledge. For example, the public officers, community leaders or subject matter specialists. Rubin and Babbie (2005: 417) further reveal that questionnaires or interviews can be employed to obtain these expert opinions or responses.

Thus, the target population for this study constituted government regulators responsible for or considered as stakeholders in environment management from national level to the district level. Initially, the sample of this research comprised environment regulators in Kigali City and the REMA officers in charge of environmental regulation and pollution control; research, environmental planning and development; and finally environmental education and mainstreaming. The sample was initially seventeen (17) respondents, comprising of five (5) environmental officers of Kigali City of which three (3) were from the corresponding three districts making up Kigali City, and two (2) from Kigali City Council (KCC). In addition, another 12 of REMA's officers were selected to make the sample of seventeen (17) respondents. However, to ensure that the data is statistically significant and represents different views; six (8) environment analysts (former EIA officers) from the RDB; three (3) environmental officers from RBS and four (4) officers in charge of the sanitation unit in RURA were approached. To conclude, the sample in total is thirty two (32) respondents.

3.3.4 Data collection

Bryman (2008: 165) postulates that the researcher needs to decide what kind of population is suited to the investigation of the topic and also needs to formulate a research instrument and then decide how it should be administered. For instance, there are different ways that a survey can be conducted and different ways through which the research instruments are administered (Bryman, 2008: 167). In addition, as an instrument, a self-administered questionnaire can also come in several different forms, that is, supervised questionnaire, postal questionnaire or internet-based questionnaire (Bryman, 2008: 167).

Cohen *et al.* (2007: 226) contend that the use of the internet for administering surveys is becoming commonplace in many branches as the internet based survey reduces costs and the time taken to distribute, gather and process data. According to Cohen *et al.*, (2007: 226), internet-based surveys can be in different forms including emails, emails with attached questionnaire, emails directing potential respondent to a website, or simply a website. The difference between surveys administered by email (email survey) and surveys administered *via* the web (web survey) is that in the case of email surveys, the questionnaire is sent via email to the respondent and it is mainly employed in relation to smaller, more homogeneous online user groups while with a web survey, the respondent is directed to a website in order to answer the questionnaire. Web surveys have also been used to study larger groups of online users (Bryman, 2008: 644).

In relation to the administration of the research instrument using email-based surveys, De Vaus, (2002: 124), Rubin and Babbie (2005: 299) and Bryman (2008: 644) note that there are two main ways in which the internet is used; the questionnaire may be part of e-mail message (embedded questionnaire) or an attached file (attached questionnaire). In case of the embedded questionnaire, the questions are to be found in the body of the email while with an attached questionnaire, the questions arrive as an attachment to an email that introduces it.

Sheehan and Hoy (1999 cited in Bryman, 2008: 644) further assert that the advantage of an attached questionnaire over the embedded questionnaire is that to return the questionnaire, respondents have the opportunity to fax or send the completed questionnaire by postal mail to

the researcher. In addition, Bryman (2008: 644) postulates that the questionnaire is easy to complete as the alignment of questions and answers is clear contrary to the embedded one where the formatting of the questionnaire is limited. However, Cohen *et al.* (2009: 233-234) advise that by using the attached questionnaire, the researcher must bear in mind that sometimes the respondent may refuse to open the attachment because of concerns about a virus or the respondents may not have same software as the sender which leads to the inability to read the questionnaire. Furthermore, the respondent may be unfamiliar or inexperienced with the internet and the media.

In this research, the attached email technique was used as all questionnaires were sent to respondents in the form of an attached file to email addresses. In addition, the questionnaire was sent in Microsoft word 1997-2003 format as this is the widely used software in text treatment and the researcher assumed that all respondents were familiar with it.

3.3.5 Secondary Data

Tashakkori and Teddlie (2003: 314) define secondary data as data that was originally recorded or “left behind” or collected at an earlier time by a different person from the current researcher often for an entirely different purpose from the current research purpose. In addition, Stewart and Kamis (1984 cited in Blaikie, 2003: 18) give a clear definition and types of secondary data:

Secondary information consists of sources of data and other information collected by others and archived in some form. These sources include government reports, industry studies, archived data set, and syndicated information sources as well as traditional books and journals in libraries. Secondary information offers relatively quick and inexpensive answers to many questions and is almost always the point of departure for primary research.

In this study, secondary data used comprised government documents including the Rwandan National Constitution, National Environment Policy, Rwanda Vision 2020, MDG documents, international agreement on e-waste and different case studies of e-waste in different country reports. They were used not only to help the researcher to have an insight on the hazardous and management framework of e-waste but also in the construction of the questionnaire.

Additionally, the secondary data was used in the analysis and interpretation of the study findings.

3.3.6 Data analysis

Blaikie (2003: 28) asserts that once appropriate data has been collected or generated, it is possible to see whether, and to what extent, the research questions can be answered, and that data analysis is an important step in this process. In this study, data was analyzed based on the methodology which utilizes a quantitative approach. In addition, qualitative information was used to explain the quantitative data.

In quantitative research, according to Rubin and Babbie (2005: 552), the data analysis process consists of quantification, where data through different techniques are converted into numerical formats and can be subject to statistical analysis. Rubin and Babbie (2005: 552) further indicate that quantitative analysis is always done by computer programs such as the use of the Statistical Package for Social Science (SPSS) and/ or Microsoft Excel, which require that the data collected be translated into numerical format by coding the responses.

The analysis of data gathered in this study was pre-coded before the analysis and the research findings presented in numerical summaries and tables. In addition, data was analyzed using SPSS and Microsoft Excel. Furthermore, in the analysis and discussion of the data, verbatim responses from the respondents were used. The comments or responses to open-ended questionnaires were transcribed and/ or quoted to provide more insight to the respondent's views on the current state and management of e-waste in Kigali.

3.4 Limitations of the study

One of the barriers in this study was to obtain information and available literature that could provide secondary data on the level of e-waste generation and disposition, as well as the extent of environmental and health contamination in Kigali, Rwanda. This type of information was limited and highlights the importance of conducting research in this area, as this study does.

In addition, the methodology used to collect data appears to have limits. In this regard, the respondents did not respond to their questionnaires within the requested timeframe, as such

delaying the whole study. Furthermore, some respondents who were contacted before undertaking data collection withdrew during the course of the research, indicating that they were unable to participate.

3.5 Conclusion

To reach the objectives outlined as well as to provide the responses to the questions posed at the beginning of the research, an appropriate research methodology was adopted. In this chapter the methodology was explained. The chapter described the background to the study by looking at socio-economic aspects as well as environmental profile. In addition, the chapter has explained that research was used with regard to a quantitative approach where the survey method was adopted through a self-completion questionnaire. Furthermore, the approach used to recruit respondents was described where a purposive non-probability sampling method was used to guide the selection of the sample. Moreover, the chapter described reasons for using secondary data through document analysis. The limitations of the study were also discussed. Lastly, the data analysis process that the research employed was explained.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 Introduction

The aim of this chapter is to present and describe the survey results. After analyzing the collected data, the results of this study are also discussed in this chapter. The results are thematically presented in five sections, in accordance with the objectives of this research. These relate to: the awareness amongst environmental regulators on e-waste, e-waste generation in Kigali, the e-waste legal framework and management practices in Kigali, the challenges faced in e-waste management as well as precautionary measures to prevent e-waste pollution within the city. The results are shown in frequencies and percentages which are presented in tables and/ or figures. In addition, the discussion of survey results is based on an analysis of obtained results and its comparison with other survey findings of different authors and researchers.

4.2 Respondents in the study

The targeted sample of this study was 32 regulators from various environmental sectors. Twenty eight respondents participated in the survey while four declined to participate. The latter included all targeted environmental officers from the RURA. Of the total number of respondents from the various sectors, the REMA (43%) constituted the largest portion of the responses; followed by the RDB (28%). The RBS and District environmental officers each constituted 11% of the responses while the KCC constituted 7% of responses (Figure 4.1).

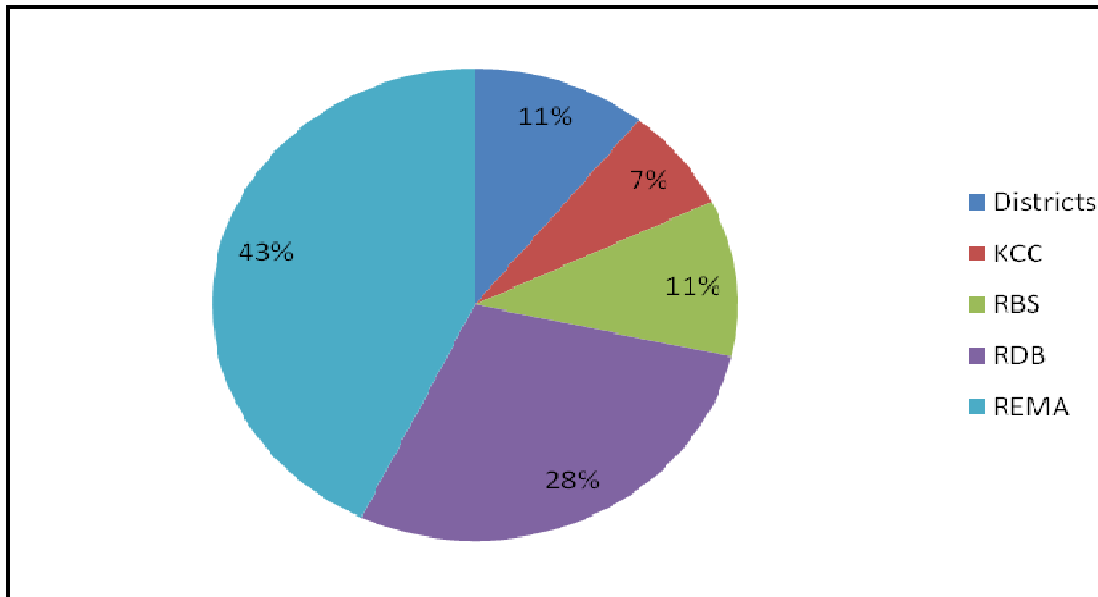


Figure 4. 1 Percentage of Environmental Regulators per sector (n=28, % responses)

4.3 Awareness amongst environmental regulators of e-waste in Kigali

This study aimed at assessing the awareness amongst environmental regulators on e-waste problems in Kigali. In this regard, a range of questions were asked regarding various aspects of e-waste such as the hazardous nature of e-waste, general types of EEE that fall under e-waste, and e-waste management practices. The findings are presented in the following section.

4.3.1 Awareness on the hazards of e-waste

Table 4. 1 Knowledge of hazardousness of chemicals contained in EEE (multiple responses)

| | Frequency (n=28) | Percentage (%) |
|---------|---------------------|-------------------|
| Lead | 25 | 89.3 |
| Mercury | 14 | 50 |
| Cadmium | 14 | 50 |
| CFC | 28 | 100 |
| Plastic | 9 | 32.1 |

Table 4.1 indicates that 89% of the respondents were able to identify lead as the heavy metal that constitutes a hazard to the environment while 50% of the respondents revealed the awareness of mercury as a hazard element and 50% of the respondents appeared to be aware of cadmium as hazardous chemical. In addition, all respondents recognized CFC (chlorofluorocarbon) as hazardous to the environment. Furthermore, 31% of the respondents recognized plastics as a threat to the environment.

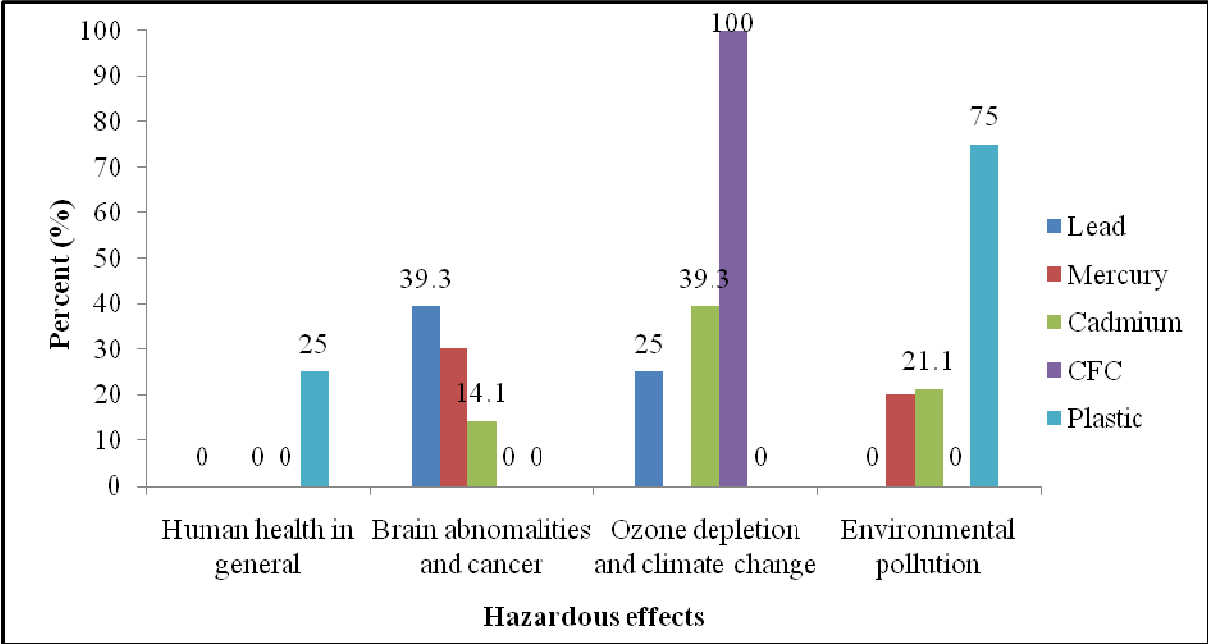


Figure 4. 2: Awareness of the effects of heavy metals on the environment and/ or human health (n=28): multiple responses

When asked what the effects of the aforementioned elements were on the environment and/ or to the human health, four general categories of effects were identified by respondents, as illustrated in Figure 4.2. More than 35% of the respondents linked lead hazard to human health including causing brain abnormalities and cancer as well as to environmental pollution. Thirty percent of the respondents indicated mercury as being responsible for various forms of cancers. In addition, 14% of the respondents recognized the hazard of cadmium and related it to brain abnormalities and various forms of cancer while more than 20% of the respondents considered cadmium as one of ozone-depleting substances. In addition, 75% of the respondents considered plastic as a source of environmental pollution without specifying effects. Pinto (2008: 67) indicates that plastics contained in e-waste when burned in open air emit hazard chemicals such

as furan and dioxin that cause severe health problem such as malformations of the foetus and impairment of the immune system. Thus plastics are not only source of environmental pollution but also hazardous to human health. According to these findings, it appears that **less than 50% of environmental regulators** are aware of the hazardous effects of heavy metals contained in e-waste on the environment and human health.

The findings regarding the level of awareness towards the hazardous effects of heavy metals contained in e-waste correspond with observations made by Osibanjo and Nnorom (2007: 498), who state that “there is lack of awareness in government and public circles of the potential hazards of the present WEEE in the developing countries to human health and the environment”. In the same light, the GoR’s (2006b: 45) findings pertaining to an assessment of the level of awareness on Persistent Organic Pollutants (POPs) reveals that only a few informed actors are aware of the seriousness of their harmful effects on health and the environment while many high ranking decision-makers, public servants and the public in general are unaware of almost all the adverse effects of POPs. Although, this is specifically related to POPs, it provides, to an extent, the level of awareness with regard to hazardous chemical and hazardous waste amongst environmental regulators.

Schleup (2009: 1), on the other hand, contends that the problem of e-waste in Africa is relatively new recent, and related environmental and health problems that are still minimal have come to the awareness of the general public very recently. Thus, a very limited portion of the public, such as a few academics, researchers and/ or decision-makers is aware of the nature of e-waste hazards (Schleup, 2009: 1). A survey on e-waste management at the National University of Rwanda found that only a minority of the university community including students, lecturers and staff have a good understanding of e-waste and its implications (Utkucan *et al.*, 2010: 35). The majority were aware of e-waste but were not aware of the hazardous nature of e-waste.

In contrast to these observations, all respondents appeared to be aware of the hazardous nature of CFCs, which were attributed to ozone depletion and as having an impact on current climate change scenarios. According to Smith *et al.* (2001: 5), CFCs constitute the largest man-made source of ozone depleting substances (ODS). In addition, CFCs are greenhouse gases with high global warming potential compared to other GHGs such as CO₂ (Zhao *et al.*, 2011: 555).

According to Zhao *et al.* (2011: 555), although various measures are being implemented across the world to phase out CFC sources, CFC emissions are expected to increase in developing countries due to the long lifespan of CFCs contained in refrigerators and other cooling systems. In addition, the DanWatch (2008: 2) indicates that most of the used EEE imported are outdated products that might also include banned CFC containing equipment such as refrigerators. Thus the knowledge of CFCs, from an environmental regulator point of view, is necessary to strengthen the implementation of a CFC phase-out plan.

Table 4. 2 Level of awareness on type/s of e-waste (multiple responses)

| | Frequency (n=28) | Percentage (%) |
|----------------------------|---------------------|-------------------|
| Computer | 28 | 100 |
| Radio | 13 | 46.4 |
| TV set | 26 | 92.9 |
| Batteries (Alkaline, lead) | 11 | 39.3 |
| Fridge | 15 | 53.6 |
| Toys | 13 | 46.4 |
| DVD player | 20 | 71.4 |

When asked what electrical or electric items fall under e-waste; most of the respondents recognized computers (100%), TV sets (92.9%), DVD players (71.4%) and fridges (53.6%) as sources of e-waste while less than the half of the respondents considered toys (46.4%), radios (46.4%) and batteries (39.3%) to be part of e-waste (Table 4.2). These findings are consistent with that of Sinha-Khetriwal *et al.* (2009: 154) who observed in their study related to the adoption of extended responsibility in developing countries, that the majority of people often misunderstood e-waste as comprising only of computer and other IT equipment. This might, however, result in e-waste management measures that address only waste generated from IT equipment such as computer and TV sets while neglecting other e-waste sources, mainly electrical appliances.

A cross tabulation (Figure 4.3) to assess whether the knowledge of electrical and electronic items fall under e-waste was related to the knowledge of the hazardous chemicals contained in those EEE revealed that more respondents considered computers, TV sets, batteries and fridges as the main items containing hazardous heavy metals. The findings represent mixed perceptions of the hazardousness of e-waste. For instance, although only 53.3% of the respondents considered fridges as comprising e-waste, all respondents pointed out that fridges contain hazardous chemicals mainly CFC. In addition, while 71% of the respondents considered DVD players and 92.9% of the respondents considered TV sets as part of e-waste, only 50% of the respondents believed that DVD players and TV sets contain hazardous chemicals. On the other hand, of those who indicated computers to be part of e-waste, 85.7% were aware that computers contain hazardous elements.

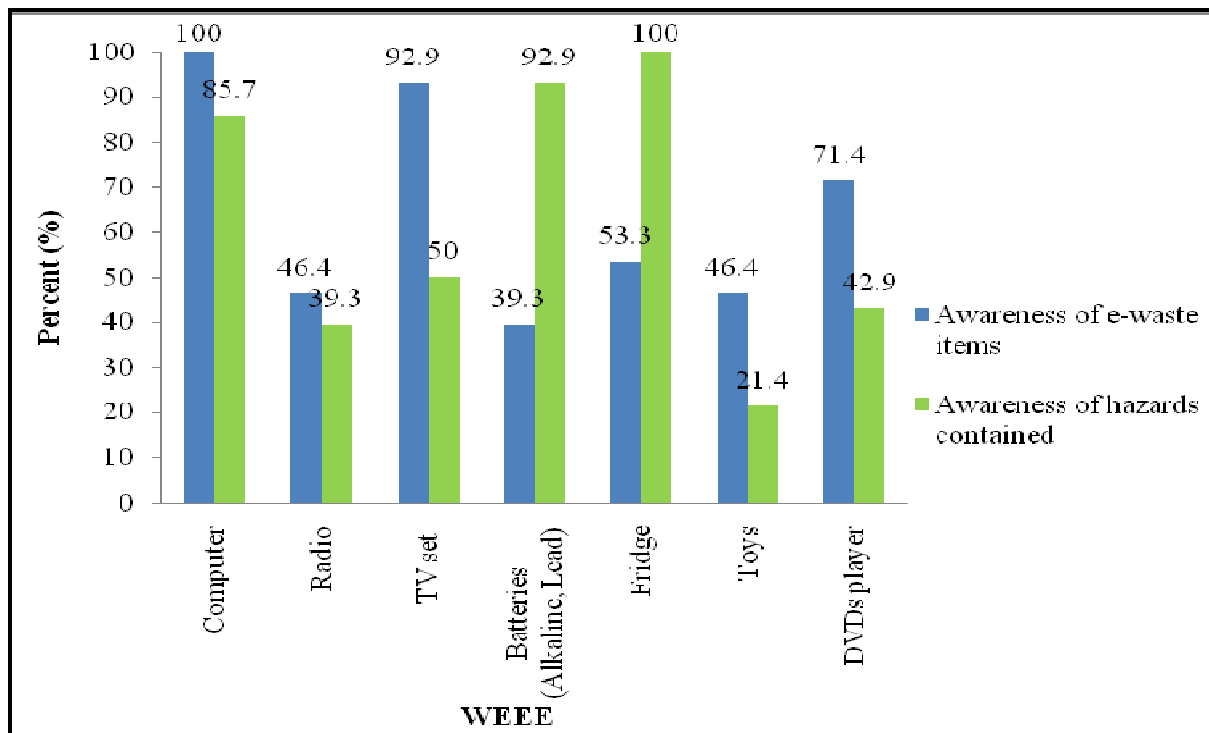


Figure 4. 3 Level of awareness of the presence of hazardous chemicals in EEE (n=28)

A high level of awareness of the presence of CFCs in fridges was expected from respondents. Since 2008, after banning the CFC containing equipment, the GoR initiated different programs mainly through the media to raise awareness amongst the population about the hazardous nature of CFC and emphasis was put on fridges. One respondent stated that “one way to implement the

international protocol concerning Ozone Depletion Substances (ODSs) has led the GoR to put in place regulations on the importation of equipment containing CFCs in the country. To enforce this measure, several people including custom officers from the Rwanda Revenue Authority, police officers, refrigerator repairers and environmental officers have benefited from several training programs on how to test, track and eliminate CFC gases in the imported refrigeration material”.

4.3.2 Awareness of e-waste management practices

In addition to the awareness of the management of CFC contained in fridges, Table 4.3 indicates that 96.6% of the respondents were aware of electronic re-use practices in e-waste management. On the other hand, a large portion of the respondents revealed that they were not aware of other e-waste management practices. In this regard, 71% of the respondents were unaware of the recycling option, while 53.6% were unaware of take-back to producer practices and 60.7% of the respondents were unaware of environmentally sound disposal of e-waste. Although a further option included in the questionnaire (Appendix I), was strongly unaware, none of the respondents were strongly unaware of e-waste management practices.

Table 4. 3 Awareness of e-waste management practices (multiple response) in % (n=28)

| | Strongly aware | Aware | Unaware |
|-----------------------|----------------|-------|---------|
| Re-use | 50 | 46.4 | 3.6 |
| Recycle | 3.6 | 25 | 71 |
| Take-back to producer | 7.1 | 39.3 | 53.6 |
| Disposal | 17.9 | 21.4 | 60.7 |

The lack of awareness amongst environmental regulators on e-waste management in Kigali draws similarities with waste management literacy in other parts of the world. For example, the UNEP (Bushehri, 2009: 6) reports, in a study on e-waste management in Arabian countries, that one of the significant constraints that the majority of countries are facing in e-waste

management includes the lack of knowledge and information on e-waste management practices amongst environmental regulators and amongst decision-makers. Chung and Lo (2008: 276) also observed in a survey on technological capacity and waste management literacy amongst environmental administrators in Asia that generally in developing countries waste management literacy remains very low. Chung and Lo (2008: 276) further portray that, for instance, when asked about the waste management hierarchy, the majority of the environmental administrators admitted to be unaware of it.

Ogawa (1996: 3) argues that most of developing countries lack human resources, especially in relation to technical expertise necessary for waste management planning and operation at both national and decentralized levels. This is attributed to the lack of training on waste management practices amongst environmental regulators, particularly those in charge of solid waste management at decentralized levels (Ogawa, 1996: 3). The lack of technical capacity in waste management results in the absence of adequate waste management systems; inadequate planning, enforcement and/ or implementation of adopted measures as well as the lack of monitoring of waste management practices taking place within the country (Buenrostro and Bocco, 2003: 258-259; Manga *et al.*, 2009: 559).

Table 4. 4 Attendance of training and/ or workshops on e-waste management

| | Frequency (n=28) | Percent (%) |
|-----|---------------------|----------------|
| Yes | 4 | 14.3 |
| No | 24 | 85.7 |

When respondents were asked whether they attended any workshop or training specifically related to e-waste management, 85.7% of the respondents revealed that they had not attended any (Table 4.4). In contrast, 14.3% of the respondents indicated to have attended a workshop on e-waste. When asked what the workshop was intended for, all respondents revealed that the workshop was aimed at how the country can set policy, law and standards for e-waste

management. This indicates that although the majority of environmental regulators revealed a limited knowledge toward e-waste, the problem of e-waste is not completely unknown amongst decision-makers as well as environmental regulators in Rwanda. Habumuremyi (2010: 2) reveals that the RURA is establishing a unit/ department that will be in charge of creating awareness on e-waste, promoting e-waste management and setting up a regulatory framework for e-waste management. Habumuremyi (2010: 3), however, portrays that the service is very new and most of its actions so far are at the stage of planning and human capacity building as well as drafting an e-waste policy.

4.4 E-waste generation in Kigali

In this section, the findings on the respondents’ perceptions of the extent of the e-waste problem in Kigali and the potential sources of e-waste as well as items that are commonly discarded in Kigali are presented. In addition, the perceptions of the respondents toward waste management in the country are described with regard to the legal and institutional framework.

4.4.1 Perception of e-waste problem in Kigali

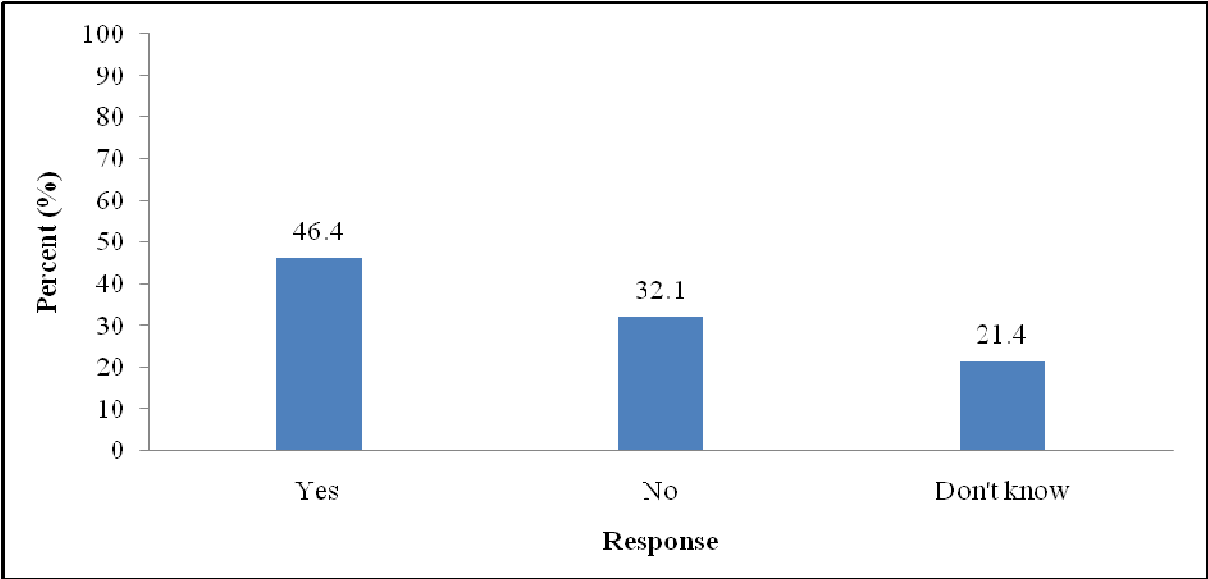


Figure 4. 4 Perception of e-waste problem in Kigali (n=28)

Figure 4.4 indicates that 32.1% of the respondents perceived that e-waste was not an environmental problem in Kigali while 21.4% of the respondents did not know the extent of the

e-waste problem within Kigali. All respondents, who replied that e-waste is not an environmental problem in Kigali indicated that it is very difficult to confirm whether e-waste is really an environmental problem in Kigali as to date there is no survey that has been conducted on e-waste in the country. According to Allam and Inauen (2009: 3), the problem of e-waste in developing countries is based on the fact that many countries do not know the real extent of e-waste stock either imported or generated domestically, consequently a ‘no news is good news’ situation is the one that is likely to be applied.

The respondents, who replied that e-waste is not an environmental problem, further stated that although there is a potential future e-waste threat, currently the impact is not visible as very little is being disposed of as independent of domestic waste. This opinion is shared by Mataheroe (2009: 76) and Wasswa and Schleup (2008: 32) in e-waste surveys conducted in Tanzania and Uganda, respectively, who reported that the scale of the problem of e-waste in both countries is still relatively small. Wasswa and Schleup (2008: 32) explain that “the total amount of installed electronics is still very low and subsequently, the problem of adverse impacts of e-waste generation is currently low. In addition, the problem of imported computer junk seems to be minor as most of imported second-hand computers seem to be functioning”. However, one should be concerned in cases where environmental regulators view e-waste to be a problem only when it starts to contaminate the environment and human health.

Further, as illustrated in Table 4.5, all respondents who had disagreed that e-waste is currently an environmental problem in Kigali, strongly agreed that the potential factors which could contribute to e-waste becoming a future environmental problem in Rwanda include the donation and importation of old and cheaper electrical and electronic secondhand equipment from developed countries. In addition, 44.4% of the respondents strongly believed that the lack of laws and regulation regarding e-waste in the country constitutes a significant factor that also contributes to the rise in e-waste.

Table 4. 5 Potential factors that contribute to e-waste growth (multiple response) in % (n=9)

| Factors promoting e-waste in Kigali | Strongly agree | Agree | Disagree | Strongly disagree |
|---|----------------|-------|----------|-------------------|
| Importation of cheaper EEE secondhand equipment | 100 | 0 | 0 | 0 |
| Donation of old electronic equipment from developed countries | 100 | 0 | 0 | 0 |
| Rapid growth of ICT in country | 0 | 22.2 | 77.8 | 0 |
| Free tax on ICT equipment imported to attract investors | 11.1 | 0 | 88.9 | 0 |
| Lack of laws and regulations regarding e-waste | 44.4 | 0 | 0 | 55.6 |

Rwanda is not exempted from the import of secondhand or refurbished EEE that might be imported without conformity testing for their functionality (Nnorom and Osibanjo, 2008b: 1473; Osibanjo and Nnorom, 2007: 492). One respondent for instance states that “a considerable quantity of secondhand electronics is being imported in the country as donations and cheap electronics. I have held that sometimes, these computers do not work more than two years. In addition, recently the RBS has found a container from China full of very old computers, meaning that the export might have occurred in the past without the knowledge of the environmental authority”. In this regard, Habumuremyi (2010: 2) affirms that there are, in fact, increasing numbers of various Chinese companies in Kigali that are importing very cheap used computers into the country.

It appears that in Kigali, in addition to the computers brought by NGOs from developed countries, there is a transboundary movement of e-waste from developing countries that is taking place. This affirms Shinkuma and Huong’s (2009: 27) observation that a significant quantity of electrical and electronic secondhand equipment being imported in China is rebuilt and then re-exported to other developing countries mainly in lower income countries of Asia and Africa.

Table 4.5 indicates that a significant proportion of the respondents do not consider the following criteria as contributing to e-waste management problems in Kigali: the rapid growth of ICT (77.8%), discharge of tax on ICT equipment to attract investors (88.9%) and the lack of e-waste legislation (55.6%). These perceptions are inconsistent with the literature on e-waste (Osibanjo and Nnorom, 2007; Puckett *et al.*, 2005; Schwarzer *et al.*, 2005) which highlight the rapid growth of ICT sector, discharge of tax on ICT equipment as well as the lack of legislation framework constitute potential factors that worsen the problem of e-waste in developing countries. In this regard, the rapid growth and free tax on ICT equipment in many countries has contributed to the increase of electronic equipment and the focus of various countries has been more on economic development with emphasis on the ICT sector without taking into consideration its effect on the environment.

Although the environment has been declared as a cross cutting issue that must be taken into consideration by all sectors of development in Rwanda; the Rwanda ICT policy, at the present, does not make provision for the consideration of the impacts of ICT equipment and activities on the environment and human health. In addition, by law, any development project and/ or policy in Rwanda is subjected to EIA. However, according to Munyazikwiye (2010: 81), the ICT-related projects are amongst those least subjected to EIA though the sector is considered to be one of the development sectors that have expanded enormously in recent years in Rwanda. In addition, the SEA that constitutes an important tool which can assist to address the environmental issues at the policy formulation and planning level is not conducted in Rwanda (Munyazikwiye, 2010: 93). One cannot, however, ignore that environmental management authorities such as the REMA, RBS and RDB are young institutions confronted with the rapid pace of development, coupled with inherited environmental problems related to overpopulation, pressure on natural resources, post-genocide reconstruction and so forth. The context of environmental management in Rwanda is therefore complex.

On the other hand, the ICT policy in Rwanda advocates for the use of ICT tools such as Geographical Information System (GIS) and remote sensing technologies in planning and decision-making processes for more protection and management of the environment. However,

the environmental consequences of using these tools in relation to e-waste management, is not considered.

Figure 4.4 indicates that 46.4% of all respondents agreed that e-waste constitutes an environmental problem in Kigali. When asked what the main source of e-waste in Kigali was, 79.5% of the respondents indicated import of electrical and electronic secondhand equipment as the main source of e-waste (Table 4.6). In addition, the majority of respondents revealed that a significant stock of e-waste is discarded by business/ offices/ government institutions (76.7%) and educational institutions (universities and schools) (84.6%). In contrast, only 33.8% of the respondents considered the household to be a major source of e-waste in Kigali. Similar results were observed in an assessment of the state of e-waste in Uganda where reports indicated that more than 90% of discarded IT equipment are mainly discarded by government, educational institution, NGOs and businesses while the private households were perceived as the least significant generators of IT equipment waste (Wasswa and Schlupe, 2008: 32).

Table 4. 6 Sources of e-waste in Kigali (multiple responses) in % (n=13)

| Source of e-waste | Strongly agree | Agree | Disagree | Strongly disagree |
|--|----------------|-------|----------|-------------------|
| Imported e-waste | 15.4 | 61.5 | 23.1 | 0 |
| E-waste generated by Business offices/ Government institutions | 46.2 | 30.7 | 23.1 | 0 |
| E-waste generated by School/Universities | 46.2 | 38.4 | 15.4 | 0 |
| Local e-waste generated by household | 20.8 | 13 | 48.5 | 17.7 |

According to Kahhat and Williams (2010: 504), compared to developed countries such as the USA and EU countries where one or more IT equipment per household member may be the norm; in developing countries IT equipment such as computers remains a privilege for high income households. Kahhat and William (2010: 502-503 report that a survey on computer

ownership in Peru revealed that although computer ownership in Lima’s residential sector remains low, the high and upper middle class was found to have a higher computer ownership compared to other Lima’s inhabitants. Similar, with only 0.89% of the households possessing a personal computer in Kigali, high income households were the ones with greater possibility to acquire a computer or other expensive IT equipment (NISR, 2008: 9). Nevertheless, the large stocks of obsolete electronic equipment being held by institutions and offices present an opportunity for easier control over generated e-waste mainly for a young e-waste management system.

Table 4. 7 Items commonly discarded and source (multiple responses) in % (n=13)

| Discarded items | Source | | | |
|---|----------|-------------------------|-----------------------|-----------|
| | Business | Government institutions | Learning institutions | Household |
| IT equipment (e.g. computer, switcher, telephones) | 100 | 100 | 100 | 0 |
| Consumer electronics (e.g. TVs, DVD players and other entertainment electronic) | 100 | 0 | 0 | 75 |
| Home appliances (e.g. fridge, ovens, telephones, microwave) | 100 | 0 | 100 | 75 |
| Batteries | 0 | 0 | 0 | 100 |
| Toys | 0 | 0 | 0 | 100 |

With regard to commonly discarded items, all respondents revealed that IT equipment that are generally used in institutions were the ones generally discarded (Table 4.7). Furthermore, all respondents considered businesses such as restaurants, hotels and hospitals to be the source of electrical appliances mainly fridges, ovens and so forth. In contrast, 75% of the respondents considered the household to be a source of other electrical and electronic products such as home appliances, consumer electronics, batteries and toys. With the majority of cellular phone owners being located in Kigali, the household constitutes the main source of obsolete cellular phones as

well as their components in Kigali. In addition, the NISR (2008: 9) indicates that more than 90% of households in Kigali can afford a TV set thus households constitute a potential source of obsolete TV sets within the city in the future.

Table 4. 8 Portion of Kigali inhabitants affected by e-waste (multiple responses) in% (n=13)

| People affected by e-waste | Strongly agree | Agree | Disagree | Strongly disagree |
|--|----------------|-------|----------|-------------------|
| Vulnerable people searching for food in dump sites | 69.2 | 7.7 | 7.7 | 15.4 |
| Informal recycler | 0 | 30.8 | 69.2 | 0 |
| People who work in municipal landfills | 69.2 | 7.7 | 7.7 | 15.4 |
| People living in neighborhood of dumpsite | 0 | 7.7 | 0 | 92.3 |

When asked who amongst the city inhabitants is likely to be affected by e-waste, 69.2% of the respondents strongly agreed and 7.7% agreed that vulnerable people scavenging for food in a dumpsites as well as people who work in municipal landfills are the ones that are likely to be affected by e-waste in Kigali (Table 4.8). The Nyanza dumpsite in Kigali is regularly visited by a large number of people who depend on waste scavenging for their livelihood.

As revealed in the literature review, Sepúlveda *et al.* (2010: 36) state that the chemicals contained in e-waste can leach into groundwater or be released in fumes and ashes when the waste is burned. According to the UNDP and GoR (2008: 25), the Nyanza dumpsite in Kigali is frequently burnt by waste scavengers, hence, various people who go to the dumpsite such as landfill workers and scavengers are likely to be exposed and/ or affected by hazardous substances released from e-waste disposed of with other waste. Writers (2007: 1) reports that in Nairobi, scavengers as well as children living near dumpsites have started to manifest a high level of hazardous chemicals contained in e-waste in their blood. It is believed that these chemicals are a direct result of e-waste contamination (Writers, 2007: 1).

On the other hand, 69.2% of the respondents felt that informal recyclers within the city are not affected by e-waste. In addition, 92.3% of the respondents disagreed with the assertions that e-waste affects people living in the neighborhood of dumpsites (Table 4.8). Only 30.8% of the respondents felt that people who are engaged in informal recycling activities within the city are affected by e-waste. In addition, 7.7% of respondent believed that people living in the neighborhood of dumpsites might be affected by e-waste. For Magashi and Schluep (2011: 31), most informal EEE processing is carried out by electronic repairers within their shops who are exposed to hazards when searching for working components. In addition, the quantity of obsolete EEE obtained and processed by informal recyclers remains very low. Wasswa and Schleup (2008: 25) indicate that “in Uganda for example, there are no communities that are directly affected by e-waste and few who might get exposed to toxic substances are informal collectors and dismantlers during the dismantling and sorting process”.

Eugster and Fu (2004: 22) observe that in contrast to crude material recovery activities; collection, disposal and disassembly of discarded EEE do not pose significant harm to human health. However, Ewasteguide (2010) and the E-waste Association of South Africa (EWASA) (2010) stress that there is lack of data with regard to the time-lag between exposure and reaction to the hazardous chemicals emanating from e-waste recycling activities. Thus, e-waste being a new type of waste in Kigali as in other African countries, could signify that the signs and symptoms of contamination may not yet be realized or diagnosed.

4.5 Legal framework for solid waste management in Rwanda

According to 89.3% of the respondents, the country in general has a legal framework for waste management (Table 4.9). A small percentage (3.6%) of the respondents said the country does not have any legal framework for waste management and 7.1% of the respondents were unaware if the country has a legal framework on waste management (including environmental analysts from the RDB and environmental officer from the RBS).

Table 4. 9 Awareness of legal frameworks on solid waste

| | Frequency (n=28) | Percent (%) |
|------------|---------------------|----------------|
| Yes | 25 | 89.3 |
| No | 1 | 3.6 |
| Don't know | 2 | 7.1 |

These results on the awareness of a legal framework are not surprising since as noted in the literature review the city council and all districts have released directives that prohibit the city inhabitants from discharging any type of waste in public areas (Sano, 2007: 65). Thus, the majority of Kigali inhabitants has subscribed for waste collection from their houses. However, the directives do not provide any framework for other waste or for later stages in waste management such as disposal and recycling processes.

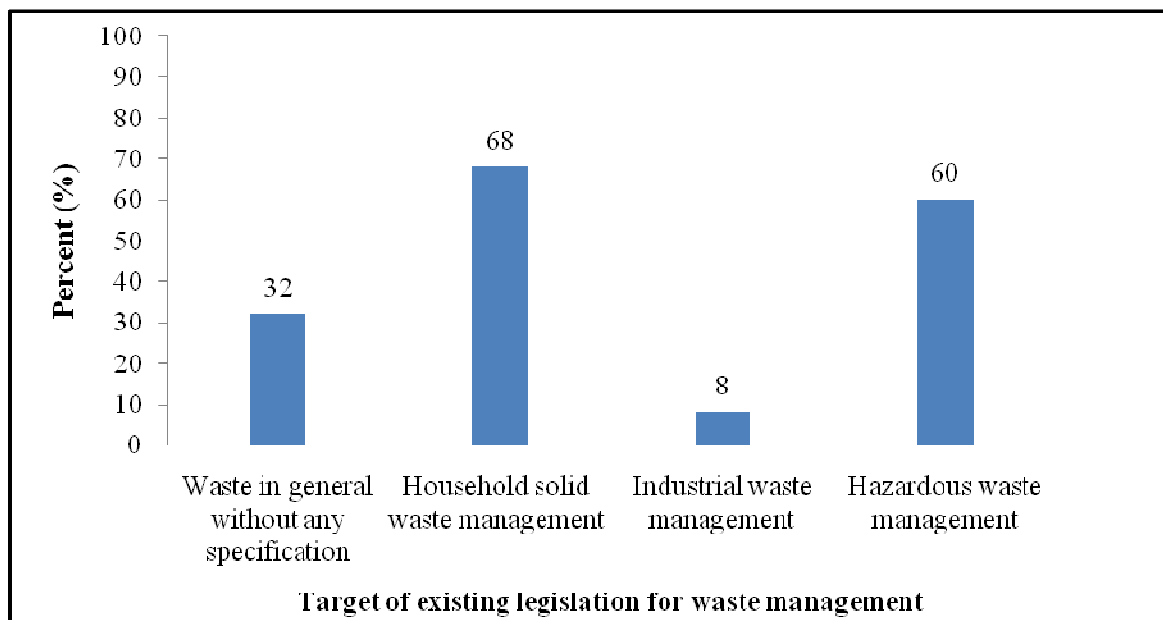


Figure 4. 5 Target of current legislation for waste management (n=25): multiple responses

When asked what type of waste fall under the current legal framework for waste management, 32% of respondents pointed out that the existing legislation for waste management governs wastes in general without any specification (Figure 4.5). Sixty eight percent of the respondents

felt that the legislation addresses household waste management while 60% of the respondents believed that the current regulatory framework also deals with hazardous waste. Only 8% of the respondents indicated industrial waste management.

Regarding the scope of existing regulatory framework for waste management, 89.3% of the respondents revealed that the existing legislation for waste management aims at collection and disposal of household waste while 70% of the respondents indicated that the country also has an established legal framework that considers the control and ban of toxic products as well as control of transboundary movement of hazardous waste (Figure 4.6).

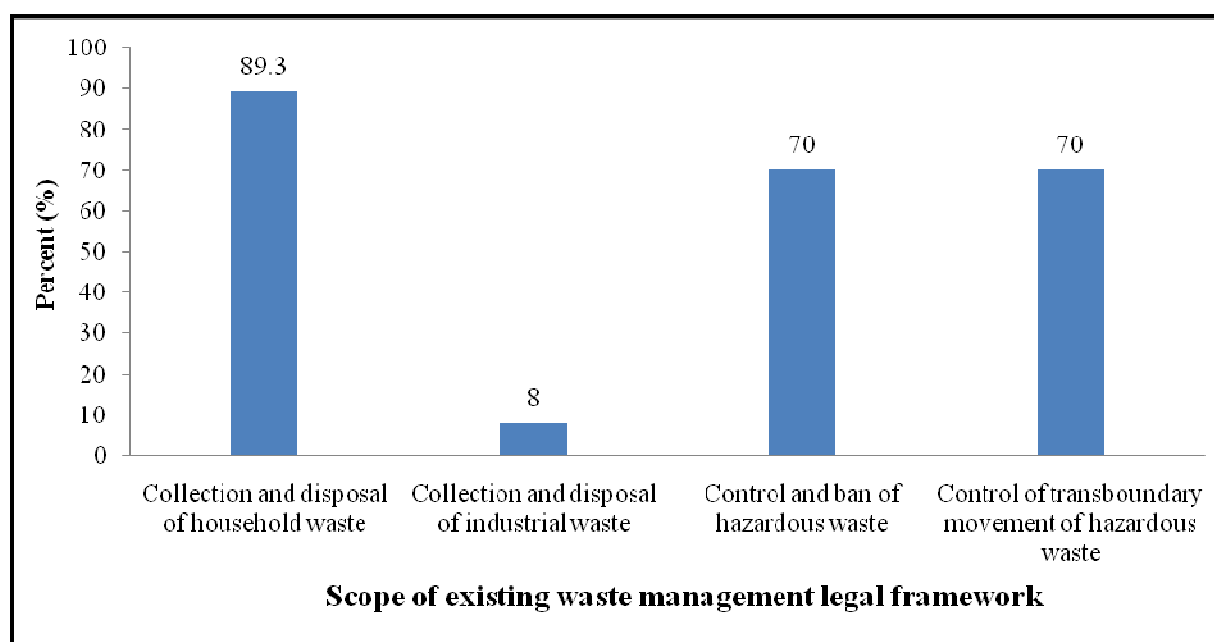


Figure 4. 6 Scope of current legal framework for waste management (n=25)

The above results regarding the control and ban of hazardous toxic waste was not surprising, as since 2006, the GoR has banned non-recycled plastics bags, CFC containing products and other ODS products into the country as well as POPs such as pesticides (GoR, 2008a; 2008b). Hence, the majority of the respondents indicated that the current waste legislations address the movement of toxic products. In addition, the organic law for environmental protection (GoR, 2005) prohibits any dumping, disposal or keeping hazardous waste that may encourage the breeding of diseases and which may harm people and the environment. Similarly, directives on

hazardous substances do not address other activities relating to their transport, deposit, storage and disposal.

In addition, the majority of the respondents perceived that the existing legal framework for solid waste does not address the management of industrial waste. WaterAid (2008: 3) explains that, as observed in Nepal, most of the directives or regulations toward solid waste management established by municipalities are aimed at cleaning streets and collecting waste from households without addressing other types of waste or other aspects of waste management such as waste disposal, separation and treatment. Boyle (2000: 522), however, argues that the focus of local government is also determined by the national government overview as the national policy gives the incentive for local government to adopt a certain approach to waste management and sanitation in general. As revealed by the UNDP and GoR (2008: 10), the GoR has not yet established a solid waste management policy or any regulatory framework to support decentralized solid waste management.

4.6 Institutional framework for solid waste management

Table 4. 10 Stakeholders in solid waste management in Kigali (multiple responses) in % (n=28)

| Stakeholders in solid waste management in Kigali | Yes | No |
|--|-----|----|
| Local authority | 100 | 0 |
| Government institutions | 43 | 57 |
| Public | 88 | 12 |
| Private sector | 65 | 35 |
| NGOs | 89 | 21 |

All respondents noted that amongst the current institutions engaged in environmental protection, the main institution responsible for solid waste management in Kigali is the local authority (Table 4.10). This was expected since the National Decentralization Policy and Environmental

Organic Law stipulate that the decentralization entities, namely the districts and sectors, are responsible to determine the modality of waste management under their jurisdiction, to set up pollution control mechanisms, and to warn competent authorities in case of breach of environment related regulations and disasters that constitute a threat to the environment. In addition, Sano (2007: 45) states that waste management decentralization was accompanied by fiscal decentralization, thus the funds which used to be provided by the government to the city council for sanitation infrastructure development are now given to district councils.

In this regard, Henry *et al.* (2006: 96) observed, in their study on municipal solid waste management in Nairobi, that the local authorities are often faced with financial difficulties as the available budget is spent on other areas such as the payment of wages and day-to-day running expenses of the districts. Thus, most decentralized authorities become economically constrained in the establishment of efficient management systems relating to municipal solid waste (Henry *et al.*, 2006: 96). They further claim that these economic constraints encourage decentralized authorities in developing countries to embrace new ideas that can improve the management of solid waste, mainly by seeking partnerships with the private sector and NGOs or by financing informal collectors such as CBOs, which at the same time create jobs for the poor.

In accordance with Henry *et al.*'s argument, more than 80% of the respondents considered NGOs and the public as other main stakeholders in solid waste management in Kigali while 65% of the respondents identified the private sector as part of the main stakeholders in the current waste management system in Kigali. In this regard, Kigali is currently applauded as being one of the cleanest cities in Africa due to its well organized CBOs that have helped districts and the city to clean and collect garbage (Christensen, 2009: 19; Sano, 2007:65). In addition, various businesses (mainly cooperatives) are investing in household waste collection.

From the above findings, it appears that various stakeholders are participating in waste management as well as in the environment protection process in Kigali. From an ecological modernization point of view, to mitigate environmental pollution resulting from economic development, the environmental management shifts from centralized and closed institutions to decentralized and participatory institutions (Van Khoa, 2006: 34-36; Choy, 2007: 17-18). This

reduces bureaucracy and facilitates the participation of various stakeholders in environmental management decision-making. Van Khoa (2006: 34-36) and Choy (2007: 17-18) further argue that participatory processes can create and encourage more ownership amongst different stakeholders that can lead to voluntary actions with regard to environmental protection. This might include projects such as recycling activities carried out by CBOs and NGOs in Kigali (UNDP and GoR, 2008: 1). This not only reduces the quantity of e-waste that the districts have to deal with but also contributes to reduce deforestation.

Barry and Doran (2006:257-258) and Mol (1995 cited in Buttel, 2000: 61), however, assert that the steering capacity of the state is necessary to bring about these environmental changes and initiatives by establishing favourable conditions for the adoption of environmentally friendly practices. Included in these conditions are clear institutional frameworks for environmental management.

In this regard, 57% of the respondents felt that government institutions are not the main stakeholders in the current waste management system in Kigali (Table 4.10). In general, government as an institution includes central government and decentralized authorities or local authorities. However, responsibilities of government toward waste management refer to central government including all ministries and government agencies which have a role to play in one way or another in waste management. In the question regarding their knowledge of the existence of a government body to manage solid waste (Table 4.11), 32.1% of the respondents stated that they were aware that such an institution does exist, 39.2% of the respondents felt that there is no particular government body in charge of waste management and 30% of the respondents indicated that they were not aware of a body.

Table 4. 11 Existence of government institutions responsible for waste management

| | Frequency (n=28) | Percent (%) |
|------------|---------------------|----------------|
| Yes | 9 | 32.1 |
| No | 11 | 39.2 |
| Don't know | 8 | 28.5 |

The respondents who indicated that there is no particular government body in charge of waste management were asked who is responsible for waste management at national level, while those who agreed that such institution exists were asked to name it. Their responses were similar. More than 80% of the respondents indicated that MINELA, the REMA and RURA are responsible for waste management at the national level. The MINELA is in charge of preparing and ensuring the implementation and evaluation of policies and strategies for environmental protection and sanitation. The REMA is the environmental watchdog for the government and the RURA and as the public utility authority, are responsible for establishing standards and techniques for waste treatment within the country.

In addition, the respondents who agreed that there are institutions responsible for waste management noted that other Ministries and/ or government agencies are also responsible of waste management. These are the Ministry of Infrastructure, Ministry of Health, and RBS The Ministry of Infrastructure is in charge of providing the country with adequate infrastructure for waste disposal while the Ministry of Health is in charge of preparing policies and strategies related to the environmental health. These results were expected as currently there is no clearly defined government institution responsible of waste management. This supports the view of the REMA (2009: 25) who states that “currently, there is institutional conflict regarding responsibility for environmental health and sanitation in the country”. The REMA (2009: 25) further recommends that “laws and implementing structures have to be harmonized in a way to clarify the prevailing situation with regard to the institutional framework for waste management”.

According to Ogawa (1996: 4), this situation is common to most of developing countries where several agencies at the national level are usually involved, at least partially, in solid waste management and often with no defined mandates in relation to solid waste management and without any single agency or committee designated to coordinate their projects and activities. Ogawa (1996: 5) maintains that the lack of effective legislation for solid waste management is partially responsible for the roles of the relevant national agencies not being clearly defined as legislation related to solid waste management in many developing countries is usually fragmented and included in several policies and laws with some clauses on solid waste management regulations. This often results in the duplication of responsibilities, ineffective or the absence of overall solid waste management systems as well as loss of state financial resources. For example, different departments are allocated budgets, but have the same responsibilities and manage the same natural resource, hence the wastage of state financial resources.

4.6.1 Existence of a legal framework for e-waste management

Table 4. 12 Existence of a legal framework for e-waste management in Rwanda and Kigali

| | Frequency (n=28) | Percent (%) |
|------------|---------------------|----------------|
| Yes | 0 | 0 |
| No | 26 | 92.1 |
| Don't know | 2 | 7.1 |

Table 4.12 indicates that 92.1% of the respondents state that the country as a whole does not possess any legal framework for e-waste management. Various authors such as Dittke (2007: 1) in South Africa, Mataheroe (2009: 74) in Tanzania; Wasswa and Schluep (2008: 13) in Uganda, and the UNEP (2007: 37) reveal that legal framework for e-waste management does not exist in many developing countries but instead e-waste falls under various aspects of environmental, sanitation and health policy, regulations or standards. The current legal framework for the environment as depicted in chapter two does not address the problem of e-waste. However, if e-

waste was recognized as hazardous waste the same legal framework can address partially environmental and health hazards related to e-waste in Kigali.

Table 4. 13 Existence of regulations on secondhand EEE imports

| | Frequency (n=28) | Percent (%) |
|------------|---------------------|----------------|
| Yes | 8 | 28.6 |
| No | 17 | 60.7 |
| Don't know | 3 | 10.7 |

According to Shinkuma and Huong (2009: 26-27), although many developing countries do not possess a legal framework to manage domestically generated e-waste; some countries address the problem of imported e-waste by introducing regulations limiting their import, including the import of secondhand EEEs. When asked if there are any regulations or standards regulating secondhand EEE (Table 4.13), 28.6% of the respondents reported that such regulations exist in the country, 60% of the respondents indicated that they do not exist and 10% of the respondents were unaware of the existence of regulations on secondhand imported EEE.

Table 4. 14 Scope of existing regulations on secondhand EEE (n=8)

| Standards/regulations on secondhand electronic equipment | Yes | No | Don't know |
|--|------|----|------------|
| Limiting age of electronic second hand equipment allowed to enter Rwanda | 0 | 25 | 75 |
| Provide punitive measures for illegal import of second hand electronic equipment | 0 | 25 | 75 |
| Control on the import of secondhand electronic spare parts | 12.5 | 75 | 12.5 |
| Banning electronic secondhand equipment entering Rwanda | 100 | 0 | 0 |

Of those who agreed that the country regulates second-hand imported EEE, when asked the scope of the regulations on secondhand EEE; all respondents revealed that the existing regulatory framework bans mainly secondhand electronics (Table 4.14). Furthermore, one of the respondents who agreed that the country regulates secondhand EEE stated that “the current

The respondents who agreed that the country regulates secondhand EEE, stated that “the current regulation on second-hand equipment has come out as a public notice without any legal provision. In addition, the regulation is very recent and few people are aware of it. Furthermore, the ban concerns very old secondhand electronic equipment mainly computers”. This raises questions regarding the criteria that environmental regulators are using to determine the age of this equipment. Inconsistent or the lack of explicit criteria could present loopholes for different interpretation by the range of sectors (environmental institutions, customs officers and electronics importers) of what is permissible to enter as obsolete EEE in Rwanda. Furthermore, this situation could lead to complications in monitoring and enforcement measures.

Only 12.5% of the respondents reported that existing regulations also regulate the import of secondhand electronic spare parts (Table 4.14). E-waste can also be imported as spare parts for the electronic industry. Due to the lack of control in most developing countries some imported spare parts are at the end of their life; thus entering directly into the waste stream instead of being re-used in the electronic industries (Chi *et al.*, 2010: 7). Kigali is experiencing an increase in electronic repair shops. In addition, the country is promoting the local electronic industry. However, the already established electronic enterprises remain at the stage of assembling of imported materials, thus the **import of old and unused electronic spare parts** might also occur in Kigali if there is any control for EEE entering the country.

With regard to the control of secondhand EEE entering the country, 87.5% of the respondents felt that the existing regulation banning their entry is ineffectively implemented. Reasons for this include the lack of daily monitoring and the lack of adequate material and knowledge amongst institutions, including customer services, to determine the usability of imported secondhand EEE.

Table 4. 15 International conventions applicable to e-waste management (in %) (n=27)

| International Conventions | Yes | No | Don't know |
|---------------------------|------|-----|------------|
| Kyoto Protocol | 22.2 | 0 | 77.8 |
| Montreal Convention | 7.4 | 7.4 | 85.2 |
| Bamako Convention | 63 | 0 | 37 |
| Basel Convention | 82.1 | 0 | 17.9 |
| Stockholm Convention | 14.3 | 3.6 | 82.1 |

According to the GoR (2005: 6), Rwanda is signatory to various conventions including Basel, Stockholm, Montreal and Bamako Convention that address issues related to environmental pollution including hazardous waste. Respondents were asked which of these conventions impact on e-waste management. The results in Table 4.15, reveal that the majority of respondents felt that the Bamako Convention (63%) and Basel Convention (82.1%) are applicable to the management of e-waste while the Kyoto Protocol (22.2%) and Stockholm Convention (14.3%) appear to have less of an impact. Although results thus far indicate a limited awareness of domestic e-waste management, the results indicate a strong awareness of international concern for e-waste management, particularly with regard to the Basel Convention. This is seen as a positive step toward translating guiding international policy on e-waste management (the Basel Convention), into domestic and local e-waste management legislation in the future.

Table 4. 16 Implementation of multilateral environmental agreements in Rwanda

| | Frequency (n=28) | Percent (%) |
|--------------------|---------------------|----------------|
| Strongly effective | 1 | 3.7 |
| Effective | 9 | 33.3 |
| Ineffective | 17 | 63 |

When asked how effectively these international conventions are implemented in the country, 63% of the respondents believed that the conventions are ineffectively implemented while 47% of the respondents agreed that these international conventions are effectively implemented within the country (Table 4.16). The majority of the respondents who agreed that these abovementioned international conventions are effectively implemented in the country, give two main reasons: that international conventions have their focal points (a party responsible for receiving and submitting information with regard to the convention implementation) in the country to follow their implementation; and that all policies and laws with regard to the environment are legislated, taking into consideration these multilateral environmental agreements that Rwanda is signatory to. The findings concur with the findings made by Rummel-Bulska (1998: 426), who states that many developing countries have adopted the Basel Convention's provisions into their national legislation, delineating the focal points to be executed by the relevant competent authority.

Rummel-Bulska (1998: 427), however, indicates that the majority of the Parties to the Basel Convention, mainly developing countries, have not as yet set up the necessary administrative instructions and procedures for the designated authorities; and many of these designated authorities face various impediments in their operation that include for instance lack of staff and expertise, lack of awareness and sufficient resources. Thus, the transboundary movements and environmentally unsound management of hazardous waste continue to take place. Similarly, the majority of those who felt that conventions are ineffectively implemented also argued that secondhand EEE continue to enter the countries with limited control and without any planning for their end-of-life treatment.

On the other hand, Kyoto Protocol, Montreal and Stockholm Convention have received more attention from the government and actions have been taken in this regard. These include the national implementation plan for Stockholm the convention (GoR, 2006b), measures and strategies to reduce green house gas emissions (GoR, 2005: 43-52), banning of CFC containing products, plastic bags and hazard pesticides such as DDT (Dichloro Diphenyl Trichloroethane). Since these conventions address issues such as disturbance of climate system, soil filtration, crop contamination and so forth, they impact directly on natural resources and therefore the

agricultural sector. With an economy that still depends heavily on agriculture, the current measures toward environmental protection seems to be more in accordance with these conventions than to those related to transboundary movement of hazardous waste, which is usually relegated to addressing the “end-of-pipe” pollution problems in most developing countries (Darby and Obara, 2005: 19).

4.6.2 End-of-life treatment for obsolete EEE in Kigali

According to 92.9% of the respondents (Table 4.17), discarded EEE are dumped or kept in storerooms. Various surveys on e-waste in African developing countries reveal that a large amount of discarded electronics are kept in storerooms (Finlay, 2005: 7; Mureithi *et al.* 2008: 502). According to Mureithi *et al.* (2008: 502), although storing obsolete equipment is the less preferred option in waste management, it constitutes a preferred option to contain e-waste propagation where there are no other options to hinder their hazardousness.

Table 4. 17 End-of-life treatment options (n=28) multiple responses

| End-of-life treatment options | Yes | No | Don't know |
|--------------------------------------|------|------|------------|
| Re-used | 57.1 | 14.2 | 28.7 |
| Formal recycled | 0 | 46.4 | 53.6 |
| Informal recycled | 14.3 | 35.2 | 50.5 |
| Re-use to extract spare parts | 21.4 | 0 | 78.5 |
| Donate/re-sell to friend or relative | 89.3 | 0 | 10.7 |
| Backyard burning | 7.1 | 14.3 | 78.6 |
| Dumped in Stocks | 92.9 | 0 | 7.1 |
| Landfilled with other wastes | 75 | 25 | 0 |

Mataheroe (2009: 30) and Mureithi *et al.* (2008: 502) postulate that when equipment are not stored, they are mostly donated to relatives, employees or schools; or in other cases sold to the general public. Similarly, 89.3% of the respondents indicated that discarded equipment in Kigali

are donated or sold by last owner. According to 57.1% of the respondents the equipment continues to be re-used, while 21.4% of the respondents believed that they are used to extract spare parts. Mataheroe (2009: 28) and Odhiambo (2009: 2790) indicate that equipment which is not economical to repair such as computers, cellular phones and printers, are used to extract spare parts that are used to repair other functional equipment. This can also be observed amongst the EEE repairing shops, mainly for cellular telephone and computer repairers in Kigali.

Odhiambo (2009: 2789) contends that although donation constitutes a way to manage local discarded EEE, in Kenya for example, equipment such as computers donated by companies and governments to education institutions are old with short lifespans and do not last long and quickly degenerate into e-waste. Odhiambo (2009: 2789) reveals that discarded equipment is donated without any pre-test for functionality due to the lack of a formal recycling for e-waste in Kenya.

When asked if there is any existence of formal recycling of e-waste in Kigali, 46.4% of the respondents pointed out that formal recycling of e-waste do not exist in the country while 53.6% of the respondents do not know anything about it. Various studies on e-waste such as Widmer *et al.* (2005: 454) and Osibanjo and Nnorom (2007: 499) report that within African countries, formal recycling of e-waste is taking place only in South Africa.

When respondents were asked if there are any informal e-waste recycling activities within Kigali, only 14.3% of the respondents indicated that the activity is observed in Kigali, 35.2% of the respondents stated that it does not take place within the city and 50.5% were unaware of such activity. Furthermore, backyard burning practices of e-waste was indicated by 7.1% of the respondents while 14.3% the respondents refuted that backyard burning is occurring within the city and 78.6% of the respondents were unaware of it. Wasswa and Schleup's (2008: 25) findings from a case study in Uganda reveals that informal recycling is done on such a small scale that to perceive them becomes difficult. In addition, one respondent declared that the burning of e-waste includes very limited quantities of e-waste such as ink cartridges and batteries that are burnt with papers from offices. However, with the absence of any monitoring system within the city, the extent of informal recycling and burning of obsolete EEE in Kigali is

difficult to establish. For instance, 75% of the respondents believed that e-waste is also disposed of with other waste (Table 4.17). Thus, the burning of e-waste might occur at a larger scale than is perceived.

4.7 Perception of potential challenges to e-waste management in Kigali

Table 4.18 illustrates the respondents' perception of the challenges that the city might face in the management of e-waste in the future. With the absence of any managerial system for e-waste in Kigali, these challenges can be interpreted as barriers to establish e-waste management in Kigali as well as in other localities in Rwanda.

Table 4. 18 Potential barriers for e-waste management in Kigali (multiple responses)

| Challenges faced in e-waste management | Frequency (n=28) | Percentage (%) |
|--|------------------|----------------|
| Ignorance among population on e-waste | 27 | 96.4 |
| Absence of legislation covering e-waste | 27 | 96.4 |
| Lack of funds | 24 | 85 |
| Lack of infrastructure | 22 | 78.6 |
| Lack of political will on behalf of government | 0 | 0 |
| No adequate staff for monitoring | 20 | 71.4 |
| Lack of e-waste generator databases | 22 | 78.6 |
| Consideration of e-waste as an opportunity to generate income by population | 5 | 17.9 |
| Absence of private sector investment in e-waste environmentally friendly recycling | 21 | 75 |

Ninety six percent of the respondents perceived ignorance amongst the general population as the challenge to e-waste management in Kigali. Nnorom and Osibanjo (2008b: 854) consider that the lack of awareness amongst the general population towards e-waste constitutes the most significant reason behind the present low-end management of e-waste in developing countries, as consumers are unwillingly to part with old EEE, to pay for disposal and recycling of their

waste or worse, dispose of their obsolete EEE into household waste. For 17.9% of the respondents, consumers in Kigali also consider their obsolete EEE as assets for income generation and parting with them becomes difficult. Utkucan *et al.* (2010: 40) add that Rwandans are attached to their owned electronic equipment even though they are no longer working due to the following reasons: the possessions are perceived as a sign of wealth and/ or they may hold sentimental or financial value.

In addition, to pay for waste treatment in Rwanda is a new concept amongst the population, thus to pay for the collection and disposal of an item that appears to have an economic value becomes problematic. Hence, when designing formal e-waste management systems for Kigali the cost factor needs to be taken into consideration.

According to 96.4% of the respondents, the absence of a legal or regulatory framework covering e-waste constitutes another potential challenge to the management of e-waste in Kigali. The absence of clear legal framework regulating waste management, as discussed earlier, results in the absence of clarity of regulatory responsibility and enforcement as well as the absence of compliance and liability.

Allam and Inauen (2009: 3) argue that lack of political will in developing countries has also contributed to the absence of a proper e-waste management system. In contrast, all respondents perceive decision-makers in Rwanda as having a will to establish legislation and managerial systems for e-waste. This might be attributed to the actions mentioned earlier that the government has initiated with regard to e-waste such as workshops at a national level to design e-waste policy and seizing very old electronic equipment entering the country.

Respondents state that lack of funds (85%) and lack of infrastructure (78%) are the challenges that Kigali is facing to establish a proper e-waste management system. Puckett *et al.* (2005: 12) reveal that the lack of funds has also hindered many developing countries to implement the multilateral environmental agreements and other existing regulations that can impact on the problem of e-waste that various countries are facing.

In addition, 71.4% of the respondents felt that Kigali as well as Rwanda, lacks qualified and trained staff to implement a proper e-waste management system. In addition, 78.6% of the respondents cited the lack of e-waste databases in Kigali as a contributory factor. According to Widmer *et al.* (2005: 455), the lack of reliable data and databases constitutes a challenge to policy-makers wishing to design e-waste management strategies and/ or for private investors who might want to make investments in e-waste recycling.

Lastly, 75% of the respondents indicated that the absence of private sector investments in e-waste recycling constitutes a challenge to the management of e-waste in Kigali. In this regard, Nnorom and Osibanjo (2008b: 855) assert that multinational companies that have expertise in e-waste management lack interest in investing in e-waste management in developing countries. In addition, contrary to developed countries where ICT companies are responsible of their products, in developing countries they are not, thus leaving behind environmental pollution (Nnorom and Osibanjo, 2008b: 855).

4.8 Precautionary measures adopted toward e-waste growth in Rwanda

All respondents indicated that initiatives must be taken to raise awareness on e-waste amongst different stakeholders in environmental management in Rwanda (Table 4.19). These include the general public, government institutions, NGOs and the private sector. According to the conclusions of the Waste conference that took place in South Africa in 2008 on how to address the problem of e-waste in Africa, all participants agreed that raising awareness is crucial for all stakeholder groups in environmental protection and in all countries for sustainable e-waste management (WasteCon, 2008).

In addition, 78.6% of the respondents pointed out that laws and regulations dealing specifically with e-waste should be established. All respondents further indicated that the regulatory framework should address different aspects regarding e-waste management including e-waste disposal, re-use and recycling. Similarly, various studies on e-waste in Africa agree that to cope with e-waste problems, a legal framework recognizing e-waste as a separate type of waste as other hazardous waste such as medical waste should be established (Mataheroe, 2009: 80; Nnorom and Osibanjo, 2008a: 1478; Osibanjo and Nnorom, 2007: 499). In addition, Oelofse

and Godfrey (2008: 242-246) postulate that the legal framework for waste should also address other aspects of waste management such as the legal definition for waste, waste categorization or classification and so forth. Furthermore, as advised by Osibanjo and Nnorom (2007: 499), the legal framework for e-waste should take into consideration the local reality and/ or conditions as well as technical capacity within a country to manage e-waste.

Table 4. 19 Precautionary measures to prevent e-waste hazard in Kigali (multiple responses)

| Preventive measures | Frequency (n=28) | Percent (%) |
|---|---------------------|----------------|
| Raise awareness on e-waste amongst different stakeholders in environment management in Rwanda | 28 | 100 |
| Establish laws and regulations dealing specially with e-waste | 22 | 78.6 |
| Regulation of e-waste disposal, re-use and recycling | 28 | 100 |
| Create fund to promote proper e-waste recycling and disposal. | 20 | 71.4 |
| Prevent entrance of secondhand electronic equipment | 10 | 35.7 |
| Promote private sector’s investment in the e-waste recycling | 28 | 100 |

However, the success of laws and regulations goes along with an adequate implementation, enforcement and a monitoring system. Thus, the government must also take steps to allocate sufficient resources and to increase human capacity within the institutions regarding e-waste management. In addition, ambiguity with regard to institutional frameworks should be avoided by establishing clear criteria and objectives for e-waste management.

Furthermore, 35.7% of the respondents viewed the ban of secondhand electrical and electronic products from entering the country as a measure that would prevent the e-waste problem in Kigali. Although the suggestion is in accordance with different NGOs such as Greenpeace and the Basel Convention Network, Puckett *et al.* (2002: 40-42) advocate that for the ban of

transboundary movement of e-waste including secondhand equipment, it is in disagreement with Williams *et al.*'s (2008: 6449-6450, 6453) suggestions that the importance of secondhand electrical and electronic products should be recognized in the development of the ICT sector in developing countries. Hicks *et al.* (2005: 465) state that developing countries should ensure the quality of imported secondhand EEE by establishing standards and a quality certification system for imported secondhand EEE.

According to the Rwandan environmental law (GoR, 2005), the State is required to establish the means for proper recycling of waste, to promote and to disseminate modern technical knowledge in a way to prevent environmental contamination. In this regard, 71.4% of the respondents felt that the government should create a fund to promote proper e-waste recycling and disposal so as to prevent the environmental pollution associated with e-waste in Kigali and Rwanda as a whole. Lastly, all respondents agreed that initiatives must be undertaken to promote and facilitate private sector's participation in e-waste recycling.

4.9 Conclusion

It has been observed that with regard to e-waste awareness amongst environmental regulators, only a limited number of environmental regulators are aware of e-waste impacts on the human and natural environment. In addition, the level of awareness toward the hazardousness of e-waste and type of products which fall under e-waste appears to be low. The majority of the respondents associated e-waste mostly with electronic equipment and not electrical equipment. Furthermore, environmental regulators appear to have limited information about e-waste management practices. However, this low level of awareness may be attributed to the lack of training on e-waste management amongst environmental regulators in Kigali.

Concerning the state of e-waste within Kigali, the perception of environmental regulators appeared mixed. On the one hand, some respondents perceive e-waste as an environmental problem within the city, while on the other hand; other respondents perceive e-waste as a future threat to the environment in Kigali but not as environmental problem at present. However, there is agreement that there is a large stock of obsolete EEE amassed within institutions and households storerooms, which will, in all likelihood, pose huge disposal problems in the future.

Environmental regulators indicated several options for e-waste management practices within Kigali which include stocking, donating or selling obsolete equipment as well as the disposal of e-waste with household waste. In addition, respondents reported that obsolete EEE are re-used to extract useful parts to repair functional equipment. Furthermore, all respondents revealed that formal recycling of e-waste does not exist in Kigali while the informal recycling is assumed to take place on a very small scale. Similarly, the majority of respondents felt that only a limited portion of Kigali inhabitants is currently exposed to the hazardous contamination of e-waste.

All respondents further pointed out that the city as well as the country does not have any managerial system or any legal and institutional framework for e-waste management. It however appears that the problem of e-waste is amongst other problems that the city is already facing to establish a sustainable waste management system. This is attributed to the lack of adequate infrastructure, funds, expertise in waste management as well as clear legal and institutional frameworks to empower decentralized authorities responsible for waste management.

Lack of awareness amongst the general public on e-waste and lack of legislation addressing e-waste were identified to be potential barriers to sustainable e-waste management. In addition, lack of funds, infrastructure, human capacity and lack of private sector participation were regarded as other potential constraints to establish a proper e-waste management in Kigali.

However, the problem of e-waste is viewed as preventable. According to the environmental regulators, initiatives must be taken to raise awareness on e-waste amongst different stakeholders in environmental protection in Rwanda, to establish legal frameworks dealing specially with e-waste, and to promote public and private sector partnerships to establish sustainable e-waste management. Lastly, some respondents believe that the ban of secondhand EEE will prevent the problem of e-waste in the country. The analysis and discussion of findings will help further to establish recommendations for sustainable e-waste management within Kigali.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The main aim of this research study was to investigate the level of environmental awareness and management strategies regarding e-waste amongst environmental regulators in Kigali, Rwanda. In this chapter, the research objectives will be discussed with reference to the key research findings and results of the previous chapter. The chapter further integrates and discusses the EMT with regard to the findings of the study. Recommendations, including the identification of future areas of research will be forwarded in the overall concluding remarks.

5.2 Summary of key findings

This section indicates the links between the key findings emerging from the analysis and the objectives. The three objectives that frame the study are discussed below.

Objective one: To assess the awareness amongst environmental regulators toward e-waste in Kigali, Rwanda

In this regard, different aspects were examined including awareness on the presence of hazardous element in EEE, knowledge of the effect of chemicals contained in e-waste on human health and the environment, as well as knowledge of general type of EEE which are categorized as e-waste. The results show that environmental regulators in Kigali are aware of e-waste. However, the knowledge of the hazardous nature of e-waste with regard to the environment and human health remains very low.

For the majority of environmental regulators, e-waste refers only to electronic equipment. In addition, the large number of environmental regulators appeared to be unaware of the presence of the hazardous elements in EEE except in computers (85.7%), fridges (100%) and batteries (92.9%). Furthermore, environmental regulators showed a low level of awareness regarding the hazard of chemicals contained in e-waste. In this regard, although more than 50% of environmental regulators recognized lead, mercury and cadmium as hazardous chemicals; less

than 30% of environmental regulators were able to identify the environmental or health effects of these hazardous chemicals. All respondents were aware of the hazardous nature of CFC on the environment. This was found to be related to the campaign undertaken by the government to increase the awareness of environmental hazards of CFC amongst the population in the country.

Objective two: To examine the role of different environmental laws and regulations in place on e-waste management

The second objective of this study sought, firstly, to assess if the existing legal framework for environmental management in Rwanda adequately addresses the problem of e-waste. Secondly, to assess the role and responsibilities of different government institutions engaged in environmental protection with regard to e-waste management.

Currently, there is no policy or law that specifically addresses the problem of e-waste in Kigali and Rwanda as a whole. In addition, the existing legal framework does not provide any definition of e-waste as well as the types of EEE that fall under e-waste. The initiative to legislate a national e-waste policy remains in the drafting stage. Nonetheless, the current legislation for environment protection bans the import of CFC contained in fridges. This ban has been introduced under national measures and strategies to reduce GHG emissions. In addition, there is a ban on the import of ‘very old’ secondhand electronic equipment in the country, as stated by 28.6% of respondents. However, there exist no clear criteria which explicitly define ‘very old’.

Furthermore, the majority of existing policies or laws pertaining to environmental protection partially address different aspects related to e-waste management including illegal e-waste import and its disposal within the country. These include:

- Rwandan constitution
- National environmental policy
- Environmental law
- Environmental impact assessment requirement for any project

- Ministerial orders prohibiting the import and/ or export of hazardous chemicals and other polluting substances
- Municipality order prohibiting of dumping waste in an open area

Regarding the institutional framework, there is, to date, no government institution which specifically deals with the monitoring and management of e-waste in Rwanda. However, there are initiatives by the RURA to set up such structures in the future. In addition, the RBS import inspection service has started to seize some of the very old secondhand equipment, mainly computers that are on the market. The lack of a clear institutional framework for e-waste management is the result of the absence of a legal framework regulating e-waste management. Each institution takes actions within its agenda without coordination between them thus increasing the potential of overlapping actions and poor monitoring with regard to e-waste in Kigali.

Besides the RURA, it was found that other institutions in charge of environmental management and other government institutions have the responsibility to deal with the problem of e-waste as well as other hazardous waste. These include:

- The MINELA which is responsible for the legislation of national policy for waste including hazardous waste for efficiency resources recover and protection of the environment.
- The REMA with responsibility to introduce programs to raise awareness on e-waste, to promote waste management into the environmental concerns of the country, to disseminate the know-how with regard to environmentally sound management of e-waste and promote the SEA within the country development framework.
- The Ministry of infrastructure that is responsible for providing the country with secure and sanitary landfill where hazardous waste can be disposed of.
- The RBS to set clear standards for EEE entering the country; and to promote green products import (however, this need a strong collaboration with Ministry of Commerce and Industry and RDB).

- The RDB (environmental analysts) to carry out EIA for ICT related projects in Rwanda.
- The Ministry of ICT is in charge of national ICT policy implementation, its role is essential for inclusion of environmental concerns with regard to e-waste into national ICT policy and to coordinate and to facilitate the capacity building with regard to re-use and refurbishment of electronic equipment.
- Customer services that can facilitate the control of transboundary movement of hazardous waste into the country and to build up a national database of EEE by registering new or secondhand EEE entering the country.
- Decentralized institutions with responsibilities to ensure that obsolete EEE are not dumped and/ or burnt in open areas, collected and disposed of with household waste, as well as to raise awareness amongst the population on e-waste.

Objective three: To assess different methods for solid e-waste disposal in Kigali

The third objective of the study sought to question the extent of e-waste, the fate of obsolete EEE as well as the capacity within regulatory bodies to implement and monitor e-waste management in Kigali. It was found that the real extent of e-waste remains unknown. Similarly, there is a lack of statistics on the current stock of electrical and electronic products within the country. According to 32.1% of the respondents, the problem of e-waste has not as yet reached an alarming level.

Nevertheless, all respondents recognized that currently there is a large stock of obsolete electric and electronic products stockpiled within various institutions across the city. In addition, it has been found that there is a growing quantity of e-waste imported into the country as donations or secondhand items for sale from developed countries and other developing countries, mainly China, thus increasing the potential of e-waste stock in Kigali.

Regarding management practices of the obsolete EEE, Kigali does not possess any formal e-waste management system as indicated by all the respondents. The management of discarded

EEE includes various low-end waste management alternatives. In this regard, the large stock of obsolete EEE remains within institutions and household storerooms. In addition, through informal arrangements, a high level of equipment re-use was reported by 89% of the respondents. The equipment discarded by the last owner is sold or donated to a friend, family or to the public at large to be re-used.

Informal recycling to extract precious components using acid bath, as reported in Asian countries such as India and China, does not occur in Kigali. On the other hand, the open burning of e-waste is taking place within the city, however, at a very small scale. Only, 7.1% of respondents affirmed that e-waste is burnt in open air. In addition, as declared by 75% of respondents, it is believed that some obsolete EEE components are disposed of with other household waste in the only Kigali landfill, the Nyanza dumpsite. Furthermore, the obsolete equipment that cannot be re-used, are used to extract components to repair other functional equipment.

With regard to capacity to implement and to monitor e-waste management within environmental institutions, it was found that environmental regulators lack technical capacity with regard to e-waste management. In addition, Kigali lacks an effective management system for solid waste that can incorporate management of e-waste. Furthermore, the city lacks adequate infrastructure and financial resources to manage hazardous waste including e-waste in an environmentally sound manner.

5.3 Implication of EMT in the management of e-waste in Rwanda

The framework that informed this research is the EMT. The study focused on the win-win perspective between economic growth and the environment as promoted by ecological modernization, in way to examine how Rwanda is reconciling the emerging ICT sector in the country and its environmental effect related to e-waste.

Ecological modernization emphasizes the use of preventive measures and highly developed technologies as tools to achieve environmental sustainability. The results indicate that the actions from the government have inclined more on the benefits and usability of technology for economic growth without taking into consideration the negative aspects of ICT tools on the

environment. In addition, Rwanda as is the case with the majority of developing countries, is not an electronic producer; therefore it is extremely difficult to pinpoint the potential hazard of e-waste at the source. Furthermore, the capacity to recycle e-waste using state of the art technology to hinder e-waste pollution remains low.

On the other hand, it is believed that environmental sustainability can be achievable through the internalization of environmental concerns into government policy in a way to impact on the market actors. Thus, as an electronic consumer, Rwanda can incorporate the principle of preventative measures and fix the problem upstream. The country for instance can change import and taxing policies by favoring electrical and electronic equipment which do not contain hazardous substances such as electronics manufactured in compliance with EU directive on e-waste; thus encouraging market actors to adopt more green electrical and electronic products. In addition, a plan for e-waste management can be required for the ICT industry such as telecommunication companies and electronic assembly enterprises to obtain operating licenses. As such, it might create incentives from the corporate sphere to consider the problem of e-waste in project planning.

The EMT also puts emphasis on participatory and decentralized environmental management as a way to reduce heavy inefficient bureaucracy and to encourage various stakeholders to take into account environmental issues and be responsible for their environment. Although the GoR introduced decentralization as a way to facilitate good governance and public participation in Kigali as well as in Rwanda, a command-and-control policy approach remains dominant in environmental management practices. In addition, though decentralized authorities are now in charge of waste management in Kigali, they lack awareness on e-waste management and information as well as financial resources and technological capacity to handle the problem of e-waste. On other hand, the e-waste problem provides an opportunity for more participation in environmental management. For example, without the willingness from EEE owners to part with obsolete appliances and to participate in e-waste management financing, sustainable e-waste management cannot take place in Kigali. However, for effective participation, environmental awareness campaigns with regard to e-waste amongst all stakeholders are needed.

5.4 Recommendations

The combination of results obtained in this study and the literature about e-waste leads to a number of recommendations that if adopted can prevent pollution related to e-waste in Rwanda. The recommendations are presented below.

For a better management of e-waste in Kigali as well as in Rwanda, a legal framework dealing specially with e-waste should be established. In addition, the regulatory framework should treat e-waste like other hazardous waste such as medical waste requiring particular management approaches. Furthermore, the legal framework should provide a clear definition and identify the types of EEE falling under e-waste in Rwanda. Moreover, the adopted legal framework should clearly define the financing scheme for e-waste management in the country.

The banning of electrical and electronic secondhand equipment is not encouraged, primarily for the following reasons: firstly, the Rwandan purchasing power remains low therefore cheap and functionally secondhand equipment give many Kigali inhabitants an opportunity to access ICT facilities. Secondly, there are obvious environmental benefits of reusing products, such as extending the lifespan of equipment, reducing energy consumption and extraction of raw material to manufacture new equipment. But on the other hand, standards for electrical and electronic secondhand equipment entering the country are needed such as age limit or secondhand electronics manufactured with less hazardous elements. In addition, NGOs importing secondhand electronics must be liable for their products. In this regard, an import permit can be established where NGOs and other electronic importers should ensure to take-back EEE at the end of their life.

Regarding the institutional framework for e-waste management, an institution at the national level to govern and coordinate various decisions and initiatives with regard to hazardous waste including e-waste should be established. In addition, the institution can coordinate other aspects of sanitary and environmental health to reduce overlapping actions and to minimize the government expenditure. Furthermore, the set institution should be empowered with adequate human, technical and financial resources. Thus, professional training on e-waste and other

hazardous waste environmentally sound management is needed amongst environmental regulators.

A system for e-waste collection, refurbishment and recycling should be designated and implemented. With infrastructure that the country has, pre-process workshops can be established where valuable and non-hazardous material can be recovered. Partnerships with the private sector, academic and research institutions, electronic enterprises, CBOs as well as cooperatives that have already invested in recycling of other waste are essential. Academic and research institutions should also be enhanced by empowering them with enough financial resources for research to be conducted on e-waste and other waste material recovery and refurbishment. In addition, the institutions should be facilitated to disseminate know-how with regard to e-waste and other industrial byproduct recovery amongst recyclers in Rwanda.

For strategic planning of e-waste management in Kigali as well as in Rwanda, it is crucial to assess how much of e-waste had been and is generated, and the amount that will be generated in future. Thus, a national database on the extent of e-waste as well as on the EEE stock in the country should be established.

However, all these initiatives cannot succeed without the participation of the general public. Thus, programs to raise awareness of e-waste hazard amongst the public, policy-makers, corporate sphere, and electronic importers should be initiated. These can include workshops as well as radio and TV talk shows.

5.5 Conclusion

This research aimed at assessing the level of awareness amongst environmental regulators. In addition, the legal and institutional frameworks as well as e-waste management practices taking place within Kigali were assessed. With the adopted research methodology, the set objectives of the study were met. However, to have a more comprehensive and advanced picture of the e-waste situation in Kigali as well in Rwanda, future research on e-waste and other effects of ICT tools and technologies on the environment and human health in Rwanda are highly encouraged.

These should focus on:

- The establishment of an e-waste national database;
- The extent of e-waste environmental and health contamination in Kigali;
- The socio-economic and environmental impacts of imported secondhand EEE in the Rwandan context;
- The feasibility to create viable refurbishment and recycling projects in Kigali;
- A sustainable e-waste management financing scheme; and
- Potentials and barriers to adopt an extended producer responsibility regulation in Rwanda.

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APPENDICES

Appendix I: Survey Questionnaire

SCHOOL OF ENVIRONMENTAL SCIENCES

QUESTIONNAIRE

*AN ASSESSMENT OF THE LEVEL OF ENVIRONMENTAL AWARENESS AND
MANAGEMENT STRATEGIES, REGARDING ELECTRICAL AND ELECTRONIC
EQUIPMENT WASTE AMONG ENVIRONMENTAL REGULATORS IN KIGALI, RWANDA*

Please note:

- *All responses will be treated confidentially*
- *Some questions require you to give detailed answers*
- *Other questions require you to indicate your level of agreement with the statements provided. For such questions, please use a tick.*

Section A. Personal Information

1. Name/s (Optional)
2. Occupation
3. Institution

Section B. Awareness among environmental officers on electronic waste (E-waste)

4. From the list provided below, which elements do you consider as hazardous to the environment?

| <i>Lead</i> | <i>Mercury</i> | <i>Cadmium</i> | <i>CFC (Chlorofluorocarbon)</i> | <i>Plastic</i> | <i>None</i> |
|-------------|----------------|----------------|-------------------------------------|----------------|-------------|
| | | | | | |

5. For the elements that you know, what are their effects on the environment and/ or to human health?

.....

.....

.....

6. Which of these items would you consider as solid electronic waste? Which do you think contains hazardous elements?

| | <i>Old computer</i> | <i>Discarded radio</i> | <i>Discarded TVs</i> | <i>Discarded Alkaline batteries</i> | <i>Old fridge</i> | <i>Old toys</i> | <i>Old DVD player</i> |
|------------------------------|---------------------|------------------------|----------------------|-------------------------------------|-------------------|-----------------|-----------------------|
| Solid electronic waste | | | | | | | |
| Contains hazardous element/s | | | | | | | |

7. Do you think that electronic equipment constitutes a threat to the environment?

| | | |
|------------|-----------|-------------------|
| <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
| | | |

8. Please briefly provide a reason for your answer

.....

.....

.....

Section C. Electronic waste in Kigali

9. Do you think that electronic waste is a problem in Kigali?

| | | |
|------------|-----------|-------------------|
| <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
| | | |

10. If yes, what are the main sources of electronic waste?

| <i>Source of e-waste</i> | <i>Strongly agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly disagree</i> |
|---|-----------------------|--------------|-----------------|--------------------------|
| Imported e-waste | | | | |
| e-waste generated by business offices/ government institutions | | | | |
| e-waste generated by school/universities | | | | |
| e-waste generated by household | | | | |

11. If yes, what type of electrical and electronic equipment is commonly discarded?

.....

.....

.....

12. If no, which of the factors below do you think promote electronic waste in Kigali?

| <i>Factors promoting e-waste in Kigali</i> | <i>Strongly agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly disagree</i> |
|---|-----------------------|--------------|-----------------|--------------------------|
| Importation of cheaper electronic secondhand equipment | | | | |
| Donation of old electronic equipment from developed countries | | | | |
| Rapid growth of ICT in country | | | | |
| Free tax on ICT equipment imported to attract investors | | | | |
| Lack of legislation and regulation regarding e-waste | | | | |

13. If electronic waste is a problem in Kigali, whom does it mostly affect?

| <i>People affected by e-waste</i> | <i>Strongly agree</i> | <i>Agree</i> | <i>Disagree</i> | <i>Strongly disagree</i> |
|---|-----------------------|--------------|-----------------|--------------------------|
| Vulnerable people scavenging in dumpsites | | | | |
| Informal recycler | | | | |
| People who work in municipal landfills | | | | |
| People living in neighborhood of dumpsite | | | | |

Section D: Legal framework awareness and legislation on electronic waste

14. Is there any legislation with regard to waste management in Kigali?

| <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|------------|-----------|-------------------|
| | | |

15. If yes, what does the current waste management legislation target?

| <i>Targets for current waste management legislation in Kigali</i> | <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|---|------------|-----------|-------------------|
| Waste in general without any specifications | | | |
| Household solid waste management | | | |
| Industrial waste management | | | |
| Hazardous waste management | | | |

16. What is the scope of current waste management legislation?

| <i>Scope of current waste management legislation in Kigali</i> | <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|--|------------|-----------|-------------------|
| Collection and disposal of household waste | | | |
| Collection and disposal of industrial waste | | | |
| Control and ban of toxic products | | | |
| Control of transboundary movement of hazardous waste | | | |

17. Are there any laws and/ or regulations specifically governing electronic waste in Rwanda?

| | | |
|------------|-----------|-------------------|
| <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
| | | |

18. If yes, how effective are the existing laws regarding the management of waste and/ or in the prevention of electronic waste growth?

| <i>Effectiveness of current laws on waste management</i> | <i>Strongly effective</i> | <i>Effective</i> | <i>Ineffective</i> | <i>Strongly ineffective</i> |
|--|---------------------------|------------------|--------------------|-----------------------------|
| Define which products are considered as e-waste | | | | |
| Regulate e-waste disposal | | | | |
| Prevent e-waste entering household waste | | | | |
| Promote e-waste re-use | | | | |
| Promote e-waste recycling | | | | |

19. Are there any standards or controls on the quality of secondhand electronic equipment?

| | | |
|------------|-----------|-------------------|
| <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
| | | |

20. If yes, what is the extent of existing standards or regulation on secondhand electronic equipment?

| <i>Standards/regulations on secondhand electronic equipment</i> | <i>Yes</i> | <i>No</i> | <i>Don't Know</i> |
|---|------------|-----------|-------------------|
| Limiting age on secondhand electronic equipment allowed to enter Rwanda | | | |
| Provide punitive measures for illegal import of secondhand electronic equipment | | | |
| Control on the import of secondhand electronic spare parts | | | |
| Banning electronic secondhand equipment to enter Rwanda | | | |

21. How effective are the existing standards or regulation in preventing the import of electronic waste as secondhand equipment?

| <i>Strongly effective</i> | <i>Effective</i> | <i>Ineffective</i> | <i>Strongly ineffective</i> |
|---------------------------|------------------|--------------------|-----------------------------|
| | | | |

22. Which of these international environmental conventions do you consider related to electronic waste management?

| <i>International conventions applicable to e-waste management</i> | <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|---|------------|-----------|-------------------|
| Kyoto Protocol | | | |
| Geneva Convention | | | |
| Bamako Convention | | | |
| Basel Convention | | | |
| Stockholm Convention | | | |

23. How effective is the implementation of international agreements related to e-waste?

| <i>Strongly</i> | <i>Effective</i> | <i>Ineffective</i> | <i>Strongly ineffective</i> | <i>Don't know</i> |
|-----------------|------------------|--------------------|-----------------------------|-------------------|
| | | | | |

24. Please provide reasons for your answer

.....

.....

.....

Section E: Electronic waste management awareness, disposal and challenges

25. Have you ever attended any training (seminar and/ or workshop) regarding electronic waste management?

| <i>Yes</i> | <i>No</i> |
|------------|-----------|
| | |

26. If yes, what aspects did the training specifically involve/cover?

.....

.....

.....

27. How aware are you about electronic waste management practices?

| <i>Awareness of waste management practices</i> | <i>Strongly aware</i> | <i>Aware</i> | <i>Unaware</i> | <i>Strongly unaware</i> |
|--|-----------------------|--------------|----------------|-------------------------|
| Re-use | | | | |
| Recycle | | | | |
| Take-back to producer | | | | |
| Disposal | | | | |

28. Who do you consider as a stakeholder in solid waste management in Kigali?

| <i>Stakeholder in solid waste management in Kigali</i> | <i>Yes</i> | <i>No</i> |
|--|------------|-----------|
| Local authority | | |
| Government institutions | | |
| Public | | |
| Private sector | | |
| NGOs | | |

29. What are the roles and responsibilities of each of the persons you consider as a stakeholder?

.....

.....

.....

30. Is there any government body to manage solid waste?

| <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|------------|-----------|-------------------|
| | | |

31. If yes, outline the government body/bodies

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

32. If no, who is responsible for solid waste management? Please elaborate.

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

33. Is there any specific management system for e-waste?

| <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|------------|-----------|-------------------|
| | | |

34. If yes, what are the government bodies responsible for e-waste management?

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

35. What are the responsibilities of each institution regarding e-waste management?

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

36. To the best of your knowledge, how are electronic wastes managed in Kigali?

| <i>Management of e-waste in Kigali</i> | <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|--|------------|-----------|-------------------|
| Landfilled | | | |
| Formally recycled | | | |
| Re-used | | | |
| Take-back to producer | | | |

37. If there is no electronic waste management, what is the fate of electronic discard? (What happens to discarded electronic equipment?)

| <i>Fate of electronic discard</i> | <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|---|------------|-----------|-------------------|
| Re-use to extract spare parts | | | |
| Donate or re-sell to friend or relative | | | |
| Backyard burning | | | |
| Dumped in stocks | | | |
| Landfilled with other waste | | | |

38. What challenges does Kigali face with regard to electronic waste management?

| <i>Challenges in e-waste management</i> | <i>Yes</i> | <i>No</i> | <i>Don't know</i> |
|--|------------|-----------|-------------------|
| Ignorance among population on e-waste | | | |
| Absence of legislation covering e-waste | | | |
| Lack of infrastructure | | | |
| Lack of funds | | | |
| Lack of political will | | | |
| Inadequate staffing for monitoring | | | |
| Lack of e-waste generator databases | | | |
| Consideration of e-waste as an opportunity to generate income | | | |
| Absence of private sector investment in environmentally friendly e-waste recycling | | | |

39. If electronic waste is not yet a problem, what should the preventative measures be?

| <i>Possible preventative measures</i> | <i>Yes</i> | <i>No</i> |
|--|------------|-----------|
| Raise awareness amongst stakeholders in environmental management | | |
| Establish laws/regulations dealing specifically with e-waste | | |
| Regulation of e-waste disposal, re-use and recycling | | |
| Create fund to promote proper e-waste recycling and disposal | | |
| Prevent entrance of secondhand electronic equipment | | |
| Promote private sector investment in e-waste recycling | | |

40. Are there any comments that you would like to make regarding e-waste as an environmental problem and/ or management issues in this regard, in Kigali?

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.....

.....

Thank you for your cooperation

Appendix II: Cover Letter

MUGABE RUBONA ROBERT
M.S.c. Student
School of Environmental Sciences
University of KwaZulu-Natal, Durban

25 April 2010

Dear Sir/Madam

I am conducting a research entitled “An assessment of environmental awareness and management strategies regarding electrical and electronic equipment waste amongst environmental regulators in Kigali, Rwanda” for the partial fulfillment of a masters degree in environmental sciences.

I would like to kindly request your participation in this study by answering a questionnaire. The information collected will be used solely for the purposes of completing my dissertation and degree.

Your anonymity and confidentiality will be preserved at all times and under no circumstances will your personal details be referenced in this dissertation. Furthermore, your participation is entirely voluntary and you may withdraw your permission to participate in this study without an explanation at any time. However, I hope that you will feel comfortable to participate in this project.

You will find attached, the questionnaire.

Yours faithfully

Robert R. MUGABE