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Assessment of e-wastes status and trends in Rwanda and development of recommendations for the prevention and management of e-wastes

Client: REMA

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Final report

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Acronyms

AEHA Association for Electrical Home Appliances

APME Association of Plastic Manufacturers in Europe

ARF Advance Recycling Fee

B2B Business to Business

B2C Business to Consumer

BFR Brominated flame retardant

BNR : Banque National du Rwanda

CFC Chlorofluorocarbon

HCFC Hydrochlorofluorocarbons

CPU Central Processing Unit

CRT Cathode Ray Tube

DHS Demographic and Health survey

DNA Deoxyribonucleic acid

EEE Electrical and Electrical Equipment

EIA Environmental Impact Assessment

EPR Extended Producer Responsibility

ESM Environmentally Sound Management

ETC International Environmental Technology Centre

EU European Union

FR Flame Retardant

GDP Gross Domestic Product

HDPE highdensity polyethylene

HDTV high definition TV

ICT Information and Communication Technology

IETC International Environmental Technology Centre

IT Information Technology

JICA Japanese internation communication.

Kg Kilogram

KHI Kigali Health Institute

KIE Kigali Institute of Education

KIST Kigali institute of Science and technology

LCD Liquid Crystal Display

MAGERWA Magasin General du Rwanda

MFA Material Flow Analysis

MINAGRI Ministry of agriculture

MINICOM Ministry of commerce and industry

MIT Massachusetts Institute of Technology

MOU Memorandum of Understanding

MPPI Mobile Phone Partnership Initiative

NCDC National Curriculum Development Centre

NGO Non Governmental Organization

NUR National University of Rwanda

NURCB National University of Rwanda Consultancy Bureau

ODS Ozone Depleting Substance

PAHs Polyaromatic hydrocarbons

PBB polybrominated biphenyls,

PBDE Polybrominated diphenyl ethers

PC Personal Computer

PCB Polychlorobrominated flame retardants

PCB Printed Circuit Board

PRO Producer Responsibility Organizations

PSF Private sector feferation

PVC polyvinyl chlorides

PWB Printed Wire Boards

RBS Rwanda Bureau of Standard

RCN Rwanda Computer Network

RDB: Rwanda Development Board

REMA Environment Management Authority

RHA: Rwanda Housing Authority

RNP Rwanda National Police

RRA : Rwanda revenue authority

RURA Rwanda Utility Regulation Authority

StEP Solving the E-waste Problem

TBBA Tetrabromo bis-biphenol-a

TCE Trichloroethylene

TCT Tumba college of Technology

TV Television

UK United Kingdom

ULK: Universite libre de Kigali

UNCTAD United Nation Conference on Trade and Development

UNEP United Nation Environment Programme

UPS Uninterruptible power supply

USEPA United States Environmental Protection Agency

USA United States of America

VCR Video Cassette Recording

WEEE Waste Electrical and Electronic Equipment

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The document has been prepared by the National University of Rwanda Consultancy Bureau team headed by Dr. Hermogene Nsengimana, Vice Dean of the Faculty of Science in collaboration with Mr. Jean Pierre Bizimana, Lecturer in the Faculty of Science and Mr. Yves Sezirahiga, Assistant Lecturer Faculty of Law.

EXECUTIVE SUMMARY

Rwanda is expected to have generated huge volume of Electronic Waste, as its information and communication technology infrastructure has grown significantly in the past and is expected to grow exponentially in the future. To mention few, projects such as fiber optic coverage of the whole country, one laptop per child or an increase in electricity access will boost the use of Electrical and electronic equipments (EEE). The above situation has triggered the Rwanda Environment Management Authority (REMA) with an increasing interest in assessing the Electronic Waste (e-waste) and development of recommendations for its prevention and management. With this regards, the Rwanda Environment Management Authority has agreed to commission a comprehensive study that assess e-wastes status and trends in Rwanda and develop recommendations for the prevention and management of e-wastes analyses..

The overall objective was to develop a solid understanding of e-waste status, prevention and its management in Rwanda with emphasis on computer and cellphones. To achieve the above defined objective, both primary and secondary data collection methods have been used. The review of literature helped to identify the existing standards, regulations and policy on e-waste; the state of e-waste in Rwanda and its consequences on human health. A desk study was carried out to acquire and analyse relevant information pertaining to the e-waste from the previous studies and from government instructions.

This study has specific objective formulated as follow:

- To gather and assess the most relevant environmental, economic and social characteristics of e-waste in Rwanda as well as in the world, considering the main steps in the e-wastes chain: production – commercialization - utilization - collection - dismantling - pre-processing - end processing of metal- and non-metal fractions.
- To perform recycling system evaluations leading to recommendations for long term development of eco-efficient resource cycles.

- To analyze the transboundary shipments and logistics of equipments susceptible to generate e-waste and its underlying driving forces, dynamics, regulations and the constraints for sustainable resource cycles.
- To describe best available and emerging technologies for large and small volume e-wastes management in the country.

- To analyze together with "Policy" legislative and policy development bodies, roadmaps and strategies concerning e-wastes management infrastructure adapted to local conditions to reduce environmental and social problems.
- To investigate on appropriate financing mechanisms for different kinds of e-waste management projects and markets.
- To provide timely information of environmental initiatives and possibilities to participate in the prevention and management with regard to e-waste and its specific value chain…
- To define the smallest throughputs of necessary material recycling process technology to work eco-efficient and describe the required cross boarder infrastructure needed including the possibilities to control safe treatment and corresponding policy implications
- To enhance communication and transfer the implications of treatment technologies, environmental issues, economic possibilities and social dimensions into e-waste management strategies.

- To enhance communications and development/ transfer of e-waste treatment technologies to facilitate growth in both capacity and environmental/social quality of electronics management infrastructure.
- To enable, empower, improve and report on standards for monitoring and supervising relevant waste streams.

The preliminary findings show an increase in the EEE imported, the ICT equipment have increase 5 times more from 2001 to 2010. The subscribers on mobile network have dramatically increased from 1.6 to 25 % penetration with a current subscriber number of around 3 millions.

The EEE inventory in public institution shows that 85% of all EEE is composed by the laptops. Among the 15% EEE remaining 14% are not working,

It was also found that some courses and modules from high learning institution, KIST, NUR, Tumba College among others may be reviewed and accommodated e-waste treatment technologies.

The findings also revealed that there is a draft on e-waste management that still under discussion and no other regulation on E-waste management in Rwanda exist. It should be noted that RURA with RBS have established guideline in order to allow only penetration of useful of EEE (allow only EEE with less than five years lifespan).

The main recommendations drawn from this study include the following;

- The protection of human life and environment protection: The government shall ensure safety of citizens and the environment from hazardous materials embodied in ICT equipment by establishment of e-waste facilities in the country and through monitoring.
- Globalization: The policy implementation shall take into consideration the trend of Globalization and the government insure that the Basel convention is respected for any transboundary movement of EEE.
- Community and private sector participation: Government shall encourage citizen participation recognize the contribution of the private sector through mobilisation and sensitization on the proper management and handling of e-waste on a sustainable basis with economical benefit approach.
- The government through different authorities shall provide specific e-waste regulation (legal and regulatory) from the acquisition, handling to the final disposal processes.
- The Ministry of Education and the Ministry of Public work, Ministry of sport and youth shall develop a critical human resource base knowledgeable in handling e-waste by revising the curriculum and introduce technical courses, modules...in their respective institution, high learning, technical college, youth gathering (e.g. IWAWA camp) and use the college and high learning institution as pilot studies.
- All stakeholders should be involved for resource mobilization for efficient management and disposal of e-waste: consumer, retailer, producer...
- To provide guidance on the standards of ICT equipment that is imported in the country.
- To establish incentives for encouraging both local and foreign investors to establish e-waste facilities in Rwanda.

- There is also a need to harmonize data as it has noted some inconsistence in data during literature review.
- The principle of 3R is paramount in the E-waste management in Rwanda

1 INTRODUCTION

Rwanda is expected to have generated huge volume of Electronic Waste, as its information and communication technology infrastructure has grown significantly in the past and is expected to grow exponentially in the future. To mention few, projects such as fiber optic coverage of the whole country, one laptop per child or an increase in electricity access will boost the use of Electrical and electronic equipments (EEE). The above situation has triggered the Rwanda Environment Management Authority (REMA) with an increasing interest in assessing the Electronic Waste (e-waste) and development of recommendations for its prevention and management.

This report is a result of the implementation of the contract signed between the National University of Rwanda Consultancy Bureau (NURCB) and the Rwanda Environment Management Authority (REMA) titled "*Consultancy services for the assessment of e-wastes status and trends in Rwanda and development of recommendations for the prevention and management of e-wastes*".

Although there are many types of Electrical and electronic equipment, this study focused mainly on computers and its accessories and telephones.

1.1 Specific objectives

Gather and assess

- To gather and assess the most relevant environmental, economic and social characteristics of e-waste in Rwanda as well as in the world, considering the main steps in the e-wastes chain: production – commercialization - utilization - collection - dismantling - pre-processing - end processing of metal- and non-metal fractions.

- To perform recycling system evaluations leading to recommendations for long term development of eco-efficient resource cycles.
- To analyze the transboundary shipments and logistics of equipments susceptible to generate e-waste and its underlying driving forces, dynamics, regulations and the constraints for sustainable resource cycles.

Propose practices and standards

- To describe best available and emerging technologies for large and small volume e-wastes management in the country.
- To analyze together with "Policy" legislative and policy development bodies, roadmaps and strategies concerning e-wastes management infrastructure adapted to local conditions to reduce environmental and social problems.
- To investigate on appropriate financing mechanisms for different kinds of e-waste management projects and markets.

Communicate recommendations

- To provide timely information of environmental initiatives and possibilities to participate in the prevention and management with regard to e-waste and its specific value chain…
- To define the smallest throughputs of necessary material recycling process technology to work eco-efficient and describe the required cross boarder infrastructure needed including the possibilities to control safe treatment and corresponding policy implications
- To enhance communication and transfer the implications of treatment technologies, environmental issues, economic possibilities and social dimensions into e-waste management strategies.

Transfer of technology

- To enhance communications and development/ transfer of e-waste treatment technologies to facilitate growth in both capacity and environmental/social quality of electronics management infrastructure.

Monitoring and reporting standards

- To enable, empower, improve and report on standards for monitoring and supervising relevant waste streams.

2 Literature review

While awareness around e-waste and the hazards posed by improper recycling is growing, the allure of inexpensive access to technology is still too great for many developing nations to want to strictly regulate electronics (Wanjiku 2009). Because of the well-documented hazards of e-waste being handled improperly in their countries, Uganda has banned secondhand computers from entering the country, while Kenya taxes secondhand imports to dissuade waste importing (Wanjiku 2009). However, Rwanda still allows donated and refurbished computers to enter the country (Wanjiku 2009). As other African countries begin tightening enforcement of the Basel convention, and begin placing all-out bans on imports of secondhand electronics as Uganda has done, the amount of waste entering countries without bans will likely increase. This puts Rwanda in a critical place where developing a plan and infrastructure to properly deal with e-waste is crucial to the future human and environmental health of the country.

2.1 E-WASTE DEFINITIONS

E-waste is a popular, informal name for electronic products nearing the end of their „useful life". Computers, televisions, VCRs, stereos, copiers, and fax machines are common electronic products... There is no clear definition for e-waste; for instance whether or not items like microwave ovens and other similar „appliances" should be grouped into the category has not been established" (California Integrated Waste Management Board 2005).

"Electronic waste or e-waste is any broken or unwanted electrical or electronic appliance... E-waste includes computers, entertainment electronics, mobile phones and other items that have been discarded by their original users. While there is no generally accepted definition of e-waste, in most cases e-waste consists of expensive and more or less durable products used for data processing, telecommunications or entertainment in private households and businesses" (Wikipedia 2006).

In the case of this study, as the main aim is to assess e-waste related to computers and cellphone, it is imperative to define what are the term used by regulatory authority in Rwanda (RURA and RBS) when defining the e-waste:

1. The term Used computer covers :

i) Refurbished computers (computer with "reused components")
ii) computers whose age is more than 1 year and less than five years whether being in use or not

2. A Computer whose age is more than five or equal to five years (5) old whether being in use or not is considered to be a waste
3. A new Computer is less than or one year old from the date of its manufacture with relevant certificates such as manufacturers/Supplier conformity declaration certificates.

Note: The above definitions apply for used spare parts.

2.2 Global and Rwandan context on e -waste

Although electronic waste (e-waste) seems to have only recently become a problem, this issue has been building since the time the electronic products and computers were first manufactured.

There are three major reasons that would answer why used EEE are an environmental concern:

1. Represent a rapidly growing waste stream
2. Contain hazardous or toxic substances
3. Waste valuable resources

2.2.1 E-waste as a rapidly growing waste stream

Electronic Waste is considered to be one of the fastest growing waste streams in the world. The increasing "market penetration" in developing countries, "replacement market" in developed countries and "high obsolescence rate" make the Electronic Waste as one of the fastest growing waste streams. Technical solutions are available, but in most cases a legal framework, a collection system, logistics, and other services need to be implemented before a technical solution can be applied.

According to United States Environmental Protection Agency (US EPA) estimates, electronic products constitute approximately one percent of municipal solid waste. Research completed in Europe shows that electronic waste is growing at three times the rate of other municipal waste.

The rapid shift to new technology leads to an increase in the amount of discarded consumer electronic products and the obvious example is the TV industry shifting from analog television to digital, high definition TV (HDTV). Studies have shown that obsolete or no longer usable

electronics, particularly computers, are often placed in storage for considerable periods of time. This prolonged storage may be due to a perceived value of the equipment and/or a lack of disposal opportunities.

2.2.2 Hazardous substances in electrical and electronic equipment

Given the high toxicity of the component materials in e-waste especially when burned or recycled in an uncontrolled manner, the Basel Convention has therefore identified e-waste as a hazardous substance and has developed a framework for controls on transboundary movements of such wastes. Environmental groups claim that the informal processing of electronic waste in developing countries causes serious health and pollution problems Electronic Waste can contain over one thousand different substances, many of which are toxic. Inadequate disposal and poor recycling practices to recover metals such as gold, copper and silver contribute to potential harmful impacts on the environment and pose health risks to exposed individuals. The Electronic Waste stream is thus important not only in terms of quantity but also in terms of its toxicity.

2.2.3 Waste valuable resources

End-of-life electronic equipment contains valuable resources such as precious metals, engineered plastics, glass, and other materials, all of which require energy to manufacture. If these resources are not recovered, additional pollution will be generated to manufacture new products out of virgin materials.

Today the electronic waste recycling business is in all areas of the developed world a large and rapidly consolidating business. Electronic waste processing systems have matured in recent years, following increased regulatory, public, and commercial scrutiny, and a commensurate increase in entrepreneurial interest. This may be applicable only in developed countries whereas in developing countries a lot effort should be made as little has been done on policy and regulation and few recycling facilities can be found.

Best management practices are guidelines for selecting the most environmentally desired methods for managing e-waste stream. E-waste collection programs need guidelines to assure that products are managed in a way that protects public health and the environment and conserves valuable resources.

2.2.4 Rwanda context

More countries are planning for e-waste assessment projects and management measures as the quantities of Electronic Waste generated are predicted to grow substantially in the future both in industrialized countries and in developing countries. The dropping lifespan of electronic and electrical products, high consumerism of those products, low recycling rates and illegal transboundary movement from developed to developing countries will increase the Electronic Waste generated per year.

Rwanda is expected to have generated huge volume of Electronic Waste, as its ICT infrastructure has grown substantially in the past and is expected to grow exponentially in the future. Rwanda is currently undergoing rapid advances in the use of ICTs. Starting with the active use of computers by Rwandans in 1990s, the country believes in ICT implementation in all sectors of production to increase the pace of socioeconomic development and create value for all citizens. We could mention the program such as one laptop per child, fiber optic and electricity distribution in the whole country that may increase the use of electronic and electric material. Although Rwanda is a signatory to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, at this stage no much has been done about e-waste.

A very significant proportion of ICT users in Rwanda rely on second-hand equipment, primarily from Europe. In recent years, used and end-of-life computers and accessories, televisions, transformers, and mobile phones have been imported from the United Kingdom (UK), Germany, Belgium and France. Most of the used computers have been distributed to students from the National University of Rwanda, the Kigali Institute of Technology (KIST), and the Kigali Institute of Education (KIE), and to small businesses and enterprises in Kigali and other towns of Rwanda.

Other major problems in Rwanda, are due to nonexistence of recycling units of electrical and electronic equipment in the country. With the increasing quantity of these products turning to waste recycling and reuse of these products is complex. The volume of E-waste increases faster than the infrastructure and know-how for its environmentally friendly handling. Global statistics and reports estimates that Electronic wastes generated worldwide each year comprises more than 5% of all municipal solid waste. This has triggered an increasing scientific and political interest for how to safely dispose of and recycle Electronic Waste and solutions have been proposed

from the perspective of new industrial product designs, manufacturing and recycling philosophies (e.g. the extended producer responsibility) and green procurement policies.

In Rwanda, there are currently no specific legislations regulating the management and safe disposal of Electronic Wastes. However, there are legislations already developed and others being developed concerning the management of wastes in general such as Organic Law N° 04/2005 of 08/04/2005 determining the modalities of protection, conservation and promotion of environment in Rwanda and Law N° 39/2001 of 13/09/2001 establishing an agency for the regulation of certain public utilities that will handle the removal of waste products from residential or business premises. These laws will be for high importance for this study.

2.3 Impact of E-waste on human, social, economy and environment

2.3.1 E-waste and human health

E-waste is much more hazardous than many other municipal wastes because electronic gadgets contain thousands of components made of deadly chemicals and metals like lead, cadmium, chromium, mercury, polyvinyl chlorides (PVC), brominates flame retardants, beryllium, antimony and phthalates. Long-term exposure to these substances damages the nervous systems, kidney, and bones, reproductive and endocrine systems. Some of them are carcinogenic and neurotoxin. A study conducted by Greenpeace in 2005 in electronic recycling yards in Delhi clearly indicates the presence of high levels of hazardous chemicals including dioxins and furans in the areas where this primitive / unauthorized recycling takes place. Disposal of e-wastes is a critical problem faced and poses a threat to both health and vital components of the ecosystem. There are number of channels through which e-waste goes to the environment.

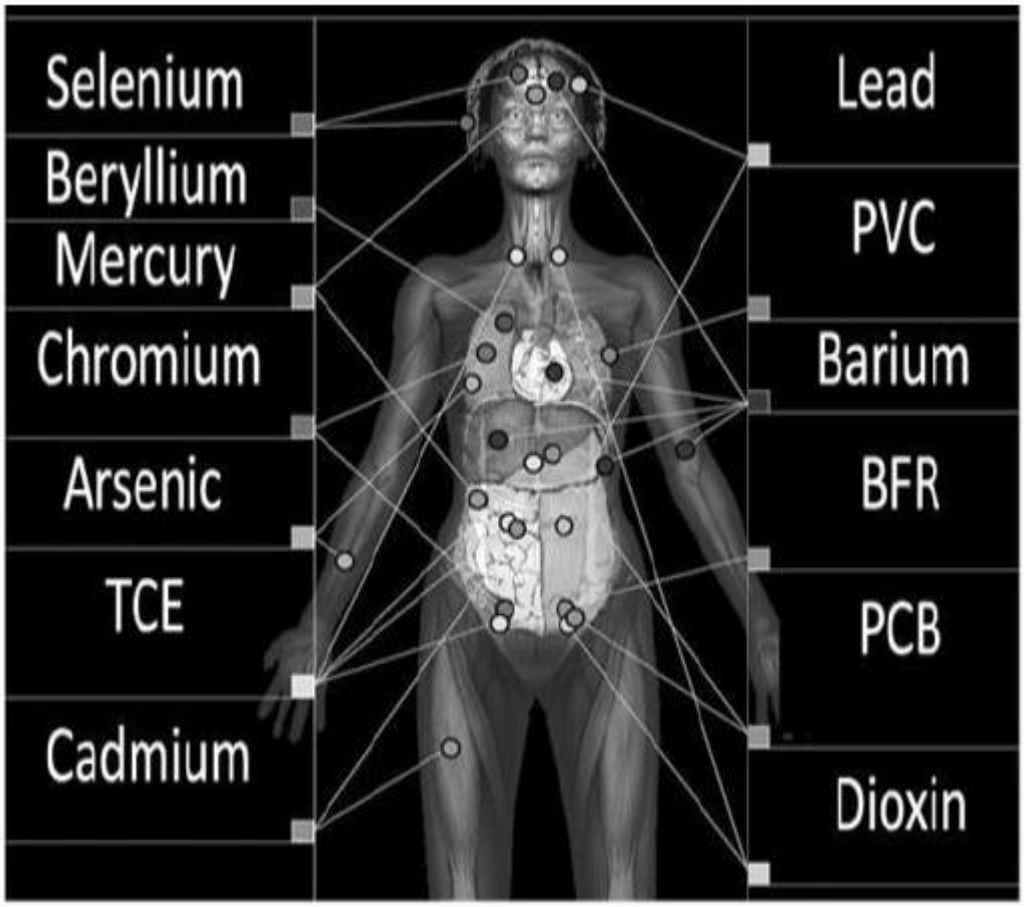


Figure 2-1: Target organs by e-waste pollutants (Source: (Silicon Valley Toxics Coalition 2009)

Table 2-1: Pollutant from EEE and human effect

Pollutant	Location in EEE	Human effect
Antimony trioxide	a flame retardant, added to cathode ray tube (CRT) monitor glass, found in printed circuit boards and cables	Toxic to humans in ways similar to arsenic; fatal in large doses
Arsenic	in older cathode ray tubes and in light emitting diodes	Arsenic is a known cancer-causing substance (carcinogen). It is known to cause skin and lung cancer.
Barium	In CRT	When fish and other aquatic organisms absorb the barium compounds, barium will accumulate in their bodies.
Beryllium	often allied with copper to	Long term exposure can be

	improve copper's strength, conductivity and elasticity. Old motherboards, contact springs found in printed circuit boards, relays, and in the mirror mechanism of laser printers. In power supply boxes which contain silicon controlled rectifiers and x-ray lenses	carcinogenic, especially for the lungs. Extreme exposure can lead to a potentially fatal condition known as Acute Beryllium Disease
Cadmium	circuit boards and semiconductors Rechargeable NiCd-batteries, fluorescent layer (CRT screens), printer inks and toners, photocopying-machines (printer drums)	Breathing high levels of Cd can cause lung damage and death. Long term exposure to low levels of Cd can cause elevated blood pressure and kidney damage. Cadmium is a known carcinogen
Chlorofluorocarbon (CFC)	Cooling unit, Insulation foam	
Chromium	in steel as corrosion protection, Data tapes, floppy-disks, circuit boards, photocopying-machines (printer drums)	Chromium has a variety of effects depending how it enters the body. Chromium is a carcinogen if inhaled. Chromium may also cause DNA damage
Chromium VI	Data tapes, floppy disks	
Cobalt	component in steel for structural strength and magnetivity	This agent is carcinogenic in experimental animals at a relatively high dose
Lead	cathode ray tubes, solder, batteries, printed wiring boards (circuit boards), solder on components, mobile phone coatings,	Initial symptoms of exposure are anorexia, muscle pain, malaise, and headache. Long-term exposure to lead decreases the overall performance of the nervous system. High level exposure causes brain damage and death.
Lithium	Batteries including mobile phone batteries	Burning sensation. Cough. Labored breathing. Shortness of breath. Sore throat.
Mercury	switches (mercury wetted) and housing, fluorescent lamps providing backlighting in liquid crystal displays (LCDs) for monitors and laptops, batteries, printed circuit boards	Short term exposure to all forms of mercury causes lung damage, nausea, vomiting, diarrhoea, increases in blood pressure or heart rate, skin rashes, and eye irritation Long term

		exposure permanently damage the brain, kidneys, and developing foetus.
Nickel	batteries, electron gun in CRT , printed circuit boards	Nickel fumes are respiratory irritants and may cause pneumonitis
Polybrominated flame retardants (including polychlorinated biphenyls (PCB), polybrominated biphenyls (PBB), Polybrominated diphenyl ethers (PBDE), and tetrabromo bis-biphenol-a (TBBA))	plastic casings, cables, and circuit boards, condensers, transformers	
Polyvinyl chloride (PVC)	Cable insulation	When burnt it produces highly toxic dioxins; research is finding if PCV is a hormone disruptor.
Selenium	circuit boards as power to supply rectifier, photocopying-machines (printer drums)	
Zinc sulphide	interior of CRT screens, printed circuit boards	

2.3.2 Socio-economical impact

Four sub-sectors have been considered decisive for a social impact analysis of e-waste management. That is to say; Collection, Refurbishment, Material recovery mainly for reuse, recycling and final disposal. In general recyclable waste is viewed as a resource and income-generating opportunity. Electronic-waste is mostly handled by the informal sector and provides jobs for people that have difficulty accessing formal employment by:

- Collecting (and re-selling waste)
- Practicing re-pairs both formally and informally
- Recycling and
- Disposal

There are other significant economic potentials if valuable materials in e- waste are recovered. The e-waste industry provide income-generating opportunities for both individuals and enterprises, as waste is sold and traded among collectors, processors, second-hand dealers and consumers.

Apart from companies that import ICT equipment, rwandese private sector institutions are not active in dealing with the e waste issue. Some initiatives are done by the Rwanda Computer Network (RCN), whose business is the assembly of computers parts, and e-ICT, which is an institution dealing with ICT training and maintenance. Small and medium enterprises are consumers of e waste products. Some of them collect used toner cartridges for recycling.

2.3.3 Environmental Impacts caused by E-wastes

The main environmental impacts of e-waste mainly arise due to inappropriate collection and disposal, rather than inherent toxic contents although drawing boundaries between secondary goods intended for reuse and waste materials may be a challenge.

- E-waste contains more than 1000 different substances, many of which are highly toxic. E-waste contains both valuable materials, such as gold and copper, as well as highly toxic substances, such as lead and mercury.
- The informal dumping sites and the crude methods used to reclaim materials from the e-waste without environmental monitoring generate many kinds of pollutants thus creating serious problems to ecological environment and human health.
- Polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and polybrominated biphenyl ethers (PBDEs) can also be generated through recycling plastics. The open burning of cables to recover copper produces highly toxic dioxin emissions, which are emitted to the ambient air.

However, since the introduction of a modern system of environment management in Rwanda in early 2005, there have been a lot of developments that have shaped the way the country manages the environment. Key among these developments is the introduction of the requirement for Environmental Impact Assessment (EIA) for all development projects and activities that are likely to have significant impact on the environment, so that adverse impacts can be foreseen before they are implemented and ways and means identified to eliminate or minimize them, while the positive impacts could be maximized.

The role of civil society organizations in dealing with e waste is limited due to the lack of human capacity in the field. Most interventions in environmental protection by civil society are oriented to the activities of deforestation and terracing.

3 Methodology

To achieve the main objective of this study the following activities were undertaken in different phases: literature review, data collection, data processing and analysis, final reporting and results restitution.

3.1 Literature review

The review of literature helped to identify the existing e-waste management in the world, standards, regulations and policy about e-waste; thus understand the case of Rwanda with on reducing, reuse and prevention related to importation and donation.

3.2 Data collection

This phase of the study helped to identify the main sources of e-waste, their quantity; gather all data on recorded electrical and electronic equipment (EEE).

3.2.1 Primary data collection

Guided interviews with stakeholders in order to have information about quantity of EEE, measures to be undertaken, e-waste disposal mechanism were conducted and questionnaire has also been used.

3.2.2 Secondary data collection

Although this study included field activities in order to respond to some key research questions, the findings and analyses were build on previous reports on the prospects and challenges existing in Rwanda related to the e-waste management. It comprised desk reviews dating back to early date when the concept of information technology was incepted in Rwanda.

3.2.3 Specific approach for different tasks during data collection

The main framework in order to conduct this study is on the figure 3-1. In the whole study, the researcher tried to follow the life cycle of EEE once their enter the country till its endlife and

disposal. Quantity entering the country starting at the end of nineteen century to date were recorded in order to project the future trend.

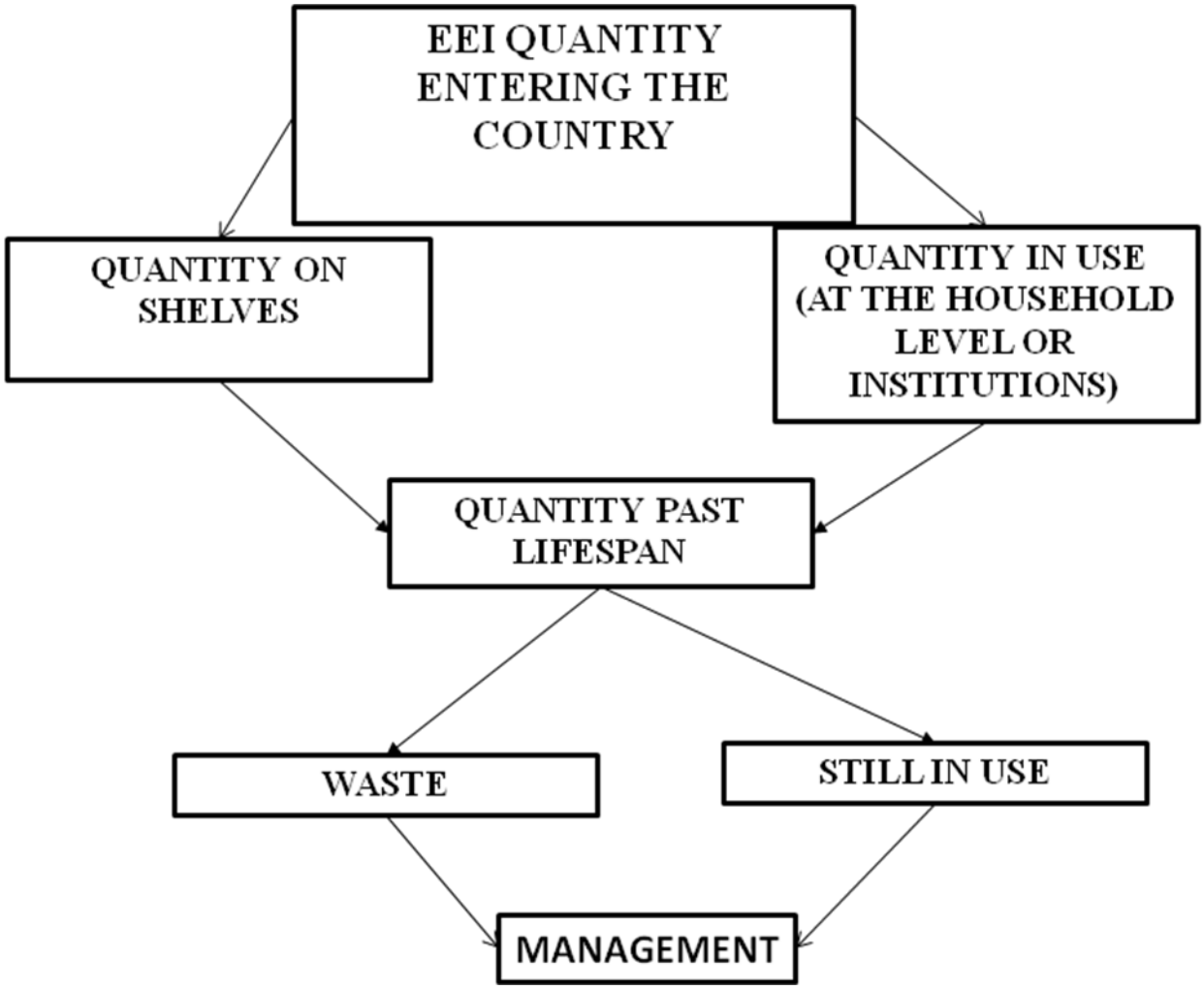


Figure 3-1: A gate to grave framework of EEE

The following are the indicative approach in order to respond to the objective of this study:

1. *To gather and assess the current situation of e-wastes management in the country including types of e-wastes, quantities, involved people and institutions, present and future projects that will lead to generation of e-wastes, etc.*

In order to gather and assess the current situation of e-wastes management in the country, one need to know the type and quantities of waste in the country and the mass flow of EEE in order to assess e-waste that will be generated in the future. In order to know all stakeholders involved,

there is a need to know different categories of e-waste. The EEE have been categorised in ten categories, the table 3-1 gave these categories but the study mainly focused on computer and cellphone waste.

Table 3-1: Different categories of source of e-waste

Category	Equipment	Rwanda case
Large household appliances	▪ large cooling appliances ▪ refrigerators ▪ freezers ▪ other large appliances used for refrigeration, conservation and storage of food ▪ washing machines ▪ clothes dryers ▪ dish washing machines ▪ cooking ▪ electric stoves ▪ electric hot plates ▪ microwaves ▪ other large appliances used for cooking and other processing of food ▪ electrical heating appliances ▪ electric radiators ▪ other large appliances for heating rooms, beds, seating furniture ▪ electric fans ▪ air conditioning appliances ▪ other fanning, exhaust ventilation and conditioning equipment	▪ refrigerators ▪ freezers ▪ washing machines ▪ clothes dryers ▪ dish washing machines ▪ cooking ▪ electric stoves ▪ electric hot plates ▪ microwaves ▪ other large appliances used for cooking and other processing of food ▪ electrical heating appliances ▪ electric radiators ▪ other large appliances for heating rooms, beds, seating furniture ▪ electric fans ▪ air conditioning appliances ▪ other fanning, exhaust ventilation and conditioning equipment
Small household appliances	▪ vacuum cleaners ▪ carpet sweepers ▪ other appliances for cleaning	▪ vacuum cleaners ▪ carpet sweepers ▪ other appliances for cleaning

	▪ appliances used for sewing, knitting, weaving and other processing for textiles ▪ irons and other appliances for ironing, mangling and other care of clothing ▪ toasters ▪ fryers ▪ grinders, coffee machines and equipment for opening or sealing containers or packages ▪ electric knives ▪ appliances for hair-cutting, hair drying, tooth brushing, shaving, massage and other body care appliances ▪ clocks, watches and equipment for the purpose of measuring, indication or registering time scales	▪ appliances used for sewing, knitting, weaving and other processing for textiles ▪ irons and other appliances for ironing, mangling and other care of clothing ▪ toasters ▪ fryers ▪ grinders, coffee machines and equipment for opening or sealing containers or packages ▪ electric knives ▪ appliances for hair-cutting, hair drying, tooth brushing, shaving, massage and other body care appliances ▪ clocks, watches and equipment for the purpose of measuring, indication or registering time scales
IT and telecommunications equipment	▪ centralised data processing ▪ mainframes ▪ minicomputers ▪ printer units ▪ personal computing ▪ personal computers (CPU, mouse screen and keyboard included) ▪ laptop computers (CPU, mouse screen and keyboard included) ▪ notebook computers	▪ centralised data processing ▪ mainframes ▪ minicomputers ▪ printer units ▪ personal computing ▪ personal computers (CPU, mouse screen and keyboard included) ▪ laptop computers (CPU, mouse screen and keyboard included) ▪ notebook computers

	▪ notepad computers ▪ printers ▪ copying equipment ▪ electrical and electronic typewriters ▪ pocket and desk calculators ▪ any other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means ▪ user terminal and systems ▪ facsimile ▪ telex ▪ telephones ▪ pay telephones ▪ cordless telephones ▪ cellular telephones ▪ answering systems ▪ any other products or equipment of transmitting sound, images or other information by telecommunications	▪ notepad computers ▪ printers ▪ copying equipment ▪ electrical and electronic typewriters ▪ pocket and desk calculators ▪ any other products and equipment for the collection, storage, processing, presentation or communication of information by electronic means ▪ user terminal and systems ▪ facsimile ▪ telex ▪ telephones ▪ pay telephones ▪ cordless telephones ▪ cellular telephones ▪ answering systems ▪ any other products or equipment of transmitting sound, images or other information by telecommunications
Lighting equipment	▪ straight fluorescent lamps ▪ compact fluorescent lamps ▪ high intensity discharge lamps, including pressure sodium lamps and metal halide lamps ▪ low pressure sodium lamps ▪ luminaries for fluorescent lamps with the exception of	▪ straight fluorescent lamps ▪ compact fluorescent lamps ▪ high intensity discharge lamps, including pressure sodium lamps and metal halide lamps ▪ low pressure sodium lamps ▪ luminaries for fluorescent lamps with the exception of

	luminaries in households ▪ other lighting or equipment for the purpose of spreading or controlling light with exception of filament bulbs	luminaries in households ▪ other lighting or equipment for the purpose of spreading or controlling light with exception of filament bulbs
Consumer equipment	▪ radio sets ▪ television sets ▪ video cameras ▪ video recorders ▪ hi-fi recorders ▪ audio amplifiers ▪ musical instruments ▪ any other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image than by telecommunications	▪ radio sets ▪ television sets ▪ video cameras ▪ video recorders ▪ hi-fi recorders ▪ audio amplifiers ▪ musical instruments ▪ any other products or equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image than by telecommunications
Electrical and electronic tools (with the exception of large-scale stationary industrial tools)	▪ drills ▪ saws ▪ sewing machines ▪ equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials ▪ tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses ▪ tools for welding,	▪ drills ▪ saws ▪ sewing machines ▪ equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials ▪ tools for riveting, nailing or screwing or removing rivets, nails, screws or similar uses ▪ tools for welding,

	soldering or similar use ▪ equipment for spraying, spreading, dispersing or other treatments of liquid or gaseous substances by other means tools for mowing or other gardening activities	soldering or similar use ▪ equipment for spraying, spreading, dispersing or other treatments of liquid or gaseous substances by other means tools for mowing or other gardening activities
Toys, leisure and sports equipment	▪ electric trains or car racing sets ▪ hand-held video games consoles ▪ video games ▪ computers for biking, diving, running, rowing, etc ▪ sports equipment with electric or electronic components ▪ coin slot machines	▪ electric trains or car racing sets ▪ hand-held video games consoles ▪ video games ▪ computers for biking, diving, running, rowing, etc ▪ sports equipment with electric or electronic components ▪ coin slot machines
Medical devices	▪ radiotherapy equipment ▪ cardiology ▪ dialysis ▪ pulmonary ventilators ▪ nuclear medicine ▪ laboratory equipment for in-vitro diagnosis ▪ analysers ▪ freezers ▪ fertilization tests ▪ other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability	▪ radiotherapy equipment ▪ cardiology ▪ dialysis ▪ pulmonary ventilators ▪ nuclear medicine ▪ laboratory equipment for in-vitro diagnosis ▪ analysers ▪ freezers ▪ fertilization tests ▪ other appliances for detecting, preventing, monitoring, treating, alleviating illness, injury or disability
Monitoring and control	▪ smoke detectors ▪ heating regulators	▪ smoke detectors ▪ heating regulators

instruments	▪ thermostats ▪ measuring, weighing or adjusting appliances for household or as laboratory equipment ▪ other monitoring and control instruments used in industrial installations (e.g. in control panels)	▪ thermostats ▪ measuring, weighing or adjusting appliances for household or as laboratory equipment ▪ other monitoring and control instruments used in industrial installations (e.g. in control panels)
Automatic dispensers	▪ automatic dispensers for hot drinks ▪ automatic dispensers for hot or cold bottles or cans ▪ automatic dispensers for solid products ▪ automatic dispensers for money ▪ all appliances which deliver automatically all kinds of products	▪ automatic dispensers for money

Looking at different categories of EEE the table 3-2 shows targeted stakeholders. Among those stakeholders there telecommunication companies, revenue and tax authorities in Rwanda, suppliers of different services such as energy...

Table 3-2: Different stakeholders visited

Category	Institution	Purpose
Fiscal institutions	MAGERWA	Estimate Electrical and electronic equipment and life cycle
	BNR	Estimate Electrical and electronic equipment and life cycle
	RWANDA-	Estimate Electrical and

	REVENUE	electronic equipment and life cycle
Data management and policy	NATIONAL INSTITUTE OF STATISTICS	Estimate Electrical and electronic equipment and life cycle (MAINLY AT HOUSEHOLD LEVEL)
	RDB	Estimate Electrical and electronic equipment and life cycle used in information technology
	RHA	E-waste quantity generated by public institutions
Telecommunication	MTN, TIGO, RWANDATEL	Subscribers
Policy and standard	RURA, RBS, REMA	Policy, Regulations related to e-waste
Education	NUR,KIST, KIE, TUMBA College	Curriculum and modules related to e-waste management, e-waste perception

In order to know present and future projects that will lead to the generation of e-wastes, some Ministries (under their projects) and institutions were consulted this include:

1. MINEDUC, Ministry in the presidential office in charge of ICT, MINAGRI

   - One laptop per child project: will allow us to know the number of laptop they supply and its future plan (number of students to be given laptops in future)
   - Rwanda Network Computer (computer known as Gorilla): this project has disseminated lots of computers to secondary schools, it will help us to know the estimated number of computer that some schools have in their premises.
   - E-Soko project under MINAGRI

2. **RDB/RITA:** the Telecenter plan helped us to know the number of computers they use precisely in rural area
3. **RWANDA INSTITUTE OF STATISTICS:** as it is responsible of statistics in the country, different conducted survey helped to know estimate Electrical and electronic equipments mainly at household level.
4. **BNR and MAGERWA:** These institutions record all the equipment imported, this helped to know the EEE imported

NGOs (CARE,JICA,KOICA,WORD VISION), universities (NUR, ULK and KIST) and Technical Schools will be referred to as they possess lots of EEE (in use or obsolete).

As there is some quantity of EEE entering illegally, a questionnaire was sent to distributors and retails such as NITI Computers, MIHIR, CHAMPIONS, MFI, CAL RWANDA and COMPUTER TECHNOLOGY which are the big distributors in RWANDA and the National Police anti smuggling unity will be interviewed.

Data collected in MAGERWA, Institute of Statistics and RWANDA Revenues Authority helped to analyze the transboundary shipments and logistics of equipments susceptible to generate e-waste and its underlying driving forces, dynamics, regulations and the constraints for sustainable resource cycles.

In general the following research questions (2-9) will build on the data collected from the first one.

2. *Gather and analyze information on the country's capacity to manage e-wastes, gaps and needed interventions to strengthen the capacity where needed.*

In order to gather and analyse information on the country's capacity to manage e-waste, field visit and literature review made by interviewing some stakeholders about the methods they use to dispose the EEE, some of them are NGOs such as CARE INTERNATIONAL, WORD VISION and UNIVERSITIES (National University of RWANDA, Kigali Institute of Sciences and Technology, TUMBA College of Technology,...).

A simple survey was conducted for private sector and NGO's dealing with waste management mainly in the cities, in order to know if there are stakeholders in E-waste disposal process that include Collectors, Refurbishers and Recyclers.

Kigali City and different cooperative dealing with waste collection were consulted, mainly COOPED and other existing waste treatment companies will be visited in order to know if

- They manage e-waste by applying waste minimisation techniques which include inventory management (Storage), production process modification, volume reduction, recovery and reuse.
- EEE are disposed together with other household wastes.
- Quantity collected per year,
- Major collection sites...
- Any training received

RWANDA BUREAU OF STANDARD which is the agency in charge of control, supervise and regulate the standards was interviewed in order to know if it:

- Collects basic information on the used materials in EEE from manufacturers in order to maintain an inventory of quantity of hazardous products that any entered EEEs (in the country) contain.
- Identifies potentially harmful substances for adverse health and environment effects
- Has a list of hazardous products that are not allowed to enter in the country

This information will guide the methodology to be used in Rwanda while handling EEE.

Curriculum in the high leaning institution, NUR, KIST, MUTARA polytechnic, TUMBA High institution…was reviewed to assess if any contain the modules on solid waste management in particular e-waste or any innovative module on recycling methods.

3. *To gather and analyze e-waste management methods in the context of a global economy: current trends and future consequences.*

Apart from literature review the presets hypotheses or borrowed strategies were addressed in interview and questionnaires in order to analyse the e-waste management methods in the context of global economy. Some of these statement are reflected in this report.

- How the collection and disposal of Electronic Wastes from the consumers and the pricing policy for collection and disposal run.
- How to implement a take back scheme with country wide collection points and follow up on the recycling and disposal process of Electronic Waste and what are the consequences
- How the recycling entity which will perform activities such as to Reduce, Reuse, Refurbish and Recycle the electronic wastes can be established.

Some key question will guide the consultant during the collection of information through literature review, interviews or questionnaire

a) ***What are the current electronic waste management practices around the globe and what are the sustainability implications of them?***

This question incorporates management practices from all sides of the globe regarding how electronic waste is handled to obtain a better understanding of different methods for dealing with e-waste, as well as various components of a recycling system, infrastructure required, etc. By analyzing management, it will be possible to obtain information that will assist in determining practices that could be applicable in Rwanda.

b) ***What is the level of awareness of electronic waste and the state of electronic waste management at Rwanda?***

This question aims at getting a stronger understanding of the systems level specific to Rwanda. This question encompasses both the current reality as well as the projected future of electronic waste. Obtaining this information is vital to meet Rwanda where they are at, as well as plan for the future.

c) ***What are possible actions that could be taken to develop electronic waste management at Rwanda?***

This question aims at suggesting strategic actions for Rwanda to take and to develop e-waste management based upon the information that has been gathered.

4. *To assess the existing practices and gaps in e-wastes, in accordance to the local and regional socio-economic framework and the respective actors involved among others the following question will be addressed through literature review and interviews*.

    - Where does Rwanda stand in the implementation of international commitment in the matter of handling Electronic Waste generated in the country?
    - How are waste management, environmental monitoring and the regulation of Electronic Waste disposal are implemented in Rwanda, East Africa Community...?
    - Are the electronic equipment producers encouraging any research in developing country for the development and standard of Electronic and for recycling e-waste?

This channels will be confronted:

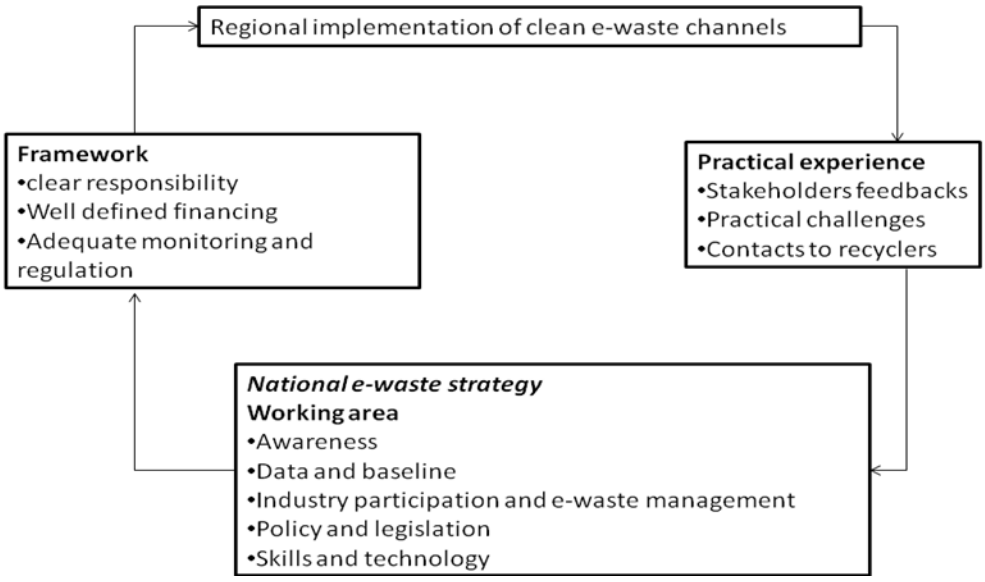


Figure 3-2: Regional implementation of clean e-waste channels to be assessed

5. *To characterize the scale of prerequisites (investment, new techniques, know-how etc.) per main step to process e-waste management in an environmentally sound way in the country, in a commercial and existing business context.*

Literature from the early mentioned institution was be documented in order to know how far is the development of legal and regulatory framework as a basis for investment, growth, and sustenance of Electronic Waste Management in Rwanda; and how Rwanda can device ways and means to encourage beneficial reuse/recycling of Electronic Waste, catalyzing business activities that use Electronic Waste; Through interview and questionnaire addressed to instutions, some key questions will guide the interview such as the institution:

- is aware that some electronic parts may be profitably recycled
- would be ready to pay for its equipment to be collected and recycled
- prepare and give some payable training or courses on E-waste treatment

RDB in collaboration with PSF and MINICOM will be consulted if they:

- plan to encourage people and companies to make E-waste an opportunity by investing in E-waste handling industry
- plan to sensitise informal business in recycling to be formalized

6. *To evaluate recycling processing alternatives in the country, given the digital divide, the local and regional framework conditions, etc. and evaluate the best technical and economic ways of linking existing and emerging markets for e-waste recycling and management.*

   Knowing the human capacity and technical capacity in Rwanda the recycling process alternatives and their economical ways was assessed: reuse and refurbishing are ones of the main methods that will be assessed. The report gives some existing either in Rwanda or elsewhere of the innovative projects undertaken and their feasibility.

7. *To define the most suitable interfaces between the main steps of the management chain in the national, regional and global context, but considering the special requirements for end processing (economies of scale, environmental infrastructure, investments etc.)*

This study explored ways and means to encourage beneficial reuse/recycling of Electronic Waste, catalyzing business activities that use Electronic Waste; through literature review and interviews.

8. *To propose the collaboration modalities with universities, technical schools, research institutions and technical institutions for sponsoring initiatives to develop small or medium innovative e-wastes management technologies suitable for Rwanda.*

The literature was reviewed in order to assess what has been done to encourage and support the ICT Sector in Rwanda to involve actively in solving the nation's Electronic Waste problems; what are the current and previous research that have been undertaken by universities, technical schools and research institution and what are their technical and human capacity. As universities are leader in innovation, they will also be contacted in order to know if the areas of research in e-waste treatment are prioritized, this means that the consultant will assess if universities are responsible to performs research, spread awareness, and facilitate implementation regarding practices, technology and systems that improve sustainability of e-waste management. Such questions will be asked, does the learning institution:

- develop e-waste management training to local community,
- disseminate research findings related to e-waste management by publishing them (locally and on e-journals, on bulletin boards,...)
- train young researchers and IT specialist in this fields

MINEDUC and Universities were interviewed in order to know if awareness programmes on safe disposal / recycling of e-waste are included in the curriculum at the Technical School and University level, apart from information of MINEDUC, our survey will be focused also on personnel interviews with some students, lecturers/Teachers and some headmaster of secondary schools. This will be done together by interviewing the human resource manager in order to know the technical capacity of their employees to deal with the problem of E-waste.

To foster partnership (in order to fund innovative research toward a good management of e-waste) with regulatory authority, recyclers, manufacturers, importers, distributors and retailers for recycling services by creating an enabling environment so as to recycle and dispose

Electronic Waste scientifically at economic costs; this was documented through literature review as there are existing programmes elsewhere (e.g HP project)

9. *To recommend practices and recycling that is appropriate for transfer back to electronic appliances back to their production countries enhance WEEE implementation.*

   It was documented on

   - What have been done to restrict against dumping Electronic Waste in Rwanda?
   - What is being done to encourage the setup and growth of an efficient, competitive and responsive Electronic Waste recycling industry in Rwanda in relation to the needs and susceptibilities of the ICT sector; is the ICT market efficiently exploited? If not why should the retailers not buy just enough?
   - What is being done to ensure adherence to social responsibility by providing of and respect for codes of practice by all stakeholders involved in Electronic Waste management;
   - What is being done to enforce labelling of all electronic devices for declaration of hazardous material contents with a view to identifying environmental hazards and ensuring proper material management and Electronic Waste disposal; and make a decision to buy or not to buy
   - In the region is there a country that has introducing take back scheme of electronic and electrical products?

Different stakeholders such as RBS, REMA and RURA were interviewed about what have been done to restrict against dumping Electronic Waste in Rwanda, this will be achieved either by:

Also an interview will be conducted about the role and responsibilities of some institutions (RURA,RBS,REMA) in E-waste management in Rwanda.

Some other key questions asked to all stakeholders:

- the cost associated with the handling, recycling, and disposal of obsolete electronic devices is the responsibility of the sellers and consumers of electronic devices, and not government or their service providers. Yes or NO

- Electronic products, components, and devices, to the greatest extent feasible, should be designed and produced for extended life, repair, and reuse. Yes or NO
- Can you support the introduction of Advance Recycling Fee (ARF) as compulsory, during the purchase of the Electronic Devices in Rwanda? Yes or NO
- What would be the role and responsibilities of different agency related to e-waste in Rwanda: the Regulatory Authority, the Environmental Authority, the Bureau of Standards and the IT Promotion Agency for Electronic Waste Management in Rwanda. Open
- Would you agree with this concept: Consumers should be obliged to return the Electronic Devices they procured at the end of their life time as Electronic Wastes to its Sellers or directly to the designated collection points? Yes or No
- What would be different responsibility of a recycler, seller, consumers…open

3.3 Methods of Data analysis and interpretation

This study adopted qualitative methods for data analysis and interpretation, which began during data collection and continued up to the time of writing the final report. This process involved the following steps:

i. Organising the multi-interviews and multi-surveys data into a format that is easy to work with; where possible, using appropriate computer assisted qualitative data analysis software
ii. Isolating patterns and processes, commonalties and differences, and connections within and between categories (i.e. the key ideas being expressed within the categories, similarities and differences in the way people responded, etc), and taking them out to the field in the next wave of data collection
iii. Interpreting the data (using key ideas/themes and connections that cover the consistencies discerned in the data base to explain the findings).
iv. Organising and combining relates themes/key ideas into categories named using own descriptive phrases or phrases in the text or in data collection instruments.

v. Confronting those generalisations with a formalised body of knowledge in the form of constructs or theories

Thus,

i. Data from secondary data sources regarding E-waste management were descriptively analyzed linking them to the consultant experiences and knowledge. Textual data from surveys, interviews, which constituted the major source of additional data, was synthesized to show the level of E-waste management in Rwanda vs. documentary sources; to establish patterns of the current institutional and individual conception in E-waste management; and stakeholders' attitudes, opinions, and general thoughts on the level of investment in the E-waste issues by the different partnerships etc.

ii. Data from Reflective Case Studies will be analyzed using historical approach on a case by case to yield detailed information for cross-national comparisons on the existing data, information on E-waste, and to inform development of future adaptive scenarios.

iii. Descriptive analysis was used to indicate percentages for categorical variables (i.e. factors that facilitate or constrain the contribution of devolved environmental management).

4 Environmental, economic and social characteristics of e-waste in Rwanda

4.1 Production and commercialization of EEE

Rwanda does not produce computer or telephone, it relies on importation of ICT equipment. In order to know the quantity of EEE entering the country, records from Rwanda Revenue Authority (RRA) have been used, RRA records imports in accordance with the Universal Harmonised System or HS system where any type of IT material has its own code but its databases do not distinguish between new and second hand products therefore difficult to know the ratio of second hand computers and other IT equipment which were imported into the country between 2000 and 2010. The mixing of different code was also a big limitation while trying to decode computer accessories and cellphone, the data from the Institute of Statistics were much clear (Table 4-1).

Table 4-1: computer EEE imported from 2004 to 2010

Type of EEE	2004	2005	2006	2007	2008	2009	2010	Total
Analogue or hybrid automatic data processing machines	4,370	5,454	6,737	8,497	3,537	-	-	**28,596**
Non portable ADP machines,comprising at least CPu& I/O unit	1,281	655	1,289	917	1,311	2,446	2,201	**10,100**
Non-portable ADP machines, nes, presented in the form of systems	814	2,242	403	102	151	876	806	**5,394**
Processing units	17	750	771	560	327	6,456	1,621	**10,502**
Input or output units, whether or not containing storage units in	749	1,808	2,525	37,249	3,368	4,986	6,790	**57,475**
Storage units	102	185	88	216	6,488	572	117	**7,768**
Other units of automatic data processing machines	959	2,103	1,859	2,276	3,952	5,509	9,233	**25,891**
Magnetic/optical readers;machines for transcribing data onto ….	518	2,677	2,131	3,156	2,387	1,302	1,488	**13,659**

There are other data that have been recovered from the RRA data presented. That show the imported different ICT material, such as desktop, radio, TV…The general view is that the importation as been increasing from 2001 to 2010, but lack of data is a big issue. The coding should be harmonized in all institution in order to know the identity of the EEE.

Table 4-2: Different EEE imported 2001 to 2010

EEE	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Desktop	1141	2263	908	4312						
Laptops	335	148	488	564	933	1303	1793			
Printers	3510	4358	4035	5,153	4,615	4,077	38,395	4,629	6,789	10,954
Fixed Phones	991	1329	1014	3334						
Radio	98313	49488	420854	568655						
TVs	7843	4722	6661	19226						

Looking at the overall ICT equipment imported as recorded in BNR, there have been a considerable increase, the ICT equipment have increase 5 times more from 2001 to 2010 (Table 4-3). The only backward of these data is that the identification of each item is very difficult, but the data are useful as they indicate the net weight which is a good indicator in e-waste treatment.

Table 4-3: Overall EEE trend

ICT product	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Quantity	144,259	85,952	455,180	185,940	149,250	112,560	143,187	187,290	91,368	1,510,103
Net Weight	545,202	499,583	525,779	664,450	1,022,041	1,560,272	1,559,651	2,100,201	3,222,061	2,513,575
CIF	8,894,214,425	5,223,126,683	4,786,201,839	6,623,859,088	12,425,703,313	14,835,911,882	14,895,960,923	18,035,120,286	44,864,541,783	37,686,220,594

In assessment of E-waste status, for comparison purpose on imported EEE in Rwanda, this study also assessed the numbers of computers imported by private sector. There was a limitation on willingness to release data and only 14% responded to the questionnaire. Among those respondents are NITI Computers, MFI office solution Rwanda, CHAMPIONS TECHNOLOGY, MICROCITY Ltd and COMPUTER HOUSE s.a.r.l.

Table 4-4: Current EEE imported by distributors and retailers in 2011

DISTRIBUTOR or RETAIR	Computers		Monitors		Printers	Photocopier	Phones	
	Laptops	Desktops	CRT	LCD			Fixed	Mobile
NITI Computers	500	450	0	280	280	10		
MFI office solution Rwanda	340	400	0	400	100	90	0	0
CHAMPIONS TECHNOLOGY	100	50	0	70	150	20	0	0
MICROCITY	150	100	0	50	50	50	0	0
COMPUTER HOUSE s.a.r.l	240	400	30	530	1090	170		
TOTAL	1280	1400	0	1330	1670	340	0	0

Among the respondents, 100% of distributors of EEE imported branded new only 1% reveal that sometimes sell second hand computers. The commonly purchased new computers are Hewlett Packard, Dell, Toshiba, Acer and IBM but few SONY brand are also imported and 100% indicated that they deal with both desktops and laptops, with 83% indicating that they deal with liquid crystal display (LCD) monitors, or flat screens. Lots of them deal with various brand of EEE except MFI Office Solution Rwanda which deal only with DELL computers and KYOCERA printers. Also findings indicated that 100% do not have any policy on extended user responsibility. The respondents did not want to reveal their import prior to 2011. Thus the comparison with the recorded data from RRA should not be made as the data for imported computer in 2011 are not yet available.

4.2 Utilization of EEE in Rwanda

4.2.1 Comparison of EEE usage in public and private sector

EEE in Rwanda is used by consumers that include public and private institutions, NGOs, individuals, etc. UN system, NGOs and the government in ICT sector are the major consumer of electrical and electronic equipment in Rwanda as reported in Rwanda Development Indicator done by

National Institute of statistics of Rwanda in collaboration with RDB/RITA in 2006. For instance estimated level of computers usage by staff per sector in 2006 is presented in table 4-5.

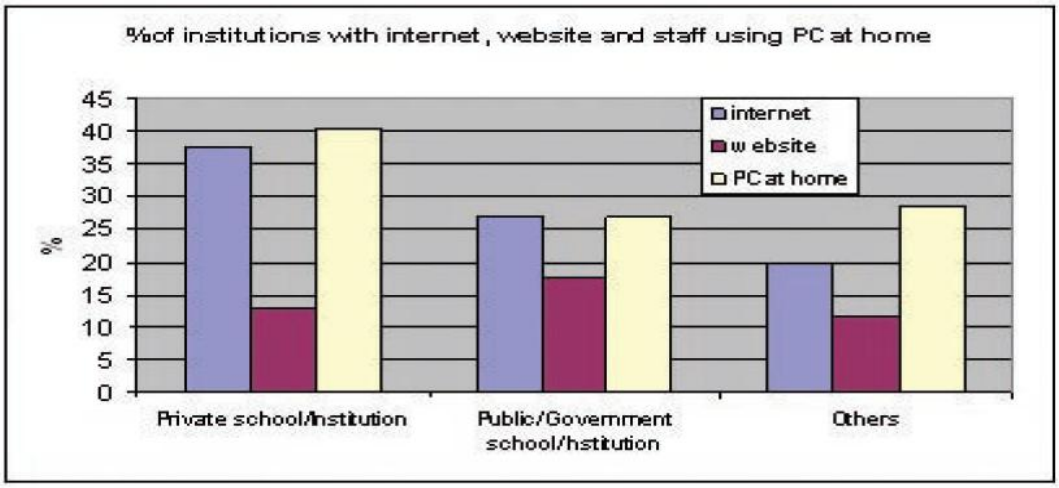
Table 4-5: Estimated level of computer usage by staff

	Estimated level of computers usage by staff			
Sectors/institutions	0 - 25%	50%	75%	100%
Public sector	30	11	22	37
Private sector	35	15	23	27
NGOs	9	23	26	42
UN system	14	0	**14**	**71**
	Low usage	Medium usage	intensive usage	

Source: ScanICT 2006 (INSR, RITA)

This table shows us that the UN System reported the highest level of ICT intensive usage with 85%, NGOs sector came in second position with 68% while the public sector performed more than the private sector with an intensive usage rate of 59% versus 50%.

According to the same report, ICT penetration in different sectors such as education, health sector, household, etc, is represented in figure 4-1.



Source: ScanICT 2006 (INSR, RITA)

Figure 4-1: ICT penetration in different sector

The figure 4-1 indicates the percentage of educational institution with internet, website and Teachers using PC at home, where private schools and institutions had a better access to internet with 38% versus 26% to public sector (public schools and institutions) and public schools had a better rate of 18% regarding web presence versus 13% for private schools. Rwanda's ICT industry is growing fast, to date those data have changed almost all schools and public institutions have computers. Moreover, with government initiatives such as *"one laptop per child"* the number of users is rising.

The following figure 4-2 shows the percentage of health institutions with PC, internet & website in 2006.

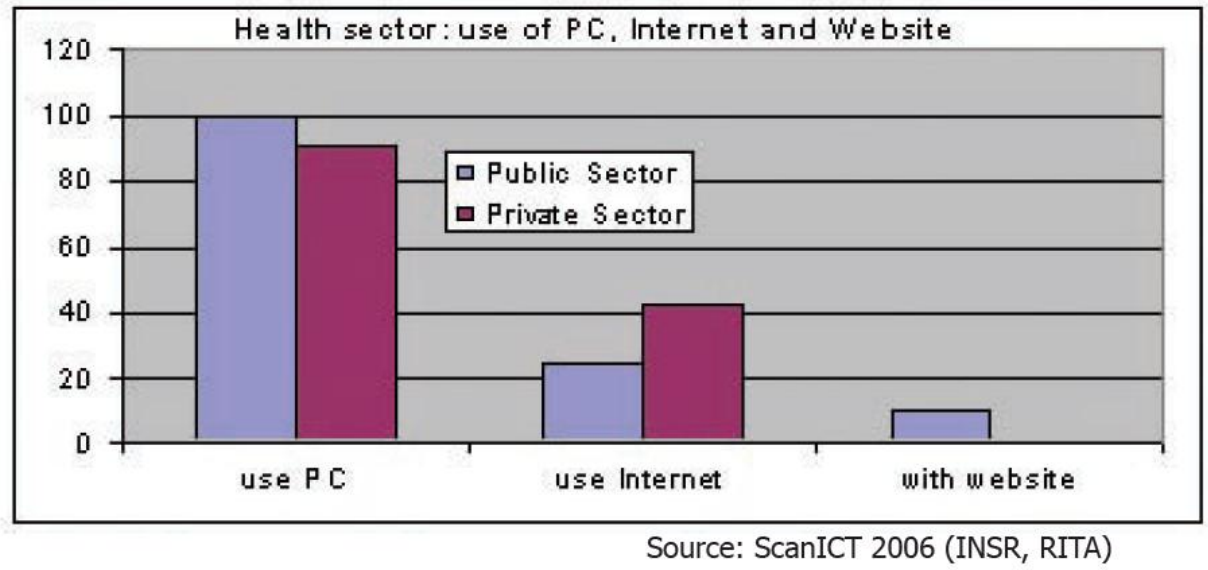


Figure 4-2: Health sector with PC and internet

The Demographic and Health survey (DHS) in 2005, indicated that at household level 4.6 % of the whole population possessed a mobile phone, with 24.1% of urban population in possession of a mobile phone. These results have much more increased with the new mobile phone provider in the country such as TIGO and Rwandatel as shown on table 4-8.

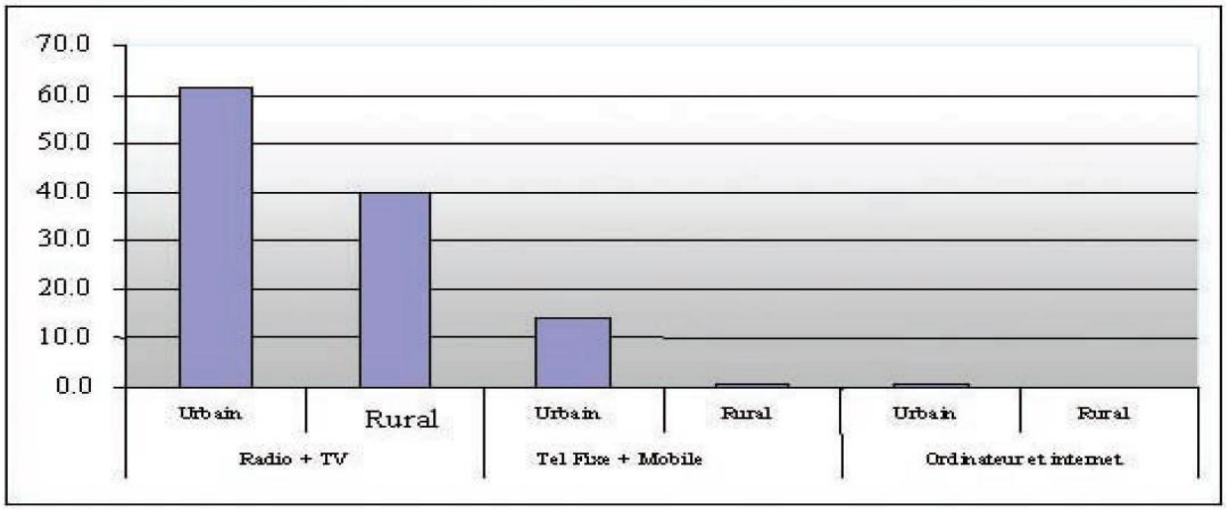
Table 4-6: Household possessing EEE (%)

Percentage of households possessing various durable consumer goods, by residence, Rwanda 2005

Durable consumer good	Residence		Total
	Urban	Rural	
Radio	65.2	42.5	45.8
Television	14.0	0.3	2.3
Mobile telephone	24.1	1.3	4.6
Non-mobile telephone	4.8	0.1	0.8
Refrigerator	7.7	0.1	1.2
Bicycle	10.5	11.1	11.0
Motorcycle/scooter	1.8	0.3	0.5
Car, truck	4.2	0.1	0.7
None of the above	31.7	55.5	52.0
Number of households	1,510	8,762	10,272

Source: DHS 2005

It appears that the urban rate for ICT indications (Figure 4-1) on Radio, phones and PC was much higher (61%, 14% and 0.8%) than the rural side with respectively 40%, 0.6% and 0, 01%). This gap was due basically to access facility like electricity, mobile network coverage with a higher density in urban than in rural.



Source: RGPH 2002, DHS 2005, EICV2 2005

Figure 4-3: ICT indications in Rwanda

4.2.2 Cellphone utilisation and trend

As far as cell phones is concerned, in Rwanda the mobile phone is becoming more and more the most used communication tool, its penetration has increased since the introduction of a third operator in GSM technology. MTN RWANDACELL, TIGO and RWANDATEL have increased their subscriber's number by offering low cost services both in voice and data due to competition, the following tables shows the penetration of cell phone from 2005 to 2009.

Table 4-7: Phone penetration in Rwanda

Indicators	Unit	2005	2006	2007	2008	2009
Tele density (fixed lines)	%	0.27	0.23	0.25	0.15	**0.34%**
Mobile phone penetration	%	1.59	2.5	6.83	14.75	**24.8%**
Public payphones	Number	6,611	8,000	8,449	7,244	**9,371**
Percentage of population covered by mobile cellular networks	%	80	85	90	92	**95**

The situation in 2009 is presented in the following table regarding the number of subscribers

Table 4-8: Mobile phone subscribers in 2009

Indicators	Unit	2009	2011 (not published)
MTN Mobile subscribers	Number	1,854,314	±3000000
RWANDATEL Mobile subscribers	Number	479,371	
TIGO Mobile subscribers	Number	95,567	±360000
MTN Fixed subscribers	Number	8,461	
RWANDATEL Fixed subscribers	Number	24,981	
TIGO Fixed subscribers	Number	9	

The Rwanda Utilities Regulatory Agency (RURA) had set a target of accelerating the number of Rwandans with a mobile phone to six million by 2012 representing a mobile penetration of 60%. RURA statistics indicate that between December 2010 and January 2011, mobile market grew by 2.1% or additional 77,654 new users. The combined active mobile subscribers of the existing three national operators -MTN, Tigo and Rwandatel- stood at 3.6 million in January from 3.5 million a month before.

If the market continues to grow by 2.1% or 77,654 new users every month, mobile users could hit 4,480,609, which is pretty below the six million mark in 2012. The slow growth could be explained by the exiting high call tariffs from one network to another because of prevailing high cost of interconnection. It could also be linked to low network coverage, which limits some parts of the country from accessing mobile services as TIGO has not yet covered the whole country.

Figure 4-2 shows that the mobile users has been increasing since 2000 at the expense of fixed phone, and it is currently estimated to be around three millions users.

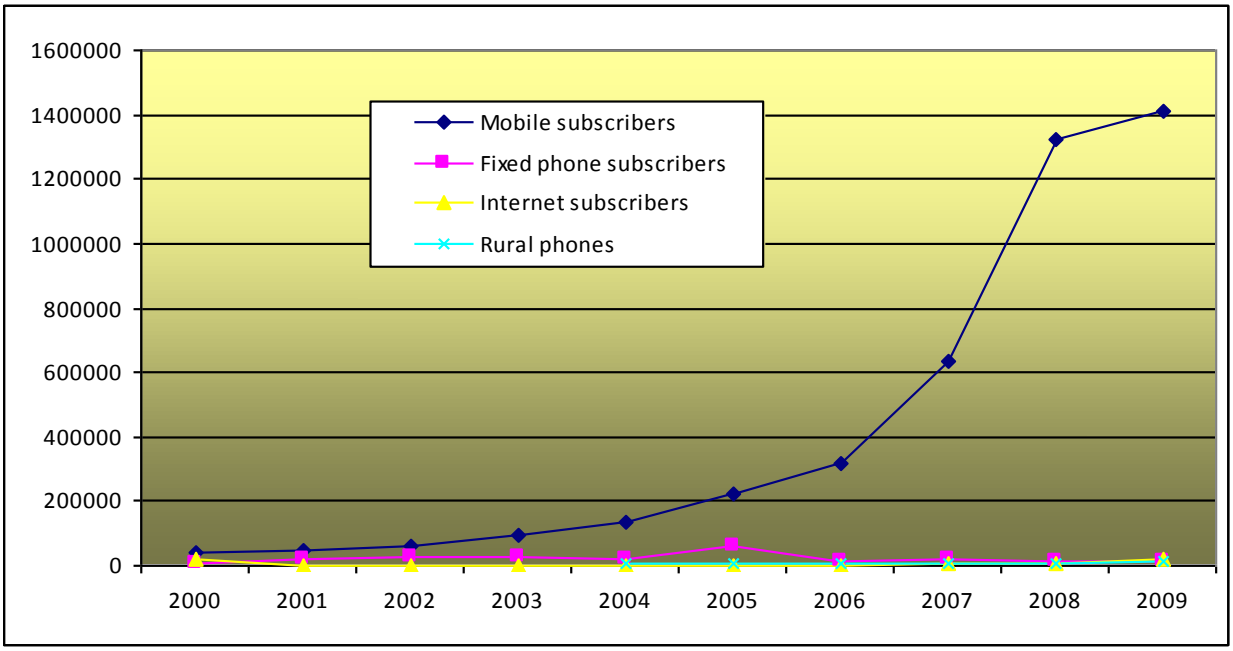


Figure 4-4: ICT usage trend

4.2.3 EEE in public institutions

Respondents consulted in different institutions, categorized ICT imports as brand new, refurbished and old. Brand new imports constitute a large share because the government recently "stopped importation of old ICT equipment". Respondents also revealed that although warranties are provided to users, there are some poor quality imports especially mobile handsets. Some donations which are mostly taken to schools are also too old for use." The tables below show the number of electronic equipment in Ministries and Government institutions.

Table 4-9: Working and non working EEE in public institutions

EEE	COURT SUPREME		HAUTE COURT		SENATE		PARQUET GENERAL		CNTS		PNILP		TB UNIT		TRAC PLUS		CHAMBER OF DEPUTIES	
	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW
Desktop	69	44	7	3	43	8	29	13	22	5	25	3	18	4	24	0	112	25
Laptops	8	6	0	0	59	8	12	4	9	1	11	13	24	1	55	2	69	38
Printers	59	23	2	1	51	10	15	7	11	8	13	3	13	3	29	2	82	10
Fixed Phones	12	5	10	4	11	5	15	7	8	3	9	4	11	3	14	2	22	4
Keyboard	69	32	9	2	41	6	32	0	26	4	25	1	13	1	26	3	112	19
RCB	68	21	9		44	11	34	5	27	5	23	2	18	0	27	1	116	23
UPS	49	38	4	9	11	4	12	15	14	21	14	6	9	7	17	1	13	1
Router	4		1	0	0	0	3	3	2	0	1	1		0	1		10	0
Scanner	2	4	0	0	2	0	4	0	2	0	0	0	1	0	2	1	2	0
Modem	0	0	0	0	3	0	0	0		0	1	0	2	0	1	0	20	1
Server	0	0	2	0	0	0	2	0	1	0	1	0	0	0	0	0	9	0
Mouses	72	9	8	0	41	1	39	2	24	2	22	1	11	1	26	0	116	21
Switch	3		1	0	3	3	4	4	3		1	1	1	0	5	0	5	0
Speakers	16	1	2	0	2	0	7	1	0	0	3	3	0	0	0	2	8	0
Total	431	183	55	19	311	56	208	61	149	49	149	38	121	20	227	14	696	142
Total of EEE	614		74		367		269		198		187		141		241		838	

Table 4-10: Working and non working EEE in public institutions

EEE	RSSP		NCHE		NLC		REMA		NPS		TIG		OLPC	
	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW
Desktop	22	1	14	0	28	3	64	6	26	0	19	3	0	0
Laptops	2	2	3	0	5	0	21	8	0	0	35	0	62526	0
Printers	13	1	16	0	26	3	39	9	14	1	17	4	0	0
Fixed Phones	7	2	9	3	8	1	10	3	6	1	5	1	0	0
Keyboard	20	0	11	1	30	1	66	2	26	1	19	1	0	0
RCB	21	1	12	0	30	2	64	0	24	1	1	0	0	0
Modem	1	0	0	0	1	0	2		0	0	20	1	0	0
UPS	18	3	9	1	25	5	25	13	21	1	17	3	0	0
Scanner	1	0		0	2	0	5	1	0	0	0	0	0	0
Mouse	18	0	11	0	29	2	61	0	27	0	21	1	0	0
Speakers	0	0	2	0	18	3	4	0	9	0	0	0	0	0
Server	0	0	1	0	11	0	3	0	0	0	1	0	0	0
Switch	0	0	0	0	2	0	4	0	4	0	0	0	0	0
Router	0	0	0	0	0	0	9	1	0	0	0	0	0	0
Total	123	10	88	5	215	20	377	43	157	5	155	14	62526	0
Total EEE	133		93		235		420		162		169		62526	

Table 4-11: Working and non working EEE in public institutions

EEE	MINISANTE		MINADEF		MININFRA		MINAFET		MINAGRI		MINALOC		MINEAC		MINECOFIN		MIFOTRA		MIGEPROFE		MIDIMAR	
	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW
Desktop	47	14	-	-	37	35	58	21	24	2	48	14	18	1	206	1	92	33	18	1	37	0
Laptops	12	1	-	-	63	5	23	3	20		41	17	25	0	65	0	11	1	12		9	0
Printers	37	13	-		66	34	64	19	32		59	13	17	1	92	3	24	60	16	3	30	0
Fixed Phones	39	5	-	-	41	8	52	5	41	7	35	5	16	2	95	2	41	6	28	4	0	0
Batteries	0	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	1	0
Keyboard	46	9	-	-	36	38	49	27	23	0	48	11	21	0	225	0	83	12	19	1	40	0
RCB	43	6	-	-	50	57	46	34	26	0	53	16	20	0	218	0	70	30	18	2	40	0
UPS	40	15	-	-	11	24	50	14	20	0	0	0	3	0	21	5	32	15	4	2	1	1
Router	2		-	-	2	0	1	0	2	0	0	0	0	0	2	0		1	0	0	2	0
Server	2	1	-	-	5	0	4	0	0	0	0	0	1	0	17	0	4	2	2	0	3	0
Mouse	51	4	-	-	38	14	56	13	23	0	45	5	21	0	154	3	79	33	23	0	40	0
Switch	9		-	-	12	0	23	0	1	0	0	0	0	4	16	0	5	0		0	5	0
Speakers	3	2	-	-	15	1	27	2	2	0	8	2	6	0	18	0	20	0	5	0	0	0
Scanner	6	0	-	-	6	2	10	1	2	0	1	4	8	1	0	0	4	1	0	0	0	0
Modem	2	0	-	-	1	0	6	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
Totl	339	70	-	-	383	218	469	139	216	9	339	87	157	9	1129	14	525	194	145	13	208	1
Total EEE	409		-		601		608		225		426		166		1143		719		158		209	

Table 4-12: Working and non working EEE in public institutions

EEE	MINEDUC		MINELA		MINICAAF		MINICOM		MINIFOM		MINIJUST		MININFOR		MININTER		MINISPOC		PRIMREAT		MINIYOUTH	
	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW
Desktops	82	2	30	8	11	0	107	1	29	0	85	7	13	1	27	4	30	5	31	4	19	2
Laptops	9	0	18	1	3	0	30	0	5	0	26	5	4	0	8	2	23	1	9	2	13	0
Printers	61	10	22	3	6	0	33	3	20	0	41	14	3	0	24	3	38	4	19	3	15	1
Fixed Phones	100	11	30	8	11	0	39	2	15	3	82	12	13	1	21	4	16	3	30	3	12	1
Speakers	22	2	6	0	2	0	59	0	0	0	4	0	2	0	13	0	11	1	8	0	0	0
Keyboard	81	7	21	2	11	0	88	1	30	0	79	9	13	1	30	2	45	3	32	9	18	0
RCB	89	8	23	4	11	0	87	2	30	0	80	4	13	1	30	2	45	2	31	8	21	1
UPS	15	8	20	1	1	0	19	0	8	0	77	11	3	0	21	4	28	16	5	1	23	2
Router	2	0	0	0	0	0	2	0	0	0	0	2	0	0	3	0	0	0	2	2	0	0
Scanner	8	1	9	1	1	0	9	0	3	0	2	2	0	0	1	0	11	1	7	1	1	0
Mouse	73	8	26	4	12	0	98	1	27	0	84	3	13	1	29	0	41	0	31	3	18	0
Switch	0	1	12	0	3	0	4	0	0	0	3	0	2	0	3	0	16	1	6	3	5	0
Modem	1	0	4	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	9	0
total	543	58	221	32	72	0	575	10	167	3	564	69	80	5	210	21	304	37	211	39	154	7
Total EEE	601		253		72		585		170		633		85		231		341		250		161	

Table 4-13: summary of EEE in public institution

EEE	Tot W	Tot NW	Total of EEE
Desktop	1571	274	1845
Laptops	63268	121	63389
Printers	1119	272	1391
Fixed Phones	914	140	1054
Batteries	61	0	61
Keyboard	1563	206	1769
RCB	1562	249	1811
UPS	660	247	907
Router	51	10	61
Scanner	112	21	133
Modem	78	2	80
Server	69	3	72
Mouses	1508	132	1640
Switch	161	17	178
Speakers	302	20	322
TOTAL	72999	1714	74713

Table 4-12 shows that in public institution, there is a big number of laptop, as the use of desktop has been slowed down by the technology and a big preference on using the laptops as there are called personal computer, they can be used in office and home.

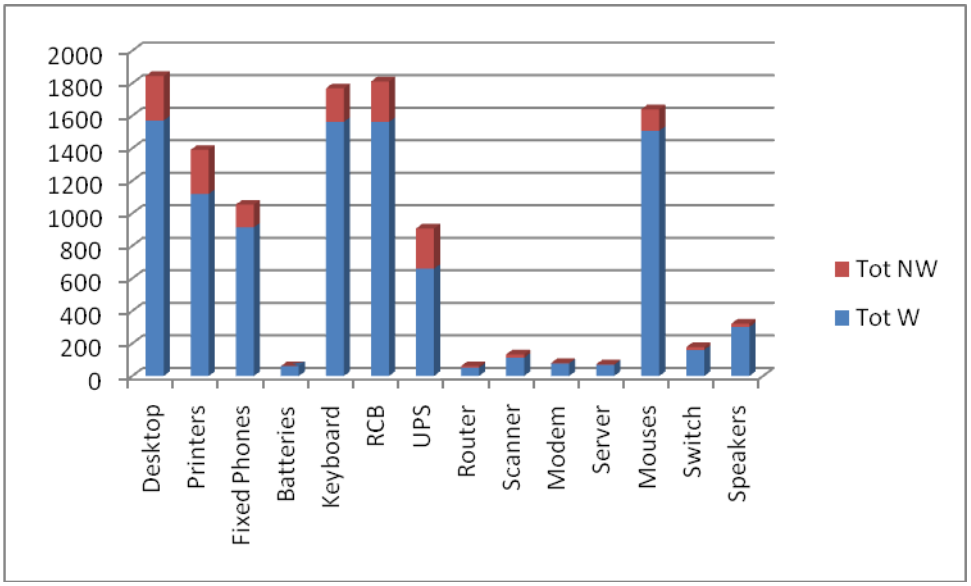


Figure 4-5: Working and non working EEE except laptops in public institutions

By omitting the laptops, 14 % of EEE found in public institutions are not working, desktop and printers constitute a very big number on non working EEE. Among those institutions, Mifotra has a very big number of EEE of 719 and Mininfra has a high ration non working and working of 57 %. The whole total number of the EEE in public institution is almost reaching 75000. These data were generated only from institutions in Kigali city, the EEE are much more higher than these number, taking into account the whole country.

4.2.4 EEE in high learning institutions

The following quantity of EEE has been identified at universities and some of them discarded or obsolete are stockpiled in their premises.

Table 4-14: EEE in high leaning institutions

EEE	UNIVERSITIES											
	KICUKIRO COLLEGE OF TECHNLOGY						KIGALI INSTITUTE OF EDUCATION					
	Possession	Age (years)	In use	obsolete	Replacement plan (years)	disposal	possession	Lifetime	In use	obsolete	Replacement plan (years)	disposal
Television sets	Yes				Over 5 years	Not yet	Yes	13	2	1	Over 5 years	Stored
Computer sets with CRT monitors or LCD Monitors and Notebook	Yes	3			3-4 years	Not yet discarded	Yes	13	1200	510	4-5 years	Stored
Photocopier	Yes	3			3-4 years	Not yet discarded	Yes	13	70	38	4-5 years	Stored
Printers	Yes	3			Over 5 Years	Not yet discarded	Yes	13	74	26	Over 5 years	Stored

Audio equipment	Yes	3			Over 5 Years		Yes	13	45	13	Over 5 years	Stored
Mobile Phones							yes					
Refrigerators	Yes	3			Over 5 Years	Not yet discarded	yes	13	10	2	Over 5 years	Stored
Air Conditioners	Yes	3			Over 5 Years	Not yet discarded	yes	10	50	5		Stored
batteries							yes	5	20	40		Stored
Others							yes				1-2 years	Stored
EEE	UNIVERSITIES											
	KIGALI HEALTH INSTITUTE						KIST					
	Possession	Age (years)	In use	obsolete	Replacement plan (years)	disposal	Possession	Age (years)	In use	obsolete	Replacement plan (years)	disposal
Television sets	Yes	5	5	3	Over 5 years	Donate to schools	yes	8	2	1	Over 5 years	Stored
Computer sets with CRT monitors or LCD Monitors and Notebook	Yes	8	160	20	3-4 years	Donate to schools	yes	8	1200	825	3-4 years	Stored
Photocopier	Yes	6	3	7	Over 5 years	Donate to schools	yes	5	3	1	Over 5 years	Stored
Used radio												
Printers	Yes	5	42	25	Over 5	Donat	yes	7	5	1	3-4	Stored

					years	e to schools					years	
Audio equipment	Yes		4	3	0-1 year	Donate to schools	yes	4	12	3	0-1 year	Stored
Mobile Phones	Yes	3	3	0	0-1 year	Donate to schools						
Refrigerators	Yes	3	9	0	1-2 years	Donate to schools	yes	3	12	0	Over 5 years	
Air Conditioners	Yes	5	9	3	0-1 year	Donate to schools	yes	5	18	0	Over 5 years	
batteries	Yes	3	30	0	1-2 years							
Others	Yes	8	160	200	0-1 year							

EEE	UNIVERSITIES											
	TUMBA COLLEGE OF TECHNOLOGY						ULK					
	Possession	Age (years)	In use	obsolete	Replacement plan (years)	disposal	Possession	Age (years)	In use	obsolete	Replacement plan (years)	disposal
Television sets							yes	5	3	0	Over 5 years	
Computer sets with CRT monitors or LCD Monitors and Notebook	yes	1			3-4 years	Not yet discarded	yes	5	241	30	1-2 years	stored

Photocopier	Yes	15			3-4 years	Not yet discarded	yes	6	6	4	2-3 years	stored
Used radio												
Printers	Yes	15			3-4 years	Not yet discarded	yes	6	20	3		stored
Audio equipment												
Mobile Phones	Yes	15			3-4 years	Not yet discarded						
Refrigerators												
Air Conditioners	Yes	15			3-4 years	Not yet discarded						
batteries												
Others	Yes	15				Not yet discarded						

Our research reveals that all computers have approximately a lifetime of 4 years as universities plan to replace them but other ICT equipments such as Printers, photocopier, Television set,… have the lifetime extended to over 5 years. Only KHI plans to disposal its EEE by donating to schools.

According to NCDC website (National Curriculum Development Centre) there isn't any course on WEEE precisely on secondary level[1]. The field study and consultation to the websites, no courses about E-waste in Rwandan universities but there are some courses that can help for better E-waste management and sustainability.

At Kigali institute of Science and Technology (KIST)**,** some courses may help in E-waste management such as

- ✓ Basic Electronics Engineering,
- ✓ Fundamentals Of Electrical Engineering,
- ✓ Computer And Information Systems,
- ✓ Computer Hardware and Maintenance,
- ✓ Operating System

At **Tumba college of Technology (TCT)** which is a technical college, integration of some courses complementary with the courses they teach can also help, according to the curricula in Electronic and Telecommunication and IT departments the main objective of the course is to have fundamental knowledge for becoming practical engineer in the domains of:

- ✓ Repair, Assembly and Maintenance of electronic devices where they have fundamental technology to design, assemble, maintain and repair electronic circuits
- ✓ Cable communication
- ✓ Wireless communication

The first one can be helpful in dismantling the WEEE.

At National University of Rwanda (NUR)**,** some researches have been conducted about E-waste such as a research entitled '' *development of NUR land environmental baseline: case of electronic wastes and other metal based wastes management''*

[1] http://www.ncdc.gov.rw/O'LEVEL%20NEWCURRICULUM.html

The results show that printers, keyboards and screens dominate the total amount of NUR E-waste collected. And other types are found in low proportions: Keyboards (10.52%), CPU (10.77%), Printers (1.78%), Photocopiers (0.81), Fax phones (0.3%), Machine in general (2.09), Mice (1.58%), UPS (uninterruptible power supply) (1.07%), and the Rest (58.01%).[2]

It reveals that there are no disposal facilities in NUR for hazardous wastes. However, The Estate Unity is responsible for the collection of all solid waste in NUR, recently they collect also some ICT equipment to be auctioned, and all those WEEE are disposed in dumping sites in Estate premise.

Briefly, universities should be the areas of research in e-waste treatment by spreading awareness, and facilitate implementation regarding practices, technology and systems that improve sustainability of e-waste management. To achieve this, the universities should:

- Disseminate research findings by posting them on the clearing house and the bulletin board as well as publishing them in e-journal and writing them on CDROM.
- train young researchers and IT specialist in this fields
- Develop a web-based bulletin board for educating the general public about effects of e-waste and the need to adhere to strict procedures of e-waste management.
- Increase funding for research projects and initiatives to develop infrastructure and markets for electronics recycling programs and derived materials (as leaders in E-waste)
- develop training modules on e-waste management for researchers, students as well as other people interested by E-waste management

4.3 Disposal of EEE

The use of EEE is different depending of interest and the disposal methods differ from one user to another user. In public office, it was found that users wait for the government institution in charge of disposing the waste to come and decide on their behalf. While in private sector, the EEE can be disposed due to many factors such as upgrading technology or malfunctioning of the EEE.

The research noted that 40% of the respondents have discarded EEE of some kind and other 60 % revealed that they are still using their computers although there are old, and all have passed 5 years old. There are therefore qualified as waste. Particularly, 80% have discarded desktop computers and

[2] Research conducted by Eng. GAFISHI M. Clement

monitors due to the fact that in tenders when they bought new computers they replaced old one by LCD monitor; 1% have discarded notebook computers and flat screen due to the fact that they were in a broken and unfixable state, 20% have discarded printers due to the lack of spare parts to be replaced, all these EEE are to be considered as waste and are stored either at GIKONDO or has been sold through auction.

Currently in Rwanda, E-waste are disposed together with other municipal waste in landfill, but many of the e-waste are still stored in office and homes. There is not any formal method of recycling and the e-waste cycle in Rwanda does not follow the normal process disposal using the known processes from collection to final disposal as described below:

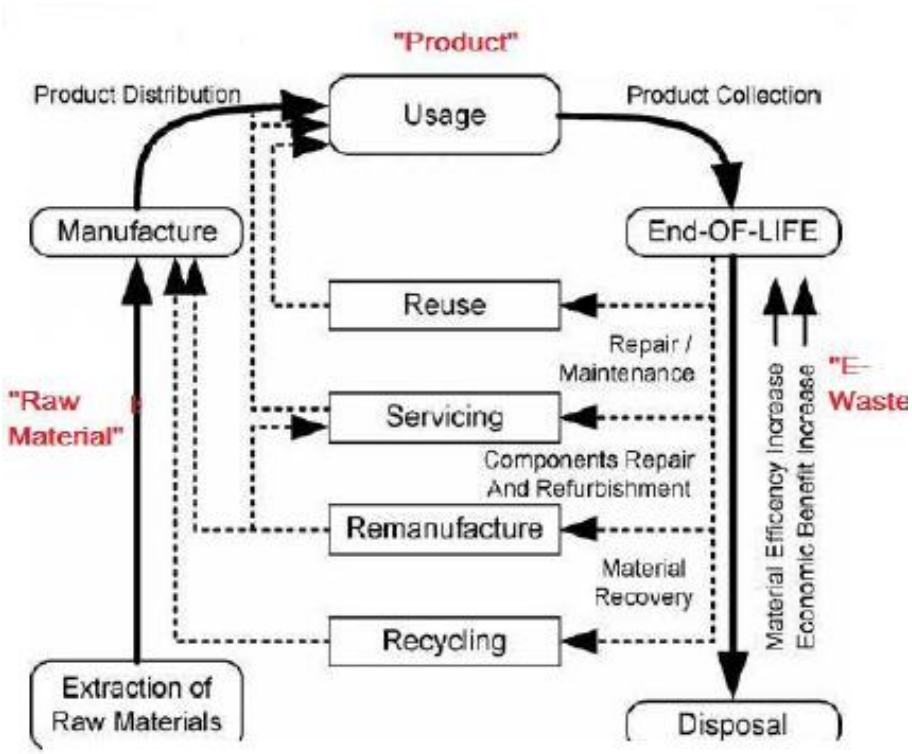


Figure 4-6: EEE life cycle

Figure 4-3 shows the EEE life cycle in Rwanda. It should be noted that the recycling and remanufacturing is not included as they do not exist in Rwanda.

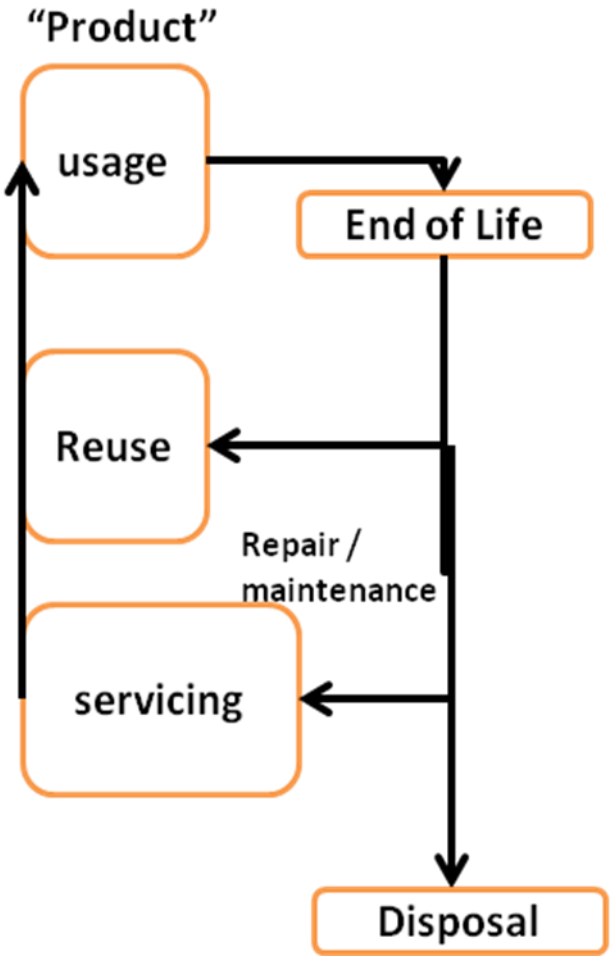


Figure 4-7: EEE life cycle in Rwanda

4.3.1 Collection

Collection systems depend on the regulation of each country. The objective of collection systems is to provide E-waste management services at reduced costs to the consumers i.e. household or business and ensure compliance at the national level. In Rwanda there are three main methods used, not only targeting the e-waste but targeting the solid waste in general, these are found in city.

- Permanent drop-off facility such as Nyanza landfill
- Special drop-off events: allocated days of collection of solid waste, usually the landfill is located near by the generated waste
- Door-to-door pick-up: it is organised locally by waste management association or individuals who use the waste to generate fertilizers or in craft industry.

The current and emerging methods will be described in chapter 5.

Old EEE collected from governmental institutions are stored at GIKONDO under the supervision of Rwanda Housing Authority (RHA) which will plan how to auction them[3]. Others are still in store of those institutions. Some of those old EEE have been discarded due to the fact that new EEE have been thus the old out of fashion EEE replaced or they were broken and could not be fixed due to lack of capacity or spare parts. All those WEEE stored at GIKONDO are mixed with other waste including waste from office furniture (tables, chairs...). It has been difficult to estimate the quantity of all the waste in that Gikondo store, it is recommended to separate the e-waste from the other solid waste stored within.

At household, most of consumers in Rwanda do not have the culture to throw or give away their stuff even if disposal opportunities are available, thus lots of E-waste are stored for prolonged period at homes. This could pose potential problem particularly in the collection process of electronic waste and could be due to a number of reasons or a combination thereof including:

- Possessions can be perceived as a sign of wealth;
- Products encompass strong sentimental value;
- Apprehension that products, though unusable, may still hold financial value and therefore are not disposed of or given away.

A varied response was obtained concerning the end of life disposal of electronics. Participants in high learning institution were asked, "When your electronic dies, what will you most likely do with it?" Some participants indicated that they would consider multiple end of life methods for their electronic. The results are show below.

[3] Interview with agent from Rwanda Housing Authority

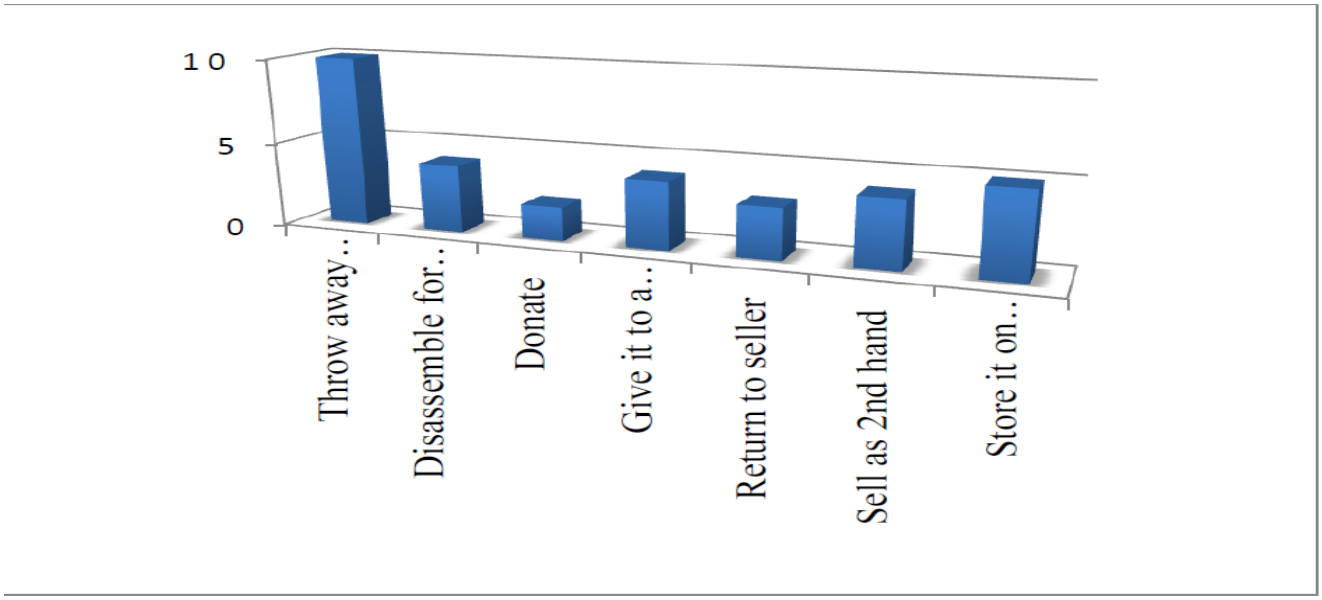


Figure 4-8: Preferred disposal methods in high learning institutions

Once the product (e-waste) is released they are usually sent in repair shops by the owner who was seeking for maintenance or refurbishment and kept there for long. As there is limited national capacity to process e-waste, repair shops after extracting some useful parts the remaining parts are stockpiled in their house or mixed with other solid waste as shown in the following figure 4-9.

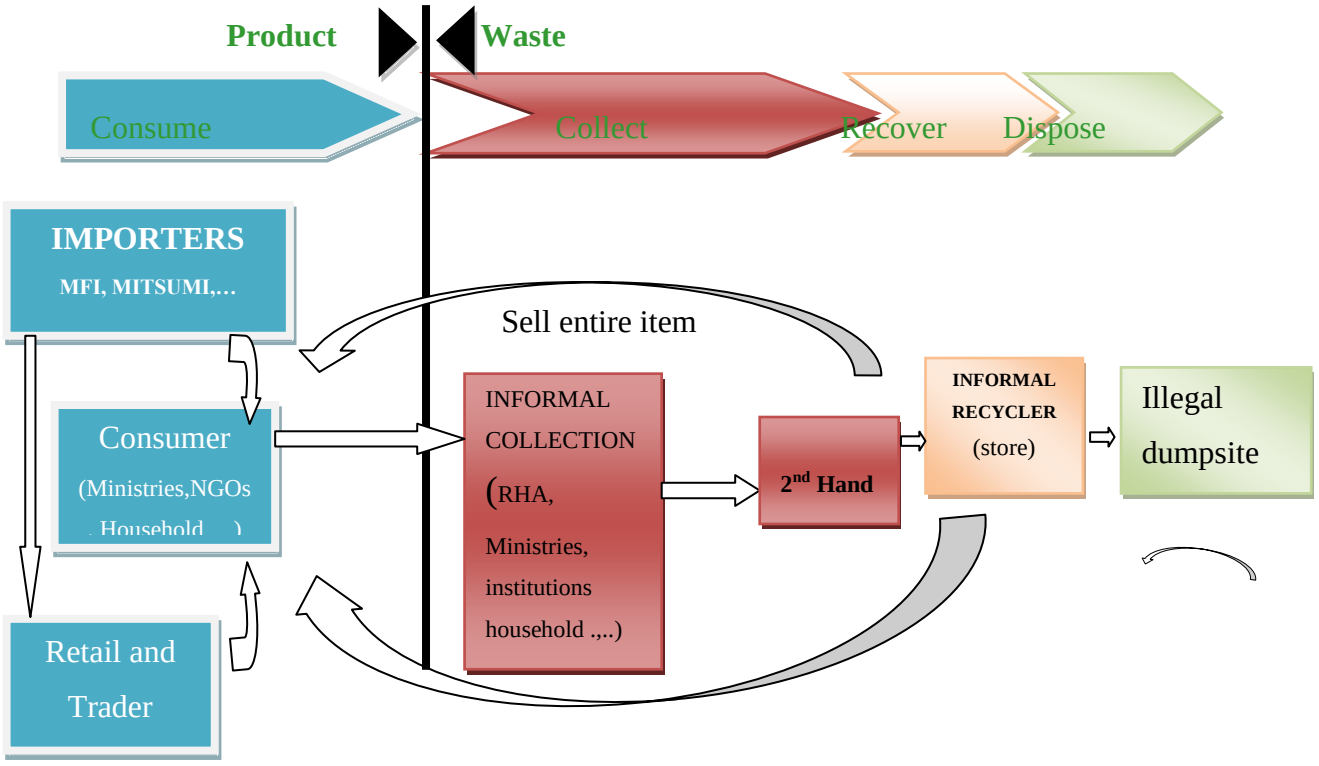


Figure 4-9:Current E-waste massflow in Rwanda

Figure 4-9 shows that in Rwanda, consumer buys computer, printers and phones either from an importer or a manufacturer who supplies directly to the market or through a retailer. After the end-of-life of these EEE, the disposal process commences. In Rwanda only informal collectors exist to collect the E-waste. These EEE may be fed into the second-hand market which seeks to extend the life cycle of the EEE by refurbishing them. This may involve changing some parts of that WEEE to make it operational. Once repaired, the computer is sold again to a consumer as a second-hand or as parts (power supply, DVD drives, hard disc…) and the process is repeated.

It has been indicated that COOPED is dealing only with solid waste in the Kigali city as formal company but it has a plan in future to deal with WEEE, in its waste recycling activities include plastic recycling and they deal only with some kind of plastic such as medical plastic waste[4] regardless those from computers or screens.



Figure 4-10: (a) ***Unloading of trucks to the disposal site*** ***(b) Plastic waste to be recycled by COOPED***

Collection of E-waste is of crucial importance as this determines the amount of material that is actually available for recovery; E-waste collection system consists of producer/ retailer take back system, municipal collection system and recycler's/ dismantler's collection system.

Best collection will ensure reuse, recycle and adequate management including avoiding damage or breaking components that contain hazardous substances. The major factors, which determine the efficiency of collection system, are given below.

- accessible and efficient collection facilities
- ensure minimal movements of products

[4] http://www.afrikaverein.de/_uploads/media/1384_Plenary%20Session%201%20Buregeya%20COOPED.pdf

- minimize manual handling
- aim to remove hazardous substances
- separate reusable appliances
- adequate and consistent information to the users.

4.3.2 Dismantling and pre-processing

In our country only dismantling is done when repairers want some parts that they want to reuse not for recycling purposes. The remains parts are stored in their premises.

In this step, there is liberation of the materials in order to direct them to adequate subsequent final treatment processes. Dismantling is done either by manual or by mechanical treatment (shredding and sorting). It includes the following steps:

- ✓ Removal of parts containing hazardous/ dangerous substances (CFCs, Hg, switches, PCB).
- ✓ Removal of easily accessible parts containing valuable substances (cable containing copper, steel, iron, precious metal containing parts, e.g. contacts)
- ✓ Segregation of hazardous/ dangerous substance and removal of easily accessible parts

Sometimes dismantling is done together with Segregation of ferrous metal, non-ferrous metal and plastic. The details will given in chapter 5. The following picture shows how to dismantler and separate the part of a desktop:

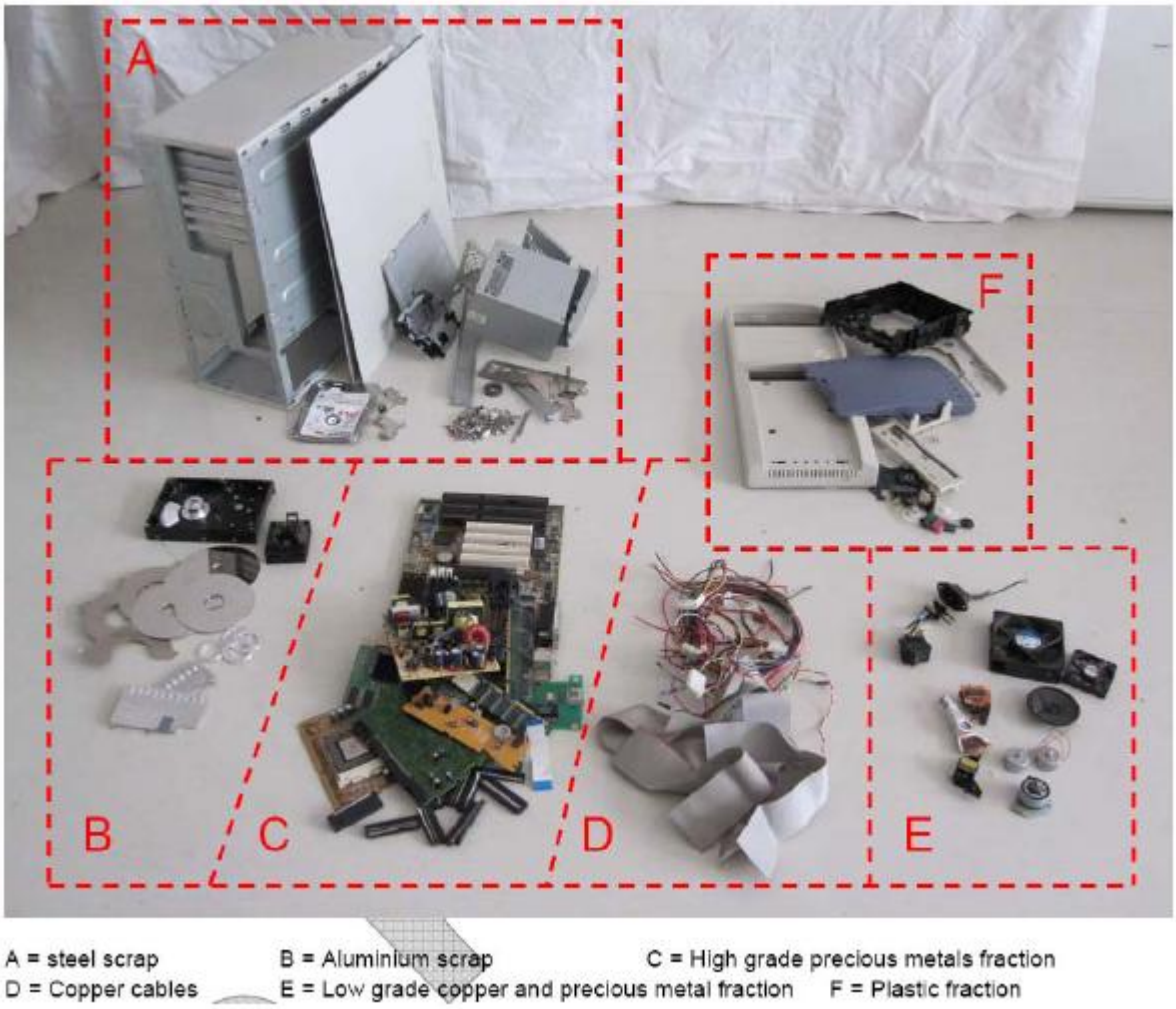


Figure 4-11: Dismantled fraction

100% of informal recyclers/repair shops indicated that they deal only with second-hand, while 90% of the those repair shops used their parts as spare parts, remaining 10% sell the second hand after repairing them (reuse) and sometimes they buy new spares parts to make a clone computers and sell them to high cost in secondary schools or individuals. The following table shows us some respondents:

Table 4-15: Refurbishment activities in Rwanda

SMALL COMPANY OR TECHNICIAN	WASTE GENERATED
Viateur	Unknown but he can repair 10 to 20 computer/week by using extracted components in old computers
FORMATECH TECHNOLOGY[5]	Unknown but he can repair 30 to 40 computer and 10 printers per week by using extracted components in old equipments and sold some used motherboards, mouse, keyboards, printers,etc
COMPUTECH (informal company)	Unknown but he can repair 6 to 24 computer and 10 printers per week by using extracted components in old equipments and store many WEEE

Some Informal computer Collector/ Refurbishers interviewed.

Lots of collectors are also refurbishers as they collect WEEE in order to refurbish them and sell to the market again. Also, a personal interview showed that ELECTRO (formal company) whose main activities are to refill ink cartridges for printers, has lots of clients where they refill approximately 8 cartridges per week.

4.3.3 End processing of metal- and non-metal fractions.

In our country after dismantling of the parts, the separated parts are stored in order to reuse them, this step does not exist in our country. The technology will be discussed in chapter 5.

4.4 Recycling system evaluations

Some products destined such as aluminum cans and newspapers, find themselves reborn as like products after a recycling process. But tracing the path of recycled EEE is considerably more complicated.

[5] Interview with company owner MANIMFASHE Emmanuel

The computer recycling process is more complicated as each part should be treated in different way:

1. CIRCUIT BOARDS: Most circuit boards and some hard drives can be marketed for resale as operational parts. Unusable circuit boards are chopped into a powder and separated into fiberglass, metals, and precious metals through a process called fire assay.
2. PLASTIC HOUSINGS: Plastic housings are separated from the electronic equipment, and materials such as labels and foam insulation are removed through air classification. Unfortunately, plastic housings on computers and monitors will not fit on newer equipment. At present, these plastics are difficult to market because they contain mixed or unmarked resins that cannot be readily identified or separated, as well as some additives such as flame-retardants that complicate recycling. Some near-term uses of these plastics include use in roadbed fill. Efforts are under-way, however, to find higher value applications for these plastics in products such as flooring, computer, and automotive parts.
3. SMALL PLASTIC COMPONENTS: The small plastic parts inside computers are typically made from uniform-colored, highdensity polyethylene (HDPE). This makes them easier to remove, grind, and process. Recyclers must take great care not to mix other materials (e.g., metals) or different resins in with these plastics. Even a small amount of contamination can cause a buyer to reject an entire load. If ground plastic resins appear to have contamination from mixed resins, the recycler can hydroseparate them because of their varying densities.
4. SCREWS, CLIPS, SMALL METAL PARTS: Screws, clips, and small metal components are sorted and separated magnetically into ferrous and nonferrous groups. The metals are sold as scrap.
5. MONITORS:Monitors are handed over to a separate demanufacturing line; where workers remove the plastic housings, metal supports, and circuit boards. The cathode ray tube (CRT) itself is a funnel-shaped, leaded glass tube with a metal frame inside. The worker separates the funnel from the front panel glass. The CRT is then crushed, and the leaded glass and metal are separated. The glass is screened, processed, and inspected for contaminants. Much of it can be sold to CRT manufacturers for use in new CRT glass. The metal is sold for its scrap value

- Other methods used for the endlife of EEE such as incineration, open burning and landfilling should be the last resort in recycling process, as they are not environmental friendly.

Recycling alone does not cover the entire parts resulting from EEE dismantling. Thus incineration and landfill are finally used for the remaining fractions.

As mentioned before, only COOPED recycle some solid waste, but in Rwanda there isn't any formal recycler of e-waste. E-waste are mixed with solid waste or rejected to illegal dumpsites and some parts such as cable are burned to recover copper used in construction.

4.5 Tranboundary shipments and logistics

The illegal trafficking of electronic waste (e-waste) is a serious crime and a growing international problem, posing an unacceptable environmental and health risk, in particular in developing countries in Africa and in Asia.

Actually in Rwanda some guidelines have been set by RBS which stipulated that no second-hand computers could be imported except some that are intended for education purposes, personal use, churches organization or orphans' centres and they define the characteristics (lifetime, technical specifications) of used computers allowed to be imported but nowadays our county is not able to deal with hazardous waste, because it does not have any processors, modern facilities and best available technology. It is useful to characterize administrative and monitoring systems by "before shipment", "during shipment", and "after shipment". At each stage, RRA agents, RNP, RBS and other agency in charge of import/export across borders should be able to track the information on each shipment and activity, from both the exporting and importing perspectives. This will help us to respect Basel convention.

Generally developed countries send E-waste to developing countries under cover as donation; this is done in order to avoid expensive disposal fee or the fact that old EEE are very cheap, lack of relevant Environmental regulations and disrespect the Basel convention which aims to protect human health and the environment against the adverse effects resulting from the generation, management, transboundary movements and disposal of hazardous and other wastes.

That is why the government of Rwanda and RBS should

- Develop the administrative and monitoring systems regarding to transboundary waste shipment.
- Rethink to the modification of some guidelines of importing used computers intended to be used in educational purposes. because some EEE are exported in working status but nearer their end of life, thus become e-waste in the developing countries.

5 Current Practices of WEEE/E-waste Management: developed and developing country comparison

This section provides an understanding of E waste management in developed and developing countries. It first presents, existing WEEE/E-waste management in developed countries is presented. Then practice in developing countries and include guidance on what should be applied in Rwanda.

5.1 WEEE/E-waste Management in Developing Countries

In developed countries, where WEEE/ E-waste management system is in operation, the entire trade value chain occurs in organized/ formal sector. Generally, in developing countries, the trade occurs in unorganized/ informal sector. An example of generic E-waste trade value chain based on material flow assessment (MFA) in a developing country is shown in figure 5-1. This chain can be further modified or customized with inter or intra linkages depending on the E-waste processing or end production in a particular country.

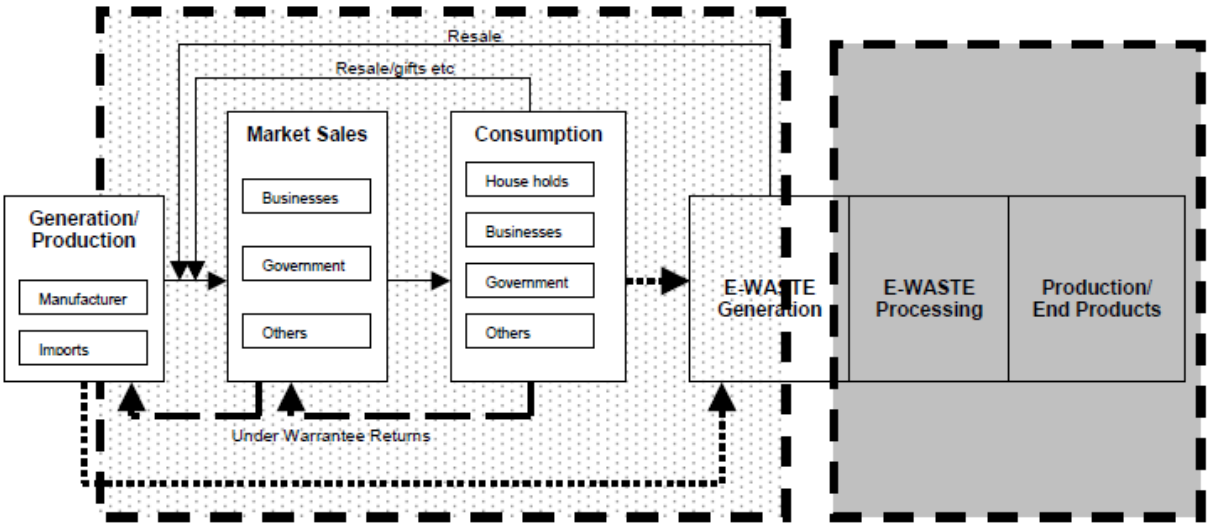


Figure 5-1: E-waste material mass flow

In majority of developing countries, the informal sector engagement starts from the point of collection and continues till the last stage in some capacity. However, in many developing countries contrary to developed; other steps operations (the dark area on figure 5-1) like E-waste processing, production/ end products are absent. WEEE/E-waste is locally collected by local scavengers without any legal

framework. It has been reported that only recyclable E-waste is well collected in developing countries like Cambodia, China, Malaysia, Sri Lanka.

5.1.1 Major Stakeholders

The major stakeholders, identified along the e-waste flow on Figure 5-1 include importers, producers/manufacturers (in some countries), retailers (businesses/ government/ others), consumers (individual households, businesses, government and others), traders, retailers, scrap dealers, dissemblers/ dismantlers and recyclers. At each step in the flow, business transaction defines the movement of the electronic item in the flow. In many developing countries, a majority of stakeholders in this category fall under unorganized/ informal sector.

5.1.1.1 Manufacturers and Retailers

WEEE/E-waste from this sector comprises defective IC chips, motherboards, CRTs other peripheral items produced during the production process and defective PCs.

5.1.1.2 Imports

Huge quantities of WEEE/ E-waste like monitors, printers, keyboards, CPUs, typewriters, projectors, mobile phones, PVC wires, etc are imported. These items belong to all ranges, models and sizes, and are functional as well as junk materials.

5.1.1.3 Individual Households

Most of the households do not directly sell obsolete WEEE/ E-waste into the scrap market. The preferred practice is to get it exchanged from retailers (in few countries) while purchasing a new item, or pass it to relatives or friends.

5.1.1.4 Business/Government Sector

The business sector that include government departments, public or private sector, were the earliest users of IT products; today they account for a sizable amount of total installed ICT equipment. The incompatibility of old systems to cater to present needs and requirements prompts them to store waiting for public auction or pass the obsolete electrical and electronic equipment to dismantlers/ recyclers in some countries.

5.1.1.5 Traders / Scrap dealers / Dissemblers/ Dismantlers

The majority of stakeholders in this category fall under unorganized/ informal sector. Immediately after securing WEEE/ E-waste from various sources, scrap dealers decide which item ought to be dismantled and which to be retained for resale of second hand products.

5.1.1.6 Recyclers

The nature and type of recyclers vary considerably between developed and developing countries. In developed countries the recycling operations may be combined with dismantling operation in integrated facilities or alternatively the scrap dealers may carry out the dismantling operation, segregate the fractions and send them to large scale smelters for material recovery technologies like open roasting, small scale smelting, acid bath, etc. They are spread over different areas in organized/informal sector and one recycler usually deals with one type of metal/ recycling operation. Generally these stakeholders are not concentrated in a single place, but spread over different areas, each handling a different aspect of recycling. The general practices observed in case of recycling in developing countries are open roasting, smelting and acid bath in the unorganized/ informal sector to recover different metals.

In addition to dangerous recycling and disposal practices followed by different stakeholders described above, there is no organized collection, sorting and transportation system in developing countries.

Table 5-1: Key comparisons points

E-WASTE MANAGEMENT	DEVELOPED COUNTRY	DEVELOPING COUNTRY	WHAT FOR RWANDA
Management of E-waste	-Some have national inventory and technical directives to deal with e-Waste. -Existence of legal framework which provide an implementation and	- Developing counties usually lack the proper storage spaces and disposal areas for E-Waste, thus either the waste is mixed in domestic landfill, burned with household waste or	- Used EEE are stored at Gikondo under the supervision of Rwanda Housing Authority (RHA) where mixed by others materials such as office furniture… RHA plan to auction them but it

	management model for the waste handling and minimization, disposal, setting up goals and standards, allocation of responsibilities and identify penalties. - Take-back policy is implemented by assigning responsibilities to producer, consumer … through take back network and separate committee for monitoring the fund. - Existence of some special regulations for management of some components such as: fluorescent tubes… - Existence of national standards to regulate EEE entering in their countries -Existence of infrastructure for the disposal of the hazardous E-waste	stored in attics for years - The importation of used EEE is allowed such as in many African countries except Rwanda. - The e-Waste collection is usually done by the informal sector due to lack of legislation and take-back policies. -Some imported EEE have low quality/improper functioning components which have to be repaired or disposed of. - The process like reuse, reassembling and repair of components is more valuable than using the precious metals as secondary raw materials.	can delay as there are stringent bureaucratic processes that are to be followed in disposal of government property. -In household, as Rwandans have not the culture of throwing away their properties, WEEE is stored at homes, offices… -No used computers are imported except those used for education purposes. - The obsolete electrical and electronic devices are repaired until they get totally broken. - Some national requirements have been formulated by RBS with the objective of verifying the quality of certain EEE coming into Rwanda but some EEE are by passing the requirement quality

	- Disposal method: incinerators	- Besides simple repairing, some broken/non functional EEE was sent to overseas for repair according to the negotiation between the shop owner and customer. -Due to lack of public awareness the residues are disposed off close to the dismantling shops or dumped in illegal site. - There is the unwillingness of consumers and enterprises to hand out their obsolete EEE or pay for WEEE recycling. - Disposal method: storage or Landfilling	(phones, TVs… from China) which will be discarded later. - There is absence of infrastructure for the recycling or appropriate management of e-waste. - The life span of some EEE is between 8-10 years, sometimes can be above 10 years. - There is not any inventory and technical directives to deal with E-Waste. Only National University of Rwanda has inventory of its E-waste but the flow of EEE in Rwanda can be known as RRA records all imported EEE. There is also a preliminary study done by RHA on computer waste in public institution - There is urgent need

			to educate the public and create awareness on environmental and health impacts of EEE imported especially schools, orphan…which allowed to import used computers - Some broken/non functional EEE stored to repair shops where they extract some parts to reuse or sell them. Lots of those repair shops are informal companies. - Disposal method: storage -Lack of awareness among the consumers about the hazards posed by the end of life of EEE,

5.2 National and Social Policies/ Laws/ Regulations/ Institutional Roles in Developed Countries

Countries in Europe and Japan have been the frontrunner in formulating policies/ laws/ regulations for E-waste followed by their institutionalization and implementation.

5.2.1 Policies/ Laws/ Regulation

"Extended Producer Responsibility" or "Product Take Back" forms the basis of policy framework in developed countries, where producers are responsible for E-waste take back. EU country members follow the EU directive on WEEE/ E-waste management and majority of countries which are not part of EU have regulations similar to WEEE directives. Countries like Japan have regulations focused on "Reuse, Recycling and Recovery". Other countries like Canada and Australia are developing their systems based on the similar principles of "Extended Producer Responsibility".

5.2.2 Institutional Mechanism

Institutional mechanism for E-waste management system is described in terms of three elements like collection systems, national registry and logistics. Each of these three elements is further described in terms of different stakeholders and their respective roles/ responsibilities.

5.2.2.1 Collection Systems

There are two generic categories of collection systems at national level i.e. "collectivesystem (monopoly)" and competition based "clearing house system" for managing E-waste.

- Collective System: The collective system is a system which is responsible for collection, recycling and financing of all or major part of E-waste within national boundaries. This is the general approach in the countries with established WEEE/ E-waste system. Their legal status differs from country to country, but they are generally nongovernmental, not-for profit companies which are set up and owned by one or more trade associations. They are organized into product categories in order to focus on achieving maximum efficiency in their recycling operations and to identify markets for recycled material and product reuse.
- Clearing House System: The clearing house system is a system in which multiple partners (producers, recyclers, and waste organizations) can provide services on a competitive basis. The government ensures that there is a register of producers and it defines the allocation

mechanisms, and reporting and monitoring systems. The responsibilities of a central national coordination body are to determine the collection obligation of each producer (via the national register) and to assign this obligation to the compliance scheme action on behalf of the producer. This body will also establish an allocation mechanism that enables compliance systems to indeed collect WEEE/ E-waste in an equitable manner from collection points throughout the territory.

5.2.2.2 National Registry

Any registered body/ agency, which maintains the register of producers/ recyclers/ waste organizations, inventory of WEEE/E-waste is defined as national registry. This body/ agency can also determine collection obligation of each producer and ensure equitable compliance. This body/ agency could be any government entity or a non-profit organization recognized/ supported by the government for discharging the above mentioned functions.

5.2.2.3 Logistics

There are three primary channels of WEEE/E-waste collection. All the three channels address "Business to Consumer" (B2C) and "Business to Business" (B2B) WEEE/Ewaste collection. These channels are municipal sites, in store retailer take-back and producer take-back.

- Municipal collection sites are usually free for households to use to an unlimited extent
- Take-back through retailers is usually free but can be dependent upon the purchase of a new product (both B2C and B2B).
- Producer take-back system may apply to larger commercial equipment and operates on a new for old basis (B2B).

Table 5-2: Developed country e-waste management, countries examples

Country/ Features	B2C WEEE Collection	B2B WEEE Responsibility	National Register	Clearing House	Collective Systems
Belgium	Local govt. to organize free of-charge collection in container parks 1:1 take-back by retailers With compensation to retail and local governments for collection by private	Producers to pay for historical non household WEEE if supplying replacement; otherwise enduser responsible	Producers complying collectively to register with Recupel only Individually complying companies to register with 3 regional environmental agencies	Not required, one system	Recupel (6 divisions); Currently no collection system for categories 7, 8, 9, 10 Individual compliance requires approval of 3 regional environmental agencies

	company (Recupel)				
Denmark	Local govt. to ensure sufficient free of-charge collection points, may organise pickup collection themselves or in collaboration with producers) Retailers accept WEEE on 1:1 basis	Producers responsible for new WEEE, unless alternative arrangements agreed Producers responsible for historic WEEE on 1:1 basis; otherwise, endusers pay	The WEEE System	The WEEE System	EPA Elretur Denmark to begin April 2006.
Estonia	Producers to financing WEEE management entirely 1:1 take-back by retailers; they must take back WEEE from any category they sell if no industry collection point within 10 km.	Producers responsible for WEEE on 1:1 basis	Environment Information Centre (EIC), to be under government control	Not provided for	EES-Ringlus Further system in preparation
Finland	1:1 take-back by retailers (or retailers must inform consumers about alternative collection) Producers responsible for organising & funding collection, may contract local authorities or waste management companies All collectable WEEE to be collected – not only 4 kg.	Producers responsible for B2B WEEE placed on the market after 13 August 2005, unless alternative arrangements agreed Producers to bear the cost of pre 13 August 2005 WEEE if a replacement is purchased; otherwise, endusers pay	Only individual compliers must register with the Pirkanmaa Regional Environmental Centre	Not required, only one system per category	SERTY Oy (household WEEE) FLIP Py (lamps and lighting) ICT Producer Cooperative (ICT) SELT Ry (lighting, heaters, surveillance and control equipment)
Norway	Retailers and Municipalities to take back free of charge. Producers to collect and take back from municipalities and retail collection centers. Collection system to recover fee from producers and importers.	Business can deliver to dealer on 1:1 take back. Producers are responsible for both historic and new.	Norwegian Pollution Control Authority	None	El-Retur AS RENAS AS Ragn-sells AS Veolia AS Eurovironment
Switzerland	Distributors, Retailers and manufacturers must take	Distributors, Retailers and manufacturers must take back	Responsibility of Environment ministry but no registry	None	SWICO – ICT SENS – White goods SENS with SLG

	back free of charge (even if no equipment is purchased). Consumers fund the collection and recycling through ARF	free of charge (even if no equipment is purchased). Consumers fund the collection and recycling through ARF	implementation. It is done by Swiss Cantons.		(Luminaries and Illuminants)
UK	Direct 1:1 take back by distributors from consumers free of charge If member of DTS, direct consumers to nearest DCF to dispose of their WEEE. Producers to finance in both cases	Not a collective obligation. Individual producer responsibility. For non hazardous luminaries, producers take back where collective system will charge flat monthly fee per item of equipment.	UK environmental agencies to issue preliminary 2007 market share percentage to based on 2006 sales data submitted with producer's registration. Environmental gency to approve and give registration number to agency.	Environmental Agency	REPIC – White goods Valpak – IT and Office Equipment Lumicon – Non-Household Luminaries
USA	On going drop off at non profit institutions Ongoing drop off at retailers 1:1 take back by retailers in some states Sporadic Collection events	Not clearly defined. States have different systems	Does not Exist	Does not Exist	Does not Exist
Japan	1:1 take back for home appliances by retailers for free. In case of non replacement with new item, consumers to pay for disposal/ recycling charges and transportation. Collection points are located at retailers, collection centers or post offices (for direct delivery to OEM) OEM responsible for collection and transportation of WEEE/E-- waste but generator to pay for collection and management costs.	Exists	Ministry monitors recycling rates	Does not Exist	Joint recycling services offered by companies eg. Hitachi and IBM Japan

5.3 National and Social Policies/ Laws/ Regulations/ Economic/ Institutional Roles in Developing Countries

The status of WEEE/E-waste in majority of African and Latin American countries is not available. Table 5-2 shows that Rwanda lies at level 1 with low E-waste management system.

Table 5-3: Policies/ Laws/ Regulations/ Institutional Roles for WEEE/E-waste in Developing Countries

LEVEL / PRACTICE	1 LOW	2	3	4	5 HIGH
Legal framework	There is no legal framework, strategy or norms.	There is only plan to develop legal framework.	A legal framework is being prepared and will be issued/enforced in very near future.	Enforcement, but the legal framework is not well conducted.	Full enforcement and model legal framework for other countries.
	Cambodia, Philippines	South Africa, Argentina, Indonesia	Sri Lanka, India	China, Malaysia,Thailand	
Inventory	There is no inventory.	There is the inventory for municipal solid waste, but no designated inventory for E-waste.	E-waste inventory is being prepared.	E-waste inventory is conducted, but lack of information and data.	E-waste inventory is fully conducted and available on website.
		Malaysia, Sri Lanka, South Africa	China, Thailand, Indonesia, Argentina, Philippines	Cambodia	India (national level)
Separate collection	There is no separate collection.	E-waste is locally collected by local recyclers, scavengers, etc. without any legal framework. Only recyclable E-waste is well colleted.	E-waste is well collected by local collection mechanism. Pilot separation and collection systems have been set up.	Collection system for E-waste is operational and includes environmentally sound disposal.	Collection systems are fully operational. Our collection is recognised as a model system by other countries.
	Indonesia, Philippines, Argentina	Cambodia, China, Malaysia, Sri Lanka, Thailand, India	Malaysia, South Africa		
Recycling/reusing technology	There is no recycling/reusing mechanism.	Only recyclable and reusable Ewaste is recycled and reused by local stakeholders.	There is a plan to set up E-waste facility.	There is E-waste recycling facility, but not achieve to full operation for all E-waste in the country.	E-waste recycling facility is fully operated for all E-waste in the country and the model as the statof-the-art recycling facility.
	Cambodia	Sri Lanka, Argentina, Indonesia, Philippines,	Malaysia, South Africa	China, Thailand, India	

The analysis of developed country and developing country as shown in table 5-1 and table 5-2 indicates that there is a huge gap between developed and developing countries related to WEEE/E-waste policies/ laws/ regulations and institutional mechanisms.

5.4 Initiative to address developed and developing gaps in e-waste management

In order to address this gap, a number of agencies have undertaken initiatives at global, regional and country level.

5.4.1 Basel Convention

- The Mobile Phone Partnership Initiative (MPPI): This initiative constituted the establishment of a sustainable Public-Private Partnership for the environmentally sound management of used and end-of-life mobile phones.
- Basel Convention Partnership on the ESM of E-waste in Asia Pacific Region: The countries in Asia and the Pacific, which are Parties to the Basel Convention, have identified WEEE/E-waste as a priority. These countries emphasized the need to obtain the latest and relevant

information on environmentally sound management of WEEE/E-waste, inclusive of information regarding know-how on cleaner technologies or processes used in the repair, refurbishment, recycling or recovery of used or end-of-life electrical and electronic. It also include preventing illegal traffic of hazardous WEEE/E-waste.

5.4.2 StEP - Solving the E-waste Problem

The StEP initiative, developed in 1984 and formally launched in March 2007, is based in the UN University, Bonn, Germany. The StEP initiative is the offspring of UNU, the UN Environment Programme (UNEP) and the UN Conference on Trade and Development (UNCTAD). Other prominent charter partners include the U.S. Environmental Protection Agency, the Massachusetts Institute of Technology (MIT), University of California at Berkeley, the Chinese Academy of Sciences, Technical University Vienna (Austria), French National Institute of Telecommunication (France), Technical University Delft (Netherlands), University of Melbourne (Australia), State Secretary of Economics and EMPA (Switzerland), Regional Environmental Centre (Hungary), the Korea Institute of Geoscience & Mineral Resources, and Umicore Precious Metal Refining (Belgium). The role of SteP is to provide analysis and dialogue from a neutral standpoint in order to find solutions, which reduce environmental risk and enhance development. Its prime objectives are optimizing the life cycle of electric and electronic equipment.

5.4.3 UNEP/ DTIE (IETC)

UNEP through International Environmental Technology Centre (IETC) is implementing "Integrated Solid Waste Management Project" based on 3Rs (reduce, reuse and recycle). ISWM covers all types of wastes in an integrated manner. UNEP DTIE-IETC is also focusing on WEEE/E-waste management and is developing two manuals on WEEE/E-waste assessment and WEEE/E-waste management.

5.4.4 GeSI: Global e-Sustainability Initiative

The Secretary to GeSI is located in UNEP/DTIE. It is an industrial organisation for which a membership fee is paid annually to run the Secretariat and handle other administrative matters. GeSI consists of Information and Communications Technology (ICT) service providers and suppliers, with the support of the United Nations Environment Programme and International Telecommunication Union. Their objectives are to share their experience and knowledge, work with stakeholders, manage

their own private sector operations in a sustainable way, raise awareness of the contribution ICT can make to society and engage in research and benchmarking.

5.5 Management of small in comparison to bigger quantity of WEEE

In countries where the e-waste generated are in small quantities, manual handling is preferred.

5.5.1 Collection

Collection system can be organized collectively (people should form cooperatives) where they can collect e-waste door-to-door or put on a collection sites that can be strategically located in many random locations like public buildings, universities, shopping malls, libraries, grocery shops, etc

The collected WEEE should be sold to the formal cooperative that operate legally in the waste management sector.

5.5.2 Transport

The transport could be done either by those cooperatives or formal cooperative where they come to pick them in appropriate area of storage; the cooperatives should be encouraged to buy the means of transportation (truck, vans, etc.) through loans.

5.5.3 Storage

Districts should facilitate cooperatives operating in this area to find appropriate land for the construction of sheds in order to improve storage conditions. This would make it possible to avoid open-air storage (rain/leaching).

5.5.4 Dismantling

Use school and private refurbishers in dismantling process, there is need of organizing those informal sector through dismantling cooperatives and offer them technical and financial support (training, professional equipment, personal protective clothing, etc.). After dismantling some WEEE, the cooperatives should sell the working parts to some companies' specialized to electronic devices and the remaining parts which could not be reused should be safely stored.

For the bigger quantity of WEEE the processes should be changed to industrial level as described for the developed countries.

6 E-waste management in the case of Rwanda

E-waste management requires technical intervention at each step from collection and transportation, treatment, and disposal. Collection and transportation system is described in terms of collection channels and infrastructure required to support it. Treatment system is described in terms of treatment technologies.

6.1 Proposed e-waste management applicable to Rwanda

6.1.1 Collection systems

E-waste collection systems is described in terms of collection channels and infrastructure required to make these channels operational.

6.1.1.1 Collection Channels

The three major E-waste collection channels, which are being successfully used, are municipal collection sites, retailer take-back, and producer take-back.

6.1.1.1.1 Retailer Take Back and Storage

In this collection mechanism, consumers can take back E-waste to retail stores that distribute similar products. They may give back the product at the retail store depending upon purchase of a new product, or without any purchase required, and is sometimes done at the point of home delivery and installation of a new item by the retailer/distributor. This service is usually free to private households.

6.1.1.1.2 Producer Take Back and Storage

In this collection mechanism, E-waste is taken back directly by producers either directly at their facilities or designing collection centres and then fed into the E-waste system. This usually applies to larger commercial equipment and operates on the principle of "new equipment replacing the old ones". This collection system in Rwanda would follow the transboundary regulation.

6.1.1.1.3 Municipal Collection and Storage

In this collection mechanism, consumers and/ or businesses can leave E-waste at municipal sites. This is what is being done in uncoordinated manner. A number of sorting containers and/or pallets should be provided at their collection site according to the product scope and logistical arrangements with refurbisher/recyclers/transporters. This collection mechanism is usually free for household, although charges apply for commercial companies.

6.1.1.1.4 Other Collection Points

Consumers and or businesses can leave/ drop off E-waste at specially created sites/centers. These can be specialized sorting centres controlled by the collective system of all stakeholders (producers, importers, retailer and consumers). A number of sorting containers and/or pallets should be provided according to the product scope and logistical arrangements with refurbisher/recyclers and transporters.

All these collection methods can be provided by the policy on the e-waste management and it is advised to include such collection site in the planned Kigali city collection site.

6.1.1.2 Collection Infrastructure

Collection infrastructure requires establishment of E-waste collection points and storage area in a city/ geographical region. The following is a conceptual approach for establishing collection points and storage areas:

1. Appropriate measures should be adopted to minimize the disposal of Ewaste as unsorted municipal waste and to achieve a high level of separation.

2. Availability and accessibility of the necessary collection facilities should be ensured taking into account in particular the population density.

3. The collection and transport of separately collected E-waste shall be carried out in a way, which optimizes reuse and recycling of those components or whole appliances capable of being reused or recycled.

4. Sites for storage (including temporary storage) of E-waste prior to their treatment should have impermeable surface for appropriate areas with the provision of spillage collection facilities and where appropriate, decanters and cleanser-degreasers. It should also be covered.

6.1.2 E-waste Treatment Systems

The major options for disposal of E-waste in the absence of any treatment option are land filling and incineration. However, the presence of hazardous elements and compounds in E-waste offers the potential of increasing the intensity of their discharge in environment due to land filling and incineration. Therefore, the major approach to treat E-waste is to first reduce the concentration of these hazardous chemicals and elements through decontamination/ dismantling, recycling and recovery of items of economic value and finally dispose E-waste fractions through either incineration or land filling or a combination of both. This is recommended for Rwandan e-waste system.

The E-waste treatment options include the following unit operations:

6.1.2.1 Decontamination/ Dismantling

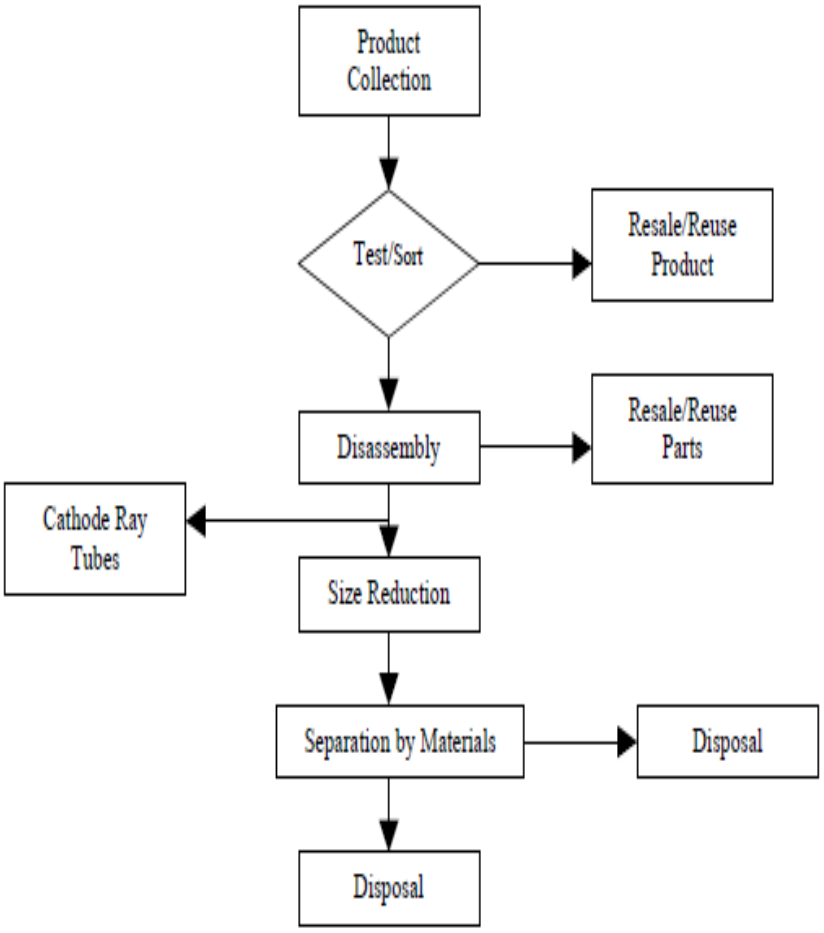
Decontamination/ Dismantling is done manually. It includes the following steps.

1. Removal of parts containing hazardous/ dangerous substances (CFCs, Hg switches, PCB).
2. Removal of easily accessible parts containing valuable substances (cable containing copper, steel, iron, precious metal containing parts, e.g. contacts)
3. Segregation of hazardous/ dangerous substance and removal of easily accessible parts.
    a. Segregation of ferrous metal, non-ferrous metal and plastic: This separation generally carried out after shredding and followed by mechanical and magnetic separation process.
    b. Recycling/recovery of valuable materials: E-waste fractions after segregation consisting of ferrous and non-ferrous metals are further treated. Ferrous metals are smelted in electrical arc furnaces, non-ferrous metals and precious metals are smelted in smelting plants.
    c. Treatment/disposal of dangerous materials and waste: Shredder light fraction is
    d. disposed of in landfill sites or sometimes incinerated, CFCs are treated thermally, Poly Chlorinated Biphenyl (PCB) is incinerated or disposed of in underground storages, Mercury (Hg) is often recycled or disposed of in underground landfill sites.

6.1.3 E-waste Treatment Technology

The simplified flow diagram for WEEE/E-waste treatment is given in figure 5-1 It starts from product collection followed by product testing in order to sort reusable and non-reusable E-waste separately.

Non-reusable E-waste is disassembled and Ewaste fractions are sorted into reusable and non reusable parts. Non-reusable Ewaste parts undergo size reduction, separation and recovery of different materials, while the remaining E-waste fractions are disposed.



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-1: E waste treatment system

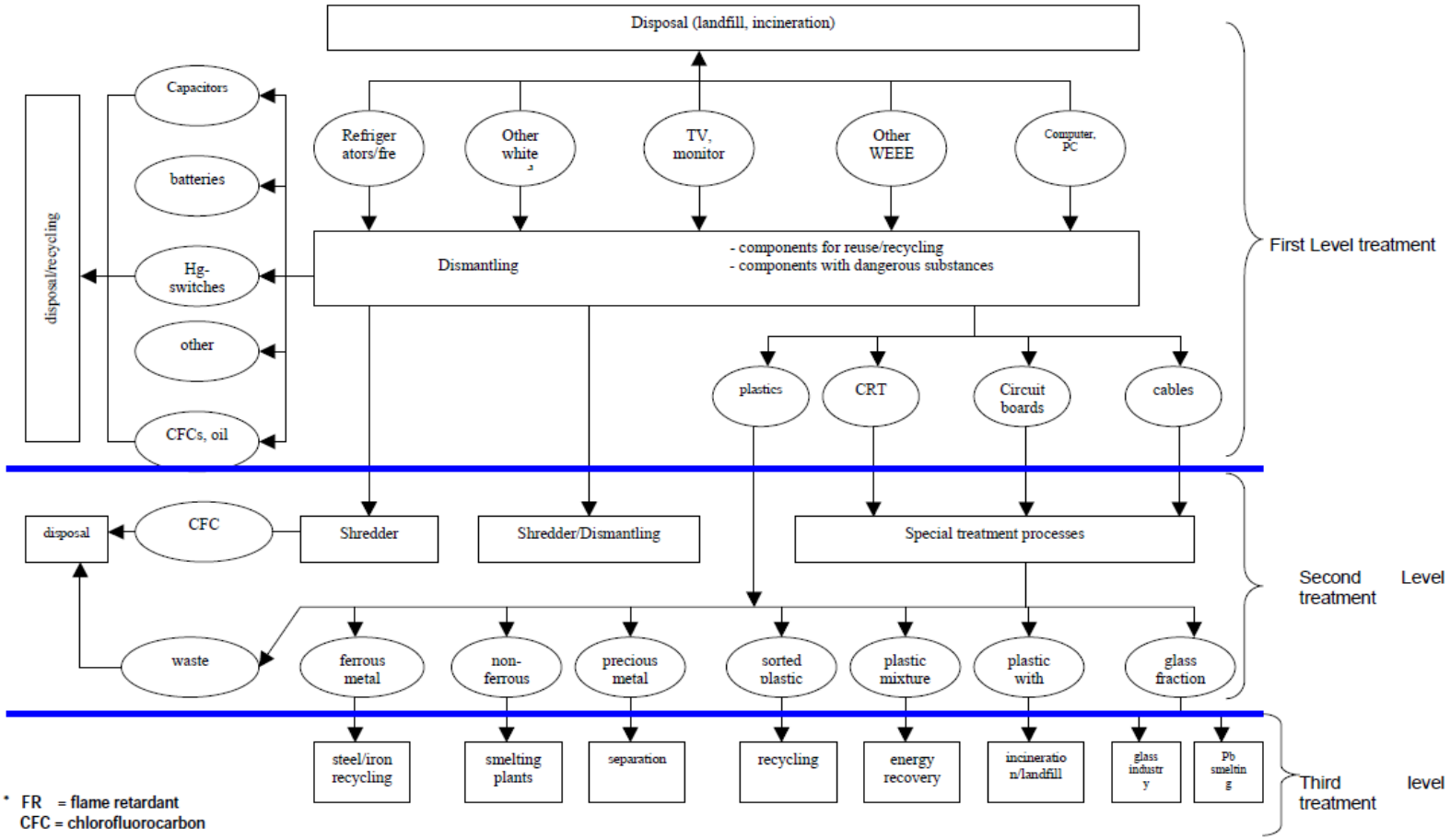
This treatment system is used at three levels:

1. First level treatment

2. Second level treatment

3. Third level treatment

All the three levels of WEEE/ E-waste treatment systems are based on material flow. The material flows from first level to third level treatment. Each level treatment consists of unit operations, where E-waste is treated and output of first level treatment serves as input to second level treatment. After the third level treatment, the residues are disposed of either in hazardous waste landfill or incinerated. The efficiency of operations at first and second level determines the quantity of residues going to hazardous waste landfill site or incineration.



Source: Prepared by modifying Figure 6.1 from the report "Waste from electrical and electronic equipment (WEEE) – quantities, dangerous substances and treatment methods", EEA Copenhagen, 2003

Figure 6-2: The three level of treatment

The guiding principles for designing the layout for all the level should be developed as technical requirements for facilities. The technical requirement should indicate requirements for appropriates area of collection, appropriate storage for dissembled spare parts, appropriate containers for storage of batteries, capacitors containing PCBs or PCTS, and other hazardous waste such as radioactive waste…

6.1.3.1 First Level WEEE/E-waste Treatment

Input: E-waste items like TV, refrigerator and Personal Computers (PC)

Unit Operations: Following three unit operations occur at first level of treatment

1. Removal of all liquids and Gases

2. Dismantling (manual)

3. Segregation

All the three unit operations are dry processes, which do not require use of water. The first step is to decontaminate E-waste and render it non-hazardous. This involves removal of all types of liquids and gases (if any) under negative pressure, and their recovery and storage. Further, all other hazardous E-waste residues are dismantled and segregated. These segregated hazardous WEEE/ E-waste fractions are then sent for third level treatment.

Output:

1. Segregated hazardous wastes like CFC, Mercury (Hg) Switches, CRT, batteries and capacitors

2. Decontaminated E-waste consisting of segregated non-hazardous E-waste like plastic, circuit board and cables.

The guiding principles for fixing up the layout of first level E-waste treatment facility are given below:

• Establish the capacity of E-waste treatment facility in terms of Ewaste numbers (or tonnes) per day.

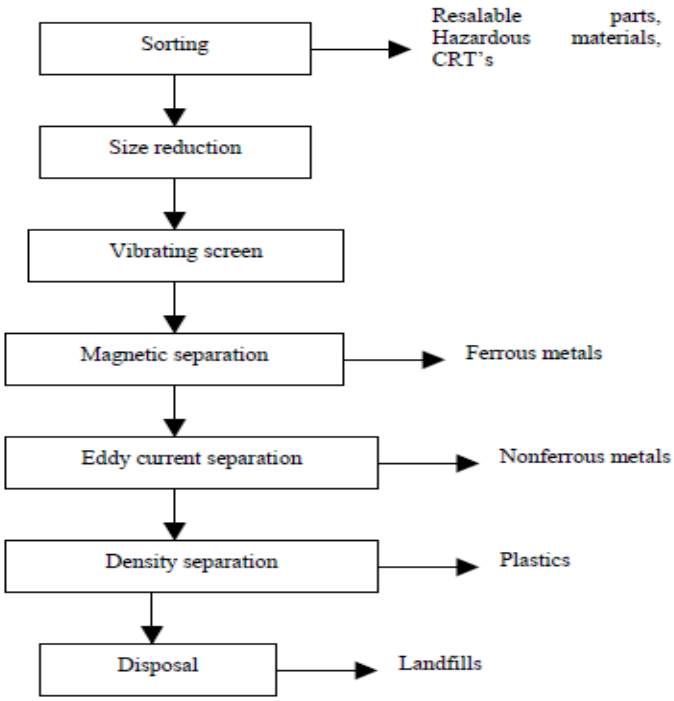
• Establish the time taken by an operator/ worker to dismantle one particular E-waste item.

• Calculate the number of operators/ workers required per day and the number of operating shifts.

• Calculate the working area required for each operator/ worker based on dismantling area and location of collection bins for segregated E-waste components

• Calculate the total area of the facility based on working area requirement for total number of workers and associated utilities.

6.1.3.2 Second Level WEEE/ E-waste Treatment



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure an technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-3: Second level treatment

Input: Decontaminated E-waste consisting of segregated non hazardous E-waste like plastic, circuit board and cables.

Unit Operations: There are three unit operations at second level of E-waste treatment

1. Hammering
2. Shredding
3. Special treatment processes

Special treatment processes are given below.

1. CRT treatment consisting of separation of funnels and screen glass
2. Electromagnetic separation
3. Eddy current separation
4. Density separation using air or water.

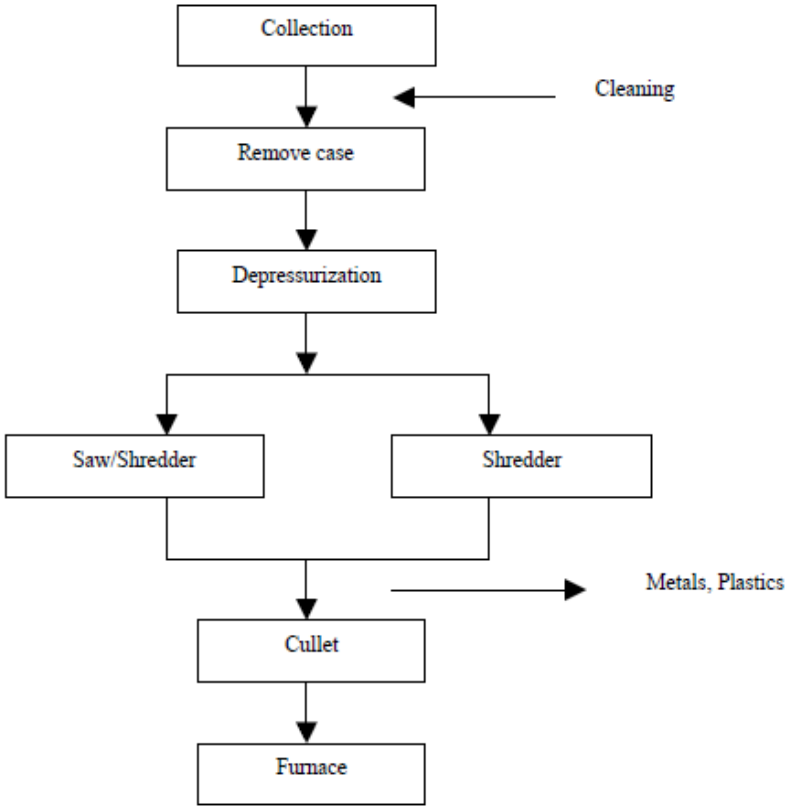
The two major unit operations are hammering and shredding. The major objective of these two unit operations is size reduction. The third unit operation consists of special treatment processes. Electromagnetic and eddy current separation utilizes properties of different elements like electrical conductivity, magnetic properties and density to separate ferrous, non ferrous metal and precious metal fractions. Plastic fractions consisting of sorted plastic after first level treatment, plastic mixture and plastic with flame retardants after second level treatment, glass and lead are separated during this treatment. The efficiency of this treatment determines the recovery rate of metal and segregated WEEE/ E-waste fractions for third level treatment.

Output: Output from the second level treatment technology is given below.

1. Ferrous metal scrap (secondary raw material)
2. Non ferrous metal scrap mainly copper and aluminium
3. Precious metal scrap mainly silver, gold, palladium
4. Plastic consisting of sorted plastic, plastic with flame retardants and plastic mixture

6.1.3.2.1 CRT treatment technology

A simplified conceptual flow diagram for CRT treatment is given in figure 5-4.



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-4:conceptual flow diagram for CRT treatment

Input: CRT segregated after first level E-waste treatment

Unit operations:

1. Dismantling: CRT is manually removed from plastic/ wooden casing

2. De-pressurization and Splitting: Picture tube is split and the funnel section is then lifted off the screen section and the internal metal mask can be lifted tofacilitate internal phosphor coating. Different types of splitting technology used are given below.

- NiChrome hot wire cutting: A NiChrome wire or ribbon is wrapped round a CRT and electrically heated for at least 30 seconds to cause a thermal differential across the thickness of the glass. The area is then cooled (e.g. with a water-soaked sponge) to create thermal stress which results in a crack. When this is lightly tapped, the screen separates from the funnel section.
- Thermal shock: The CRT tube is subjected to localized heat followed by cold air. This creates stress at the frit line where the leaded funnel glass is joined to the unleaded panel glass and the tube comes apart.

- Laser cutting: A laser beam is focused inside and this heats up the glass. It is immediately followed by a cold water spray that cools the surface of the glass and causes it to crack along the cut line.
- Diamond wire method: In this method, a wire with a very small diameter, which is embedded with industrial diamonds is used to cut the glass as the CRT is passed through the cutting plane.
- Diamond saw separation: Diamond saw separation uses either wet or dry process. Wet saw separation involves rotating the CRT in an enclosure while one or more saw blades cut through the CRT around its entire circumference. Coolant is sprayed on to the surface of the saw blades as they cut. This is to control temperature and prevent warping.
- Waterjet separation: This technology uses a high-pressure spray of water containing abrasive, directed at the surface to be cut. The water is focused through a single or double nozzle-spraying configuration set at a specific distance.

4. Cleaning: Internal phosphor coating is removed by using an abrasive wire brush and a strong vacuum system to clean the inside and recover the coating. The extracted air is cleaned through an air filter system to collect the phosphor dust.

5. Shredding

Outputs: Metals, Plastic and Glass Cullet

Cullet glass is reused as a raw material by CRT manufacturers. Recovered CRT glass also goes to the lead smelter, where they act as fluxing agent in the smelting process.

Guiding principles for selection of second level E-waste treatment technology are

given below.

1. The proposed technology for sorting, treatment, including recycling and disposal of E-waste is fully based on dry process using mechanical operations.

2. The pre-comminuting stage includes separation of plastic, CRT and remaining non CRT based E-waste. Equipments like hammer mill and shear shredder will be used at comminuting stage to cut and pulverize E-waste and prepare it as a feedstock to magnetic and eddy current separation.

3. A heavy-duty hammer mill grinds the material to achieve separation of inert materials and metals.

4. After separation of metals from inert material, metal fraction consisting of ferrous and non-ferrous metals are subjected to magnetic current separation. After separation of ferrous containing fraction,

non-ferrous fraction is classified into different non-metal fractions, electrostatic separation and pulverization.

5. The ground material is then screened and de-dusted subsequently followed by separation of valuable metal fraction using electrostatic, gravimetric separation and eddy current separation technologies to recover fractions of copper (Cu), aluminum (Al), residual fractions containing gold (Au), silver (Au) and other precious metals. This results in recovery of clean metallic concentrates, which are sold for further refining to smelters. Sometimes air or water may be used for separation at last stage.

6.1.3.3 Third Level E-waste Treatment

The input, output and unit operations at third level treatment are described in table 4.5.

Table 6-1: Input and output of third level treatment

Input/ WEEE Residues	Unit Operation/ Disposal/ Recycling Technique	Output
Sorted Plastic	Recycling	Plastic Product
Plastic Mixture	Energy Recovery/ Incineration	Energy Recovery
Plastic Mixture with FR	Incineration	Energy Recovery
CRT	Breaking/ Recycling	Glass Cullet
Lead Smelting	Secondary Lead Smelter	Lead
Ferrous metal scrap	Secondary steel/ iron recycling	Iron
Non Ferrous metal Scrap	Secondary copper and aluminum smelting	Copper/ Aluminum
Precious Metals	Au/ Ag separation (refining)	Gold/ Silver/ Platinum and Palladium
Batteries (Lead Acid/ NiMHand LiION)	Lead recovery and smelting Remelting and separation	Lead
CFC	Recovery/ Reuse and Incineration	CFC/ Energy recovery
Oil	Recovery/ Reuse and Incineration	Oil recovery/ energy
Capacitors	Incineration	Energy recovery
Mercury	Separation and Distillation	Mercury

The description of some of the third level E-waste processes are described below.

6.1.3.3.1 Plastic Recycling

There are three different types of plastic recycling options:

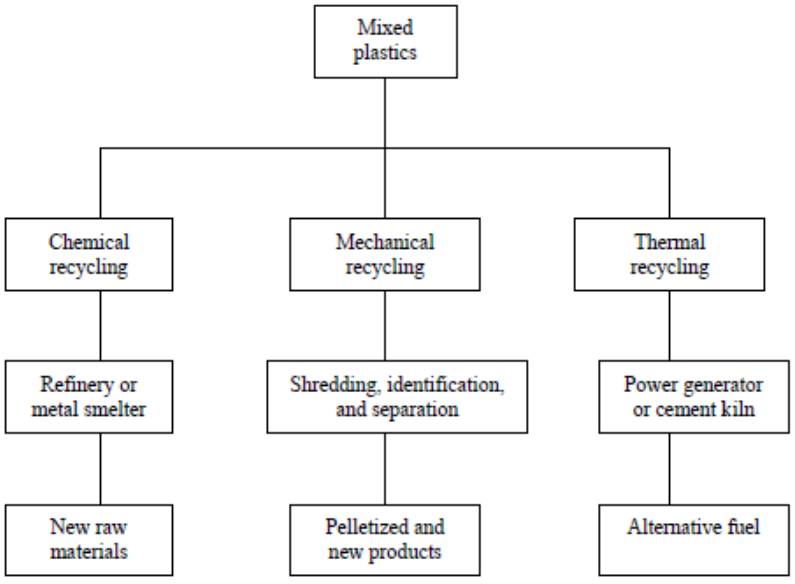
1. chemical recycling,
2. mechanical recycling and
3. thermal recycling.

In chemical recycling process, waste plastics are used as raw material ls for petrochemical processes or as reductant in a metal smelter.

In mechanical recycling process, shredding and identification process is used to make new plastic products.

In thermal recycling process, plastics are used as alternative fuel.

The two major types of plastic resins, which are used in electronics, are "thermosets" and "thermoplastics". Thermosets are shredded and recycled because they cannot be re-melted and formed into new products, while thermoplastics can be re-melted and formed into new products.



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-5: Plastic recycling

6.1.3.3.1.1 Mechanical Recycling Process

The first step is sorting process, where contaminated plastics such as laminated and/ or painted plastics are removed. The methods, which may be used for sorting, are grinding, cryogenic method, abrasion/ abrasive technique, solvent stripping method and high temperature aqueous based paint removal method. Any of the method is used for removal of paints and coating from waste plastics.

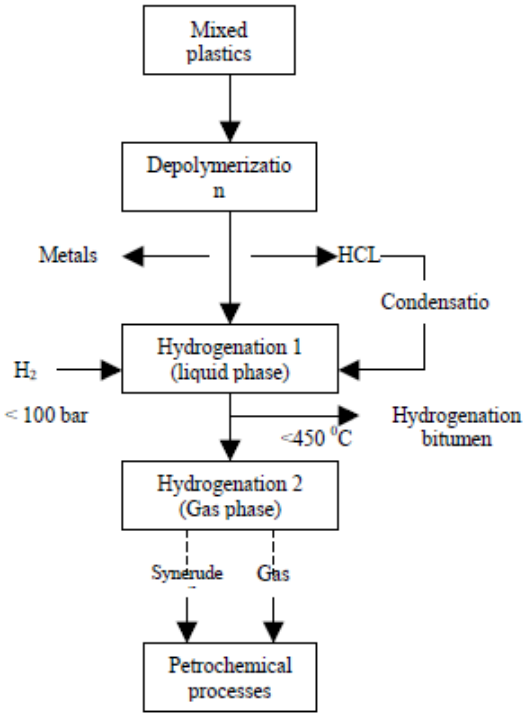
Shear-shredder and hammer mills are generally used for size reduction and liberation of metals (coarse fraction) followed by granulation and milling for further size reduction. Granulators use a fixed screen or grate to control particle size, while hammer mills allow particles between hammers and the walls to exit the mills.

Magnetic separators are used for ferrous metals separation, while eddy current separators are used for non ferrous metals separation. Air separation system is used to separate light fractions such as paper, labels and films.

Resin identification can be carried out by using a number of techniques like hydrocyclones, triboelectric separator, high speed accelerator and X-ray fluorescence spectroscopy. In hydrocyclones separation technique, plastic fractions are separated using density separation technique, which is made more effective by enhancing material wettability. In triboelectric separation technique, plastic resins are separated on the basis of surface charge transfer phenomena. Different plastic resins are mixed and contact one another in a rotating drum to allow charging. Negatively charged particles are pulled towards the positive electrode and positively charged particles are pulled towards negative electrode. This technique has been found to be most effective for materials with a particle size between 2-4 mm. In high accelerator separation technique, a high speed accelerator is used to delaminate shredded plastic waste, which is further separated by air classification, sieve and electrostatics. X-ray fluorescence spectroscopy is effective in identifying heavy metals as well as flame-retardants. After identification and sorting of different resins, they are extruded and palletized.

6.1.3.3.1.2 Chemical Recycling Process

This process was developed by the Association of Plastic Manufacturers in Europe (APME). The different steps in this process are given below:



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-6: Chemical recycling of plastics

1. Mixed plastic waste is first de-polymerized at about 350-400° C and dehalogenated (Br. and Cl). This step also includes removal of metals.

2. In hydrogenation unit 1, the remaining polymer chains from depolymerized unit are cracked at temperatures between 350-400° C and hydrogenated at pressure greater than 100 bar. After hydrogenation, the liquid product is subjected to distillation and left over inert material is collected in the bottom of distillation column as residue, hydrogenation bitumen.

3. In hydrogenation unit 2, high quality products like off gas and syncrude are obtained by hydrotreatment, which are sent to petrochemical process.

6.1.3.3.1.3 Thermal Recycling Process

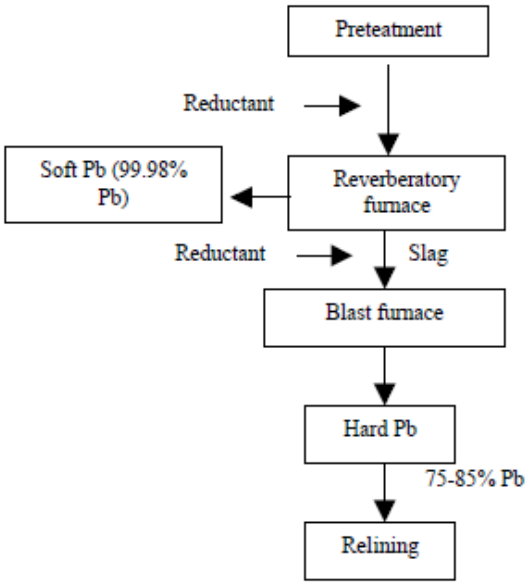
In thermal recycling process, plastics are used as fuel for energy recovery. Since plastics have high calorific value, which is equivalent to or greater than coal, they can be combusted to produce heat energy in cement kilns. Association of Plastic Manufacturers in Europe has found thermal recycling of plastic as the most environmentally sound option for managing E-waste plastic fraction.

6.1.3.3.2 Metals Recycling

Metals recycling has been described below in terms of lead recycling, copper recycling and precious metals recycling. After sorting of metal fractions at second level E -waste treatment, they are sent to metal recovery facilities. These metal recovery facilities use the following processes to recover metals.

6.1.3.3.2.1 Lead Recovery

Reverberatory furnace and blast furnace are used to recover lead from E-waste fraction. The process is shown in figure 5-7 and involves the following steps.



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure and technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-7: Lead recovery

A reverberatory furnace is charged with lead containing materials and reductants. In this furnace, the reduction of lead compounds is carried out to produce lead bullion and slag. Lead bullion is 99.9% while slag contains 60-70% wt. % lead and a soft (pure) lead product.

2. Slag in reverberatory furnace is continuously tapped onto a slag caster. It consists of a thin, fluid layer on top of the heavier lead layer in the furnace.

3. Lead bullion is tapped from the furnace when the metal level builds up to a height that only small amounts of lead appear in the slag.

4. Lead is recovered from the slag by charging it in blast furnace along with other lead containing materials and fluxing agents like iron and limestone.

5. Hard lead is recovered from the blast furnace, which contains 75-85 wt. % Pb and 15-25 wt. % Sb. Slag contains 1-3% lead. Slag contains Cao, SiO2 and FeO.

6. Flue gas emissions from reverberatory furnace are collected by baghouse and feedback into the furnace to recover lead. Slag from blast furnace is disposed of in hazardous waste landfill sites.

6.1.3.3.2.2 Copper Recycling

The copper recycling process is shown in figure 5-8. It involves the following steps:

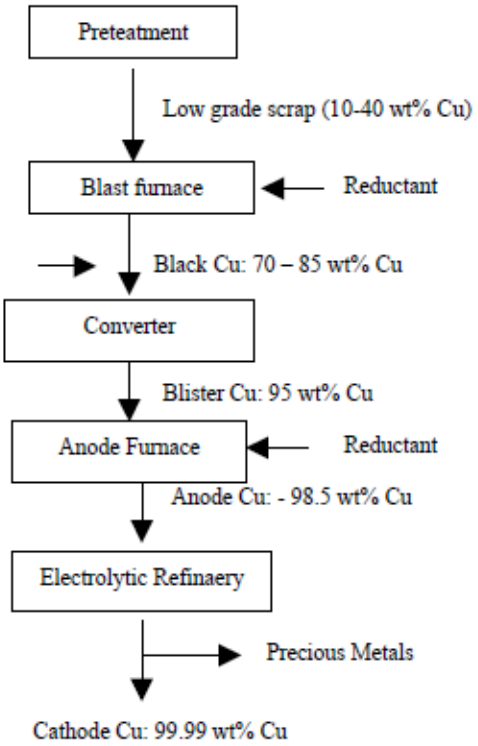
1. E-waste fraction containing Cu is fed into a blast furnace, which are reduced by scrap iron and plastics to produce “black copper”. Black copper contains 70-85 wt. % copper.

2. The black copper is fed into the converter and oxidized using air or enriched oxygen to produce blister copper having 95 wt. % purity. Sn, Pb and Zn are removed, while Fe is removed as slag.

3. Blister copper and scrap Cu are melted and reduced by coke or wood or waste plastic in the anode furnace. Other less noble metals are oxidized and removed from blister copper. Sulfur is also removed from the anode furnace.

4. Recovered anode copper is further purified in electrolytic process where it is dissolved in H_2SO_4 electrolyte with other elements such as Ni, Zn and Fe. The pure copper 99.99 wt. % purity is deposited on the cathodes.

5. The by-products of copper recovery process and slag are reused for roof shingles, sand blasting and ballasts for railroads. The anode slime from electrolytic process is used for precious metal recovery. The entire secondary recovery of Cu uses only one-sixth of the energy that would be required to produce Cu from ore.



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure an technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-8: Copper recovery

6.1.3.3.2.3 Precious Metals Recovery

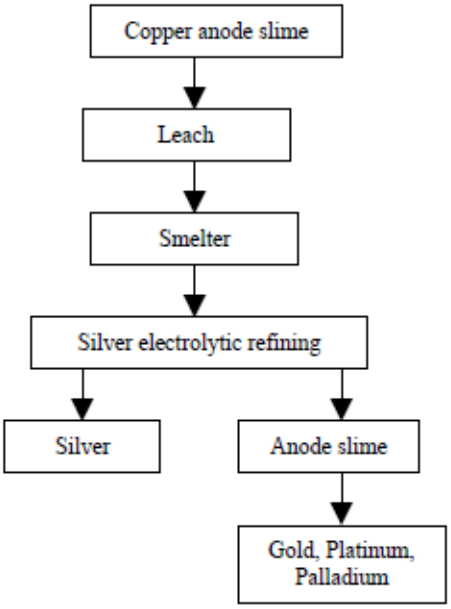
The precious metals recovery process is shown in figure 5-9. It involves the steps shown in the flow chart. The anode slime recovered from copper electrolytic process shown in figure 5-8 is used for precious metal recovery. The process involves the following steps.

1. Anode slime is leached by pressure.

2. The leached residue is then dried and, after the addition of fluxes, smelted in a precious metals furnace. Selenium is recovered during smelting.

3. The remaining material from smelter is caste into anode and undergoes electrolysis to form high-purity silver cathode and anode gold slime.

4. The anode gold slime is further leached and high purity gold, palladium and platinum sludge are recovered.



Source: Hai-Yong Kang, Julie M. Schoenung, Electronic wate recycling: A review of U.S. infrastructure anc technology options, Resources Conservation & Recycling 45 (2005) 368-400, Elsevier

Figure 6-9: Precious metal recovery

6.1.4 Emerging methods for small volume e-wastes management

Today, donating or recycling cell phones, computers, PDAs, chargers, and batteries has never been easier. Donating working cell phone, computer or PDA can benefit the community, much more in developing country. This should be differentiated with dumping method, thus the EEE should be donated when there are in good working order. It should be developed some programs to donate EEE to technical school and other charities or sell them at a discount to those in need.

There should be put on place the "Drop Off" area, where the owner may drop their EEE. This drop off can be managed by private sector and different environmental association and oragnisation.

6.2 Institution framework and sustainable strategies concerning e-wastes management infrastructure

Since environmental degradation is such a pervasive problem, a wide-reaching and comprehensive enforcement apparatus is required to cope with it. Different institutions having impact, being direct or indirect, on the environment protection have due regard to the preservation and protection of the environment, the conservation of natural resources and the health and safety of environment

beneficiaries. It is in this regard; the Ministry of Information and Communications Technology, Ministry of Trade and Industry, Ministry of Health, Rwanda Bureau of standard, Rwanda Environment Management Authority, Rwanda Information Technology Authority, Rwanda Revenue Authority, Rwanda Police, should collaborate in order to avoid interference of their respective missions.

6.2.1 Ministry of Information and Communications Technology (ICT)

The ministry of ICT shall be responsible for the following

(a) Development of a strategic plan for implementing the e-waste policy detailing the time frame, baseline, targets, outputs and outcomes of the policy.

(b) Policy, regulation, standards, guidelines and quality assurance as concerns E-waste.

(c) Provision of technical support, supervision and guidance, as well as undertaking monitoring and evaluation. This will be through various activities which include but not limited to the following:

(i) Providing technical support in development of institutional e-waste policy guidelines

(ii) Developing a PPP policy to guide policy implementation within the private sector

(iii) Setup of e-waste skills development schemes for government (Local Governments and central)

(iv) Taking lead in e-waste awareness and education

6.2.2 Ministry of Trade and Industry

MTI will;

(a) Notify World Trade Organization (WTO) member states on electronic Equipment standards set, policies and regulations developed that affect quality of imports into the country.

(b) Develop a mechanism to audit and monitor compliance of electronic equipment with set standards.

6.2.3 Ministry of Health (MOH)

MOH will develop policies that govern health and safety standards on e-waste management and will conduct a continuous survey on the trend of respiratory diseases related to E-waste

6.2.4 Rwanda Environment Management Authority (REMA)

Environmental Authority will be entrusted by the Ministry with the following responsibilities related to Environment Protection:

- The Environmental Authority shall prepare and publish technical guidelines for the safe disposal of hazardous materials separated from the Electronic Wastes after the safe recycling.
- The Environmental Authority in collaboration with the Ministry of Infrastructure, the Regulatory Authority and other competent authorities shall identify suitable sites for the safe disposal of hazardous materials from Electronic Wastes.
- The Environmental Authority shall coordinate the environmental impact assessment process of the identified disposal sites.
- The Environmental Authority shall coordinate the environmental impact assessment activities of the Electronic Waste Recycling plants before they are set up or licensed by Regulatory Authority.
- The Environmental Authority shall coordinate inspection, monitoring and follow up activities to ensure compliance of recycling and disposal activities of Electronic Wastes with applicable environmental regulations in place.
- The Environmental Authority shall initiate the preparation of regulations related to the safe disposal of hazardous materials from Electronic Wastes.
- Preparing rules and regulations which shall be approved by the Minister in charge of environment.
- providing the strategic vision and action plan aiming at the improvement of environment protection; provide E-waste handling licenses in Rwanda dealing with collection, transportation (including export and extraction facilities).
- initiate research on e-waste treatment and management suitable for Rwanda.
- Put on an awareness mechanism through the whole community

6.2.5 Rwanda Information Technology Authority (RITA)

RITA will contribute to enforcing the policy by;

(a) Integrating e-waste management into licensing conditions.

(b) Advise the Ministry of ICT and other relevant bodies on e-waste matters in the communications sector.

(c) Provide technical support in matters of e-waste management in the communications sector.

(d) Regulate and enforce standards on e-waste in the sector.

(e) Educate the communications sector stakeholders in matters of e-waste management.

RITA‟s role in the implementation of the e-waste management policy is not limited to:-

(a) Regulate and enforce standards on e-waste.

(b) Provide technical support and advice for e-waste disposal in public and private sector.

6.2.6 Rwanda Bureau of Standards

The main responsibilities of the Bureau of Standards as the body with powers to define national standards are as follow:

- defining national standards, co-ordinating all the activities in relation to standards, ensuring their application and metrology observance in the country, providing reference metrology standard, controlling its observance and ensuring its dissemination all over the country;
- Granting environment standards certificates;
- Ensure that all the Electronic Devices that are imported and manufactured in Rwanda meet the established standards;
- ensure that consumers are properly explained the risks of the products to the environment;
- promoting and co-ordinating all the activities in relation to the definition of environment standards, their application, and metrology observance;
- assisting the Government in defining, devising and implementing standardisation policy and determining priorities;
- advising on all issues pertaining to standardization in the country and collaborating with Regulatory authority or any other national or international organizations in matters relating to environment standardization;
- setting up a standards inspection system for imported and exported products and ensuring their respect of environment control at all points of marketing and consumption within the country;

- setting up a national program for the issuance of environment certificates for electronic devices;
- providing facilities or making arrangements for the examination and testing of electronic devices and any material or substance that constitute a potential environment pollutant;
- formulating and assisting in setting up a national system of certification and accreditation of electronic waste collectors and recyclers;
- Notify World Trade Organization (WTO) member states on electronic Equipment standards set, policies and regulations developed that affect quality of imports into the country. Develop a mechanism to audit and monitor compliance of electronic equipment with set standards.

6.2.7 Rwanda Revenue Authority (RRA)

RRA shall have the following main responsibilities, in accordance with taxation incentives for e-waste recycling equipment

- participating in fixing, collecting, controlling and managing incentives in accordance with the law and modalities pertaining thereto established by the regulatory authority;
- granting tax waivers or incentives measures as provided for by relevant policy legal provisions according to the procedures it prescribes;
- exercising judicial police powers to investigate environment pollution conducts
- carrying out any other activity related to the protection of environment upon request by the regulatory authority as far as potential cross-border pollutants are concerned;
- Monitoring customs and collecting statistics of electronic imports into the country.
- Keep track of electronic equipment imported into the country and ensure that the set out standards are enforced.

6.2.8 Local Governments

The Local Governments shall participate in enforcing the policy by;

(a) Linking with the communities and shall carry out sensitization about IT services as well as promotion and awareness campaigns in the communities.

(b) Sensitizing the community, the actual collection and disposal of e-waste through Kigali City Council (KCC), under Ministry of Local Government, in Kigali city.

6.2.9 Rwanda national police (RNP)

As environmental crime includes (but is not restricted to) illegal activities relating to: the collection, transportation, treatment and disposal of hazardous substances and waste; the Rwandan National Police plays its ordinary mission, with a special focus on the protection of environment.

The police shall have power to implement the Organic Law No 04/2005 of 08/04/2005 determining the modalities of protection, conservation and promotion of environment in Rwanda with the following duties:

- Investigating anti-environmental conducts related to the E-waste and tracking individuals degrading the environment in the country;
- impose sanctions in respect of anti-environmental conducts in compliance with the rules established by the regulatory authority;
- Monitoring customs and collecting statistics of electronic smuggled into the country. Keep track of electronic equipment smuggled into the country and ensure that these acts are eliminated. Use Interpol and other international mechanism in order to tackle illegal circulation of EEE and disposal of e-waste

6.2.10 Mandate of Rwanda utilities regulatory agency

The Regulatory Agency has the responsibility to:

- ensure that certain utilities provide electronic devices throughout the country to meet in transparency all reasonable environmental standards established by the regulatory authority;
- ensure that all E-waste collectors and recyclers have adequate means to finance their activities;
- Device ways and means to encourage beneficial reuse/recycling of E-waste, catalyzing business activities that use E-waste facilitate and encourage private sector participation in electronic recycling businesses or investments as a mechanism of protecting the environment;
- ensure compliance by stakeholders with the laws and regulation governing their E-waste collecting and recycling activities;
- control the selling of electronic devices;

6.2.11 Private sector

The private sector shall operationalize the policy through planning and establishing refurbishing and e-waste collection, transportation, treatment and recycling facilities firms.

6.2.12 The role of other Stakeholders

Stakeholder sectors to the IT sector include but are not limited to Agriculture, Health, Education, Tourism, Finance, Trade and commerce, Ministry of Internal Affairs, Ministry of Gender, Development partners, media, Ethics and Integrity.

These will participate in

(a) Developing institutional e-waste policy guidelines and implementation plans.

(b) E-waste awareness campaigns.

To become an innovative, world class and self-sustainable University that is responsive to national, regional and global challenges.

The researchers in collaboration with the Environmental Authority shall

- Conduct research on environmental effects caused by Electronic Wastes, and recommend measures to be taken to mitigate or offset the negative effects.
- Provides training, consultancy, applied research services and extends advocacy in the area of environment protection to industries, regulatory bodies, Government Organizations and NGOs and works towards bringing about change for a more balanced development.

Promote Information, Education and Communication activities in schools, colleges, industry etc. to enhance the knowledge base on E-waste management.

6.2.13 Legal Framework

The available legislation related to e-waste is reflected in National Environment laws of Rwanda; which is broad and does not specifically address electronic waste management. The use of ICT equipment has tremendously grown across all sectors, all this equipment will reach end of life as e-waste. This requires a

specific legal framework to protect the environment and the human life in Rwanda. To this end, the Government of Rwanda shall:

(a) Review and amend the relevant Laws and Acts to address the gaps in the existing legal framework for e-waste.

(b) Develop standards aimed at controlling the importation of used ICT equipment: a strategy has been put on under RBS management in order to curb the entrance of ICT equipment that have a very short lifespan

(c) Develop laws to discourage landfill dumping of ICT equipment to protect the environment.

(d) Establish gazetted areas for environmental protected industrial parks where recycling of e-waste is done to reduce the negative impact of e-waste on the environment.

(e) Develop product stewardship framework legislation which will cater for ICT equipment at the end of life stage.

(f) Establish a Producer Responsibility Organisation (PRO) for all manufacturers, importers and resellers of electronic equipment where they will be charged membership fees to cater for the cost of collection and recycling.

(g) Develop take-back system legislature that requires producers/ importers and distributors/ sellers to take back old and end of life products.

(h) Develop a legal framework for national collection recycling scheme.

I. Strategy for E-waste management

In recognition of the urgent necessity of proper management of E-waste in the country, and in addition to the existing rules and guidelines established by the RURA and RBS, the regulatory authority shall recommend for consideration of the Government the following:

i. Promulgate an all-embracing national E-waste Management law, and an all-encompassing policy there under, for substituting the existing Hazardous Waste Regulation, as the latter are not comprehensive enough to attain the aforesaid objectives.

ii. Initiate the process for complete national level assessment, covering all the cities and all the sectors. Such base line study must envelope inventories, existing technical and policy

measures required for emergence of national E-waste policy/strategy and action plan for eco-friendly, economic E-waste management. The study should also culminate in identifying potentially harmful substances and testing them for adverse health and environmental effects for suggesting precautionary measures.

iii. Create a public-private participatory forum of decision making, problem resolution in E-waste management. This could be a Working Group comprising Regulatory Agencies, NGOs, Industry Associations, experts etc. to keep pace with the temporal and spatial changes in structure and content of E-waste. This Working Group can be the feedback providing mechanism to the regulatory Authority in the Government that will periodically review the existing rules, plans and strategies for E-waste management.

iv. Creation of knowledge data base on end of useful life determination, anticipating the risks, ways of preventing and protecting from likely damage and safe and timely disposal of E-waste.

v. The Government should promote Information, Education and Communication (IEC) activities in schools, colleges, industry etc. to enhance the knowledge base on E-waste management.

vi. Creation of data base on best global practices and failure analyses for development and deployment of efficacious E-waste management and disposal practices within the country.

vii. Device ways and means to encourage beneficial reuse/recycling of E-waste, catalyzing business activities that use E-waste.

viii. Formulate and regulate occupational health safety norms for the E-waste recycling, now mainly confined to the informal sector.

ix. Review the trade policy and exam classification codes to plug the loopholes often being misused for cross-border dumping of E-waste into Rwanda.

x. Insist on stringent enforcement against wanton infringement of Basel convention and E-waste dumping by preferring incarceration over monetary penalties for demonstrating deterrent impact.

xi. Foster partnership with manufacturers and retailers for recycling services by creating an enabling environment so as dispose E-waste scientifically at economic costs.

xii. Mandate sustained capacity building for industrial E-waste handling for policy makers, managers, controllers and operators. Enhance consumer awareness regarding the potential threat to public health and environment by electronic products, if not disposed properly.

xiii. Enforce labeling of all computer monitors, television sets and other household/industrial electronic devices for declaration of hazardous material contents with a view to identifying environmental hazards and ensuring proper material management and E-waste disposal.

xiv. Announce incentives for growth of E-waste disposal agencies so that remediation of environmental damage, threats of irreversible loss and lack of scientific knowledge do not anymore pose hazards to human health and environment.

xv. Consider gradual introduction of enhanced producer responsibility into Rwandan process, practices and procedures so that preventive accountability gains preponderance over polluter immunity.

A. Standards for collectors

(a) Applicability.

These standards apply to a person that collects electronic devices.

(b) Registration.

A collector shall register with the Secretary of RBS (or REMA) by completing the form provided by the Secretary. If a recycler collects directly from a covered entity they do not need to register as a collector if they are registered as a recycler of electronic devices.

(c) Prohibited activities.

A collector is prohibited from the following:

(1) Disposing of any electronic device; and

(2) Initiating a transfer of electronic devices to any person, except the following:

i. A destination within the country, for reuse of whole devices that are functional and are used for the same purpose for which it was originally purchased.
ii. An agency in the country that is a registered recycler of electronic devices.
iii. An out-of-country recycling facility that is operated in accordance with that country's laws and regulations.
iv. A foreign destination, provided there are no hazardous waste components that are a part of the electronic device.

(d) Facility management standards.

A registered collector shall manage its facility(ies) located in Rwanda in the following manner:

i. Access to the collection location shall be controlled at all times. An attendant shall be present to ensure that electronic devices are appropriately separated, to perform record keeping and to ensure that collection is conducted in accordance with this procedure during the hours of operation;
ii. Employees have been trained on the materials that can be accepted at the collection location, (materials management standards, the record keeping requirement), and how to respond to releases from broken or poorly maintained electronic devices;
iii. The facility shall have a procedure in place to address releases from electronic devices; and
iv. The facility shall provide access to Regulatory personnel to inspect the facility, review any records, or conduct any other sampling or auditing to determine the proper operation of the facility.

(e) Materials management standards.

A registered collector shall manage electronic devices in a way that prevents releases from any electronic device, or component of an electronic device, to the environment. Registered collectors shall:

i. Store electronic devices on an impervious surface within a structure or transportation unit such that the electronic device is protected from precipitation.Outdoor storage is prohibited at any time;

ii. Maintain adequate storage space to accommodate periods of peak deliveries;

iii. Package electronic devices in a manner adequate to prevent breakage during transportation, storage, and handling. Such packaging must lack evidence of damage that could cause breakage under reasonably foreseeable conditions;

iv. Clean up broken and damaged electronic devices immediately. All clean-up materials and debris that may contain focus materials must be managed by placing them in a covered container that prevents the further release of the materials and, labeled as "electronic waste," "used electronics," or another term acceptable under the Hazardous Waste Management Regulations;

v. Place any electronic device that shows evidence of breakage, leakage, spillage, or damage that could cause the release of glass particles or other constituents under reasonably foreseeable conditions in a container. Any such container shall be closed, structurally sound, and compatible with the electronic device and shall be capable of preventing leakage, spillage or releases from damaged electronic devices, glass particles or other hazardous constituents from such damaged waste to the environment;

vi. A collector may not accumulate electronic devices for longer than one year from the date the electronic device is delivered to the facility by the generator;

vii. Containers, pallets, or packages containing electronic devices shall be clearly marked with the words "electronic waste," "used electronics" or another term acceptable under the Vermont Hazardous Waste Management Regulations.

(f) Recordkeeping and reporting requirements.

All collectors shall annually report the following to the Secretary of the regulatory authority, on a form provided by the Secretary:

i. The types of electronic waste collected (e.g. computer, television, mouse, etc.);

ii. The amount of electronic waste, by weight, sent to a recycler from all covered entities during the preceding program year;

iii. The amount of electronic waste, by weight, that was collected under the standard plan, an approved manufacturer opt-out plan, or outside of an approved plan;

iv. The amount of electronic waste and banned electronic devices, by weight, that was collected from covered entities; and

v. The amount of electronic waste, either by weight or number of devices that was removed at the point of collection for reuse or refurbishment.

B. Standards for recycling facilities

(a) Applicability.

These standards apply to a person that recycles, reuses, or refurbishes electronic devices within Rwanda.

(b) Registration.

A recycling facility (recycler) shall register with the Secretary on a form provided by the Secretary.

(c) Prohibited activities.

A recycling facility (recycler) is prohibited from:

i. Disposing of any electronic device. A recycler may initiate a shipment of parts that are not recyclable to a facility that is permitted or certified to accept those materials;
ii. Reusing or refurbishing any electronic device except when in compliance with this policy; and
iii. Initiate a shipment of electronic wastes to any person, except the following:
    a. Another in-country recycling facility that complies with all standards set forth in this policy;
    b. An out-of-country recycling facility that is operated in accordance with that state's laws and regulations; or
    c. A foreign destination, shipped in a manner consistent with their facility management standards.

(d) Facility management standards.

A recycler shall submit either a self certification or a certification by an accredited certifying body (RBS or REMA) that the recycler conforms to established Standards.

C. Requirements for the reuse of electronic waste

(a) Redesigned electronic device

To redesignate an electronic device as reusable equipment and allow for its management as a commodity and not as a waste, the electronic device shall be tested by the person making the redesignation to ensure that the equipment can perform its key functions. The following are the minimum reuse testing standards for electronic devices to document the electronic device meets its key function, for use of diagnostic software, it is required the device pass the diagnostic test.

(1) Laptops.

Diagnostic software that indicates what functions are failing, such as hard drive, RAM or power supply failures. Make sure cooling fans are working. Batteries must be tested to meet requirements below for reuse. Mercury lamps must all be functional. No screen burn or scratches/damage.

(2) Batteries.

Ensure that each battery is capable of holding at least 80% of its original capacity (and not simply that it will hold a charge).

(3) Desktop computers.

Diagnostic software that indicates what functions are failing, such as hard drive, RAM or power supply failures. Make sure cooling fans are working. Batteries inside desktops meet the standard for batteries above.

(4) CRT Monitors.

Diagnostic programs that test for color, contrast, pixels. Visual for screen burn and scratches. Must have cabling intact. If the device is going into the “semi knockdown market” in another country (to build a new device around a used cathode ray tube), the following must be accomplished prior to exporting only good tubes: all circuit boards and other focus materials must be removed from the device, and the CRT tube itself must be tested with a “Picture Tester/Restorer” and determined that it is a viable tube for reuse.

(5) LCD Flat Screens (TVs and Monitors).

Diagnostic software testing for color, contrast, pixels, etc., replace any bad backlighting, look for screen damage.

(6) Plasma Flat Screens.

Diagnostic software testing for color, contrast, etc. Testing for lighting, screen damage.

(7) CRT Televisions.

In addition to all necessary tests listed above for CRT Monitors, a refurbisher must ensure that any TV going into reuse is capable of receiving the type of broadcast signal (digital or analog) in use in the market where it will be reused.

(8) Printers.

Wipe data on printer memories, print a test page successfully, make sure the paper feed is working, light carriage is fully functional, visual inspection for broken parts, clean inside and out, toner cartridge functional, provide full toner cartridge if part of the deal.

(9) Fax machines and Multifunctional Machine (e.g. Printer/fax/copier/scanner in one).

Wipe data on printer memories, print a test page successfully, make sure the paper feed is working, light carriage is fully functional, visual inspection for broken parts, clean inside and out, provide full toner cartridge if part of the arrangements.

(10) RAM.

Insert into test bench computers for testing functionality using diagnostic program.

(11) Circuit boards.

Insert into test bench computers for testing functionality using diagnostic program.

(b) Alternative electronic waste redesignation.

Recyclers may propose alternative methods to be used to redesignate electronic devices. An alternative redesignation proposal shall contain the following:

i. Clearly identify the type of electronic devices or banned electronic devices covered by the alternative;
ii. Document the alternative process to be used;
iii. State how the alternative proposal assures that the management of the electronic devices within the country is at least as protective of human health and the environment; and
iv. State how the alternative proposal provides for a level of assurance that materials are properly managed.

D. Other proposed solutions to e-waste

The proposed solution in this policy is comprised of five following main strategies:

- A recycler tax credit,
- consumer tax credit,
- Consider prohibiting the disposal of e-waste three years after enactment of this policy, provided sufficient recycling facilities area available,
- Recycle all e-waste generated by recognised facilities,
- Study the feasibility of nationwide recycling program.

I. A recycler tax credit

In essence, this measure can create an economic incentive for recyclers through the creation of a tax credit, with the aim of encouraging organizations to expand or create e-waste recycling businesses.

The benefit to recyclers may be enough to actually change the behavior of some businesses and companies and lead to an increase in the number of recycling facilities and the number of electronic devices being recycled.

II. **Consumer Tax Credit**

The Consumer Tax Credit can addresse e-waste disposal by individuals. A consumer is defined as any taxpayer who recycles at least one unit of e-waste.

Like the Recycler Tax Credit, this solution creates a financial incentive for consumers to recycle. However, it may not be an adequate incentive for most consumers, particularly if recycling is not convenient (i.e. a consumer must deliver e-waste to a collection-point, regardless of distance).

III. **Prohibiting Disposal of E-waste**

This proposed solution targets the behavior of e-waste consumers and landfill operators. It proposes making it illegal (three years after enactment) for a solid waste operator to receive qualified e-waste, unless it is recycling the e-waste.

A ban on the disposal of e-waste effectively requires recycling. This creates a clear mandate to address the problem of e-waste. The regulatory authority should issue guidelines to assist in the development of recycling procedures.

IV. **Recycling all E-waste Generated by recognised decentralised facilities**

All e-waste generated within the country should be recycled and the Responsibility for ensuring this should be assigned to the decentralised Agencies. This solution provides the immediate reduction of a large source of e-waste. It creates a culture of recycling within the country that denotes a certain commitment to the issue, and may make future e-waste legislation more robust and amenable to policymakers.

It also provides an opportunity for the regulatory authority to become familiar with the obstacles and impacts of e-waste recycling, and may provide a model for future programs.

V. **Study Feasibility of Countrywide Recycling Program**

The solution proposes the regulatory authority conduct a feasibility study for a countrywide recycling program that preempts any existing program.

The study should include an analysis of multiple approaches including (1) collection of an advanced recycling fee, (2) collection of an end-of-life fee, (3) producer responsibility, and (4) extension of a tax credit. Within a given period (one year for example), the results of the study must be reported to Ministry in charge of environment.

Included in the report must be a cost-benefit analysis of each program, and the quantities of e-waste recycled. A cost-benefit and feasibility analysis of including emerging e-waste streams (such as cell phones and personal organizational devices) in the program will also be included in the report.

This approach concedes that many options are available and deserve equal consideration before taking action. It allows for a reasonable amount of time for the regulatory authority to consider alternatives and provides the opportunity to incorporate new information while considering a plan.

6.2.14 Restrictions on Transboundary Movement

In the organic Law N° 04/2005, determining the modalities of protection, conservation and promotion of environment in Rwanda. Date of entry into force: 08 April 2005 and other instruction and regulation such as instruction n° 01/04 of RBS on quality certificate for imported product, date of entry 1/12/2004 and Arrêté Ministériel n° 005/04/10/MN showing allowed chemical or industrial product to be imported in Rwanda,date of entry into force 25/10/2004, there are many restrictions imposed on hazardous waste. E-waste should also be classified in hazardous waste as it contains those products. Rwanda restricts::

- the export of hazardous wastes and other wastes for final disposal.
- the export of hazardous wastes and other wastes for recovery
- the import of hazardous wastes and other wastes for final disposal
- the import of hazardous wastes and other wastes for recovery.
- Restrictions on transit

Rwanda has no restrictions on the transit of hazardous wastes and other wastes.

6.3 Financing mechanisms for e-waste management projects and markets.

Financial viability is key to the sustainability of e-waste management and should be assessed in all the steps from collection, transportation, treatment to disposal. The financial viability is in turn dependent on regulatory system in place as it will define the standards and institutional mechanism for E-waste management.

Before discussing the financial mechanism it should be noted that in developing countries:

- EEE manufacturers and importers are not responsible for treatment and disposal of E-waste or its fractions,
- E-waste fractions/ materials also flow from EEEE manufacturers and importers to collectors/ traders/ recyclers for recycling and disposal

6.3.1 Financing Models

It is proposed three mechanism or models, that would be implemented in phases:

- Phase 1: Setting up company managing all the scrap
- Phase 2: Consumer pays
- Phase 3: Extended producer responsibility

6.3.1.1 Setting up company managing all the scrap

As there is no regulatory mechanism in Rwanda, which stipulates the management and handling of post-consumer E-waste generated within the country, it is proposed a starting point that should be initiated by Rwanda government but working hand in hand with the private sector.

1. Develop a scrap industry which accepts scrap from many sources including all sort of metal and E-waste, the established scrap metal industry would absorbs the E-waste stream to recover valued material
2. In this financial model, it is the waste collectors who pay consumers a positive price for their obsolete appliances. The small collectors in turn sell their collections to traders who aggregate and sort different kinds of waste and then sell it to recyclers, refurbishers...
3. Therefore, the purchase price offered by recycler/refurbisher drive the E-waste collection, transportation and its treatment. The collection and transportation costs are built into the price offered by recycler to trader and the price offered by the trader to the collector. Finally, the raw material producer offers the price to the recyclers/ refurbisher as per the local metals, glass, plastic and other items rate or as per wholesale domestic or international market.
4. This recycling network consists of a series of private–private relationships among waste pickers, itinerant buyers, dealers, wholesalers and recycling enterprises. The entire industry is based on a network existing among collectors, traders and recyclers, each adding value, and creating jobs, at every point in the Ewaste trade value chain.
5. Since the low level of initial investment is required to start a collection, dismantling, sorting or recovery business, it is a mandate to the government to initiate this industry.

The main negative impact is when this industry is run without any environmental monitoring as the main incentive for the players is financial profit, not environmental or social benefits. The biggest

drawback would be the uncontrolled emission of hazardous toxics that would go into the air, water and soil.

6.3.1.2 Consumer pays

This alternative consists of:

1. Consumers pay an end-of-life fee for product disposal and treatment as opposed to the producer responsibility concept in the previous concept. This fee is paid to the retailer, and passed on to one or more industry consortia who are responsible for the collective management of E-waste in the specified categories.
2. The fee can also be paid in advance by Advance Recycling Fee (ARF) charged on all new appliances. The ARF is used to pay for the collection, the transport and the recycling of the disposed appliances, there should be a good estimate of waste that will be generated in the future.

6.3.1.3 Extended producer responsibility

The entire financial model is based on "Extended Producer Responsibility", where the producing organizations are responsible for E-waste take back and treatment. This financial model integrates all the steps in e-waste management, collection, transportation and treatment:

1. Producers are responsible for the costs of picking up E-waste from collection facilities and for refurbishing waste products for reuse or for recycling and recovery.
2. There is a shared responsibility on product that have been on the market prior to the regulation or policy (called historical products). The costs of waste management are to be shared by all producers in existence at the time those costs are incurred.
3. End users other than households may be made partly or totally responsible for financing the management of historical products.
4. For new products (i.e., those put on the market after m), producers have "individual responsibility
5. No visible fees are permitted to fund the management of waste from new electrical and electronic products. When producers put a new product on the market, they must provide a financial "guarantee" that waste management of the product will be paid for.

6.3.1.3.1 Fee Structure

In order to avoid high price on the market, the fee structure should be well designed. The fee structure consists of different options. These options include actual costs of recycling, projected costs of recycling per category and cross subsidization. Cross subsidization occurs if the fee charged on one category of E-waste is higher than its recycling costs. The differential is used to pay for the recycling of another category of E-waste, whose recycling costs are higher than the fee charged.

6.3.1.3.2 Funding for supply chain

The fee charged catalyses financial flow along the E-waste supply chain. This financial flow meets the costs of E-waste collection, transportation and treatment.

1. Producers/ Importers pay the waste management company to manage their E-waste responsibilities under the existing regulation. A fixed fee is paid to the company for each product placed on the market. This fee is passed on to the consumer with no mark up, this is very important as kind of awareness. The scheme covers also household E-waste.

2. Households pay a visible fee on the purchase of new EEE. Households pay a local municipal waste tax to fund general waste collection and operation of municipal sites. Households may return E-waste free of charge to municipal collection sites. Municipalities provide some means of collection. Households may also return E-waste to a retailer/distributor free of charge on the basis of 1:1 new for old purchase. Retailers may charge for collection of the old product from household:

3. Retailers are obliged to take back E-waste on a new for old basis from consumers. They may then transfer the E-waste to a municipal waste site, or direct to the company sorting stations or pay for collection by the company.

4. Municipal collection sites receive E-waste and take responsibility for delivery to sorting stations operated by the municipalities or company. Municipalities are not reimbursed.

5. Sorting stations receive E-waste free of charge and sort for collection and treatment.

6. Transport, treatment and recycling are done by the company.

This process should involve a financial guarantee, producers have to provide a financial guarantee for fulfillment of their take back obligation for electrical and electronic products placed on the national market, this guarantee is very important as in Rwanda there is no local producer, but in a case where

the producer has accepted to be member of a collective scheme, there should not be any imposed guarantee.

6.3.2 Resource Mobilization

The e-waste issue is a new area and therefore does not have sufficient funds allocated to it. To this end, the Government of Rwanda shall:

(a) Increase the budgetary allocation to the initiatives targeted at reducing e-waste risks.

(b) Put in place mechanism for resource mobilization from development partners: In order to ensure sustainability of national collection facilities, a fund should be set up that will be collected from both the sellers and buyers of electronic equipment. To this end, the Government of Rwanda shall develop a legal framework for applying the Advanced Recycling Fee (ARF) that requires consumers to pay a recycling fee when purchasing ICT equipment and extended producer responsibility.

6.3.3 Drivers for development and implementation of financial model

The drivers are:

1. Enabling regulatory framework
2. Recycling standards and treatment.
3. Enabling collection and transportation system. This will include distance and geography, population size and density and consumer behavior etc.
4. Enabling recycling infrastructure
5. Economics of collection, transportation, treatment and disposal. This will include costs of collection, cost of transportation, cost of treatment and cost of disposal.

The key success factors for establishment and operation of financial model for Ewaste management are given below:

1. Consultation process: It is broadly accepted that national systems should be run and managed by industry/ recyclers/ producers within a sound legislative framework established in consultation with stakeholders.
2. Understanding local context

6. Build systems that meet local specifics of culture, geography and industry, and that take into account existing practices of waste collection.

7. Build upon existing infrastructure. Use experience with existing collection systems.
8. Build First, Measure and Monitor Later: The experience of countries having E-waste management systems show that countries should get any system up and running before committing themselves to performance and target setting.
9. Balance Costs and Environmental Impact: The lowest cost solution may compromise the desired environmental outcome. Therefore it is important that there are acceptable and realistic figures for volumes, costs and standards.
10. One Face for the Consumer: The success or failure of a WEEE/ E-waste programme is dependent on the clarity with which it can be explained to the consumer, and the ease with which the consumer can engage with the collection and financing system. Different collection systems for different products cause consumer confusion and affect efficiency.
11. Efficient sorting and charging system: Current market share model, either through fees on products sold, or allocation of actual costs to products placed on the market.

6.4 Communication strategy on e-waste management

Most Rwandese are not aware about the environmental hazards caused by discarded electronic equipment, asking retailers of cellphone who sell second hand products 100% demonstrated that e-waste refurbishment can be a good business to earn their living but they did not know that they contain hazardous material. Thus community awareness campaigns are needed.

In order to create an e-waste knowledgeable nation through promotion of efficient handling and sustainable management of e-waste, awareness should be created among generators of E-waste at all levels of governance and the general public, this will be achieved when some measures are taken such as:

1. Develop a strategy for education efforts including partnerships with manufacturers/ retailers/ recyclers.
2. Develop of a national e-waste resource web portal
3. Organize annual events to promote e-waste awareness.
4. Design and conduct consumer awareness campaigns to ensure understanding of how to safely dispose of e-waste and how to access safe disposal systems.
5. Encourage procurement of environmentally friendly ICT equipment across government.
6. Mainstream e-waste issues in the national education curriculum.
7. To encourage institutions to conduct awareness programs for their employees and their families.

8. To establish incentives for encouraging both local and foreign investors to establish e-waste facilities in Rwanda

6.4.1 Communication on environmental issues

The general objective of the communication strategy of the environmental issues related to e-waste management should be to highlight the need to protect environment and changing e-waste to income generation products. It should demonstrate relevance in terms of supporting, mentoring, and networking the players within the e-waste management system. Timely information of environmental initiatives

6.4.2 Sustainability in environmental communication

In the current debate on sustainable development, communication and education as the driving forces of environmental learning processes have an impact on at least two levels:

1. perceptions of the environment are to a large extent determined by cultural contexts, visions, lifestyles and value judgements which are acquired through communication
2. criteria and options for decisions regarding sustainable practices are a result of public discourse and transparently communicated alternatives

Ultimately, environmental sustainable development cannot be based on behavioral manipulation alone but relies on a shared vision which will help civil society to develop adequate skills to manage its environment. Understanding where the project is in its progression from identification, formulation, implementation and management is an essential basis for determining which communication instruments should be used. Different steps should be undertaken for effective communication:

1. Recognizing, regular opinion/attitude surveys: media content analysis, continuous networking with NGOs, e.g. consumer groups, regular meetings with interest groups
2. Gaining control: conduct Knowledge-Attitude-Practice (KAP) surveys, integrating communication in the mix of policy instruments, design of communication strategy, communication with those involved
3. Solving: communication as a complementary instrument, information on other instruments (laws, incentives, etc.), monitoring and Evaluation through qualitative research
4. Maintaining control: Regular public information, reporting on changes in policy design and implementation, up-dated opinion/attitude surveys.

6.4.3 Guidance on communication of environmental issues

Many project projects around the world indicate that environmental practitioners should define the environmental communication as supporting goal of a project. These some guidance in environmental communication:

1. plan the communication strategy ahead, taking research, continuous monitoring and evaluation, process documentation and an exit strategy seriously right from the beginning in project planning,
2. start locally at a modest level, and link issues raised, problems addressed and solutions proposed to existing trends, services and potentials,
3. make use of up-stream compatibility of media, e.g. newspaper to TV
4. diversify the operational levels e.g. use local event such as umuganda, churches, city newspaper, local radio and national radio and TV
5. use participatory approaches in media production, management, training etc. to increase local ownership and credibility and, hence, program effectiveness, significance and sustainability

6.4.4 Requirement needed for cross boarder infrastructure

As our country has signed the Basel convention[6] on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, this convention should be implemented

6.4.4.1 Possibilities to control safe treatment

RRA take records on all EEE imported in Rwanda and RBS control their standards, for better control all EEE entering in Rwanda some regulations are to be established such as:

- To amend some guidelines set by RBS aimed to control the importation of used EEE.
- To ensure that E-waste from other countries are not reaching the country for disposal.
- To encourage procurement of environmentally friendly EEE across government, Private sector and NGOs.
- To label all entering EEE, their specifications, manufacturer name and date of fabrication and establish direct contact with the manufacturer if needed

[6] http://www.rema.gov.rw/index.php?option=com_docman&task=cat_view&gid=123&Itemid=74&lang=en

- To establish a Producer Responsibility Agency (PRA) for all importers and resellers of electronic equipment whose responsibility is to charge membership fees reserved for collection and recycling.
- PRA should build a database of all entered EEE (donated, imported, etc) and ensure that at their EoL are safely recycled or disposed.
- PRA should provide technical support, supervision and guidance, as well as undertaking monitoring and evaluation of all stakeholders in E-waste processing (collector, recycler, dismantlers, …)
- To develop a legal framework for national collection recycling scheme so that illegal collection could be prohibited
- To develop a mechanism to audit and monitor compliance of electronic equipment with set standards.

6.4.4.2 Policy implications

For better management of EEE at their EoL, some policy could be established on treatment technology, the governmental should:

- Implement the National Waste Management Plan
- Provide specific e-waste regulation (legal and regulatory) from the acquisition, handling to the final disposal processes.
- Establish specific regulation on shipments of E-waste within, into and out of the country
- To establish a policy of how producers of EEE take-back EEE from households and establish a take-back and recycling system for them.

6.5 Transfer of technology and Human Resource Development

The existing skills in the area of e-waste are limited yet these skills are a prerequisite for successful national protection against e-waste hazards for both the environment and human health. To this end, the Government of Rwanda shall;

- train engineers whose role is to support and advice for e-waste disposal in public and private sector: this can be done in technical college and e-waste should be donated to these colleges in order to use them in e-waste dismantling and disposal training,

- develop curriculum on E-waste management which will be taught on secondary level and at universities level: Level one in e-waste treatment can be trained at this level as it is a manual process
- develop a formal and efficient e-waste recycling sector by applying best available processes and practices. This will be achieved by developing and improving skills and competencies of entrepreneurs and other stakeholders through training (low level): train existing technician that are involved in refurbishing activities
- Take lead in e-waste awareness and education: involve all stakeholders, and conduct research on waste and culture or behavior.
- Develop e-waste business models which will yield social benefits like jobs and skills transfer from central to local governments in partnership with the private sector
- Provide technical support and advice for e-waste disposal in public and private sector. Facilitate development of e-waste training modules or manual to cover technical maintenance, dismantling, sustainable e-waste management and waste to art projects to provide for environmental and human health benefits. The training will also cater for training those in the e-waste industry (both informal and formal) to avoid health and environmental risks and local entrepreneurs on e-waste business opportunities. This can lead to job creation for the semi-illiterate.

6.5.1 E-waste management infrastructure

There is no existing infrastructure for e-waste management. The Government of Rwanda shall establish e-waste management Infrastructure by:

(a) Developing sustainable models for e-waste management from umudugudu level to the national level

(b) Encourage set up of facilities to handle refurbishing and e-waste recycling at regional level in the country.

(c) Develop incentives for growth of e-waste disposal agencies by encouraging beneficial reuse/recycling of e-waste.

(d) use existing opportunity such as the development of Kigali city landfill to accommodate e-waste treatment

(e) use technical college and University laboratory as preliminary essay on e-waste treatment

7 Monitoring and reporting standards

Prior to the monitoring system inside, outside the country the government of Rwanda should:

- Conduct of national inventories
- Establishment of mechanisms for information exchange at the national and regional level

7.1 Human health protection

Monitoring of the impacts on human health and the environment of activities concerning or related to the management of electrical and electronic wastes.

a) Prevention and minimization: Establishment of goals, both intermediate and long-term, to reduce the quantity of electrical and electronic wastes ending up in landfills
b) Introduction of cleaner production approach to minimize, and where feasible, to eliminate hazardous substances in Electrical and Electronic Equipment (EEE) and consequently their wastes
c) Development of economic and regulatory incentives to stimulate best practices.

7.2 Monitoring of E-waste management facilities

It should be intended to promote best practices and use of sound recycling technologies adapted to the national specificities. The following should be monitored:

a) Check the use of appropriate methods for evaluation, testing, characterization and classification of electrical and electronic wastes
b) Check the existence of the environmental management systems, such as Extended Producer Responsibility (EPR), standards and guidelines or principles for environmentally sound management or certification scheme.
c) Check the Information and training program such as establishment of a regional information collection and dissemination clearing house or network accessible to all concerned stakeholders (e.g. Governments, industry, NGOs, municipalities, research institutions), increase of awareness at all levels and public participation on WEEE/E-wastes issues. Development of training curricula for trainers, promotion of the transfer, within the region, of expertise, know-how on best practices and technologies.

7.3 Monitoring on the border and outside the country

A number of activities should be undertaken in a monitoring program, it includes:

1. Assessment of any initiated pilot schemes on collection and segregation of Ewastes, including take-back schemes; initiate pilot repair, refurbishment and recycling schemes; and training of customs and enforcement officers to control or verify export or import of electrical and electronic wastes and work on the identification of electronic wastes in the Harmonized System of the World Customs Organization.
2. Determination of collection and transportation system

7.4 Monitoring inside the country

Several activities should guide the monitoring process:

1. Monitor the state of area of collection point and storage point: The area of collection point/ storage facility is fixed as per following guiding steps such as E-waste capture rate for the geographical area served in a given time frame (week/ month/ year), volume of each of the separated E-waste item based on tonnage captured in a given time frame
2. Check the collection area capacity and monitor the number of Collection Points/ Storage Facilities: Collection target defines the number of collection points, Calculate the population served, Calculate each of the E-waste capture rate per inhabitant per year
3. Assess the transportation system: the number of trucks/ trailers of different capacities required to transport the E-waste
4. Assess the frequency of collection based on accessibility
5. Monitor the storage area: leakage, the facility should have balance, weatherproof covering, impermeable surface, spillage collection facility and equipment for treatment of water.
6. Set up equipment specifications for all level of E-waste treatment facility.
7. Monitor the treatment of different metals and step up standard requirement
8. Identify and determine hazardous and non recyclable E-waste fractions disposal options.
9. Monitor the hazardous waste landfill sites: it is advised to be closest to E-waste treatment facility.
10. Monitor the hazardous waste incineration facility

As general guidelines for E-waste treatment facilities establishing the Environmental Impact Assessment report along with detailed project report of the E-waste treatment facility should be provided.

Conclusion

This report shows that the E-waste management in Rwanda does not exist and is needed in order to guide, promote and ensure the safe management of e-waste.

The main recommendations and findings drawn from this study are summarized in the table 7-1.

Table 7-1: Recommendation summary

Objective related to	Findings	Action to be undertaken	Responsible
Gathering data and assessment of the situation	E-waste, mainly computers and cellphone contain many hazardous materials that have adverse health effect	The government shall ensure safety of citizens and the environment from hazardous materials embodied in ICT equipment by	
	Initiative from RHA to assess the number of computers in public institutions	Inventory to be conducted at national level including households, this inventory may include all EEE	REMA and National Institute of Statistics
	There is no awareness on the risk related to casual disposal of EEE	Community and private sector participation: Government shall encourage citizen participation recognize the contribution of the private sector through mobilisation and sensitization on the proper management and handling of e-waste on a sustainable basis with economical benefit approach.	
	Mixed data, inconsistent and non informative on EEE	There is a need to harmonize data: environment as a cross cutting sector there should be someone in charge of environmental data at RRA, National Institute of Statistic and Magerwa. There should be a mechanism to record the information existing on hard copies in Magerwa.	
E-waste management	There is no e-waste recycling unity in	Municipalities should set up the collection unities handling household	

	Rwanda	EEE and take back free of charge by paying to owners a small fee. Apply the 3R approach by reducing the quantity entering the country, reuse the EEE and recycle as much as possible (donate to technical schools either high learning or secondary schools) Globalization: The e-waste management shall take into consideration the trend of Globalization and the government insure that the Basel convention is respected for any transboundary movement of EEE (control on donation, set up guideline on acceptable imported EEE). Set up pilot laboratories, using existing schools and institutions (KIST, Tumba College of Technology and National University of Rwanda) for introductory e-waste management Development of appropriate methods for evaluation, testing, characterization	

		and classification of electrical and electronic equipment at the entry of imported material Development of environmental management system mechanisms To establish incentives for encouraging both local and foreign investors to establish e-waste facilities in Rwanda (tax waiver for example).	
	Draft policy under development	The government through different authorities shall provide specific e-waste regulation (legal and regulatory) from the acquisition, handling to the final disposal processes. This report should serve as a tool to improve the existing policy.	
	There are existing requirements developed by RURA and RBS for imported used computers, computer spare parts and other used elecrtronics	To provide guidance on the standards of ICT equipment that is imported in the country. To put up a mechanism in order to trace the origin and lifespan of the imported EEE (requirement to the importers to provide more details on the product) To deal (do business) with producers that	RBS, RURA, REMA, PSF, MINICOM

		accept a take back scheme at least on computer and cellphones	
Prevention and minimization		Introduction of cleaner production approach to minimize, and where feasible, to eliminate hazardous substances in Electrical and Electronic Equipment (EEE) and consequently their wastes, by dismantling, shredding and only store the parts that contain hazardous material (e.g CRT) while building the infrastructure and human capacity Development of economic and regulatory incentives to stimulate best practices (start collecting EEE by paying a small fees to owner)	
Financing mechanisms		The Municipalities should funds the process for households e-waste management Government for public institutions (and each institution should include a budget related to e-waste handling) All stakeholders should be involved for	

		resource mobilization for efficient management and disposal of e-waste: government, consumer, retailer, producer... this would be a step by step process (government financing first, and later on use the money collected by imposing fees on retailers and importers) Government should provide assistance to importers to look at the take back strategy while importing EEE	
Information and training		Establishment of a regional information collection and dissemination clearing house or network accessible to all concerned stakeholders (e.g. Governments, IGOs, industry, NGOs, municipalities, research institutions) Increase of awareness at all levels and public participation on WEEE/E-wastes issues Development of training curricula for trainers and manual for dismantling Set-up of task force of expert for: Promotion of the transfer, within the country, of expertise, know-how on best practices and technologies. Implement a pilot in two or more city	

		using high learning institution or technical schools in the country on the collection and treatment (at least at the level of dismantling) of computer and mobile phones Develop guideline on the refurbishment of computer and mobile phones Opening a dialogue with all stakeholders on initiatives that could be carried out for ESM of e-waste and available information that would address issues associated with illegal traffic. The Ministry of Education and the Ministry of Public work, Ministry of sport and youth shall develop a critical human resource base knowledgeable in handling e-waste by revising the curriculum and introduce technical courses, modules...in their respective institution, high learning, technical college, youth gathering (e.g. IWAWA camp) and use the college and high learning institution as pilot studies.	

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