E-WASTE MANAGEMENT:
A CASE STUDY OF LAGOS STATE, NIGERIA

Benedicta A. Ideho
Social and Public Policy
Master's Programme in
Development and International Cooperation
Department of Social Sciences and Philosophy
University of Jyväskylä
Finland
Autumn, 2012

Abstract

E-WASTE MANAGEMENT: A CASE STUDY OF LAGOS STATE, NIGERIA
Benedicta A. Ideho
Master's Thesis
Social and Public Policy
Development and International Cooperation
Department of Social Sciences and Philosophy
University of Jyväskylä
Supervisor: Marja Järvelä
Autumn, 2012
Pages: 75 pages + 2 appendices

End-of-life electronics, otherwise known as e-waste has steadily become a visible threat to the environment. With the electronic industry fast becoming the world's largest manufacturing industry and also, arguably, the industry with the shortest life span products, it is essential that the method of disposing the resultant e-waste becomes an integral part of electronic manufacture and consumption.

Utilizing Garrett Hardin's theory "Tragedy of the Commons" as a theoretical framework and a qualitative approach through a case study with participant observations, quantitative structured questionnaires and semi-structured interviews, this study seeks to determine the relationship between socio economic factors and informal e-waste management practices in Nigeria.

The study revealed that even though health hazards associated with the interaction with e-waste were evident, stakeholders in the informal management of e-waste were willing to continue in the trade due to the economic benefits it offers. Though there is provision for management of hazardous waste in the National policy guidelines as well as regulations set by the National Environmental Standards and Regulations Enforcement Agency for importation of electronic devices, the lack of effective management systems and implementation creates a loophole for the presence of e-waste in Lagos state. This study also revealed that the national electronic/IT sector is organized and regulated by the associations involved in the electronic business.

It is therefore recommended that Nigeria develops an effective policy framework which encourages the development and manufacture of national IT knowledge and appliances. There should be efficient systems to enforce regulations and prohibit the importation of e-waste into the country. The government should also encourage investors in standard recycling of resultant e-waste from local consumption and encourage national IT initiatives that will reduce the dependence on importation of electronics and promote green development.

Key words: e-waste recycling, disposal methods, electronics, Ikeja computer village, Lagos state

Dedication

Home is always where you run to, no matter where you are.

Home is my family. The lessons to live, love and matter and the support they give unconditionally.

Acknowledgments

My profound thanks go to Jehovah the Almighty God, for His unending love and continuous support which; He grants me every day. I appreciate everyone who has been a part of this work; for providing the motivation, information and editorial support needed to make it a success.

I am particularly grateful to all D&IC Professors and staff; especially to my beloved Supervisor Prof. Marja Järvelä for her contributions, support and encouragement; Dr. Sakari Taipale for his insightful guidance and contributions and Princewill Tafor, for his patience, guidance and constructive ideas. My sincere thanks also go to Prof. Jeremy Gould for his fatherly advice and Emilia Lipponen, your patience, smiles and dedication is very humbling.

To my friends who were patient with my e-waste ramblings over lunch and outings, for tolerating my unending sporadic ideas, words cannot describe my appreciation.

Table of Contents

List of Figures and Tables

List of Abbreviations

BAN	Basel Action Network
CAPDAN	Computer and Allied Products Dealer Association of Nigeria
CII	Confederation of Indian Industries
CRT	Cathode Ray Tube
EEE	Electrical Electronic Equipment
EPA	Environmental Protection Agency
FEPA	Federal Environmental Protection Agency
GSM	Global System for Mobile communications
IC	Integrated circuits
ICT	Information Communication Technology
ITU	International Telecommunication Union
LAWMA	Lagos State Waste Management Authority
LCA	Life Cycle Analysis
NESREA	National Environmental Standards and Regulations Enforcement Agency
OAU	Organisation of African Unity
OECD	Organization of Economic and Cooperative Development
PWBs	Printed wiring boards
WEEE	Waste Electrical and Electronic Equipment
WSIS	World Summit on the Information Society

PART ONE: RESEARCH PROBLEM AND METHODS

Chapter One: Introduction

Nine out of every ten homes possess an obsolete electronic device such as an outdated computer, a refrigerator or a mobile phone. It is probably covered in dust, lying at the base of your cabinet or trash can and grimy from lack of use. Obsolete electronic devices or electronic waste (also referred to as e-waste) are becoming common sites everywhere, giving birth to what some experts are predicting to be the largest toxic waste problem of the 21st century (Schmidt, 2002). To illustrate just how much of e-waste we tend to generate, Paul Bonomini, a contemporary artist designed and built what is now known as the WEE (e-waste) man (see Figure 1.1).

Figure 1.1: The WEE Man

Source: Paul Bonomini, Eden Project (2011)

The WEE man comprises of mobile phones, MP3 players, lawn mowers, computer mice, satellite dishes and computer parts for brains. Towering at seven meters, the WEE man represents the rapid evolution of consumption and disposal habits of electronics goods (Bonomini, 2011).

Over the past decade, the world has witnessed a significant increase in technology, especially in the area of communication. Computers are now created with DNA chips, giving them a close

representation of human attributes, mobile phones now exhibit such similar traits as well, multi-touch features, body sensors, voice sensors, and even predictive thinking (Mauk & Metz, 2011). Between 2000 and 2005, the Organization of Economic and Cooperative Development (OECD) noted a 22% growth in Information and Communication Technology (ICT) in China. Amongst US, Japan, Germany, UK and France, China was rated as the 6th largest ICT market in 2006. This growth rate is interesting considering that less than 1% of China's population possessed a computer ten years ago (StEP, 2011). A look at the Waste Electrical and Electronic Equipment (WEEE) Directive (EU, 2010) revealed that rapid product innovations and its replacement, (especially in ICT and office equipment) in addition to the migration from analogue to digital technologies and to flat-screen TVs, monitors, compact and multi-tasking devices such as the iPad, iPhone and Kindle, are fuelling the increase of electronic waste. The advent of lower prices for many electrical goods has caused an increase in global demand for many products that eventually end up as electronic waste. Computer devices constitute only a part of the electronic waste stream. As shown in United Nations University Review report of 2007, batteries, fridges and other cooling and freezing appliances, as well as household appliances, accounted for 44% of total e-waste (United Nations University (UNU), 2007).

As a result of this rapid and remarkable growth, e-waste or discarded electronic equipment is thus regarded as the fastest growing waste stream in the industrialized world. E-waste is a crisis born not only out of quantity generated but also from the cocktail of toxic ingredients. Substances such as lead, beryllium, flame retardants found in e-waste pose as both occupational and environmental health threat (Puckett, et al., 2002). Industrialized and technologically advanced nations such as USA, the UK and other wealthy economies generate most of the world's electronic products and subsequently generate most of the e-waste (ibid). Rather than developing an ecological means of manufacturing and dealing with e-waste, these countries utilize another means of disposing their mounting collection of e-waste – exporting the e-waste to the developing countries especially Africa and Asia in the guise of 'second hand' electronics (ibid). This study therefore seeks to understand the relationship between the social-economic impact of e-waste and environmental health risks experienced by inhabitants of its host community.

1.1. Background to the Study

1.1.1. My Journey into the World of E-Waste

Until recently, it never occurred to me that one of my very favorite electronic gadgets, my mobile phone, may be a source of happiness or pain to some child somewhere else in the world. This may be regarded as a momentary case of self-reflection but the reality, once I got curious enough to search the web pages of the Internet was quite daunting not to say alarming at the least. My curious search led me to a dumpsite in Nairobi, Kenya. Dandora, as the dumpsite is known, is one of Africa's largest dumpsite with the expanse of land measuring 30 acres, filled with both electronic and solid waste from all parts of Nairobi, its environ and across the Kenyan border. The site was intended to fill up an old quarry but increased popularity made it a mountainous dumpsite. As a measure of eliminating the growing volume of waste, the inhabitants result to burning which leaches hazardous chemicals into the soil and the Nairobi River flowing next to the site (Njoroge, 2007).

Figure 1.2: Dandora Dump site, Nairobi, Kenya.

Source: TonyKarumba/Afp/GettyImages. (Business Week, Biggest Garage Dump, 2009)

It is estimated that Dandora dumping site receives over 2000 metric tons of waste daily. Dumping at this site is unlimited which ensures that a steady stream of solid, industrial,

agricultural, and electronic waste is strewn all around the dump (Njoroge, 2007). A striking characteristic of the Dandora dumpsite is its secondary usage as a stable means of income for low-income inhabitants living close by. Scores of people including children sort the waste into food, recyclables, and electronics. Electronic gadgets possess components such as gold and copper that is in high demand in the electronic industry, thus, the inhabitants manually sort e-waste by burning and extracting the gold and copper for subsequent sales (ibid). A study carried out by Njoroge (2007) on 328 children between the ages of 2 and 18, revealed a link between environmental pollution and public health issues. Children who lived around the dumpsite tested to high prevalence of lead in their blood. The process of waste sorting exposes both children who reside in the environment and adults who engage actively in the e-waste processing to toxins emitted from burning and decaying e-waste (ibid). The effect of this exposure will be discussed in details in the later part of this thesis.

This practice was new to me and prompted me to search for more insight into similar dumpsites around the world. My next search stop is India, a country estimated to have a population of 1.21 billion persons. Indigenously, India employs various methods of dealing with its waste specifically, e-waste. One of such practices of getting rid of obsolete electronic items is to exchange them from retailers when purchasing a new item (Kurian, 2007). 78% of all installed computers in India are perceived to have originated from the business sector (Toxics link, 2003). Computers considered obsolete by the business sector are sold by auctions or transferred to educational institutes or charitable institutions that reuse them. A total of 1.38 million obsolete personal computers are estimated to emanate each year from business and individual households in India (Toxics Link, 2004). According to a report of Confederation of Indian Industries (CII), a total estimate of 146,000 tons of broken down electronics and electrical equipment is generated in India per year (CII, 2006).

However, there are also parts of India which engage actively in informal e-waste recycling. Due to lack of waste sorting at source, it is quite difficult to ascertain the quantity of e-waste generated and disposed each year and the resulting extent of environmental risk it poses especially to the waste host community (Kurian, 2007).

Further search led me to Guiyu in China, Karachi in Pakistan and Lagos in Nigeria. Studies carried out by Basel Action Network (Puckett, et al., 2002) reveals that China with a population of over 1.3 billion persons, exhibits same characteristics as Dandora in Kenya.

Guiyu is an area made up of four small villages which lie along the Liamjiang River: Haumei village, Xliampeng village, Longgang village, and Beiling village. These villages are collectively referred to as Guiyu (ibid). Guiyu, often referred to as "e-waste capital of the world", employs over 150,000 workers coming from the four villages, who dismantle and recapture valuable metals and parts that can be reused or resold from old computers. Unlike Dandora in Kenya which is a mixture of solid municipal waste and electronic waste, Guiyu is regarded as a 'recycling center' for electronic devices. In this informal recycling, it is not uncommon to see computer parts, cables and huge tangles of wires scattered about the streets and river banks (Hwa, 2011). Additionally, there is also a high level of specialization in the process of taking-apart an electronic device. According to Puckett (2002), specialization is usually attributed to specific e-waste shelters and yards. Puckett further estimates that various sections involved in e-waste in Guiyu earn over $75 million per annum from processing about 1.5 million tons of e-waste. This is not surprising considering the fact that the US alone discards about 130,000 computers every day and over 100 million cellular phones annually (Toxics link, 2003). 75% of e-waste in Guiyu comes from North America (Puckett, et al., 2002). Many workers migrate from distant villages or provinces to work in Guiyu earning an equivalent of about $7 to $10 per day (ibid). While this can be regarded as a welcome change to joblessness and 'low income rate', the adverse effect it has invoked on both land and man cannot be ignored because the workers adopt primitive methods without the use of protective equipment such as acid stripping to extract gold from circuit boards, plucking of micro-chips from circuit boards with hands and burning plastics to determine the type of material used in the production of such plastics (Hwa, 2011).

Karachi, Pakistan located in Shershah, shares a similar story with Guiyu, China. However, unlike Guiyu, Karachi is a huge scrap market which attracts workers from surrounding countries including Afghanistan; but like Guiyu, workers are specialized in different areas of extracting re-usable parts of electronic devices. Every part of the electronic device has its own shop where

extracted parts are either sold off to local e-waste brokers, goldsmith, or exported. Plastics extracted from the computer monitor are usually exported to China (Khan, 2009).

It is quite interesting to see the various ways by which people from different parts of the world interact with e-waste. While the generation of income is a common goal for all parties involved in the e-waste business, the methods employed to achieve this goal are diverse and different depending largely on the perceptions and tools available to the participants as will be seen in the later part of this thesis.

1.1.2. Nigeria: Case Study

Nigeria, a country where this study is carried out, is home to over 150,000,000 people (Index mundi, 2011) with an increasing consumption of electronic gadgets from 36 states and a federal capital state. One of such states is Lagos which was formally the federal state capital of Nigeria. It is a megacity with over 17,000,000 inhabitants, 356,861 hectares of drylands and 75,755 hectares of wetlands, thus it is regarded as the smallest state in Nigeria (due to land availability) (Lagos State Government, 2011). With a population as large as this and the existence of a thriving IT sector, it is no wonder that e-waste management is an issue here.

Nigeria lacks an indigenous IT industry which implies that the IT sector is basically import oriented. Besides the e-waste which is locally generated by consumers in Nigeria, a large quota of the e-waste is either unintentionally or intentionally imported as used Electrical and Electronics Equipment (EEE) (Schmidt, 2006). Recently, the mounting threat posed by the existing methods of informal recycling and disposal methods has attracted the media (Puckett, Westervelt, & Gutierrez, 2005). Suffice it to say that this attraction has not gained adequate recognition among policy makers and manufacturers of electronics alike. Studies under the direction of the E-waste Africa project (Wasswa & Schluep, 2008; Magashi & Schluep, 2011; Finlay & Liechti, 2008) revealed that there is a steady increase of EEE in Africa, specifically in Nigeria. This invariably, increases the amount of e-waste generated in the future (Schluep, et al., 2009).

Nigeria houses one of the largest IT market in West Africa – Ikeja Computer Village. Ikeja computer village was once a residential area until the early year 2000 when Internet technology became a household name in corporate Nigeria. Eager to cash in on the birth of a major industry, savvy businessmen acquired properties in the most lucrative part of Ikeja (a street known as Otigba) to commence trade in IT equipment and electronic devices. By 2003, two years after Global System for Mobile communications (GSM) services was launched in Nigeria, Ikeja computer village became a household name among Telecommunication users, within and outside the shores of Nigeria.

Nigeria has a huge appetite for technology, but due to limited financial resources, infrastructure and indigenous IT industry, much of this growth is facilitated by import of 'second hand' or 'hand me down' equipment from rich developed countries whose consumers are all too happy to find buyers for them. As a result, this sector has become a thriving terrain for middle men and brokers who channel these used equipment from the industrialized North to the under developed South. Unlike Guiyu in China, Dandora in Kenya and Karachi in Pakistan, refurbishing of used electronic devices and unlocking mobile devices is a more lucrative practice in Ikeja. Where such devices are beyond repair, they are taken apart and used as spare parts for other broken devices. Scraps and non-reusable parts are either discarded in the main waste dumpster, burnt in major trash cans or just left to lie around in the environment.

A common phenomenon with these countries is the location of the dumpsites. These dumpsites are usually situated at strategic points where refurbished or reusable parts are easily accessed. This is coupled with the obvious income generating ability the dumping of e-waste creates as well as the environmental and health hazards associated with the decomposing of e-waste materials on land, air, and water. The channel by which a large amount of e-waste is introduced in the host community is also a common feature. Besides the presence of the above factors and the obvious cash generated, it is puzzling that regardless of the environmental and health hazards faced by the host communities, e-waste recycling and refurbishing practices continues to thrive in these places. Perhaps like the old adage which says *"...the river cleans itself after every 10 mile"*, the environment may be perceived by the host community as a common good that is non-

exhaustible and thus can replenish itself? It could also be that the desire to ensure a steady stream of income far outweighs the concern for the "non-exhaustible" environment.

1.2. Objectives and Research Question

The main objective of this research is to determine the relationship between socio-economic factors and informal e-waste management practices in Nigeria. This thesis aims to answer the following research question:

What are the economic benefits and health hazards inherent in informal e-waste management?

1.3. Significance of the Study

The utilization of electronics in our everyday life is almost as important as our very existence in this fast-paced globalized world, but the effective management and long term effects of the resultant waste has not fully been grasped by consumers. This is mainly due to the fact that there is only an emerging body of knowledge on e-waste in the field of waste management; and a limited data on e-waste generation among developed and developing nations. Additionally, e-waste is perceived and managed differently amongst different countries. Therefore understanding the key concepts of e-waste management and the relationships between the economic impact of e-waste and its negative effects on the host community will serve as a base for better environmental and socially friendly practices for e-waste management.

1.4. Limitations of the Study

The electronic waste stream is an emerging body of knowledge in the field of waste management. Therefore, established data is presently limited for example on the amount of e-waste generated among other forms of waste. E-waste is presently more an informal sector hence the reliance on for example, import figures, can sometimes not reflect the true status of the influx of e-waste across borders in Nigeria. Data on the economic importance and size of informal e-waste recycling among the professions in e-waste is pretty difficult to collect. This is because

both activities are carried out almost simultaneously therefore there are estimates among stakeholders about the number of informal e-waste recycling practitioners working part-time or full-time in Lagos.

1.5. Methodology

This research combines both quantitative and qualitative methods. Quantitative survey data enabled sample opinions from the target population. The use of key informant interviews was also utilized as a measure of reliability and validity of data (Houston & Sudman, 2004). Conceptual information needed for this research was also gathered from books, Journals and online articles obtained from web pages of internationally recognized organizations in e-waste management.

Ikeja computer village and Olusosun dumpsite in Lagos State Nigeria were chosen as case studies because of their size, location, level of international recognition and peculiar economic activities. Ikeja Computer village is a transit point for electronic devices to all 37 states in Nigeria and neighboring West African countries. Olusosun dumpsite, otherwise known as 'Bowler' is a major dumpsite in Lagos employing over 1,000 workers who make their living from sorting waste.

To determine the target population, two methods of sampling was employed: stratified random sampling and quota sampling. Stratified random sampling was applied to determine the primary stakeholders in the electronic industry in Ikeja, Lagos, Nigeria. They are the Electronic Importers, the Electronic Repairers, Computer and Photocopying Services and the Local Recyclers (waste scavengers). They were chosen according to their profession and activities in the electronic industry. Applying the quota sampling method helped to further specify the target group by dividing them into the stakeholder groups listed above. 100 participants were chosen from the four groups. Structured questionnaire was administered utilizing the closed ended question format (See Appendix A).

1.5.1. Data gathering at Ikeja Computer Village

To gain access to the sample population, permission and assistance was obtained from the Computer and Allied Products Dealer Association of Nigeria (CAPDAN) officials located at the Ikeja computer village. CAPDAN is the association in charge of electronic activities in Nigeria. A representative was assigned to me and we spent 61 days administering the questionnaires. 20 questionnaires were administered to participants in the Computer And Photocopying Services profession, 21 questionnaires administered to Electronic Importers profession, 27 administered to Electronic Repairers profession and 32 questionnaires administered to Local Recyclers (waste scavengers) totaling a 100 questionnaires. The research group were pre-informed before the exercise and an off-peak business time was agreed upon to enable them participate fully. I also had the opportunity of interviewing a local shop owner in the Electronic Repair/refurbishing profession (a key informant in this study) who was willing to answer my questions about his job and his interaction with e-waste (See Appendix B).

1.5.2. Data gathering at Olusosun dumpsite

The Lagos State Waste Management Authority (LAWMA) has the responsibility of managing dumpsites in Lagos state. To gain access to Olusosun dumpsite, permission and assistance was obtained at the headquarters of LAWMA at Ijora Olokpa, Lagos. The dumpsite occupies over 42 hectares of high walled land. Due to rapid development, the dumpsite is now surrounded by private and commercial houses and business. I was allowed to take supervised pictures and a 15 minutes interview with the chairman, Mr. Fatayi Kurumi of the Scavengers Association who was also present at the dumpsite. As a key informant in this study, data gotten from him was compared against the questionnaire data collected from the local recyclers (waste scavengers) group (See Appendix B).

Figure 1.3: The dumpsite at Olusosun, Lagos State, Nigeria occupies over 42 hectares of high walled land

Source: Benedicta Ideho, 2011

Figure 1.4: Scavengers busy at the dumpsite at Olusosun, Lagos State, Nigeria.

Source: Benedicta Ideho, 2011

PART TWO: THEORETICAL FRAMEWORK AND E-WASTE POLICIES IN NIGERIA

Chapter Two: Theoretical and Conceptual Framework

2.1. Conceptual Framework

To waste or not to waste- it's all in the definition
(B. Quin)

What exactly is e-waste?

E-waste is a combination of a broad and increasingly growing range of electronic devices such as large household devices (refrigerators, air conditioners) and mobile devices. Thus e-waste has a plethora of definitions. Each definition depends on the interpretation of an electronic device's usefulness. The OECD definition for e-waste is pretty simple: e-waste is regarded as any appliance using an electric power supply that has reached its end-of-life (OECD, 2001). Solving the E-waste Problem (StEP, Solving the E-waste Problem: A Synthetic Approach (StEP). Draft Project Document, 2005) on the other hand, defines e-waste as a reverse supply chain which collects products no longer desired by a given consumer and refurbishes it for other consumers via recyclers.

According to the EU Waste Electrical and Electronic Equipment Directive (WEEE), e-waste is regarded as any substance or object which the holder disposes of or is required to dispose of in accordance with the provisions of the national law in force (EU. Directive, 2002a). In the UK, the Environment Agency, however, defines e-waste according to their end-of-life usefulness. An equipment is not considered waste when it can still be repaired, can be sold or given away, can be given out in exchange for a new one, donated for charity purposes, sent out for refurbishing or returned to a retailer in accordance with the organizations' return policies. On the other hand, an equipment is considered waste if it does not satisfy the above situations (Environmental Agency, 2012)

The US Environmental Protection Agency (EPA) defines e-waste by categorization. It categorizes e-waste according to non-hazardous waste which includes household electronic waste and scrap metals met for recycling and *non-waste* which includes all products and commodities meant for recycling such as scrape metals, circuit boards and CRT (Cathode Ray Tube) glass (Tonetti, 2007). Ironically, EPA also considers discarded CRT monitors as "hazardous household waste" (Morgan, 2006); but considers CRTs set aside for testing or re-usable parts of obsolete gadgets (working and repairable electronics) and scrap materials also known as secondary scrap (copper, steel, plastic, etc.) to be "commodities" if they are not discarded, speculatively accumulated, or left unprotected from weather and other damage. Additionally, the EPA policy states that obsolete electronics are not considered waste until a specialized decision is made stating their continuous usability hence the use of *non-waste* as indicated in the definition above (Tonetti, 2007).

E-waste can also be referred to as end-of-life products. End–of–life products are products considered by its original users to be non-usable. They include products that have material values and those that do not. Fleischmann (2001) and Flapper, Numen, & Wassenmow (2005) however, refer to end-of-life products as products with no other residual value than material value. Yet, Balakrishnan, Anand, & Chiya (2007) defines e-waste as any obsolete equipment that is dependent on electric currents or electromagnetic fields in order to work properly, including equipment for the generation, transfer and measurement of electric current.

One of the shortcomings on the above definitions is that there is no clear consensus on whether the term e-waste should be applicable to refurbishing industries, resale and used products or only to products that cannot be used for its intended purpose. Notably, the substances contained in the electronic devices such as lead or mercury is not critically involved in the definitions of what should be regarded as e-waste. Therefore, due to the generic nature of the term “e-waste”, and the differences in perceptions of what should constitute e-waste, approaches and methods of disposal varies greatly as perceived in the definitions. For example, the EPA definition for e-waste is problematic simply because it does not give a clear distinction between electronic devices considered as hazardous e-waste and those considered as non-hazardous e-waste. This

leaves room for ambiguity that can easily be exploited by stakeholders involved in recycling and general e-waste management. Regardless of these differences, a common ground for the various definitions is that e-waste is made up of electronic products which are no longer considered usable by consumers and can thus be discarded. For the purpose of this research, e-waste will be generally referred to as discarded obsolete or non-usable electronic devices.

Commendably, the EU has a clear and holistic approach to e-waste management. Major players in consumption and disposal of e-waste are represented in its regulations. An excerpt from the Draft European Parliament Legislative Resolution, second reading amendment states clearly:

> *The purpose of this Directive is to contribute to sustainable production and consumption by, as a first priority, the prevention of WEEE and, in addition, by the re-use, recycling and other forms of recovery of such wastes, so as to reduce the disposal of waste and to contribute to the efficient use of resources and the retrieval of critical raw materials. It also seeks to improve the environmental performance of all operators involved in the life cycle of EEE, e.g. producers, distributors and consumers and, in particular, those operators directly involved in the collection and treatment of WEEE (European Parliament, 2001).*

The regulation also recognizes environmental management as an integral part of sustainable e-waste management. As Redclift, (2001) puts it, the environment is most times understood in relation with the functions it performs which is reflected by the social practices and commitments of human societies. The environment is sometimes neglected in these social practices such as the 'getting and spending' habits that characterize modern complex societies. The propensity to consume is linked to income and employment. This also increases the volume and quality of waste produced. According to Sachs (2001), consumption can be addictive; it not only increases as the level of income increase, but goods which were originally experienced or perceived as luxuries are regarded as necessities. Thus, the recognition of consumption patterns is an integral part of addressing the presence of e-waste in an environment. This sadly, is neglected in some of the management practices carried out by some societies as indicated in the definitions above.

2.2. Theoretical Framework

> *…what is common to the greatest number has the least care bestowed upon it. Everyone thinks chiefly of his own, hardly at all of the common interest (Aristotle, politics, Book 2, III).*

Before the advent of Garrett Hardin's theory 'The Tragedy of the Commons', Aristotle has examined the nature of man to care for only that which he believes is his. This reflects the need for private property rights and the neglect for what is considered to belong to everyone in this case, a common good. Aristotle could not have done a better job of summarizing the present evolving trend of the technological world. It is applicable in that technology as a market driven sector, derives its strength from the increasing demand for a fast paced easy life, the desire to extend economic growth and an increase in economics of scale. Each manufacturer seeks to grab the larger share of the market by increasingly improve perceived services in their technological devices. This growth is not in proportion with the ecosystem which is a Common Pool Resource (CPR) (Ostrom, 1990). As Daly (1992) rightly puts it:

> *The economy grows in physical scale, but the ecosystem does not. Therefore, as the economy grows, it becomes larger in relation to the ecosystem. Standard economics does not ask how large the economy should be relative to the ecosystem (Daly, 1992 p180).*

The pursuit for economic growth as perceived in Daly's words takes into cognizance the way we metabolize nature (Redclift, 2001). Redclift attributes this 'metabolism' to social commitments, economic advancements and perceptions of consumption habits. He wondered if the society and the current environmental challenges will be significantly better if consumption is reduced to modest proportions. Judging by the speed to which technological advancements practically govern the way we live, that is not likely to happen in the near future. The technology industry discards as fast as it produces. Perhaps, at the risk of sounding technical, this trend can be attributed to Gordon Moore's Law of transistors. The law states that the "*number of transistors that can be placed on an integrated circuit will double approximately every two years"* resulting in rapid improvements in computing speed which in turn ensures a constant development of more powerful and advanced models of electronic devices (Moore, 2012); thus tempting consumers to discard working electronics for more advanced models usually after only a year or

two of use. This behavior is encouraged by persuasive and obtrusive advertising promising more advanced model and sophisticated features. Additionally, the high dependence on speedy internet facilities, education and communication purposes also enhances this process.

However, at the heels of economic growth, fast technological advancement and subsequent increase in consumption is its partner pollution. Pollution here refers to e-waste. This leans towards Garrett Hardin's theory on the Tragedy of the Commons which indicates "*a dilemma arising from the situation in which multiple individuals, acting independently and rationally consulting their own self-interest, will ultimately deplete a shared limited resource even when it is clear that it is not in anyone's long-term interest for this to happen"* (Hardin, 1968). Additionally, Hardin asserts that as regards pollution, the rational man acknowledges that his share of cost of waste before releasing into the commons is less than the cost of purifying his wastes before discharging them (ibid). Naturally, many others who utilize the commons also think the same way, thus:

> *…we are locked into a system where everyone behaves in an independent, rational and free enterprise manner, compelled to increase output without limit in a world that is limited (Hardin, 1968, p4).*

Pollution in Hardin's theory is not a question of overexploiting or extracting from a common as in the case of over fishing, but of introducing harmful substances into the environment which is the commons in this case (ibid). The environment such as air and water is a common property or a common pool resource that cannot essentially benefit from the direct application of private property as proposed by Hardin (1968). These resources cannot be shared or landmarked hence, Hardin's theory has been criticized on grounds of historical inaccuracy and for failing to distinguish between common property and open access resources.

In spite of this, it has proven to explain the present state of the electronic industrial world and the way the resultant waste is managed. A deeper reflection shows that Hardin's theory is based on the premise that the world available to the human population is finite with no exception (including space), meaning at some point, it will be exhaustible especially with the increase in global population and consumption levels.

As mentioned above, pollution also accompanies economic growth, development or so called modernization. In the developed and industrialized countries, the management of e-waste and the corresponding pollution is a problem of growing proportions (Redclift, 2001).

As regulations tighten in response to the growing problem of e-waste in the industrialized communities, companies seek for alternative routes of handling their e-waste in order to lower costs and improve profitability (Puckett, et al., 2002). This is in accordance with Hardin's predictions on human's ability to put immediate profitability above long term effects (Hardin, 1968). The easiest solution to this problem as perceived by these industrialized companies is to 'bridge the digital divide' and integrate the nations who need to keep up with the fast technological pace by exporting this e-waste to them, thus seemingly averting the problem of e-waste in their environment. Interestingly, the recipients of this e-waste, usually developing countries, need the income to be gained from this transaction as well as the foreign exchange it generates (Redclift, 2001). It appears to be a win-win situation but this is at the expense of environmental sustainability or the ecosystem of the host community.

It is quite obvious that e-waste proves to be a menace to environmental sustainability and also a source of income for its host communities. It is a dilemma because with e-waste comes pollution. Pollution has also been regarded as a consequence of population (ibid). A peculiar phenomenon about e-waste is its presence in large cities. This can be attributed to the size of the population which ensures high levels of consumption, the presence of sea ports which aids the means of exportation and importation of goods and large industrial electronic presence which fuels consumption and importation. Lagos state where this study was carried out is a megacity and as such faced with a number of social and environmental issues such as housing, water and waste disposal methods. Myllylä (2001), who perhaps is one of the most optimistic advocates for a megacity future, put forth an encouraging approach to mega city regions and their potential development, regarding them as a place of abundant human and natural resources:

> *…the sheer size of the megacities presents a situation for which we have no collective experience. No precedent exists for feeding, sheltering or transporting so many people in so dense area, nor for removing their waste products or providing clean water… there is enough creativity and energy in the cities today to address the challenges, but there are*

too few mechanisms to channel these forces into the policy making process or to multiply the effects of approaches to that work…. Conventional solutions are not the answer… (Myllylä, 2001, p16)

The citation above indicates a lacking in environmental knowledge system that enables humans to live in large urban settlements along with the sustenance of their ecological functions (Myllylä, 2001). In her study "Street Environmentalism" Myllylä (ibid) asserts that Environmentalism as a concept is a very heterogeneous domain of environmental concerns, philosophies, ideologies and action. According to Milton and Kay (1995), environmentalism is a "quest for a viable future, pursued through the implementation of culturally defined responsibilities". Myllylä interprets this as a social commitment which arises from the idea that human activities influencing the environment ought to be controlled in some ways.

2.3. The Digital Divide

Ignoring the obvious environmental hazards, it may seem to be a 'win-win' situation where both parties, in this case, the countries in need of technology (which ensures rapid integration in the globalized world) and the technologically advanced countries (who rapidly evolve the digital world). The digital world is characterized by an increase in access to the internet as well as a corresponding increase in devices to access information (International Telecomunication Union, 2011). The International Telecommunication Union (ITU) report of 2011 revealed that of the 7 billion persons in the world, one third was on the internet. 65% do not have access to the internet while 35% gain access to the internet as indicated in the Figure 2.1 below.

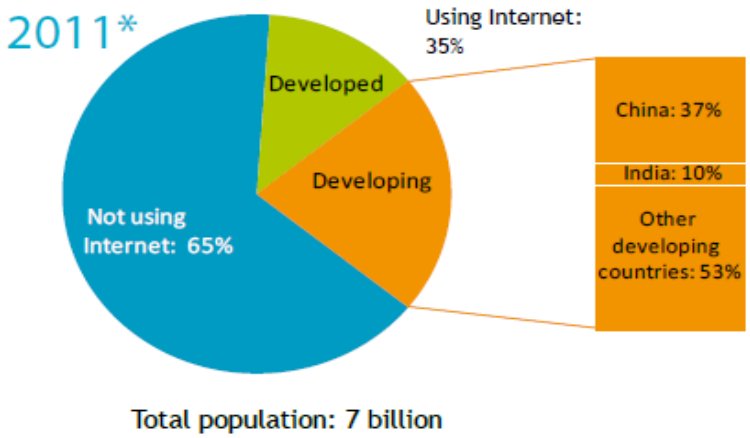

Figure 2.1: Share of Internet users in the Total World Population.

Source: ITU World Telecommunication/ICT Indicators database, 2011
*Note: * Estimate.*

Progress in the ICT world is measured by the channel of distribution such as availability of infrastructures and technologies especially in the aspect of internet speed and broadband (International Telecomunication Union, 2011). These are drivers of the digital world and this is also the means by which the mode of communication and information accessibility is shaped. The rapid development in this sector has given birth to concerns on marginalization hence the concept "digital divide" (Hargittai, 2003).

Hargittai (2003) gives a broad definition of the 'digital divide' as the gap between those who have access to digital technologies and those who do not. It is also defined as the gap between those who use and understand digital technologies and those who do not. In retrospect, one of the reasons for shipping e-waste to the non-technologically advanced societies by the cornered companies in the industrialized societies is to 'bridge the digital divide'. But alas, the poor justification of "building bridges over the digital divide" is an excuse used to obscure and ignore the fact that these channel of bridging the "digital divide" double as toxic waste pipelines to some 'poorest' communities and countries in the world (Puckett, 2005). This leads to decreasing environmental resource in this case the 'commons' of the host community.

This economic benefit of e-waste to the exporters and the host communities pales in comparison to the failures of the electronic industry to design their products such that they can be safely recycled anywhere in the world. From this premise therefore, even if China, India, Nigeria or Pakistan possess state-of-the art technologies for recycling and the resources and infrastructure to sustain and ensure that such technologies work optimally, the export of all of the world's e-waste would still be an unjust, inappropriate export of pollution to a particular region of the world simply because it is appears to be in need of it.

2.4. Rationale for Trans-boundary Movement of E-waste

According to Puckett (2005), the export of e-waste remains a *'dirty little secret of the high-tech revolution that many would rather not talk about'*. Scrutiny has been meticulously avoided by the electronic industry, government officials, and people involved in e-waste recycling. This willful denial has been often aided by the cynical labeling of this trade with the ever-green word "recycling" (ibid).

First, the trans-boundary movement of e-waste begins its journey from the manufacturers of electronic gadgets who refuse to eliminate hazardous materials or design for disassembly. Second, government policies fail to hold manufacturers responsible for end-of-life management of their products hence consumers become the unwitting recipients of a toxic product abandoned by those with the greatest ability to prevent problems. Laden with the choice of doing right, consumers willingly turn to recycling. Alas, this obvious solution to e-waste simply produces more problems not for the direct consumers, as they have performed their sole duty of properly discarding their toxic waste, but for the recyclers who are faced with market realities of actually recycling the end of life electronics.

While there are a number of E-waste recyclers who genuinely practice environmental ethics and are trying hard to make the most out of poor upstream design, there are many others who have discovered a loophole for "recycling"— recycling via export indirectly or directly as the case may be through brokers (Puckett, 2002). Indeed, it has been estimated that between 50 to 80 percent of the e-waste collected for recycling in the western U.S. are not recycled domestically,

but is very quickly placed on container ships bound for destinations like China, Pakistan, India, and Nigeria (Puckett, 2002). The economic gains of shipping off used electronics are more lucrative than it is to domestically recycle them. Thus, even the best-intentioned recyclers are often forced to engage in the disguise of "bridging the digital divide". In all fairness, recycling is very capital intensive. However, consumers often pay a fee to get them recycled occasioned by tax cuts from the government but it just seems the right solution is to ship them off to countries who "need" them (Puckett, 2005).

According to Puckett's detailed report on e-waste in Nigeria:

> *…They (recyclers) see that the real solution is producer responsibility. Few of us realize that the obsolete computer we pay someone to take, in hopes it would be recycled, might end up in China or some other far-off Asian destination. Although it has been a secret well-kept from most consumers, the export "solution" has been a common practice for many years. But until now, nobody, not even many recyclers, seemed to know the fate of these "Made-in-USA" wastes, or what "recycling" in many of these developing countries really looks like (Puckett, 2002 p4).*

The act of shipping e-waste off shore is strongly encouraged by the dynamics of global economics, poor environmental standards and poor working conditions of the recipient countries. It is also heightened by the need to keep up with the technologically advanced societies. The global market runs on technology which most of the developing societies cannot afford directly. If this rapid growth in technological advancement is not met with adequate producer responsibility and regulated market forces, toxic waste will always travel "downhill" on an economic path to the developing countries with least resistance (Varun, 2011). This downhill movement of e-waste from the affluent countries will continuously invade the world's poorest countries where cheap labor is readily available, and environmental and occupational protections are painfully inadequate. Unrestricted trade and movement of hazardous wastes leave the recipient countries with a choice between poverty and poison – a sad and destructive choice that nobody should have to make.

2.5. The Giant of Africa: The Nigerian Context

This research was carried out in Lagos State, Nigeria as part of my internship. In order to understand the relationship between the social-economic impact of e-waste, the environmental and health risks experienced by inhabitants of its host community in Nigeria, it is pertinent to explore the geographical, economic, organizational and socio-political realities of Lagos state, Nigeria.

2.5.1. Geographical Context

According to the Lagos State Government data, the city features above 17.5 million inhabitants making it one of the biggest cities – and the fastest growing – in the world (Lagos State Government, 2011). It is the economically most important city of Nigeria and has a regional importance as well for other West African countries because many internationally operating companies have affiliates or headquarters in Lagos. The availability of sea ports such as Apapa Port or Tincan Island Port also contributes to its position as a major actor in the international trade amongst other West African countries. Lagos also shares border with some West African countries such as Bénin and Cameroun, therefore it acts as a channel by which goods are exported.

This role as a major population and ecommerce center for goods and services is also reflected in the amount of e-waste generated and recycled in Ikeja Computer village and within Lagos. With the absence of an indigenous technological industry, the import and refurbishing of 'second-hand' electronics is a sure way of providing Nigeria and its neigbouring countries with IT at affordable prices. As internationally agreed at the World Summit on the Information Society (WSIS) in 2005, *all people and societies shall make use of Information and Communication Technologies (ICTs) to bridge the digital divide and to stimulate economic development*. This is a fact that policy makers in particular and the population in general cannot deny. Hence, informal recycling of e-waste as a profession became an important income generating activity for small businesses operating in Nigeria. This sector provides over 30,000 jobs for the populace (Schluep, et al., 2009). Therefore, it becomes clear that every reform of the sector requires a careful investigation of its impact on businesses and employment.

2.5.2. Economic Context

Ironically, what has been considered waste and hazardous to both humans and the environment is actually the livelihood of the host community where the e-waste is disposed. Scavenging of e-waste materials by the host community is an economical aspect of e-waste that cannot be ignored. According to the Computer and Allied Product Dealers Association of Nigeria (CAPDAN), Nigeria has a thriving repair market, but no capacity to safely deal with electronic waste, most of which winds up in landfills and informal dumps. Toxicity of this action is discussed in chapter three of this thesis. What makes e-waste such a valuable asset to inhabitants where they are disposed?

E-waste is an emerging problem as well as a huge business opportunity given that discarded electronic waste is the fastest growing stream of waste in industrialized countries. This is not surprising considering that the electronic industry thrives mainly on new evolving products giving rise to increasing growth and production rate. This increasing growth rate is encouraged by consumer's appetite for latest electronic devices. The easier, light weight yet sophisticated the device, the higher the consumption rate as in the case of Smart phones (International Data Cooperation (IDC), 2012). The frequency by which manufacturers churn out more advanced and sophisticated electronic devices gives rise to a throw-away principle resulting in an increase in obsolesce at the same time it also ensures monetary benefits for producers.

Obsolete computers are literally regarded as a 'gold mine'. A metric ton of electronic scrap from used computers contains more gold than can be extracted from a 17 ton gold ore (United States Geological Survey, 2001). Ironically, e-waste contains both toxic and valuable materials in them with elements including iron, copper, aluminum, gold and other metals in e-waste estimated at over 60%, while plastics account for about 30% and the hazardous pollutants comprise only about 2.70% (Widmer, Oswald, Kraft, Sinha- Khetrumal, Schnellman, & Böni, 2005). There is a thriving market for copper and iron in the electronic industry. The economic benefits of re-using extracted materials far out-weigh extracting the raw materials from mines and converting them for manufacturing purposes. It is no wonder then that the host community where e-waste is housed find it a valuable source of income amidst the obvious health and environmental hazards.

2.6. Stakeholders and Organizational Context

2.6.1. Stakeholders

E-waste recycling and refurbishing sector in Lagos, Nigeria is a well-organized activity mainly structured around the main sources of obsolete electrical and electronic products. However, it is quite difficult to ascertain the route by which electronic devices are imported as they travel through different countries and complex waters. The process involves a lot of middle men and brokers who prefer to remain anonymous. With the exception of the importers whose basic role it is to import electronic goods into the country and resell, it is important to define the other stakeholders in this activity to ensure clarity in their respective roles.

Electronic Importers

The general flow of e-waste starts with the importers who in most cases double as brokers. They work closely with the sea port authorities. The importers operate under the umbrella of Computer and Allied Product Dealer Association of Nigeria (CAPDAN) a regulatory body in charge of coordinating affairs in the IT industry. Importers purchase containers by its weight and not by the value of what is inside them, so it is not uncommon to find a large collection of junk e-waste amongst high quality gadgets. Depending on the size, a container can carry up to 300 – 500 computers and accessories. These are sorted according to their quality. The low quality gadgets are taken for repair/refurbishing. Those considered scraps or junk are either disposed of at the dumpster or given out to waste collectors and recyclers.

Electronic Repairers/Refurbishing

Refurbishers also doubling as electronic repairers, specialize in the repair and rebuild of old and/or non-functioning electronic devices; turning them into second-hand and functioning equipment either by replacing or repairing defective components. It also involves performing cleaning and repair activities in defective products in order to make the second hand equipment appealing to the customers. Even though the professionals in this field often like to distinguish themselves (repairers from refurbishers), there is no significant difference between their activities. In this study, both groups taken together are generally referred to as Electronic Repairers.

Electronic repairers specialize in the repair of specific electronic products such as photocopier, computers or mobile devices. Besides repair and refurbishing activities, most electronic repairers also engage actively in marketing and sale of the refurbished products.

Waste Scavengers / Collectors

They refer to those stakeholders who carry out the collection of e-waste. Waste collectors are also referred to as scavengers. Unlike the electronic repairers who focus on specific electronic products, waste scavengers' activities involve all kinds of waste (e-waste inclusive). In Lagos state, Nigeria, waste scavengers are divided into two main groups: those who are registered with the Lagos State Waste Management Authority (LAWMA) as well as the Scavengers Association and those who operate illegally. The latter group often face the risk of being caught by LAWMA officials if found operating without a license. Those registered with LAWMA also work with Lagos State Environmental Protection Agency (LASEPA). In this study, waste collectors registered with LAWMA and the Scavengers Association will be referred to as waste scavengers.

The waste scavengers are further categorized into those who practice their activities on major dumpsites such as the Olusosun dumpsite and those who operate in residential areas and business outfits. At the dumpsite, waste scavengers make use of bags for sorting waste while those who practice their trade in residential areas and business outfits, utilize small handcarts they push. Most waste scavengers who engage in e-waste are also actively involved in scrap metal business. Therefore, an area such as Ikeja computer village where there is high concentrations of electronic repair/refurbishing enterprises becomes a favorite spot. More than 60% of wastes collected in this area are e-waste. While some waste scavengers mainly focus on collection and sorting, majority of them also engage actively in recycling of sorted wastes.

Recyclers

Unlike their counterparts in China, Pakistan and India, recyclers in Nigeria do not engage in acid or chemical bath of electronic components to extract materials from them, rather, they disassemble obsolete e-waste to recover metals and other perceived working parts such as memory chips, Integrated circuits (IC), aluminum, copper and steel. The extracted materials are then sold to traders. Whereas some informal recyclers may focus specifically on e-waste alone,

others engage in recycling wastes containing all types of metals. Although it is not a popular practice, a small percentage of recyclers also engage in the open incineration of cables and other plastic parts. This is done to extract copper and other metals from the e-waste. Printed wiring boards (PWBs) are separated, collected, and either sold to traders in Nigeria or exported, mostly to Asian destinations (Puckett, 2005). In few cases, recyclers deal directly with end-processing units, such as industries who re-melt and refineries, selling them the recovered metals. However, the common practice among recyclers is to sell extracted materials to middle-men who take them to end processing units. Many recyclers are also active in the collection of waste as indicated above.

Local Businesses

Local businesses in this context refer to those involved in rendering computer and photocopying related services. This sector is one of the thriving industries in the Nigerian economy; because such amenities are not provided centrally by the government, the populace depends on local businesses for computer or technologically related services. These businesses in turn depend on the importers, refurbishers and repairers for their electronic equipment. Broken devices are often times sold back to the repairers who use them as spare parts for repair of other devices. The local businesses channel most of the imported electronic devices to the consumers.

There is a close working relationship between the stakeholders. For example, the importers need the refurbishers to ensure their loss is minimized when a container is discovered to hold devices worth little above their capital for importation. The refurbishers in turn, most times, sell their broken or discarded e-waste to the recyclers who tear them apart for further extraction of valuable materials. The collectors transit between the importers, recyclers and refurbishers; collecting valuable e-waste from the importers and selling to the recyclers or the refurbishers.

2.6.2. Organizational context

1

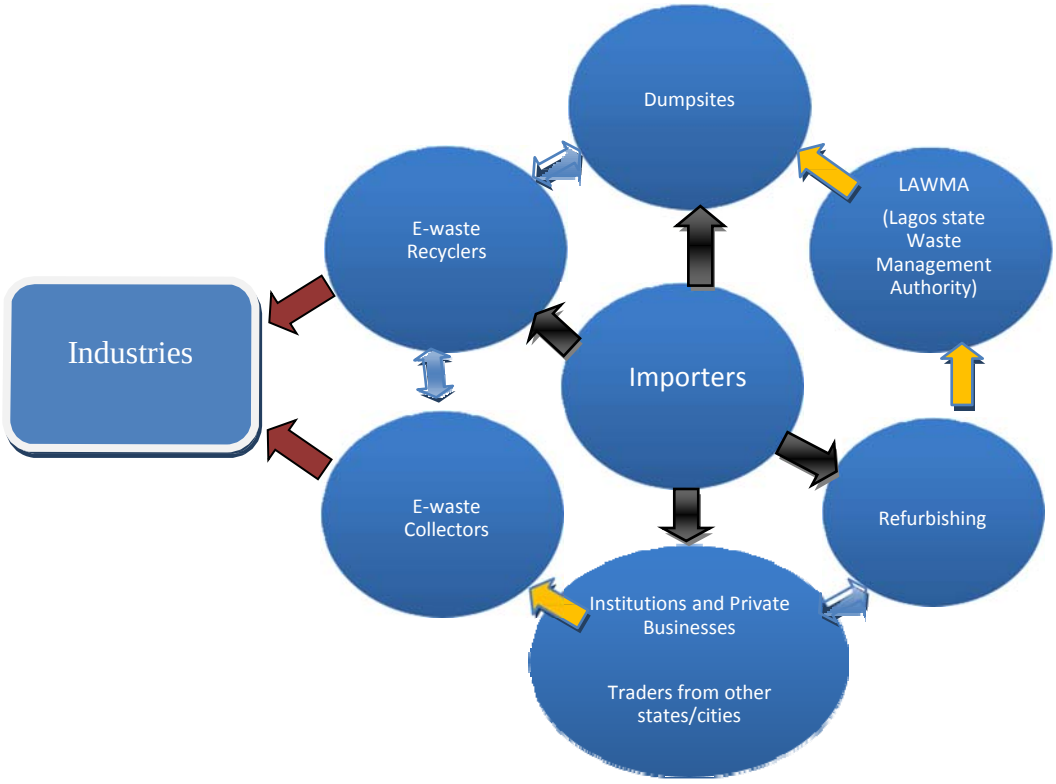

Figure 2.2: Organizational flow chart for electronics and e-waste transmission

As shown in the Figure 2.2, the imported equipment is mostly passed on to retailers who in turn sell the equipment to private and corporate consumers. Used and obsolete electronic products are passed on to the refurbishing sector, which is organized in four major markets in Lagos. In addition, some traders from other Nigerian cities also purchase imported equipment from Lagos to be directly transported to other markets outside of Lagos.

The informal waste scavengers are generally very mobile. Equipped with handcarts, they comb the streets of Lagos collecting e-waste as well as other valuable metal-containing wastes in exchange for money. Their clientele are mostly private households and businesses who are

[1] The yellow and black arrows indicate a one-way-directional flow while the blue arrows indicate a two-way-directional flow

upgrading their equipment. Amongst this group, there are also waste scavengers who due to financial constraints focus more on obtaining valuable e-waste from roadside dumps or the central waste dump sites. They sometimes purchase e-waste that can be bought for almost little or nothing. To facilitate easy access and reduce cost, informal waste scavengers own small and medium sized yards close to sites where they collect waste. Here, they manually dissemble, sort and store extracted materials which are then sold to traders. E-waste perceived of no value are discarded or burned.

In this seemingly lucrative business, the informal waste scavengers are obliged to compete with the official waste collection system organized by the Lagos state Waste Management Authority (LAWMA) who delivers the collected waste to three official dumpsites in Lagos (Olusosun dumpsite, Igodun Dumpsite and Ikorodu dumpsite). To maximize the amount of waste collected and gain access to the central dumpsites, the informal waste collectors need to be registered with the Scavengers Association. Registered waste picker communities or waste scavengers living on or next to the dump sites sort valuable waste, including e- waste. Extracted and sorted e-waste is also sold to traders here. There is also a clear distinction in working conditions between the refurbishing sector that buys and repairs/refurbish second hand electrical electronic devices and the collection and recycling sector. Waste scavengers generally do not require a special skill but in the electronic repair/refurbishing sector, a certain level of technical skills is highly needed. A shop owner at the Ikeja computer village affirmed that he was a graduate from the engineering field. He pointed out that working in the electronic repair/refurbishing sector has been profitable because of his educational background and skills. Workers in the electronic repair/refurbishing field are usually paid between US$ 5.43 to 6.53 (exchange rate as at 2011)*[2] per refurbished gadget; which is more lucrative than the average income of e-waste collectors and recyclers who earn between US$3.76 to 5.69 (exchange rate as at 2011)* per weighed goods. On the other hand, recyclers and waste scavengers alike are mostly self-employed which implies that their earnings for the day may vary depending on the volume of e-waste collected or recycled. Whereas for the electronic repairer/refurbisher, the earning per day varies depending on if the electronic repairer/refurbisher is self-employed or employed in the business. The electronic

[2] *1 US dollar = 158.965 as at Nov. 2011

repairer/refurbisher sector also has its apprenticeship system where individuals are trained in the business. They (Apprentices) often do not earn money but they are provided with food and shelter and startup money when their term is completed.

There is also a significant difference in health and safety issues between the e-waste scavengers and the e-waste recyclers. In electronic repair/refurbishing, health and safety issues mainly arise from the risks of exposure to substances inherent in the electronic device they are working with, inhalation of lead fumes occasioned by soldering operations and on rare occasions, electric shock. On the other hand, the e-waste collectors face more health and security hazards. Exposure to toxic substances contained in e-waste can occur through cuts from broken CRTs, constant exposure to hazardous substances (such as dioxins and mercury from burning) during sorting at the dumpsite or during CRT crushing operations with the intent to extract metals within them.

Chapter Three: Hazards of E-waste

3.1. Introduction

In its exposed or decomposing state, e-waste contains a cocktail of toxic substances such as lead and cadmium. Lead oxide and cadmium exists in monitor cathode ray tubes (CRTs) and computer batteries. Chemicals such as mercury exist in switches and flat screen monitors; polychlorinated biphenyls (PCBs) occur in older capacitors and transformers while brominates flame retardants occurs in printed circuit boards, plastic casings and cables. Other substances such as polyvinyl chloride (PVC) cable insulation release highly toxic dioxins and furans when burned to retrieve copper from the wires (Onwughara, Nnorom, Kanno, & Chukwuma, 2010). The ICT and Environment report of 2010, based on Life Cycle Analysis (LCA), estimates that producing one desktop computer require at least 240kg of fossil fuels*[3] and 1500kg of water. The above factors indicate the amount of resource utilized to produce a computer (ICT and Enviroment, 2010).

Besides the obvious resources employed in the manufacturing process of electronic devices, improper disposing and recycling of e-waste has some serious health and legal implications. Popularly, e-waste is either land filled or it is incinerated. Land filling essentially involves burying of waste in the ground. This site is usually situated in the outskirts of a community. While this may seem a comfortable option, the resultant effect is the leaching of toxins from decaying materials into ground water and the soil. Incineration on the other hand, involves closed or thermal burning of waste. Because this process is not bullet proof, it facilitates the emission of toxic air pollutants including dioxins into the air (Puckett, 2005). Additionally, the formal and informal recycling of e-waste also poses dire occupational and environmental implications especially when necessary protective equipment is not easily available to the recyclers.

[3] Fossil Fuels= non-renewable compounds such as water, coal, petroleum and methane used industrially for production of goods (www.greenstudentu.com accessed in 2011)

3.2. Some Specific Effects of E-waste

Lead

Lead causes damage to the central and peripheral nervous systems, blood systems, kidney and reproductive system in humans (European Union, 1999). Effects on the endocrine system have been observed and its serious negative effects on children's brain development are well documented. Lead accumulates in the environment and has high acute and chronic effects on plants, animals and micro-organisms (Agency for Toxic Substances and Disease Registry, 1993). The main applications of lead in computers are: glass panels and gasket (frit) in computer monitors (3-8 pounds per monitor), and solder in printed circuit boards and other components.

Cadmium

Cadmium compounds are toxic with a possible risk of irreversible effects on human health, and accumulate in the human body, particularly the kidneys (US Department of Labor, 2011). Cadmium occurs in certain components such as SMD chip resistors, infra-red detectors, and semiconductor chips. Cadmium is also a plastics stabilizer and some older cathode ray tubes contain cadmium (ibid).

Mercury

Mercury is used in the manufacture of parts of electronic devices such as thermostats, sensors, relays, switches commonly found on printed circuit boards, mobile phones and in batteries. As an alternative to cathode ray tubes, the use of mercury is likely to increase in flat panel displays. Mercury adversely affects various organs of the body including damage to the brain, fetus and kidneys. Developing fetus is highly vulnerable via maternal exposure to the prevalence of mercury in the environment. This results in miscarriages. Mercury also affects water as inorganic compounds. It forms methylated compounds in bottom sediments of water. Additionally, mercury easily accumulates in living organisms and concentrates through the food chain, particularly via fish. It is estimated that 22 % of the yearly world consumption of mercury is from electrical and electronic equipment (European Union, 1999).

Plastics including PVC

Plastics make up 13.8 pounds of an average computer. The largest volume of plastics (26%) used in electronics has been poly-vinyl-chloride (PVC). PVC is commonly present in computer and cable casings. Recently, more manufacturers are making computer moldings with somewhat more benign ABS plastics. PVC is used for its fire-retardant properties; hence when burnt under a certain temperature, it emits dioxin compounds. Dioxins can persist in the environment for years; lodging into the air, land and food chain. Health risks from dioxin consumption include infant birth defects, cancer, developmental disorders among children and sterility (Onwughara, Nnorom, Kanno, & Chukwuma, 2010)

Brominated flame retardants (BFRs)

BFRs are commonly used in the manufacture of plastic casings of electronic equipment to prevent flammability. They are also present in the circuit boards. Due to its toxic nature, BFRs have been banned from electronic devices in the EU. This directive came into force in 2006 (European Parliament and the Council, 2003).

Barium

Barium is a soft silvery-white metal that is used in computers in the front panel of a CRT, to protect users from radiation. Studies have shown that short-term exposure to barium has caused brain swelling, muscle weakness, damage to the heart, liver, and spleen (ATSDR, 2011). There is still a lack of data on the effects of chronic barium exposures to humans. Animal studies however, reveal increased blood pressure and changes in the heart from ingesting barium over a long period of time (ibid).

Beryllium

Beryllium is a steel-grey metal that is non-magnetic, a good conductor of electricity and heat and extremely lightweight. These properties make beryllium a preferred material for the manufacture of electronic applications such as computers. In computers, beryllium is commonly found on mother-boards and “finger clips” as a copper beryllium alloy used to strengthen the tensile strength of connectors and tiny plugs while maintaining electrical conductivity (Puckett, 2002).

Beryllium has recently been classified as a human carcinogen as exposure to it can cause lung cancer (US Department of Labor, 2011). The primary health concern is inhalation of beryllium dust, fume or mist. Workers who are constantly exposed to beryllium, even in small amounts, and who become sensitized to it can develop what is known as Chronic Beryllium Disease (beryllicosis), a disease which primarily affects the lungs (ibid). Exposure to beryllium also causes a form of skin disease that is characterized by poor wound healing and wart-like bumps (ATSDR, 2011). Studies have shown that people can still develop beryllium disease after many years following the last exposure (Puckett, 2002).

Toners

The plastic printer cartridge especially those containing black and color toners, is one of the most popular item of e-waste. The black toner contains a pigment commonly referred to as carbon black. Carbon black is also a general term used to describe the commercial powder form of carbon. It may also be known as furnace black, acetylene black or thermal black. Infection occurs by inhalation; intense exposure may lead to respiratory tract irritation (ibid).

Phosphor and additives

Phosphor is an inorganic chemical compound that is applied as a coat on the interior of the CRT faceplate. Phosphor is used in the electronic industries to facilitate the display resolution and luminance of the images that is seen for example in computer monitors. Even though the effects of phosphor in CRTs is not well known or reported, the U.S. Navy has made it clear about the hazards involved in improper handling of CRTs as stated in their guidelines: "*NEVER touch a CRT's phosphor coating: it is extremely toxic. If you break a CRT, clean up the glass fragments very carefully. If you touch the phosphor, seek medical attention immediately*" (Information Systems Security, 1993).

Hexavalent Chromium/Chromium VI

Chromium VI is still used by manufacturers as protective substances against corrosion in untreated and galvanized steel plates. They are also used as decorative casings or hardeners for steel substances present in electronic devices. Chromium VI possess the ability to be easily

absorbed through cell membranes; thus producing various toxic effects in contaminated cells for example damages to DNA can occur (Information Systems Security, 1993).

It is quite obvious from the description of substances present in electronic devices that improper handling and informal recycling of e-waste is indeed an unhealthy practice to man, land, air and water.

Chapter Four: Policies on Hazardous E-waste

4.1. Policies at the International Level

From a scientific point of view, e-waste is no doubt a hazard to both environment and humans; socially speaking, it is plainly inhumane to introduce materials embedded in e-waste into communities just for the sake of making quick money and avoiding responsibilities. From a legal standpoint, however, the issue has become murky and is dependent on how seriously a government intends to deal with the hazards and its effects. Domestically, e-waste regulations exist among countries. Internationally, besides the Bamako Convention which is a treaty of African nations prohibiting the importation of any hazardous waste (including radioactive waste), the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal also known as BAN (Basel Action Network) seems to be the only internationally recognized body in charge of hazardous waste management.

4.1.1. The Basel Convention

The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (hereinafter referred to as “the Basel Convention”) came into being in 1989 as a result of toxic deposits in Africa and other parts of the developing countries. This action, occasioned by the increased awareness on the long term effects of improper disposal of hazardous waste by the industrialized countries resulted in strident regulations on disposal of hazardous waste. Thus a corresponding increase in disposal costs. Seeking alternative avenues for the increasing e-waste accumulation, industries and operators alike sought cheap disposal options in Eastern Europe and the developing nations where environmental awareness was low and strident regulations and its enforcement was lacking (Basel Convention, 2011).

This quest to flee strict laws in the home countries, lead to a seemingly free trade of e-waste across international borders; especially to the developing nations. Against this back drop, the Basel convention came into full action in 1992 (ibid). The Basel Convention is the only pan-global international agreement created to reduce the movement of hazardous waste between nations. Particular emphasize is placed on the shipment of toxic or hazardous waste from the

developed or industrialized nations to the less industrialized or developing nations. The Basel Convention aims to ensure environmental responsibility of waste by the country of origin as well as encourage reduced volume of waste generation and toxicity by countries who are signatories to the treaty. It also ensures that management of hazardous waste or its trans-boundary movement is consistent with the protection of human health and the environment where it is disposed of. The convention further promotes sound environmental waste management amongst developing nations (Basel Convention, 2011).

The Basel Convention agreement focuses on global producers of electronic waste and recyclers of electronic waste alike. As indicated in the previous sections, electronic waste contains hazardous substance which poses long and short term threat to human health and the environment. Thus, the global electronic industry is affected by the BAN (Basel Action Network) convention. Essentially, countries who are signatories to the BAN convention are obliged to ensure that e-waste generation and other hazardous waste is reduced to the barest minimum. The convention also ensures that signatory countries possess sufficient disposal facilities to ensure proper management of e-waste and other hazardous waste generated. It lays specific emphasis on ensuring that waste management is extended to the point or place of disposal.

It would seem likely that a country such as the United States would be able and willing to fulfill and implement this call for national self-sufficiency in waste management. Alas, to date, the United States is the only developed country that has not ratified the Basel Convention. U.S. officials according to Puckett (2002) have actively worked to defeat, and then weaken, the Basel waste export ban. The U.S. government policies seemed designed to encourage exportation of their waste to other countries that would have them. Not only has the U.S. refused to ratify the Basel Convention, it has also as it would appear, intentionally exempted e-wastes, within the Resource Conservation and Recovery Act, from the minimal laws that do exist (requiring prior notification of hazardous waste shipments) to protect importing countries (ibid). Reports have shown that officials at the United States Environmental Protection Agency (EPA) have admitted under questioning that export is very much a part of the U.S. e-waste disposal strategy and the

only issue of concern for the U.S. might be how to ensure minimal environmental standards abroad (Puckett, et al., 2002).

A study carried out in the UK indicated that an estimated 160,000 tons of electronic waste was exported from the UK alone in one year (2003). A sweep of container ships and trucks by the European MPEL enforcement program involving Netherlands, Germany, Britain, Poland and six major European ports found that 22% of all the waste exports checked for more than a year, were illegal Enforcement agencies; they also found large quantities of hazardous post-consumer wastes such as computer equipment, electrical cable, cathode ray tubes, disposable cameras, old tires, oil and contaminated motor parts being exported illegally (IMPEL-TFS Seaport Project, 2004). These discoveries were made before the WEEE directive entered into force in the EU which is expected to significantly decrease the volumes available for export diverting them from landfills and storage.

4.1.2. The Bamako Convention

The Bamako Convention otherwise known as the Bamako Convention on the Ban on the Import into Africa and the Control of Trans-boundary Movement and Management of Hazardous Wastes within Africa is a treaty of African nations prohibiting the importation of any hazardous waste (including radioactive waste). The Convention was negotiated at the Organization of African Unity at Bamako, Mali in January, 1991 by twelve African nations. It came into force in 1998 (Organisation of African Unity (OAU), 1991).

The Bamako Convention came into being from the realization that the affluent nations were exporting toxic wastes to Africa and from the failure of the Basel Convention to effectively prohibit the trade of hazardous waste to less developed countries. The Bamako Convention shares some similarities in format and use of language as the Basel Convention but it is more resolute in prohibiting all imports containing hazardous waste with no exceptions (such as radioactive materials) excused by the Basel Convention. Nigeria ratified the Basel Convention in May 24, 2004; prohibiting the movement of hazardous waste into its shores but has not ratified the Bamako Convention (ibid).

4.2. National Policies on E-waste: Nigeria

In reaction to the illegal dumping of toxic wastes occasioned in 1987 in Koko, former Bendel State, the Nigerian Government promulgated the Harmful Wastes Decree. This decree provides the legal framework for effective control of the disposal of toxic and hazardous waste into any environment within the confines of Nigeria. This gave birth to the creation of a regulatory body, the Federal Environmental Protection Agency (FEPA) in 1988. FEPA is responsible for protecting and developing the Nigerian environment. To facilitate this process, a National Policy on the Environment was developed thus making it a standard working document for the preservation and protection of the Nigerian environment. Administratively, States and Local Government Councils established their own environmental regulatory bodies for the purpose of maintaining good environmental quality as it applies to their particular terrain (NESREA, 2011).

Wastes is thus defined as *"substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of by the provisions of the laws of the Federal Republic of Nigeria"* (ibid)

The EIA Decree No. 86 of 1992 is an additional document with the aim of protecting the Nigerian environment. It is however, particularly directed at regulating the industrialization process as regards the environment. By this Decree, no industrial plan/development/activity falling under the FEPA's mandatory list can be executed without prior consideration of the environmental consequences of such a proposed action, in the form of an environmental impact assessment. (Federal Republic of Nigeria, 1992)

4.2.1. National Policy on Environment

Section 6.2 of the National Policy on Environment, Nigeria explicitly states the responsibilities of appropriate agencies in the administration and management of hazardous and radioactive substances. E-waste falls under the hazardous waste category. An excerpt from the policy document states thus:

> *"…appropriate governmental agencies shall therefore set up regional framework and standards for "DUMP WATCH" against trans-boundary movement of toxic,*

hazardous and radioactive wastes and for the achievement of the environmentally sound management of hazardous substances;" (National Policy On Environment, 1998 p41)

While this law is effective in itself, as of this writing, there are no direct laws prohibiting the importation of e-waste in the guise "second hand" goods. Neither are there laws to determine the health or standard of the "second hand" goods being imported. In retrospect, the policy on trans-boundary movement of toxic waste has been sidelined once-too-many because obsolete electronic devices flock into the country under the guise of "second-hand" goods and "charity" donations. Even though e-waste falls under the category of hazardous waste, imported electronic devices are considered a valuable good only until it is determined to be e-waste. It is quite difficult to ascertain the health of imported goods into the country while they are still off shore, only when they berth will their contents be examined by the port authorities.

At the state level, the Lagos State Waste Management Authority is solely responsible for managing the waste generated within the state. With no prior laws on waste sorting at source, waste are generally mixed during collection. Other agencies in waste management include the Ministry of Environment which functions as a policy regulator, the Local Government functions attributed to them by virtue of their constitutional roles and the Private Sector Participant (PSP operators) assigned with the task of waste collection, transportation and disposal. The informal waste management practitioners such as the e-waste recyclers and e-waste collectors also participate actively in the collection of waste around the state.

4.2.2. Guide for Importers of Used Electrical and Electronic Equipment into Nigeria

Even though there are no direct laws prohibiting the importation of obsolete electronic devices, the National Environmental Standards and Regulations Enforcements Agency (NESREA) regulate the shipment and importation of electronic devices into the country. In 2011, the body came out with a set of guidelines as measure of enforcing regulations. Importers are advised to register with NESREA, notify and follow the regulations laid in the document. An excerpt:

- *Your (importer) shipment may be classified as '' Waste '' and therefore treated as an illegal waste shipment by NESREA and*
- *Only functional Used Electronic and Electrical Equipment (UEEE) that meet the requirements of the guidance contained in this document and relevant NESREA Regulations can be legally imported into Nigeria.* (NESREA, Publications and Articles, 2011)

The document further highlights some guiding principles that will help importers including companies, private persons, organizations and shipping companies to differentiate between e-waste and 'second hand' electronic devices. This guideline is not designed to override the Harmful Waste (Special Criminal Provisions, etc.) Act, Cap H1 LFN 2004, which prohibits the dumping, carrying, transportation and importation of any harmful waste (including e-waste) into the country (still enforced in Nigeria) but aims to enhance the law by addressing the rising trend of e-waste in the country. (ibid)

PART THREE: EMPIRICAL RESULTS AND CONLUSIONS

Chapter Five: Data Analysis

5.1. Introduction

Based on the above reviewed literature, it is quite evident that e-waste does have substantial economic benefits to its host community as well as corresponding health and environmental hazards. Besides serving as a steady stream of income, it also helps to reduce the rate of unemployment. This chapter analyses the economic benefits and health hazards of e-waste in relation to the occupations and interactions of Lagos state citizens with e-waste.

5.2. Data Analysis

Two key informants were interviewed in this study. One of them, the Chairman of Scavengers Association, male, aged 46, was interviewed at Olusosun dumpsite, Lagos State. The other, a refurbisher, male, aged 35, was interviewed at Ikeja Computer Village (See Table 5.1 below).

Table 5.1: Key informants

Age	Gender	Work Title	Occupation	Place Interviewed
46	Male	Chairman of Scavengers Association	Local Recycler (waste scavenger)	Olusosun Dumpsite
35	Male	Electronic Repairer/Refurbisher	Electronic Repairer/Refurbisher	Ikeja Computer Village

A total of 100 questionnaires were administered to four major identified groups in the informal management of e-waste. The groups include Electronic Importers, Electronic Repairers, Computer and Photocopying Services and Local recyclers (waste scavengers) (see Table 5.1 below).

Table 5.2: Occupation distribution of participants in the informal e-waste management

Occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Electronic Importers	21	21.0	21.0	21.0
	Electronic Repairers	27	27.0	27.0	48.0
	Computer and photocopying services	20	20.0	20.0	68.0
	Local Recyclers (waste scavenging)	32	32.0	32.0	100.0
	Total	100	100.0	100.0	

Of the groups as indicated in Table 5.2, 32% respondents were Local Recyclers (waste scavenging); 21%Electronic Importers; 27% Electronic Repairers and 20% working in the Computer and Photocopying Services. These groups are identified as active stakeholders in the management of e-waste in Ikeja Computer village and Olusosun Dumpsite, Lagos and are also key players in the stakeholder analysis in chapter two (2.6).

5.2.1. Economic Benefits and Financial Implications of e-waste

Table 5.3 show that 90% of Electronic Importers and 74% of Electronic Repairers agreed that e-waste is a valuable economic asset. This is quite interesting because according to other observations at Ikeja Computer Village, more than 50% of the electronic goods imported are destined for refurbishing and dismantling.

Table 5.3: Perceived value of e-waste by occupation

			ewaste is valuable to us all		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	2	19	21
		% within Occupation	9.5%	90.5%	100.0%
	Electronic Repairers	Count	7	20	27
		% within Occupation	25.9%	74.1%	100.0%
	Computer and photocopying services	Count	1	19	20
		% within Occupation	5.0%	95.0%	100.0%
	Local Recyclers (waste scavenging)	Count	3	29	32
		% within Occupation	9.4%	90.6%	100.0%
Total		Count	13	87	100
		% within Occupation	13.0%	87.0%	100.0%

In an interview with a key informant who was a refurbisher by profession at the Ikeja Computer Village (see Table 5.1), I asked if he was happy with the electronic goods he just ordered. He responded *"well…..I will say yes and no….yes because people can buy them easily and people believe that second hand goods last longer than the new ones…maybe because they feel that it has already been tested and so it is good. And I will say no because… most times, the good second hand electronics are very few…so I am left with a lot of bad electronics to deal with"*. His response indicates that despite the challenges of being saddled with obsolete electronic materials, this was still a favorable alternative for consumers to buying brand new electronic devices.

On the flip side of things, this generates another level of income for both the Electronic Importers and the Electronic Repairers. 90% of Local Recyclers (waste scavenging) and 95% of Computer and Photocopying Services also agreed that e-waste is valuable to them. The response

of the Computer and Photocopying Services operators is intriguing because they offer services directly to the end users. Thus it is quite understandable that they would find the end results of the e-waste recycling process more profitable as it offers cheaper electronic alternatives (such as photocopier, computer sets) to purchase of new devices.

In the manual recycling process for e-waste it was observed that extracted materials were utilized in three major ways. They are either

a. exported or sold as spare parts for new products (see Table 5.4),
b. kept in storage for local electronic repairers or (see Table 5.5),
c. resold to electronic importers who in turn export them to neighboring countries (see Table 5.6).

Table 5.4: Extracted materials from e-waste sold as spare parts by occupation

			The extracted materials from waste after recycling are exported or sold as spare parts for new products		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	5	16	21
		% within Occupation	23.8%	76.2%	100.0%
	Electronic Repairers	Count	14	13	27
		% within Occupation	51.9%	48.1%	100.0%
	Computer and photocopying services	Count	0	20	20
		% within Occupation	0.0%	100.0%	100.0%
	Local Recyclers (waste scavenging)	Count	11	21	32
		% within Occupation	34.4%	65.6%	100.0%
Total		Count	30	70	100
		% within Occupation	30.0%	70.0%	100.0%

Table 5.4 presents differences in the opinion of various stakeholders about their utilization of extracted e-waste materials. 100% of Computer and Photocopying Services agreed that extracted materials from waste after recycling is exported or sold as spare parts for new products. As observed in the field, the Computer and Photocopying Service profession were amongst the end consumers of the result of electronic importation and refurbished goods. Thus they were quite knowledgeable in the quality of electronic devices they bought. Ikeja Computer Village also

served as an electronic marketplace for neighboring states and countries that came to purchase complete or parts of electronic devices as indicated by 76% of Electronic importers, 65% of Local Recyclers (waste scavenging) and 48% of Electronic Repairers. For the Electronic Importers, extracted materials from e-waste also serve as a means of recouping their investment in the e-waste trade. Most times, merchants who wish to purchase parts of electronic devices usually liaise with the Electronic Importers who in turn connect them or get such parts from the Electronic Repairers and the Local Recyclers (waste scavengers). The professional nature of the Local Recyclers ensures they have access to some electronic parts that may not be available to the Electronic Repairers, thus they are a favorite with the Electronic Importers and Electronic Repairers alike.

Table 5.5: Extracted materials from e-waste kept in storage for local electronic repairers by occupation

			The extracted materials from waste after recycling are kept in storage for local electronic repairers		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	0	21	21
		% within Occupation	0.0%	100.0%	100.0%
	Electronic Repairers	Count	2	25	27
		% within Occupation	7.4%	92.6%	100.0%
	Computer and photocopying services	Count	0	20	20
		% within Occupation	0.0%	100.0%	100.0%
	Local Recyclers (waste scavenging)	Count	0	32	32
		% within Occupation	0.0%	100.0%	100.0%
Total		Count	2	98	100
		% within Occupation	2.0%	98.0%	100.0%

Besides exporting extracted materials for sale to neighboring states and countries, they were also kept in the storage as spare parts for Electronic Repairers who often needed them for repair purposes. Table 5.5 indicates that 100% of Electronic Importers, Computer and Photocopying Services and Local Recyclers (waste scavenging) agreed to this. Interestingly, 92% of Electronic Repairers agreed that this was true. Perhaps the 7% who disagreed believe that because e-waste travels murky waters and involves a lot of players, the answer that extracted materials for sale to

neighboring states and countries were also kept in the storage as spare parts for electronic repairers may not be entirely true.

Table 5.6: Extracted materials from e-waste resold to electronic importers by occupation

			The extracted materials from waste after recycling are resold to electronic importers		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	6	15	21
		% within Occupation	28.6%	71.4%	100.0%
	Electronic Repairers	Count	2	25	27
		% within Occupation	7.4%	92.6%	100.0%
	Computer and photocopying services	Count	6	14	20
		% within Occupation	30.0%	70.0%	100.0%
	Local Recyclers (waste scavenging)	Count	2	30	32
		% within Occupation	6.2%	93.8%	100.0%
Total		Count	16	84	100
		% within Occupation	16.0%	84.0%	100.0%

In Table 5.6, 93% of Local recyclers (waste scavenging) and 92% of Electronic repairers agreed that extracted materials from waste after recycling are resold to Electronic Importers. While 71% of Electronic Importers and 70% of Computer and Photocopying Services also agreed to this question. Most times, the Electronic Importers package the extracted materials and resell them to neighboring states and countries as second hand wares. These responses indicate that the utilization of e-waste goes beyond the professions interviewed in this study. It involves both the consumers within the country and businesses outside the country.

Though the e-waste trade involves collective participation from all stakeholders involved, it is obvious that the Local Recyclers (waste scavengers) is at the bottom of the e-waste trade. Besides scavenging at the dumpsites and seeking out homes willing to dispose of their used electronic devices, they only get what the Electronic Importers and the Electronic Repairers perceive to be of no-monetary value. To ascertain the level of financial impact e-waste has on this group, they were asked to assess the impact of scavenging for electronic parts on their financial status.

A 96% Local Recyclers (waste scavengers) agreed that scavenging does have a positive impact on their financial status. This implies that scavenging for electronic parts was mainly carried out by individuals in the Local Recyclers (waste scavenging) profession. At the dumpsite in Olusosun, waste pickers (Local Recyclers) sort waste according to their importance and types. These are subsequently bought by manufacturers and private companies as attested by the Chairman of Scavengers Association (see Table 5.1) *"we sell them to manufactures and factories. For example, the bottles go to glass companies and sometimes drug manufacturers."*

Figure 5.1: Waste collectors/recycler at work at the Olusosun Dumpsite, Lagos.

Source: Benedicta Ideho, 2011

Figure 5.2: The Chairman of Scavengers Association (3rd from left) and his executives at the Olusosun dumpsite, Lagos State

Source: Benedicta Ideho, 2011

5.2.2. Health Conditions

Manual e-waste recycling is practiced among the professions interviewed in this study. However, some professions are more actively engaged in it than others. Table 5.7 below reveals that 100% of Local Recyclers (waste scavenging) interviewed agreed that people engage in manual recycling of e-waste. This reflects the activities of the local recyclers in the management of e-waste in Lagos state. Besides sorting e-waste, they also break down electronic devices in search of valuable materials for resell. 95% of Electronic Importers, 96% of Electronic Repairers and 75% of Computer and Photocopying Services also agreed that people engage in manual recycling of e-waste. The response from the respondents reveals that manual recycling of e-waste is a common practice amongst the profession involved in electronics.

Table 5.7: Informal recycling by occupation

			People engage in manual recycling of ewaste		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	1	20	21
		% within Occupation	4.8%	95.2%	100.0%
	Electronic Repairers	Count	1	26	27
		% within Occupation	3.7%	96.3%	100.0%
	Computer and photocopying services	Count	5	15	20
		% within Occupation	25.0%	75.0%	100.0%
	Local Recyclers (waste scavenging)	Count	0	32	32
		% within Occupation	0.0%	100.0%	100.0%
Total		Count	7	93	100
		% within Occupation	7.0%	93.0%	100.0%

The key informant at the Ikeja Computer Village (see Table 5.1), when asked to show the process of breaking down e-waste for example, computer devices, replied *"(laughs)…madam…it is not an easy task o! It's a long and careful one because electronics can be very fragile"* further attesting that manual recycling of e-waste does occur.

The process of manually recycling e-waste presents a number of health related issues. The respondents were asked to assess the impact of the health related issues shown in the tables below in relation to their respective occupations.

Table 5.8: Respiratory Problems as an effect from interacting with e-waste by occupation

			People face e-waste hazards like Respiratory Problems		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	9	12	21
		% within Occupation	42.9%	57.1%	100.0%
	Electronic Repairers	Count	1	26	27
		% within Occupation	3.7%	96.3%	100.0%
	Computer and photocopying services	Count	3	17	20
		% within Occupation	15.0%	85.0%	100.0%
	Local Recyclers (waste scavenging)	Count	1	31	32
		% within Occupation	3.1%	96.9%	100.0%
Total		Count	14	86	100
		% within Occupation	14.0%	86.0%	100.0%

Table 5.8 indicates that 57% of Electronic Importers agreed that they experienced respiratory problems as a result of interaction with e-waste while 42% disagreed. Considering that the Electronic Importers did not directly engage in manual recycling or refurbishing of e-waste but in most cases were resident in the same environment where the Electronic Repairers operated, it could be deduced that they may be suffering respiratory problems as a result of indirect association with the recycling and refurbishing of e-waste.

85% of Computer and Photocopying Services and 96% of Local Recyclers (waste scavenging) agreed that they experienced Respiratory problems. While the effect of e-waste can be explained for respondents in the Local Recyclers (waste scavenging) profession (because they are actively involved in the manual recycling of e-waste), the response from the Computer and Photocopying Services can be attributed to the constant presence of broken down e-waste in their environment. From observations during the interviews, broken down electronic devices such as photocopier and computer sets are stored in any available space around their business premises exposed to environmental elements such as rain fall; this was a common practice. Most times, these broken

down electronics are used as spare parts to fix any emergency situations that may occur during business hours.

Table 5.9: Burnt hands and bruises as an effect from interacting with e-waste by occupation

			People face e-waste hazards like Burnt hands and bruises		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	2	19	21
		% within Occupation	9.5%	90.5%	100.0%
	Electronic Repairers	Count	1	26	27
		% within Occupation	3.7%	96.3%	100.0%
	Computer and photocopying services	Count	0	20	20
		% within Occupation	0.0%	100.0%	100.0%
	Local Recyclers (waste scavenging)	Count	0	32	32
		% within Occupation	0.0%	100.0%	100.0%
Total		Count	3	97	100
		% within Occupation	3.0%	97.0%	100.0%

In Table 5.9, it appears that 90% of Electronic Importers and 96.3% of Electronic Repairers agreed that they experienced e-waste hazards such as burnt hands and bruises. The responses from the Electronic Importers were quite interesting because they were not directly involved in the manual recycling of e-waste unlike the Electronic Repairers who were actively engaged in the refurbishing and repair of the electronics. However, because of the nature of the electronic goods in an imported container, the Electronic Importers need to sort their goods according to its value. This exposes them to chemicals inherent in obsolete electronic devices especially when such devices are broken or damaged. Additionally, most of the Electronic Importers also had their businesses in the same environment where the Electronic Repairers practiced their activities. Due to the volatile nature of chemicals present in e-waste, it can also be said that their health afflictions may be as a result of association. All respondents from the Computer and Photocopying Services and Local Recyclers (waste scavenging) professions agreed that they experienced burnt hands and bruises as a result of their profession and association with e-waste. As observed in the field, respondents from the Electronic Repairers and Local Recyclers Profession lacked safety gears thus exposing them to chemicals from exposed e-waste. The refurbisher interviewed at Ikeja Computer Village (see Table 5.1), attested to this when he

replied to a question asked about the validity of his health problems *"Ha madam…I am very sure… it happens a lot especially after I break apart a computer. I started to wear gloves after I noticed it and try to cover my nose as well….I know these computers contain some bad chemicals."*

Table 5.10: Muscle weakness as an effect from interacting with e-waste by occupation

			People face e-waste hazards like Muscle Weakness		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	4	17	21
		% within Occupation	19.0%	81.0%	100.0%
	Electronic Repairers	Count	8	19	27
		% within Occupation	29.6%	70.4%	100.0%
	Computer and photocopying services	Count	1	19	20
		% within Occupation	5.0%	95.0%	100.0%
	Local Recyclers (waste scavenging)	Count	3	29	32
		% within Occupation	9.4%	90.6%	100.0%
Total		Count	16	84	100
		% within Occupation	16.0%	84.0%	100.0%

Table 5.10 shows that 95% of Computer and Photocopying Services agreed that they suffered from muscle weakness as a result of interaction with e-waste. This can be attributed to the presence of e-waste in their working environment as well as direct exposure to chemicals during the process of extracting parts from broken down electronic devices to substitute the existing ones. 90% of Local Recyclers (waste scavenging) agreed that they experienced muscle weakness as a result of their direct exposure to e-waste. 70% of Electronic Repairers and 81% of Electronic Importers agreed that they suffered from muscle weakness as a result of constant exposure to chemicals inherent in e-waste present in their working environment.

An interview with the Chairman of Scavengers Association in Olusosun (see Table 5.1) attested to this fact when I asked him what kind of health issues he and his members faced while working in the dumpsite. He said *"the common health issues I have noticed is cold, itching, respiratory problems. But it is hard to say which part of the waste causes it because we work a lot of waste here. So it is hard to say."*

5.2.3. Socio-economic factors encouraging the informal recycling of e-waste

Amongst the Local recyclers, the driving force for continuous informal recycling practices despite the inherent health hazards is the lucrative nature it presents. When asked if scavenging in e-waste was lucrative because of the availability of a market, 90% of the respondents agreed that there was a ready market for electronic waste, thus the need to scavenge as a means of livelihood. Though 9% of them disagreed, this response reinforces that scavenging was a lucrative and important means of income. As declared by one of the respondents during the process of administering the questionnaire, the fact that there was a ready market for the scavenged e-waste made up for the hazards inherent in e-waste. Electronic Importers, Electronic Repairers and Computer and Photocopying services however disagree, confirming that they were not involved in the process of scavenging e-waste in any way.

Low environmental awareness

Generally, besides the monthly and sometimes weekly sanitation exercise imposed by state laws, most people in Lagos state do not have knowledge of environmental laws (Domestic and International). This can be attributed to lack of education or access to such information, lack of promotional campaigns to raise environmental awareness as well as the inability to enforce such laws when the need arises. To ascertain the level of consciousness on environmental laws, respondents were asked questions on foreign and local policy awareness (see Table 5.11 and Table 5.12).

Foreign Policy awareness

In Table 5.11 below, 52% of the respondents in the Electronic Importers profession indicated that they were not aware of policies prohibiting the burning or manual recycling of e-waste in foreign countries. 74% of Electronic Repairers also indicated that they were not aware of such policies in foreign countries. This is quite interesting considering the fact that these professions have direct and indirect dealings with the importation of goods. Logically, they are supposed to have substantial knowledge on the foreign policies governing the importation of electronic devices because importation of any good requires a considerate amount of knowledge and skills on the foreign and local policies governing them.

Table 5.11: E-waste foreign policy awareness by occupation

			Do you know that foreign countries where these used electronics are being imported prohibit the burning or manual recycling of e-waste?		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	11	10	21
		% within Occupation	52.4%	47.6%	100.0%
	Electronic Repairers	Count	20	7	27
		% within Occupation	74.1%	25.9%	100.0%
	Computer and photocopying services	Count	2	18	20
		% within Occupation	10.0%	90.0%	100.0%
	Local Recyclers (waste scavenging)	Count	12	20	32
		% within Occupation	37.5%	62.5%	100.0%
Total		Count	45	55	100
		% within Occupation	45.0%	55.0%	100.0%

The Table 5.11 also reveals that 47% of the Electronic Importers and 25% of the Electronic Repairers agree that they have knowledge of foreign policies on e-waste. On the contrary, 90% of Computer and Photocopying Services responded that they were aware of such policies in foreign countries; revealing that they were in sync with the regulations in the international community where e-waste was being imported from. Likewise, 62% of Local Recyclers (waste scavenging) also agreed that they were aware of such policies. Perhaps, the Computer and Photocopying Services as well as the Local recyclers have this knowledge because they are less affected directly by foreign policies.

National Policy awareness

As shown in the Table 5.12, respondents from the Electronic Importers and Electronic Repairer profession are not aware that there is a policy for sorting e-waste from other forms of waste. However, 19% of Electronic Importers are aware that there is a policy for separating e-waste from other forms of waste. Respondents from Computer and Photocopying Services as well as Local Recyclers (waste scavenging) are also not aware that there is a policy on sorting e-waste. It can therefore be deduced that even though there are indeed national policies on proper waste management, there is very low awareness amongst the professions in this research. When asked if he was aware of any policy on e-waste in Nigeria, the Chairman of the Scavengers Association (see Table 5.1) responded *"No, I do not know of anyone at all"*

Table 5.12: E-waste National policy awareness by occupation

			Is there is a national government policy against mixing up e-waste with other waste?		
			Disagree	Agree	Total
Occupation	Electronic Importers	Count	17	4	21
		% within Occupation	81.0%	19.0%	100.0%
	Electronic Repairers	Count	27	0	27
		% within Occupation	100.0%	0.0%	100.0%
	Computer and photocopying services	Count	20	0	20
		% within Occupation	100.0%	0.0%	100.0%
	Local Recyclers (waste scavenging)	Count	31	1	32
		% within Occupation	96.9%	3.1%	100.0%
Total		Count	95	5	100
		% within Occupation	95.0%	5.0%	100.0%

Despite the challenges and environmental hazards faced by respondents in this study, e-waste still proves to be a favorable alternative source of income. The availability of a market such as national consumption as well as export to neighboring countries for the refurbished electronic devices and the extracted materials from informal recycling ensures that this trade will continue. Of the four professions, the Local Recyclers (waste scavenging) were actively involved in scavenging and manual recycling. While the Electronic Repairers were more actively involved in refurbishing broken down electronic devices purchased from the Electronic Importers. Socio-

economic factors influencing the presence of e-waste was attributed to low environmental awareness, which included the lack of knowledge on foreign and local policies. It was obvious from the responses to the interview questions that knowledge on environmental policies depends on whether the respondents were directly affected by these policies (national and foreign) or not.

It can be seen from the result analysis that the complex interdependence of each profession on e-waste as well as on the activities they perform individually creates a symbiotic relationship. This relationship between the groups is further strengthened by the economic value each profession derives from interacting with e-waste as well as the health hazards they face on varying degrees.

Chapter Six: Discussion and Conclusion

6.1. Discussion

Like their counterparts in China, India and Pakistan, informal recycling of e-waste in Nigeria is mainly practiced for economic reasons. The rapid evolution of electronic devices and the 'throw-away' habit that is being cultivated around the globe ensures that this practice will continue for a long time except drastic and determined steps are taken to address the issue. For countries such as Nigeria who lack indigenous formal recycling plants, the prevalence of manual and informal recycling will continue to be one of the means of recycling e-waste thus exposing humans and the environment to poisonous chemicals inherent in decomposing electronic devices.

As indicated in Table 5.3., 87% of the total respondents across the four professions interviewed agreed that e-waste was valuable to them. The financial value it offers is perceived to be more than the health hazards they face during the process of manual recycling of e-waste. As at the time of writing this report, Nigeria lacks an environmental regulation or legal framework targeting e-waste as a special waste stream. There are existing laws that regulate the trans-boundary movement of toxic, hazardous and radioactive wastes and the achievement of environmentally sound management of hazardous substances. However, none is specific to the presence and management of e-waste. Even though NESREA gave out a regulatory guideline for importation of electronic devices, the lack of an effective implementation system is leveraged as a loophole in the continuous importation of "second hand" electronic devices that can no longer function and therefore classified categorically as e-waste.

Although Nigeria has ratified the Basel Convention on Trans-boundary movement of hazardous waste and their disposal, it has not taken determined steps to address the growing need for a formal e-waste recycling plant as well as addressing the rising environmental pollution that is taking place as a result of improper disposal methods. Perhaps it could be reasoned that because Nigeria basically imports its technology, the implementation of the Basel Convention would mean laying bottle neck rules on the importation of 'second hand' electronic devices which may be detrimental to the local industries that depend on it. Most indigenous industries such as the Computer and Photocopying Services as well as surrounding countries depend on the

importation of these 'second hand' electronic devices. One major problem Nigeria faces is the domestication and implementation of agreements or treaties it signs. The political and legislative will to implement is quite lacking. On the flip side, this could also mean a critical look at developing the IT industry indigenously which can lead to growth. A number of factors affect the effective management of e-waste in Nigeria. Some of them include:

Low environmental consciousness

Low environmental consciousness has had adverse effects on the effective management of waste in general and e-waste in particular in Nigeria. The citizens of Lagos state are aware of only the periodic monthly environmental sanitation exercises which are mandatory and subject to fines but they are quite clueless of any other environmental regulations. So it is not a surprise that respondents from the interviews do not know of any environmental laws governing the state. For example in response to the question: "*Is there a national government policy against mixing up e-waste with other waste?*" 95.0% of the total respondents disagreed that they were not aware of any policy addressing separation of waste. But indeed, there is such a law. The Federal Republic of Nigeria Official Gazette on National Environmental Regulations 2009, Part 5, section II C clearly states that:

> *"…it shall be an offence for an owner or an occupant in care of premises or in control or management of a business to fail to segregate waste for proper management". (Ministry of Environment, 2009)*

This law as well as other laws governing various activities that could cause environmental harm is clearly stated in the document. Awareness by the regulatory authorities about these regulations is very deficient towards increasing environmental consciousness. Hence the regulations only remain on paper but never really get to be implemented.

Weak enforcement of environmental laws

Nigeria is very good at legislating environmental laws but is relatively laid back in enforcing them. The guidelines enacted by NESREA can be more effective if there was a proper system of implementation. Lack of proper equipment and the necessary awareness is a negating factor to implementing the regulations; thus e-waste still finds its way into the state in large numbers.

According to the chairman of the waste scavengers and the refurbisher interviewed in this study (see Table 5.1), *"the situation would remain the same and nothing would change much even if there were "active legislation" on E-waste*. Scavengers or waste pickers would still be collecting recyclables for living amidst a very unhealthy environment. Regulations would work if only it can be effectively implemented without the problem of lip service.

6.2. E-waste Management as a Tragedy of Common in Nigeria

It is quite a humbling fact that over four decades later, the fundamental principles underlining the potency of the Tragedy of the Commons theory still describes the fast growing consumption and activities in the technological world. Knowingly or unknowingly, the nations of the world quite agree with the Tragedy of the Commons. By utilizing the term Green Technology as a means of addressing the unsustainable practices involved in production of goods as well as the increase in consumption levels, it has been recognized that the earth is indeed finite and therefore whatever is removed must be measured according to the effect such an action will have on the overall ecosystem. According to Unhelkar (2011), environmentalism is regarded as the ability to preserve "greenies" or "techies". The ability to reduce carbon foot print and improve production processess through the use of Green IT. Thus, the main idea behind the birth of Green Technology is to ensure sustainable and ecoclogical practices in the manufacture and consumption of goods and services.

In relation to electronic devices, the spike in growth and manufacture rate in this industry, defeats the ideology behind the Green Technology revolution. The electronic industry, though persumed to be embracing the Green IT initiative, churns out devices faster than they are consumed (Unhelkar, 2011). Indeed, Nigeria as well as every country active in the consumption and disposal of electronic devices is an actor in actualizing the theory of Tragedy of the Commons. Whereas it may be perceived or assumed that the Nigerian society is not essentially a willing participant in the pollution of the environment as implied by the desire to 'bridge the digital divide'; as a sovereign entity, Nigeria is responsible for the environment in which her citizens exists. This implies that Nigeria does have the ability to correct the negative practices

inherent in the trade and informal recycling of e-waste; thereby ensuring that the Common Pool Resource (CPR) such as quality air, land and water is restored and preserved.

As humans, the assumption is that we have an obligation to protect the environment; likewise, we assume the moral obligation that everyone, irrespective of status or place of birth, has a right to proper education, employment and health care. To satisfy these demands, would mean operating in an infinite world where there is no conflict between environmental needs, societal needs and individual needs. Alas, we indeed exist in a finite world where achieving individual needs is placed far above environmental needs or societal needs. This is reflected throughout this study. The affluent countries where e-waste is being imported from are all too aware of the environmental implications of shipping their waste to the less affluent countries that need it. On the other hand, the less industrialized countries are faced with the realities of living within the aftermath of accepting e-waste and living off it. The ambiguous foreign policies indicate that the affluent countries place individual needs above environmental needs and societal needs thus creating an imbalance and exemplifying the typical herd scenario in the Tragedy of the Commons (Hardin, 1968, p.1244). The will to enforce existing national environmental laws or even create implementable frameworks as in the case of the Nigerian society is deficient leaving a loophole in the proliferation of e-waste and subsequent pollution of the environment.

The less affluent nations, who are willing to get connected with the global world regardless of the medium of achieving this goal, accept e-waste and blame the industrialized nations for it. Everyone in the e-waste scenery is looking out for themselves. Each quite aware of the implications of interacting improperly with e-waste yet not willing to create a balance between environmental needs, societal needs and individual needs: a much needed recipe in the Tragedy of the Commons.

6.3. Conclusion

It is no secret that 'second hand' electronic devices and e-waste does play a significant role in the economy of Lagos state as well as in the economy of the neighboring countries surrounding Nigeria. Embarking on an effective e-waste management scheme will involve taking into consideration the impact it will have on the professions that depend on it for a living as well as the countries who depend on it for provision of IT. The stakeholders in this study are quite aware of the health hazards inherent in their daily interaction with e-waste. In their opinion, the need to ensure a steady stream of income far outweighs the health hazards they face. A closer look at the situation shows that there are barriers inherent in the management of e-waste that needs to be carefully considered in designing an effective management system. These barriers can only be addressed if the gap between environmental policies and the subsequent implementation of it is critically examined. However, this cannot happen in a vacuum. It is essential that the stakeholders involved be included in the considerations as they play a pivotal role.

A proactive approach devoid of lip service is needed in dealing with environmental issues arising from the current management practices in the electronic industry; especially in relation to the minimal utilization of hazardous materials in the manufacture of electronic devices and overall improvement in product design. As at June 20th, 2012, Techcrunch, a web based technology outfit, reports that the new iPhone 5 is likely to be released sometime in September, 2012; which implies the 'throw away' syndrome is getting more intense as industries race to provide more sophisticated devices for consumers. What happens to the iPhone 4S which is less than 2 years old? (techcrunch, 2012). Of course these devices enable smooth upgrades to higher versions but devices such as the desktop computer that are rapidly becoming less popular are usually changed in sets. It is quite evident that there is need to revisit international policies regarding the consumption and discard of electronic devices. As discussed in the previous section, Nigeria has no problems coming up with legislations or framework to address the problems of e-waste, what is lacking is the political and legislative will to strictly enforce the laws to ensure that only healthy electronics are allowed into the borders of the country.

There is also the critical need to encourage indigenous growth in the IT sector as well as establish a formal recycling plant where collaboration with the informal recycling sector will be

taken into considerations. The electronic industry is an important industry in any economy. It is not only a vehicle for rapid income and development; it is also a potential threat to global ecosystem if effective systems are not put in place to address the waste it produces.

Bibliography

Agency for Toxic Substances and Disease Registry. (1993). *Agency for Toxic Substances and Disease Registry*. Retrieved March 4, 2012, from ASDR: http://www.atsdr.cdc.gov/tfacts13.html

Aristotle. (politics, Book 2, III). *Book Two*. Retrieved March 2, 2012, from Constitution: http://www.constitution.org/ari/polit_02.htm

ATSDR. (2011). *ATSDR*. Retrieved December 5, 2011, from Toxics Substances Portal - Barium: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=326&tid=57

Balakrishnan, R., Anand, K., & Chiya, A. (2007). Electrical and electronic waste: a global environmental problem. *Journal of Waste Management and Research*, vol. 25, pp. 307-317.

Basel Convention. (2011). *Basel Convention on the Control of Transboundary Movements of Hazardous Waste.* Switzerland: UNEP.

Bonomini, P. (2011, January). *Eden Project*. Retrieved January 30, 2012, from Eden Project: http://www.edenproject.com/whats-it-all-about/climate-and-environment/sustainability-at-eden/weee-man-electronic-waste-sculpture

CII. (2006). *"E-waste management", Green Business Opportunities.* Delhi: Confederation of Indian Industry.

Daly, H. (1992). Steady-State Economics. In H. Daly, *Steady-State Economics* (p. 180). London: Earthscan.

Environmental Agency, U. (2012, January). *Waste electrical and electronic equipment (WEEE).* Retrieved January 31, 2012, from Environmental Agency: http://www.environment-agency.gov.uk/business/topics/waste/32084.aspx

EU. (2010). *Being wise with waste: The EU's approach to waste management.* Luxembourg: Publications Office of the European Union.

EU. Directive. (2002a). 2002/96/EC of the European parliament and of the council of 27 January 2003 on waste electrical and electronic equipment (WEEE) — joint declaration of the European parliament, the council and the commission relating to article 9. *Official Journal*, L037:0024-39.

European Parliament. (2001). European ParliamentRecommendation for Second Reading. *European ParliamentRecommendation for Second Reading*, 6.

European Parliament and the Council. (2003). *Directive 2002/96/EC of the European Parliament and of the Council on on waste electrical and electronic equipment (WEEE).* Brussles: European Union.

European Union. (1999). Waste From Electrical And Electronic Equipment. *Explanatory Memorandum (3rd Draft).*

European Union. (1999). *Waste From Electrical And Electronic Equipment. Explanatory Memorandum (3rd Draft).* Brussles.

Federal Republic of Nigeria. (1992, December 10). *Environmental Impact Assessment Decree*. Retrieved September 25, 2011, from nigeria-law.org: http://www.nigeria-law.org/Environmental%20Impact%20Assessment%20Decree%20No.%2086%201992.htm

Finlay, A., & Liechti, D. (2008). *E-waste assessment South Africa.* Empa: Johannesburg, South Africa: Openresearch.

Flapper, S., Numen, V. J., & Wassenmow, V. L. (2005). Managing Closed – Loop Supply Chain. In D. Flapper S, V. J. Numen, & V. L. Wassenmow, *Managing Closed – Loop Supply Chain* (p. 200). Germany: Springer Verlag Heidel Berg.

Fleischmann, M. (2001). Quantitative modes for Reverse Logistics. In M. Fleischmann, *Quantitative modes for Reverse Logistics* (p. 200). Berlin: Springer verlag.

Hardin, G. (1968). The Tragedy of the Commons. *Science, New Series,* Vol. 162, No. 3859. pp. 1243-1248.

Hargittai, E. (2003). Informed Web Surfing: The Social Context of User Sophistication. *Society Online: The Internet in Context, Thousand Oaks, CA: Sage Publications*, 257-274. Houston, M. J., & Sudman, S. (2004). *A methodological assessment of the use of key informants.* Illinois: University of Illinois at Urbana-Champaign.

Hwa, C. I. (2011). *E-waste Trafficking: From Your Home to China.* Austin: Faculty of the Graduate School of the University of Texas.

ICT and Enviroment. (2010). Special Report Series. *Report 3: Green ICT - what producers must do*, 1.

IMPEL-TFS Seaport Project. (2004). *European Enforcement Initiative to Detect Illegal Waste Shipments*. Retrieved November 26, 2011, from European Enforcement Initiative to Detect Illegal Waste Shipments: http://europa.eu.int/comm/environment/impel/pdf/impel_tfs_seaportprojectjune2004.pdf

Index mundi. (2011, January). *Nigeria Demographics Profile*. Retrieved December 3, 2011, from indexmundi: http://www.indexmundi.com/nigeria/demographics_profile.html

Information Systems Security. (1993). *US Naval Information Systems Management Center, Information Systems Security (INFOSEC) Program Guidelines*. Retrieved December 12, 2011, from INFOSEC: http://www.fas.org/irp/doddir/navy/5239_26.htm

International Data Cooperation (IDC). (2012, February 6). *Smartphone sales growth*. Retrieved April 20, 2012, from IDC: http://www.idc.com/getdoc.jsp?containerId=prUS23299912

International Telecomunication Union. (2011). *ICT Facts and Figures.* Geneva: International Telecomunication Union.

Khan, I. S. (2009). *Pakistan: Hazardous E-waste threat to environment.* The New Publication.

Kurian, J. (2007). *Electronic Waste Management In India–Issues And Strategies.* Chennai, India: Anna University.

Lagos State Government. (2011). *Population*. Retrieved January 19, 2012, from Lagos State Government: http://www.lagosstate.gov.ng/pagelinks.php?p=6

Magashi, A., & Schluep, M. (2011). *E-waste Assessment Tanzania. UNIDO e-waste initiative for Tanzania.* Cleaner Production Centre of Tanzania & Empa Switzerland.

Mauk, J., & Metz, J. (2011). *Inventing Arguments.* Boston: Wadsworth Cengage Learning.

Milton, & Kay. (1995). *Environmentalism. The View from Anthropology.* ASA Monographs 32 London:: Routledge (first Printed 1993).

Ministry of Environment. (2009). National Environmetal (Sanitation and Wastes Control) Regulations. *Federal Republic of Nigeria Official Gazette Vol. 96*, B1072.

Moore. (2012). *Moore's Law Inspires Intel Innovation*. Retrieved February 12, 2012, from Intel: http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html

Morgan, R. (2006). *Tips and Tricks for Recycling Old Computers*. Retrieved February 26, 2011, from Smart Biz: http://www.smartbiz.com/article/articleprint/1525/

Myllylä, S. (2001). *Street Environmentalism, Civic Associations and Environmental Practices in the Urban Governance of Third World Megacities*. Tampere: Tampere University press.

National Policy On Environment. (1998). Policy Document. *National Policy On Environment Policy Document*, 41.

NESREA. (2011). *NESREA.* Retrieved December 14, 2011, from NESREA: http://www.nesrea.org/about.php

NESREA. (2011, May 25). *Publications and Articles*. Retrieved April 1, 2012, from NESREA: http://www.nesrea.org/uploads/index.php

Njoroge, K. G. (2007). *Environmental Pollution and Impacts on Public Health: Implications of the Dandora Municipal Dumping Site in Nairobi, Kenya.* Korogocho: In cooperation with United Nations Environment Programme and the St. John Catholic Church .

OECD. (2001). *Extended producer responsibility: a guidance manual for governments.* Paris: OECD.

Onwughara, N., Nnorom, I., Kanno, O., & Chukwuma, R. (2010). Disposal Methods and heavy Metals Released from Electrical and Electronic Equipment Wastes in Nigeria: Adoption of Environmental Sound Recycling System. *International Journal of Environmental Science and Development, Vol. 1*, 4.

Organisation of African Unity (OAU). (1991, January 30). *Bamako Convention*. Retrieved July 25, 2012, from Bamako Convention on the BAN of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa: http://www.cetim.ch/en/documents/conv-bamako-ang.pdf

Ostrom, E. (1990). *Governing the Commons: The Evolution of Instituions.* Cambridge University Press.

Puckett, J., Byster, L., Westervelt, S., Gutierrez, R., Davis, S., Hussain, A., et al. (2002). *Exporting Harm: The High-Tech Trashing of Asia.* Seattle: The Basel Action Network (BAN) Silicon Valley Toxics Coalition (SVTC).

Puckett, J., Westervelt, S., & Gutierrez, R. (2005). *The Digital Dump:Exporting Re-use and Abuse to Africa.* Seattle: The Basel Action Network.

Redclift, M. (2001). *Wasted: Counting The Costs of Global Consumption.* Sterling: Earthscan Publications Limited.

Sachs, W. (2001). Wasted: Counting The Costs of Global Consumption. In M. Redclift, *'Can the North Stop Consumption growth? Escaping the Cycyle of Work and Spend'* (p. 7). Sterling: Earthscan Publications Limited.

Schluep, M., Hagelueken, C., Kuehr, R., Magalini, F., Maurer, C., Meskers, C., et al. (2009). *Recycling - from e-waste to resources.* Paris, France: Empa, Umicore, UNU.: Sustainable innovation and technology transfer industrial sector studies.

Schmidt, C. W. (2002, April 01). *e-Junk Explosion*. Retrieved December 4, 2010, from Environmental Health Perspective: http://dx.doi.org/10.1289/ehp.110-a188

Schmidt, C. W. (2006). Unfair trade - E-waste in Africa. *Environmental Health Perspectives*, 114: A232-A235.

StEP. (2005). *Solving the E-waste Problem: A Synthetic Approach (StEP). Draft Project Document.* StEP.

StEP. (2011). *What is e-waste?* Retrieved January 10, 2011, from StEP- Solving the E-waste Problem: http://www.step-initiative.org/index.php/Initiative_WhatIsEwaste.html?page=2

techcrunch. (2012, June 20). *Iphone 5*. Retrieved July 28, 2012, from Techcrunch: http://techcrunch.com/2012/06/20/confirmed-the-new-iphone-will-have-a-19-pin-mini-connector/

Tonetti, B. (2007). US EPA's Regulatory Framework for "E-Waste". *Electronics Waste and Spent Lead Acid Batteries Capacity Building Workshop*, 1-4.

Toxics link. (2003). *Scrapping the hi-tech myth: Computer waste in India.* Delhi: Toxics Link.

Toxics Link. (2004). *E-Waste in Chennai: Time is running out.* Delhi: Toxic Links.

Unhelkar, B. (2011). *Green IT Strategies: Using Environmental Intelligence.* Boca Raton: CRC Press. Taylor & Francis Group.

United Nations University (UNU). (2007). *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE). Final Report.* Germany: United Nations University.

United States Geological Survey. (2001). *Obsolete computer, "Gold Mine" or high tech trash?* Denver, U.S.A,: U. S. Department of the Interior. Geological Survey.

US Department of Labor. (2011). *US Department of Labor, Occupational Safety and Health Administration*. Retrieved December 12, 2011, from US Department of Labor: http://www.osha-slc.gov/SLTC/cadmium

Varun, D. (2011). *My Digital life*. Retrieved April 4, 2011, from My Digital life: http://www.mydigitalfc.com/knowledge/recycled-hazards-018

Wasswa, J., & Schluep, M. (2008). *E-waste assessment in Uganda: A situational analysis of e-waste management and generation with special emphasis on personal computers.* Empa: Uganda Cleaner Production Center.

Widmer, R., Oswald, H., Kraft, Sinha- Khetrumal, D., Schnellman, M., & Böni, H. (2005). Global Perspective on E-Waste. *Environmental Impact Assessment Review*, 25: 436-458.

Appendix A

Survey Questionnaire

Section A: Personal Data

Please tick as appropriate:

Sex: Male [1] Female [2]

Age: below 20 [1] above 30[2]

Occupation: Electronic Importers [1] Electronic Repairers[2]

Computer and Photocopying Services [3] Local Recyclers(waste scavenging) [4]

Section B:

Please tick as appropriate

D = Disagree (1) AG = Agree (2)

S/N	Questions	Disagree (No)	Agree (Yes)
1.	E-waste is valuable to us all	1	2
2a.	The extracted materials from waste after recycling are exported or sold as spare parts for new products	1	2
2b	The extracted materials from waste after recycling are kept in storage for local Electronic Repairers	1	2
2c	The extracted materials from waste after recycling are resold to electronic importers.	1	2
3	Scavenging for Electronic parts in the dumpsite/refuse depot has improved my financial status.	1	2
4	People engage in manual recycling	1	2
5a	People face e-waste hazards like Respiratory Problems	1	2
5b	People face e-waste hazards like Burnt hands and bruises	1	2
5c	People face e-waste hazards like muscle weakness	1	2
6	There is a ready market for electronic waste, thus scavenging is lucrative	1	2
7	Do you know that foreign countries where these used electronics are being imported prohibit the burning of manual recycling?	1	2
8.	Is there a national government policy against mixing up e-waste with other waste?	1	2

Appendix B

Structured interviews with the Chairman of Scavengers Association (an official) at Olusosun dumpsite, Lagos State Nigeria

- Briefly describe what you do here at the dumpsite?
- I see you separate your waste according to types. What happens to them after you separate them?
- what kind of health issues do you get from working with e-waste
- Do you know of any policies regarding e-waste in Lagos or even in Nigeria?

Structured interview with an Electronic Repairer/Refurbisher at Ikeja Computer Village, Lagos State Nigeria

- Briefly describe what you do?
- Are you happy with the second electronics you buy?
- Can you show me the process you break down the parts of the unsold computers?
- How can you be sure it is from breaking apart the computer? Don’t you think it is something else?