WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (E-WASTE) MANAGEMENT AND DISPOSAL METHODS IN THE CITY OF ADDIS ABABA, ETHIOPIA

By

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DECLARATION

I ABENEZER WAKUMA KITILA (Student Number 57662746) hereby declare that the thesis titled **'WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (E-WASTE) MANAGEMENT AND DISPOSAL METHODS IN THE CITY OF ADDIS ABABA, ETHIOPIA' ,** which I hereby submit for the degree of DOCTOR OF PHILOSOPHY IN GEOGRAPHY at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution.

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Student signature: Date: October 19, 2018

DEDICATION

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ABSTRACT

E-waste is a world-wide, interregional, and domestic problem. E-waste management is a challenging task not only due to its speedily increasing volume but more outstandingly because of its hazardous nature. This study examined the e-waste management and disposal methods in the city of Addis Ababa to propose appropriate e-waste management model. Further, it attempted to comprehend the existing policy gap by identifying the different obstructions to the adoption of e-waste management policy. To this end, the study employs both descriptive and explanatory research designs. It selected 100 household heads from Bole and NSL sub-cities, 72 GSD personnel from the educational institutions and governmental sector offices, and 6 higher government officials. The quantitative data were analysed using IBM SPSS 21. Thus, the frequencies, the chi-square tests, t-tests, a one-way ANOVA, the partial and product-moment correlations, the ordinal, multiple and Poisson regression models were computed. The qualitative data were analysed using ATLAS ti 7. The findings of the study revealed that most of the respondents were not aware of e-waste and its management. The households generated about 4,010 number of non-functional, 2,077 obsolete, and 1,856 broken e-waste. Besides, the educational institutions and governmental sector offices generated about 11,153 non-functional, 15,911 obsolete, and 11,360 broken e-waste. The monthly income was statistically significant in the e-waste management whereas family sizes, gender, and educational qualifications were insignificant. The major e-waste causes encompass rapid obsolescence rate, breakage, and the demands for extra and innovative models or designs of electronic gadgets. The most common e-waste disposal method was storing. The recycling, reusing, donation, and refurbishing of e-waste had hardly been practiced. The study found the absence of good disposal methods and recyclers as the root causes for the prolonged storage and improper disposal of e-waste. E-waste laws, legislation, projects, activities, and recycling centres were non-existent. What is more, the administrative, economic, and socio-cultural challenges triggered the poor e-waste management of the city. Based on the findings, the study proposed a workable e-waste management model, which would most likely result in efficient and sustainable e-waste management in the city. Further, it calls for the stakeholders to work jointly to ensure proper e-waste management.

Keywords: E-waste; Electronic Equipment; E-waste Management; Educational Institutions; Government Sector Offices; Recycling, Obsolete, Addis Ababa; Disposal; Ethiopia.

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LIST OF ACRONYMS AND ABBREVIATIONS

AACA	Addis Ababa Cleansing Agency
AASWRRDO	Addis Ababa Solid Waste Re-use, Recycling and Disposal Office
AAU	Addis Ababa University
AAUFBE	Addis Ababa University Faculty of Business & Economics
AAUMC	Addis Ababa University Main Campus
AAUSF	Addis Ababa University Science Faculty
ANT	Actor Network Theory
ARF	Advanced Recycling Fee
AU	African Union
BAN	Basel Action Network
CBO	Community Based Organization
CPU	Central Processing Unit
CPUC	CPU College
CRT	Cathode Ray Tubes
CRTC	Computer Refurbishing and Training Centre
CSA	Central Statistics Agency
DMF	De-Manufacturing Facility
DVD	Digital Video Disk
E-waste	Electronic Waste
ECSU	Ethiopian Civil Service University

EE	Electronic Equipment
EEE	Electronic and Electrical Equipment
EIs	Educational Institutions
EiABC	Ethiopian Institute of Architecture, Building and Construction
EoL	End-of-life
EPA	Environmental Protection Authority
EPR	Extended Producer Responsibility
ETB	Ethiopian Birr
EU	European Union
FAO	Food and Agricultural Organizations
FDRE	Federal Democratic and Republic of Ethiopia
GDP	Gross Domestic Product
GPS	Global Positioning System
GSD	General Service Department
GSO	Governmental Sector Office
HGO	Higher Government Official
HH	Household
IBLF	International Business Leadership Forum
ICT	Information Communication Technology
INSA	Information Network Security Agency
IT	Information Technology
KMU	Kotebe Metropolitan University
LCA	Life Cycle Assessment

MCA	Multi Criteria Analysis
MFA	Material Flow Analysis
MoA	Ministry of Agriculture
MoE	Ministry of Education
MoFED	Ministry of Finance and Economic Development
MoH	Ministry of Health
MoCIT	Ministry of Communication and Information Technology
MoR	Ministry of Revenue
MoScT	Ministry of Science and Technology
MoT	Ministry of Trade
MSE	Micro and Small Enterprises
Mt	Metric Tonnes
MoT	Ministry of Trade
MUDHCo	Ministry of Urban Development, Housing & Construction
NGO	Non-Governmental Organizations
NSL	Nefas Silk Lafto
OAU	Organization of African Unity
PC	Personal Computer
PPPAA	Public Procurement and Property Administration Agency
PPDS	Pubic Property Disposal Service
PREI	Private Educational Institution
PUEI	Public Educational Institution
R2	Responsible Recycling

SPSS	Statistical Package for Social Sciences
St.MU	Saint Marry University
StEP	Solving the E-waste Problem
TV	Television
UK	United Kingdom
UKM	National University of Malaysia
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Fund for Population Activities
UNIDO	United Nations Industrial Development Organization
UNU	United Nations University
US	United States
USA	United States of America
USEPA	United States Environmental Protection Agency
UU	Unity University
WB	World Bank
WEEE	Waste Electrical and Electronic Equipment
WFP	World Food Program
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND OF THE STUDY

It is eminent that electronic and electrical equipment (EEE) production has experienced a massive progress during the last few decades. This unprecedented increase in the production and consumption of electronic equipment has consequently led to the creation and accumulation of a new type of waste known as Waste Electrical and Electronic Equipment (WEEE), commonly known as electronic waste or e-waste. E-waste is a term that is used slackly to refer to outdated, broken, or non-functional electronic devices like television sets, central processing units of computers (CPU), monitors (flat screen and cathode ray tubes), laptops, printers, scanners and the like (Bhuie *et al*., 2004; Cairns, 2005; Ramzy *et al*., 2008; E-waste guide, 2009; Zhang, 2009; Bandyopadhyay, 2010; Kalana, 2010; Luther, 2010; Geethan., *et al*., 2012; Asiimwe and Ake, 2013; Namias, 2013; Qiu *et al*., 2013**;** Kumar *et al*., 2013; Sivaramanan, 2013; Sthiannopkao and Wong 2013; Banar *et al*., 2014; Jhariya *et al*., 2014; Rudăreanu, 2014; StEP, 2014; Managing e-waste in Victoria, 2015; Tyagi *et al*., 2015).

Electronic industry is the most fast growing industry globally. According to NCHEWM (2013), the worldwide electronics industry represents 4.4 times of oil and mineral industry, 2.75 times of chemical and plastics, 2.45 times of food, beverage and tobacco, 2.44 times of transportation, and 2.20 times of electricity, gas, and water in 2006. When it comes to e-waste, according to the Global E-waste Monitor (GEWM), a humanity generated 44.7 million metric tons of e-waste in 2016, which is equivalent to 6.1 kilograms per person (Balde *et al*., 2017).

The rapid development of new technologies is increasing the e-waste problem all over the world. E-waste is, in fact, one of the world's promptly growing problems. As estimates made in the recent past show, the volume of e-waste material is growing at a rate of 3.5% per annum in most countries around the world. This growth rate

alarming because it is three times as high as the rate of increase in other individual waste streams in the solid waste sector (Bohum, 2004; EU, 2010; Kalana, 2010; Tengku-Hamzah, 2011). The advent of new designs and technologies at regular intervals in the electronic items used around the world today has markedly speeded up the rates of generation of e-waste. It is extensively renowned that the lifespan of majority of electronic equipment has been markedly reduced due to the ever growing demand for the supply of advanced electronic gadgets in this highly competitive era of fast changing needs, tastes and preferences of consumers (Bohum, 2004; EU, 2010; Kalana, 2010; Tengku-Hamzah, 2011; Adediran and Abdulkarim, 2012; Benedicta, 2012; Lundgren, 2012; Devin *et al*., 2014; Namias, 2013; Baberwal and Passi, 2015; Baldé *et al*., 2015; Managing e-waste in Victoria, 2015; Tyagi *et al*.,2015; Veit and Moura, 2015).

Further, Babu *et al*., (2007) stated the rapid economic growth, coupled with growing urbanization and changes in lifestyle and growing demand for material goods have led to an increased production of electronics and consequently the accumulation of e-waste over time. The other concern of e-waste is associated with the economic value of the components of e-waste. In this regard, Baldé *et al*., (2017) reveal the total value of all raw materials present in e-waste is estimated at approximately 55 Billion Euros in 2016, which is more than the 2016 Gross Domestic Product of most countries in the world. As cited in Marques and Silva, (2017), according to UN-related sources, about 320 tons of gold and 7.5 thousand tons of silver are used every year in the production of electronic equipment such as computers, tablets and cell phones (Agência FAPESP, 2012). Developing countries and those in transition are gradually being affected by this imminent toxic threat from e-waste because of their rapid movement towards technological development without the accompanying procedures, policies, and infrastructure to deal effectively with the waste (Hossain *et al*., 2015).

Accompanied by the rapid rate of urbanization in many developing countries, the electronic waste management has become an environmental concern (Kalana, 2010). According to Borthakur and Sinha (2013), managing the ever-increasing

volume of e-waste is a major concern for most of the countries today. It also becomes a contemporary concern, predominantly because these waste may simply find their way into developing countries where they are haphazardly and uncontrollably discarded in landfills. It is progressively causing fear all over the world because of its harmful effects on livestock, human kind and the ecology if disposed of improperly (Carisma, 2009; Adediran and Abdulkarim, 2012).

The continued e-waste generation over time has become a serious concern for various interest groups, academe and policy makers alike especially due to the lack of official and up-to-date data as regards the amount and trends of e-waste generation and disposal in developing countries (Carisma, 2009). The advent of information technology has undoubtedly led to a manifold increase in the pace of all human activities. While on the one hand electronic communication has saved the human environment by dramatically reducing paper usage, on the other hand, it has also caused prevalent environmental destruction because of the use of hazardous minerals in the production of electronic equipment.

Almost all electronic equipment used nowadays, be it computers, TV sets, CD players, cellular phones, stereos, fax machines or copiers, require a very large variety of small electrical components for their manufacture and the waste thus arising during their production or disposal is of great environmental and human health concern (Schluep *et al*., 2009). Besides, the sustainability of the planet should also be equated in terms of equipment production (Marques and Silva, 2017). For instance, "to manufacture one computer and monitor, it takes 530 pounds of fossil fuels, 48 pounds of chemicals, and 1.5 tons of water" (Electronics Take-Back Coalition, 2016).

Technologically advanced nations such as the United States of America (USA), the United Kingdom (UK) and other developed countries produce a massive amount of the world's electronic products and afterward generate most of the e-waste. These countries employed a policy that encourages e-waste exporting to developing countries particularly Africa and Asia in the semblance of second-hand electronics

than designing an environmentally friendly means of producing and dealing with e-waste (StEP, 2009; Benedicta, 2012; Lundgren, 2012; Devin *et al*., 2014).

On the other hand, EEE and Information Communication Technology (ICT) are comparatively luxurious in the developing countries compared to developed countries seeing the deep-rooted poverty levels, purchasing power and low income per capita of the society of the developing countries. Consequently, it has brought high demand for and utilization of second-hand electronic equipment. Certain equipment are outdated and have nearly reached their End-of Life (EoL) and are regularly imported illegally under the assumption of bridging the "digital divide". The equipment is typically imported without confirmatory testing for functionality and the majority of them end up being waste electrical because they are useless or couldn't serve the intended purpose (Namias, 2013; Otieno and Omwenga, 2015; Veit and Moura, 2015).

In developing countries, the chief generators of electronic waste are governmental institutions and the private sectors. According to Borthakur and Sinha (2013), it is apparent that businesses, the banking sectors, and educational institutions rely profoundly on EEE and thus adds end-of-life electronic equipment to the prevailing waste stream (Jhariya *et al*., 2014). Baldé *et al*. (2017) highlighted that more and faster networks, and new applications and services delivered at increasingly high speeds, have brought new opportunities to many people, particularly in the areas of health, education, government, entertainment, and commerce. At the same time, higher levels of disposable income, urbanization, and industrialization in many developing countries are leading to growing amounts of electrical and electronic equipment, and consequently to e-waste. Although the contribution from individual households is not manifold, the study of household e-waste would be of a great concern as it is associated with widespread lack of know-how regarding its management. Moreover, Borthakur and Singh (2012) asserted that although the global e-waste problem has been able to attract attention across the world, not much emphasis has been given to the e-waste engendered in developing countries.

Generally, electronic waste generation is a problem that requires attention Premalatha *et al*. (2014) point out that few developed countries around the world are scientifically able to recycle or dispose of electronic waste generated. In other developed countries, just a fraction of e-waste is recycled correctly, the rest either incinerated or sent to landfills that causes severe secondary problems. Sotelo *et al*. (2016) asserted that even worst, a significant part of waste flow generated worldwide is exported to developing countries where are dispose without any concern for the pollution that is causing.

1.2. THE PROBLEM

E-waste is a global, interregional, and domestic problem (Devin *et al.*, 2014). The e-waste challenge is becoming one of the political agenda in the past couple of years (Baldé *et al*., 2015). Cano (2014) as cited in Sotelo *et al*. (2016), claimed that electronic waste topic has gained international importance from its inclusion in the agendas of different agreement between countries seeking to promote actions for reducing environmental impacts such as the Basel and Stockholm Convention among others. The practical reason is that e-waste disposal is performed in a highly disorganized and uncontrolled manner in many parts of the world (Askari and Ghadimzadeh, 2014).

Electronic waste management, firstly, is a challenging task, not only due to its speedily increasing volume but more outstandingly because of its hazardous nature (Tengku-Hamzah, 2011; Baldé *et al*., 2015). Electronic waste encompasses several toxic minerals that may pose danger to the environment and human health if they are disposed of improperly. The weight of e-waste, which is 9% of its weight on average, is made of hazardous substances such as cadmium, lead, mercury and other toxic metals (Cui & Zhang, 2008; Theodros, 2010; Nimpuno & Scruggs, 2011; Tengku-Hamzah, 2011; Adediran and Abdulkarim, 2012; Leulseged, 2014; Tyagi *et al*., 2015).

Secondly, while the rates of growth of the volumes of other types of municipal waste are declining, those of e-waste is growing by 3.5% annually (Pucket *et al*. 2002; Cui and Forssberg 2003; Nnorom and Osibanjo 2008; Vasilenko, 2009; Jain, 2008; Mohan *et al*., 2008). Askari and Ghadimzadeh (2014) highlighted that it is growing rapidly, due to the wide use of this equipment, both in developed countries and in developing countries. These wastes continue to be generated at alarming rates due to fast-changing technology, drop in product prices, scale economies as well as an ever-growing demand for new features (Namias, 2013). Arora (2008) asserted that thousands of monitors, printers, computers, photocopiers, fax machines, and other electronic items are being substituted on yearly basis by new and advanced designs. Baldé *et al*. (2017) reported just 20 percent of e-waste was properly recycled in 2016 and the vast majority (80 percent) was undocumented, likely to be dumped, traded or recycled under inferior conditions.

Thirdly, the penetration of second-hand market or the importation of discarded electronic items in the form of a donation from developed countries has been overlooked. Studies confirm that the main e-waste problem in developing countries rises from the importation of both e-waste and electronic equipment from developed countries because it is the obsolete, less ecologically friendly equipment that is discarded from those western countries. In developed countries, about 80% of e-waste, is being exported in the name of free trade and donations (Toxics Link, 2004; Hicks *et al*., 2005; Joseph, 2007; Robinson, 2009; Lundgren, 2012; Borthakur and Sinha, 2013; Namias, 2013; Devin *et al*., 2014; StEP, 2014). The worst thing is that Balde *et al*. (2017) point out basic functionality tests showed that, on average, at least around 19% of devices were non-functional.

In developing countries, electronic waste management is a much more terrible challenge due to factors such as lack of proper infrastructure, weak enforcement of laws and low awareness among citizens (Baldé *et al*., 2015). It is evident that increasing storage-stockpiles and e-waste production levels offer indicators of the limited success of reuse, refurbishment and recycling efforts in developing countries. In addition, associated with an increase in the affordability of new products and

advanced technologies, it is easier for the people to purchase rather than repair, thus leading to the disposal of the obsolete equipment (Arora, 2008). The problem is aggravated by the continuing generation of e-waste at an alarming rate in developing countries. A study made by Yu, *et al*. (2010), estimated that for 2017 developing countries will start to generate more electronic waste than developed countries.

Improper management and disposal can be awfully hazardous for the environment and health. Where there is lack of policy and e-waste legislation, weak protections, incorrect practices of e-waste management and disposal occur at landfill sites and illegal dumps have posed a threat on human and environmental health (Kiddee *et al*., 2013; Baldé *et al*., 2015). Besides, Baldé *et al*., (2017) asserted that the increasing levels of e-waste, and improper and unsafe treatment, and disposal through incineration or in landfills pose significant challenges to the environment and human health, and to the achievement of the Sustainable Development Goals.

Likewise, there is low public awareness towards the hazardous nature of e-waste and the rudimentary waste management methods practiced in developing countries. Besides, it is realized that there are poor data on how much e-waste is generated and where, and to where it is exporting. This condition is aggravated by the recent system of information collection, in which second-hand, old and non-functional products are imperceptible to national statistics on production, sale, and trade in goods (Lundgren, 2012).

In Africa, Borthakur and Sinha, 2013; Manhart *et al*. (2013), as cited by Baldé *et al*. (2015), most of the obsolete electronic equipment is currently stored in different public buildings, international organizations, offices, and households or awaiting future solutions, while some of the e-waste is disposed of in an uncontrolled manner. Even though Africa produces relatively a small quantity of e-waste, is classically a dumping ground for electronic waste from other non-African nations. As result experts say that the continent might accumulate more e-waste than the European Union (EU) by 2017. As cited in Oteng-Ababio (2012) it was concluded that only about 10%of the total waste generated are recycled while about 80% are exported into developing

countries, most of which end up in landfills and incinerators (Hicks *et al*.,2005; Ravi *et al*.,2005; Antrekowitsch *et al*.,2006).

Sotelo *et al*. (2016) asserted that a significant flow of e-waste exportation is being sent from the European Union to Western Africa, causing environment pollution and significant risks to local population health. Borthakur and Singh (2012) point out that the major reasons for these exports are cheap labour and lack of environmental and occupational standards in developing countries. Furthermore, in major parts of the continent, a blend of population growth and improved access to some electronic equipment and other technology will produce a surge in e-waste over the next five years (YSFES, 2014).

There is now a growing number of countries adopting e-waste legislation. Baldé *et al*. (2017) noted that currently 66 percent of the world population, living in 67 countries, is covered by national e-waste management laws, a significant increase from 44 percent in 2014. The author further asserted that national e-waste policies and legislation play an important role as they set standards, guidelines, and obligations to govern the actions of stakeholders who are associated with e-waste. It was realized that only Cameroon and Nigeria have imposed national laws and legislation towards e-waste management, while Ethiopia, Ghana, and Kenya still didn't enforce e-waste legislation (Baldé *et al*., 2015).

The challenges of solid waste management have been growing all over Ethiopia by leaps and bounds in the recent past. Since Ethiopia has adopted a pathway to progress exploring Information and Communication Technology (ICT) possibilities, e-waste or the waste generated out of electronic and electric gadgets have emerged as major constituents of solid wastes in urban Ethiopian. The gradual but conspicuous growth of e-waste demands early planned strategies for dealing with it. Improper e-waste management is an escalating problem all over Ethiopia, but eluding necessary attention (Gudeta *et al*., 2015). A report from United Nations University (UNU)-hosted Solving the E-waste Problem (StEP) initiative indicate that about 4,300 tons of televisions, computers, mobile phones, and refrigerators are stored in major urban

centres of Ethiopia, particularly in Addis Ababa. What is more, the report asserted that e-waste treatments have been carried out improperly, while a huge volume e-waste is simply stored in offices and homes as assets rather than as electronic waste that need to be discarded (UNU, 2013).

Basically, the current volume of e-waste in Ethiopia might not be the driving force to undertake a study. However, the pressing nature of the rapid growth rate of e-waste in Addis Ababa and other cities and the multifaceted and complex issues that are associated with e-waste management in the country should be of great concern to policymakers and researchers. Similarly, from a preliminary survey that was conducted by the same writer on e-waste management in Addis Ababa University (AAU) in 2012, it could be comprehended that broken, unserviceable and outdated/ obsolete electronic waste were witnessed in the city. Besides, it was understood that e-waste was disposed of in unsafe or improper ways and a large volume of e-waste was stored in offices and households without taking any management actions. (Abenezer, 2012).

The study is different from the previous studies in many aspects. It contrasts in terms of data collection tools, data analysis techniques, variable identification, the inclusion of essential inquiries, study area, theoretical foundations, and scopes. First, many of the prominent previous works on e-waste management relied mainly on data tools, which were not pursued to address the issue in some comprehensive aspects. More explicitly, they were established on the data collection tools limited only to video documentaries and technical notes (Sivaramanan, 2013), observations and interviews (Manhart *et al.*, 2013; Askari and Ghadimzadeh, 2014;), surveys and interviews (Babington, 2012; Feras *et al.*, 2012), data collection tools not mentioned (Zhang, 2009; Adediran and Abdulkerim, 2012; Borthakur and Sinha, 2013; Tanskanen, 2013; Jhariya *et al.*, 2014; Tyagi *et al*., 2015). Similarly other authors rely on a case study analysis (Kiddee *et al*., 2013), semi-structured interviews (Mesfin, 2014), exploratory data (Otenio and Omwenga, 2015), unstructured interviews and focus group discussions (Theodros, 2010), personal communications and

conference papers (Queiruga *et al*., 2012), literature reviews and interviews (Qu *et al*., 2013).

Furthermore, observations and review of documents (Chin and Sothun, 2012), narrative reviews (Devin *et al*, 2014), document review (Bandyopadhyay, 2010; Kumar, 2013; Rudăreanu, 2014), interview, observation and review of documents (Tengku-Hamzah, 2011) questionnaires and interviews (Geethan *et al.*, 2012), and preliminary field research (Figueiredo *et al*, 2013). However, this study has attempted to fill the gaps by integrating and employing multiple data collection tools such as questionnaires, interviews, review of documents and observations to enhance the validity and reliability of the data.

Secondly, the aforementioned authors were reliant mainly on the descriptive data analysis in their analysis of e-waste management in various countries of the world. On the contrary, this study has attempted to fill the methodological gaps noticed in the earlier studies by incorporating the dependent and independent variables that affect e-waste management. Besides, this study employs not only descriptive data analysis but carried out the inferential statistics to scientifically analyse and present the results. Thus, statistical tests such as the chi-square and independent t-tests, partial correlations and product-moment correlations, one way-ANOVA, ordinal, Poisson and multiple regression models were computed to examine the mean differences, associations, and correlations that exist among variables and to figure the predictions.

Thirdly, these studies have not widely raised and answered basic questions in e-waste management. This study, however, attempts to narrow the gaps by incorporating questions such as the lifetime and storage years of e-waste, identification of the most and the least generated types of e-waste, comparison of e-waste generation among various income groups, reasons for replacing old electronic equipment, reasons for storing e-waste, purchase and procurement of e-waste, e-waste handling storages and facilities. Fourthly, they have not established their e-

waste studies on some e-waste management related theories. Besides, none of them have not investigates e-waste management in Addis Ababa.

Lastly, this study is different from previous studies in terms of scope and focus. Accordingly, domestic studies have been conducted in Addis Ababa. However, the authors tended to emphasize the study of municipal solid waste management (Yami, 1999; Selamawit, 2006; Nigatu, 2011; Bjerkli, 2013; Hayal *et al*., 2014; Mesfin and Van Dijk, 2014) and e-waste management, which is very limited in scope and participants (Theodros, 2010; Abenezer, 2012; Gudeta *et al*., 2015). This study attempts to fill these gaps by investigating electronic waste management in the case of households (HHs), educational institutions (EIs) and government sector offices (GSOs) of Addis Ababa. What is more, this study differently carried out a detail investigation of e-waste items (27 types of e-waste from EIs and GSOs, and 20 types of e-waste from the HHs) and examined the three distinctive e-waste types such as obsolete, non-functional and broken.

MUDHCo, (2015) as cited in Mohammed and Elias (2017) stated that one of the critical gaps in improving waste management operations is the absence of institutionalized research on different aspects of waste management including e-waste. On the other hand, the absence of accurate and reliable data on waste management is among the major factors determining the quality of operational plans. Moreover, neither environmental protection agencies nor waste management service providers are engaged in research, as they are bogged down with routine operations (MUDHCo, 2015). As a result, the necessary information with regard to waste characteristics, impacts, and management practices are not available in an organized manner (Mohammed and Elias, 2017).

In view of what has been stated above, it goes without saying that it is high time to undertake a geographic study that can shed some light on many of the unknown issues that surround the generation and disposal of e-waste in Addis Ababa. Conducting such a study does not only contribute towards bridging the rather wide gap in the literature. It is also hoped that its expected outcomes will considerably help policymakers to make informed decisions as they make concerted efforts to develop

e-waste management policies, programs that aim at significantly lessening the threats that improper disposal of electronic materials is posing to the environment as well as to public health (Abenezer, 2015).

1.3. RESEARCH OBJECTIVES

The intention of this research was to assess the waste from the electrical and electronic equipment management in the city of Addis Ababa to propose an appropriate e-waste management model for the city. Therefore, based on this general objective, the following specific objectives were formulated.

The specific objectives of the study were to:

1. Explain the status and variations in the awareness of e-waste, e-waste generation level and engagements in e-waste management practices.
2. Examine the e-waste management and disposal methods, and the administrative, economic, and social-cultural challenges that influence its practices.
3. Point out the stakeholders' involvements, their future plans, and recommendations on the e-waste management.
4. Identify a workable e-waste management model the practice of which would most likely result in a more effective and sustainable e-waste management system within the realities of today's Addis Ababa.

1.4. RESEARCH QUESTIONS

Based on the predefined objectives of the study, the following basic research questions have been raised and answered;

1. What is the status and why variations, in the awareness of e-waste, e-waste generation level and engagements in e-waste management practices?
2. What the e-waste management and disposal methods of the city look like and what are the major factors affecting e-waste management and practices?
3. Why is the e-waste management of Addis Ababa as poor as it appears to be and, then how do the political (administrative), economic, and social-cultural challenges influence its practice?
4. How stakeholders' do involved in e-waste management and what future plans and recommendations they propose?
5. What are the prominent e-waste management models/theories that would likely result in better e-waste management within the realities of today's Addis Ababa?

1.5. FEASIBILITY OF THE STUDY

While the researcher was studying towards a master's degree at Addis Ababa University in 2011/12, then he developed a strong interest in conducting research on electronic waste management. However, due to various constraining factors including a shortage of time and lack of adequate funding, the study was confined only to the campuses of Addis Ababa University. The results of the study have already been successfully defended as an MA thesis and then published.

It was the experience mentioned above that prompted this writer to conduct a larger study that will hopefully contribute considerably towards the development of an integrated e-waste management model for the city. Here it is important to bear in mind the fact that while extensive studies have been conducted on the management of other types of municipal solid waste, liquid waste and chemical waste in the city,

virtually, no other extensive work has ever been undertaken on e-waste management in Addis Ababa or elsewhere in the country.

In order to obtain a more depth understanding of the matter, the researcher attempted discussing the issue with various government officials and inhabitants of the city. In the course of those informal discussions, it was presumed that there were tons of e-waste kept on the premises of residential units, educational institutions, governmental offices and business organizations. The discussions also revealed that the concerned householders, officers, managers, and ICT experts have been discussing the issue informally. For instance, they posed questions like “why did e-waste increasing?”; “How could it be managed?”; “Who are the stakeholders in managing e-waste”?; “Is there any regulatory framework to manage e-waste?” Therefore, it can be understood from these emerging questions that the efforts made towards e-waste management in the city were far from adequate.

Likewise, the information gathered from the Federal Democratic and Republic of Ethiopia (FDRE) Public Property and Procurement Agency (PPPA) showed that the country has no legislation, rules, and regulations that specifically deal with e-waste. What is more, it strongly appears that in Ethiopia e-waste is most likely treated like any other solid waste. It has been observed that there is no recycling of e-waste. In addition to this, the great majority of the inhabitants of the land do not have adequate awareness about the harms that exposure to e-waste might cause. As a result, they either don’t know what to do with it or simply don’t consider it inappropriate when they throw it away like any other garbage.

On the other hand, undertaking the study in the residential areas, educational institutions and government sector offices were feasible both in terms of finance and time. It was practical that a number of data collectors or enumerators were assigned to take responsibility for data collection activities. Thus they facilitated and made the entire data collection process both possible and easy.

1.6. THE SIGNIFICANCES OF THE STUDY

1.6.1. The contribution to the discipline

The study of waste management is by its nature multidisciplinary. As such, it has attracted the attention of urban planners, engineers, chemists, physicists, and economists for a long time. It has also increasingly drawn to itself the attention of geographers, sociologists, environmentalists, lawyers and psychologists in the recent past. Scholars from most of these disciplines have in fact been striving to develop a workable research methodology on issues of waste management in general and the philosophical understanding of e-waste management in particular. Human geographers had, in fact, little to say on the issue of municipal waste management until recently. Nonetheless, the fact remains that a growing body of geographical literature has of late attempted to address the nature and complexities of e-waste management on topics ranging from international hazardous waste shipments to householder recycling habits (Watson, 2009).

The study of e-waste is by its very nature geographical because it examines the variation of the nature and /or components of electronic waste, its rates of generation, accumulation, and patterns of either recycling or disposal within a given geographical space over a period of time. Besides this, the proper handling and safety as well efficient disposal of e-waste are one of the key elements of municipal service delivery in any city. Due to its interdisciplinary nature of the study field, it does also touch on the interplay between different related disciplines and sub-disciplines such as urban planning, local government administration and environmental sciences. In connection with this, the intention to study e-waste largely emanated from the researcher’s modest understanding of the challenges that the complex processes associated with its management pose to both researchers and municipal authorities. The fact that the magnitude of these challenges have been dramatically growing while those of the challenges posed by most other municipal solid waste were lessening has particularly been the main factor that aroused the researcher's interest to address the issue of e-waste management in Addis Ababa.

Aside from what has been mentioned above, one critical issue that makes this study geographical is the researcher's interest to investigate the political, economic, social and cultural factors that influence the nature and outcomes of the e-waste management process. Here, it is particularly the nature and outcome of the critical inquiries that the researcher makes on the issues of how and why variations in e-waste management occur in different geographical settings, with varying administrative, social, and economic realms that are expected to contribute considerably towards enhancing knowledge in the discipline of Geography. What is more, it is hoped that the findings of this study have convincingly demonstrated how an inherently geographical research methodology helps to unveil many of the factors that underlie the woeful mismanagement of e-waste in a large city like Addis Ababa. In connection with this, the role that governmental and non-governmental organizations play in e-waste generation and management had also been critically analysed.

1.6.2. The contribution to the body of knowledge

The majority of the articles and academic journals published on e-waste management lack theoretical frameworks. In fact, all the blame should not be laid on the authors for not framing their studies with theory. But it is mainly the absence of appropriate theories and models that deal with e-waste management that is the principal reason behind this shortcoming. Even the existing theories cannot fully address all the issues and components that exist in the entire e-waste management process. Most researchers have undertaken researches only in larger metropolises and megalopolises based on the premise that they are engrossed with a huge volume of e-waste. In view of these, one of the main contributions of this study was proposing the leading e-waste management model which might be applied not only to the national capital alone but also to various other secondary cities and small towns across the urban hierarchy of Ethiopia. Thus, it is hoped that the model would be capable of encompassing e-waste management issues across the regions.

As mentioned above it is strongly hoped that the results of this study will help to develop a workable and highly effective waste management model for Addis Ababa. It is equally hoped that the improvements that result from the application of this robust waste management model to the realities of Addis Ababa could be taken as a best practice for tailored applications to other regional capitals and urban settlements in the country. Beyond this, the study aims at developing various management techniques of e-waste. It also envisages establishing a multi-stakeholder partnership so as to design a strategy that helps to achieve environmentally sound management of used, broken and obsolete electronic items in the city. On top of this, it encourages/stimulates interested groups to assist the institutions in exploring fundraising strategies and technical supports that include launching projects, making full use of the expertise in governmental and non-governmental organizations in joint projects.

1.7. SCOPE OF THE STUDY

Geography, sectors/cases, subjects, and themes define the scope of the study. As illustrated in Figure 1.1, firstly, the geographical system boundary for the research and data collection is Addis Ababa, Ethiopia. Thus, the households, educational institutions, and government sector offices in the city were identified as the primary focus of this study. It selects public and private colleges and universities, government sector offices which are at minister/federal level, households of Bole and NSL sub-cities. This is done based on the presumption that these are among the leading generators of e-waste in Addis Ababa. Besides this, higher government officials were included.

Thirdly, the study was also delimited in terms of study subjects. Accordingly, property administration directors, procurement experts, storekeepers, household heads, and some higher government officials were the sample respondents of the study. Finally, the thematic areas that the study has emphases in this study are issues accentuated around the objectives of the study. These include the status and generation of e-

waste, causes and disposal methods, challenges of e-waste and stakeholders' involvement in e-waste management. The noticeable constraints such as time, capacity, and financial restraints made it impossible to carry out the study in the households of all sub-cities, business organizations, government and non-governmental organizations, industries and companies. What is more, the justifications for the selection of Addis Ababa, EIs, GSOs, and HHs were treated under chapter four of the study.

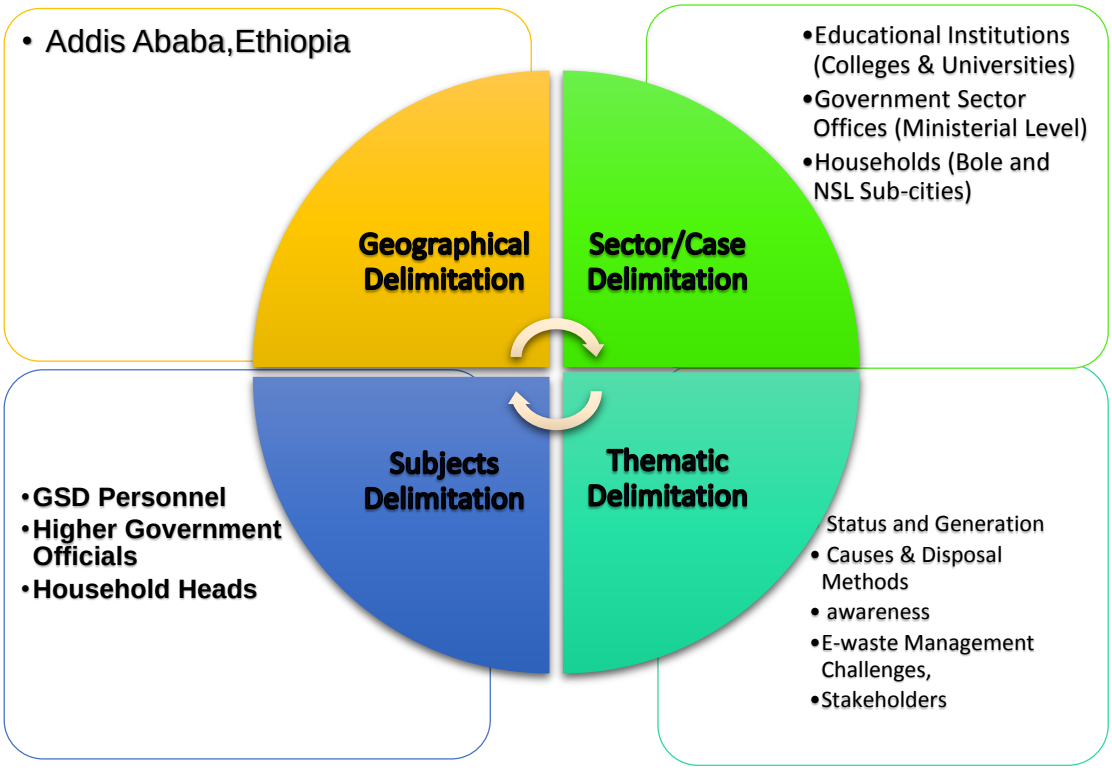

Figure 1.1. Scope of the study

Source: Field Survey, 2016

1.8. CHAPTER OUTLINE

The thesis is organized into eight chapters. Chapter one presents the introductory section of the study including; the context, problem description, objectives of the study, basic research questions, feasibility of the study, the significance of the study and proposed chapter outline. Chapter two deals with the review the theoretical and

empirical literature as well with the conceptual frameworks of the study. Following this is the description of the study area and background thematic areas in detail. This chapter discusses the history, social, economic, political, environmental, demographic and physical aspects of the study area. Besides it also presents the activities, initiations, actors, legislation, policies, and structures related to e-waste management. Chapter four discusses the methodological aspects of the study encompassing; geographical research areas, research design, research approach, data sources, data collection tools, sampling size determination and techniques, methods of data analysis and data presentation, validity and reliability of the data and ethical considerations.

The next two chapters (chapter five and chapter six) deals with the analysis, interpretation, and presentation of data on e-waste management in the households, educational institutions and government sector offices of Addis Ababa. Then, chapter seven outlines the discussions of research findings particularly linked to the previous works. Finally, chapter eight provides summary, conclusion, and recommendation to the whole chapters including the identified model of e-waste management and identification of future research themes or area.

1.9. CONCLUSION

This chapter labeled the outline and the milieu of the study. Electronic waste is, in fact, one of the world's promptly growing problems. This growth rate is alarming because it is three times as high as the rate of increase other individual waste streams in the solid waste sector. The advent of new designs and technologies at regular intervals in the electronic items used around the world today has markedly speeded up the rates of generation of e-waste. E-waste becomes a contemporary concern, predominantly because these waste may simply find their way into developing countries where they are haphazardly and uncontrollably discarded in landfills. In developing countries, electronic waste management is a much more terrible challenge due to factors such as lack of proper infrastructure, weak enforcement of laws and low awareness among citizens.

This study was different from the previous studies on the challenges and prospects of e-waste management in many aspects. Thus, it was intended to fill gaps prevailed in the previous studies in terms of methodological aspects, variables, inquires and the scopes. In line with this, the nature and outcome of the critical inquiries that the researcher makes on the issues of how and why variations in e-waste management occur in different geographical settings, with varying social, economic and cultural realms that are expected to contribute considerably towards enhancing knowledge in the discipline of Geography. The improvements that results from this study are expected to bring to the e-waste management policy and practice of Addis could be taken as a best practice for tailored applications to other regional capitals and urban settlements in the country. The next chapter provides a detail theoretical, conceptual and empirical literature on electronic waste management.

CHAPTER TWO

REVIEW OF THE LITERATURE

2.1. INTRODUCTION

Combined with the expanding utilization of electronic equipment is the developing volume of e-waste created for disposal. The proceeded with the generation of e-waste after some years has turned into a genuine worry for intrigue scholars, researchers and policy formulators (Carisma, 2009). Presently, electronic waste is the biggest growing waste stream. It is risky, complicated and costly to handle in an ecologically proper manner, and the challenge is associated with the general absence of legislation or authorization encompassing it (Lundgren, 2012).

The administration of electronic waste has become a concern in many developing nations as urbanization keeps on occurring. Dealing with the consistently expanding volume of e-*waste* is a noteworthy worry for a large portion of the nation today. It likewise turns into a topical issue, especially on the grounds that such waste now effectively discover their way into developing nations where they are recklessly and wildly dumped in landfills. It is progressively causing concern everywhere throughout the world on account of its perilous impacts on people, animals, and the biology if not legitimately discarded. For the most part, e-waste is a noteworthy crosscutting issue with worldwide hugeness and it along these lines entails a cross-sectoral execution (Kalana, 2010; Adediran and Abdulkarim, 2012; Lundgren, 2012; Rudareanu, 2013; Borthakur and Sinha, 2013).

Based on these brief introduction, this chapter examined the sources, causes, generation, characteristics, management and disposal methods, challenges and the effects of e-waste. It also presents policies, conventions, models, and strategies for e-waste management. It further discusses the conceptual and theoretical frameworks of the study.

2.2. DEFINITIONS AND BASIC CONCEPTS

2.2.1. Electronic and electrical equipment (EEE)

In order to understand electronic waste management, basically, examining the way electronic equipment is defined deemed necessary. This is mainly due to the fact that the creation of electronic waste around the world happens through a gradual end-of-life of electronic equipment. Many authors came up with various definitions of electronic equipment or products.

The term 'electronic equipment', for example, alludes to and incorporates gear, which is subject to electric streams or electromagnetic fields with the final aim to work and contains a hard-drive or noteworthy electronic segments/printed circuit board. Additionally, as referred to by Rudăreanu (2014), EEE represent "hardware which is subject to electric streams or electromagnetic fields with the goal of working appropriately. It also refers an equipment intended for use with a current rating not greater than 1000 volts for rotating present and 1500 volts for the direct current" (Davis and Heart, 2008; Wolski, 2008; EU, 2010).

In view of these ideas, the term electronic equipment embraces an extensive variety of home and business electronic products, including TVs, screens, Personal Computers (PCs), sound and stereo gear, PC peripherals, VCR, DVD players, camcorders, phones, fax and duplicating machines, cell-phones, remote gadgets and so on. Family unit apparatuses, for example, washers, dryers, fridges, and toasters can likewise be considered as hardware items (Ramachandra, 2004).

2.2.2. E-waste

The term e-waste was first presented in the 1980s after the natural debasement because of risky items imported to developing nations (Otieno and Omwenga, 2015). There is no universally institutionalized or concurred meaning of e-waste; thus, every nation or association thinks of their own customized definition. There is a worldwide irregularity in the comprehension and use of the expression "e-waste" in both

enactment and regular utilization. This has brought about numerous definitions contained in e-waste controls, strategies and rules (Adediran and Abdulkarim, 2012; StEP, 2014; Otieno and Omwenga, 2015).

As indicated by Tanskanen (2013 pp.1001), any meaning of e-waste necessities to reflect the parts of both the item getting to be noticeably old and the choice of its proprietor to transform it into waste: electronic items wind up plainly waste at the time and place when their structure and state are never again fit for furnishing the normal execution as for the reason doled out by their proprietors. The reasons why an electronic item is never again ready to perform concerning the proposed reason can be complex: it might essentially be not any more practical in view of being harmed, or its innovation and configuration may never again be cutting edge or in vogue. Then again, a gear is not viewed as waste when it can even now be refurbished, can be traded or donated, can be given out in return for another one, given for philanthropy aims, conveyed for renovating or came back to a vendor as per the associations' return strategies (Environmental Agency, 2012).

The expression "e-waste" itself is clear as crystal, as in it is a contraction of "electronic waste". A key part of the definition is "waste" and what it sensibly suggests – that the thing has no further utilized and is dismissed as pointless or abundance to the proprietor in its present condition (StEP, 2014 pp.4)

E-waste is characterized as electronic gear that is considered to all segments or sub-congregations that are old, outdated, non-working, broken, end-of-life. It is also referred to the equipment disposed of by the first clients, and don't, in their practical state, fill any need to any expecting client. Meaning, an electronic gear that finished its lifetime, However, it can be reused after it has been repaired. Then again, it is disposed of electronic gear that is bound for recuperation, reusing or transfer. Additionally, anything of disposed of electronic hardware, paying little respect to esteem or condition (operational or non-operational TVs, clothes washers, dishwashers, coolers in houses and furthermore in workplaces PCs, printers, security frameworks and lighting frameworks are a few cases of WEEEs. All the more

expressly, practically every utilized electronic things are considered as e-waste, for example, disposed of cell phones, cameras, Compact disc players, radios, TVs, fax machines, drillers, scanners, toners, printers, ink cartridges, re-chargeable batteries, batteries, advanced mini-computers and tickers, CRT screens, electric fastens, PC mother sheets, console, mechanical and house hold electronic hardware, for example, stove, ice chest, sewing& clothes washers, fan, aeration and cooling system, processor, press, warmer, military and lab electronic gear's (Bhuie *et al*., 2004; Cairns, 2005; Ramzy *et al*., 2008; Wolski, 2008; E-waste guide, 2009; Zhang, 2009; Bandyopadhyay, 2010; Kalana, 2010; Luther, 2010; Geethan., *et al*., 2012; Asiimwe and Ake, 2013; Borthakur and Sinha, 2013; Namias, 2013; Qiu *et al*., 2013**;** Kumar *et al*., 2013; Sivaramanan, 2013; Sthiannopkao and Wong 2013; Banar *et al*., 2014; Jhariya *et al*., 2014; Rudăreanu, 2014; StEP, 2014; Managing e-waste in Victoria, 2015; Tyagi *et al*., 2015).

2.2.3. E-waste management

End-of-life administration of e-waste combines reuse of working hardware, restoration, and repair of gadgets, restoration of parts of the electronics, recycling e-waste, and disposal (Namias, 2013). E-waste administration incorporates the accumulation, arranging and reusing of electronic items (Tyagi *et al*., 2015).

2.3. E-WASTE CLASSIFICATION

E-waste incorporates an extensive variety of items, – any family unit with electrical and electronic parts with power or battery source (Baldé *et al*., 2015). E-waste involves electrical gadgets, for instance, refrigerators, ventilation systems, bright lights, clothes washers, and microwave stoves; and electronic items, for example, personal computers and frill, cell phones, TVs and stereo gear (Lundgren, 2012). It is additionally recognized and specified by Kumar *et al*. (2013) as PC and its accessories, typewriters, cell phones, remotes, minimal plates, earphones, batteries, LCD/Plasma TVs, aeration and cooling systems, refrigerators and other family apparatuses are sorts of e-squander produced in any family unit or business association.

According to Baldé *et al*. (2015), as depicted in Table 2.1, electronic equipment can be classified in to six groupings.

Table 2.1: Electronic waste classification

S.N	E-waste Categories	Typical Equipment
1	Temperature Exchange Equipment	Refrigerators, coolers, aeration and cooling systems, warm pumps.
2	Screens and Monitors	Monitors, Televisions, notebooks, laptops, and tablets.
3	Lamps	Compact fluorescent lamps, Straight fluorescent lamps, fluorescent lamps, high-intensity discharge lamps and LED lamps.
4	Bulky Equipment	Electric stoves Washing machines, garments dryers, dish clothes washers, and substantial printing machines, replicating hardware and photovoltaic boards.
5	Smaller Equipment	Microwaves, vacuum cleaners, ventilation hardware, toasters, electric pots, electric shavers, scales, adding machines, radio sets, camcorders, electrical and electronic toys, little electrical and electronic devices, little medicinal gadgets, little checking and control instruments.
6	Small IT and Telecommunication Equipment	GPS, Mobile telephones, stash mini-computers, switches, Personal computers, printers, phones

Source: Baldé *et al*. (2015)

Then again, the European Waste Directive has arranged e-waste into ten unique classes (See Table 2.2). These are extensive and little family unit apparatuses, IT and broadcast communications hardware, buyer gear, lighting gear, electrical and electronic devices, toys relaxation and games hardware, restorative gadgets, checking and control instruments and programmed distributor (EU, 2002).

Table 2.2: Electronic waste categories

No	Category	Label	Products
1	Large household appliances	Large HH	Fridges, freezers, washing machines, clothes dryers, dishwashing
2	Small household appliance	Small HH	Vacuum cleaners, carpet sweepers, coffee machines
3	IT and telecommunications equipment	ICT	Copying instrument, printers, Personal computer (mouse, CPU, screen, and keyboard), and printers.
4	Consumer equipment	CE	TV sets, Radio sets, Television sets, Video cameras, Video recorders, Audio amplifiers
5	Lighting equipment	Lighting	Luminaries for fluorescent lamps, compact fluorescent lamps.
6	Electrical and electric tools	E and E tools	Drills, saws, sewing machines, equipment for turning, milling, sanding, shearing
7	Monitoring and control instruments	M and C	Smoke detector, heating regulatory, thermostats, laboratory equipment etc.
8	Medical devices	Medical equipment	Radiotherapy, cardiology, dialysis, pulmonary, ventilators, nuclear medicine
9	Toy's leisure and sports equipment	Toys	Electric trains or cracking sets, handheld video game consoles, video games
10	Automatic dispensers	Dispensers	Automatic dispenser for a hot drinks automatic dispenser for money and bottles.

Source: EU (2002)

On the other hand Oteng-Ababio (2012) identified that EEEs are largely classified under three major heads, as: 'white goods,' like household appliances (air conditioners, dishwashers, refrigerators and washing machines); 'brown goods,' like TVs, camcorders, cameras, and 'grey goods,' including computers, printers, fax machines, scanners, etc. The grey goods are comparatively more complex to recycle due to their toxic (hazardous) composition.

2.4. GLOBAL E-WASTE SOURCES AND TRADINGS

Industrialized and innovatively propelled countries, for example, the USA, the UK and other developed nations produce a tremendous volume of the world's electronic items and in this way produce the vast majority of the e-waste. As opposed to building up ecological methods for assembling and managing e-waste, these nations use other methods for arranging their mounting gathering of e-waste – sending out the e-waste to the third world nations particularly Africa and Asia in the form of 'second hand' hardware (Benedicta, 2012).

Then again, Veit and Moura (2015) avowed that the developed and developing nations are thought to be the primary makers and creators of electronic waste. As to advanced nations, greatest electronic waste is produced in Europe and USA though, China and Latin America are winding up expansive generators of electronic waste from developing countries. E-waste exchanging between the more monetarily advanced nations for the most part from the European Union (EU) and (USA) and the less financially developed nations (for the most part in Asia and Africa) thrived amid the 1990s (Tengku-Hamzah, 2011).

In the 1990s, the European Union governments, Japan and a portion of the US states set up E-waste "recycling" frameworks. However, they did not have the ability to manage the sheer amount of e-waste they created with its risky nature. Along these lines, they started sending out the substances to developing nations, where laws formulate to safeguard humankind and the environment are either insufficient or not implemented. It is likewise less expensive to "recycle" waste in unindustrialized nations; the cost of glass-to-glass recycling of PC screens in the U.S. is ten times more than in China (Askari and Ghadimzadeh,2014; Gomes and BakriIshak, 2014).

Information Communication Technology and other EEE are generally costly in the unindustrialized nations relative to advanced nations considering the destitution levels, obtaining force and low wage per capita of the subjects of the unindustrialized nations. This has prompted a popularity for and utilization of second-hand EEE. Some of these gear is outdated and have practically reached their End-of-Life (EoL) status

and are typically foreign made and transferred unlawfully under the guise of connecting the "digital divide". The items are ordinarily transported without corroborative testing for usefulness and most parts of them wind up being WEEE on the grounds that they are unusable or can't meet the intended need (Otieno and Omwenga, 2015).

As referred to by Kiddee *et al*. (2013) the major problem of e-waste in less industrialized nations emerges from the introduction (importation) of electronic products and electronic waste from industrialised nations since it is the consignments to consist largely outdated, environmentally less friendly hardware that are disposed off from these Western nations (Hicks *et al*., 2005). As cited by Joseph (2007), e-waste from developed nations locates a simple pathway into less industrialized nations for the sake of free trade (Toxics Link, 2004). Old yet working electronic hardware is frequently transported to developing nations by good-natured donors in the West (Robinson, 2009). Besides, as referred to by Borthakur and Sinha (2013), reuse is, at last, the wellspring of some e-waste in numerous poor nations that acknowledge gifts of hardware considered out of date in rich nations.

E-waste has its own life cycle. The average life cycle (or obsolescence rate) of electronic equipment is the time span after which the item comes to its end-of-life. It is defined as; Average life cycle = Active life + Passive Life + Storage, where active life is the quantity of year the hardware can be productively utilized; passive life is the time after active life, when the gear can be revamped or reused; storage is the time amid which the gear is put away and at repair shops before destroying (Adediran and Abdulkarim, 2012). In developed nations, passive life and storage life are essentially non-existent; subsequently, the normal life cycle of electronic gear is, for the most part, the same as the active life. Accordingly, the inactive and disposal times are dealt with by the developing nations to which the gear are transported and where second-hand showcase exists for them (Adediran and Abdulkarim, 2012).

It is projected that 50 to 80 percent of e-waste gathered in advanced countries is traded to developing nations because of the cheap workforce and indulgent ecological directions (StEP, 2009). Moreover, a portion of the world's e-waste is delivered over greater distances to developing nations where rough and profligate methods are frequently used to remove materials and parts (Baldé *et al*., 2015). Of the e-squander in advanced nations that is sent for reusing, 80 percent winds up being dispatched (frequently unlawfully) to developing nations (Lundgren, 2012). What exacerbates things is that these developing countries do not have the wellbeing and security foundation to process and discard materials securely, and subsequently labourers handle lethal metals without standardized tools (Namias, 2013).

Africa, specifically, is the most recent destination for electronic waste, alluded to as the 'digital dump' by the Basel Convention Network (BAN), since numerous Asian nations are presently thinking of enactment that bans the uncontrolled importation of specific classes of utilized Electrical and electronic gadgets (Adediran and Abdulkarim, 2012). In USA and Australia, more than half the electronic waste is discarded as landfills while the rest are to be exported to Asia and Africa (Sivaramanan, 2013). It is estimated that 75% to 80% is dispatched to nations in Asia and Africa for "reusing" and disposal (Devin *et al*., 2014).

While a few governments are precluding the transfer of e-waste to unindustrialized countries, exportation is on the ascent because of financial motivations of informal recycling. Industrialized countries benefit from shabby work costs in unindustrialized countries, while the foreign made e-waste makes occupations for unindustrialized countries and gives second-hand items to reuse (Namias, 2013). To the extent Africa is concerned, it is realized that numerous African nations get second-hand hardware. The greatest volume of electronic hardware transfers to Africa is not pre-tried for usefulness. Thus, it is unrealistic to survey whether these exports are legitimately characterized as unsafe waste under the Basel Convention (Veit and Moura, 2015).

Electronic waste basically originates from a few sources. Kalana (2010) asserted that the sources are residue materials from electronic items fabricating process, disposed of electrical created from a repair shop, out of date electronic hardware originating from governments, organizations, and families, and out of date electronic items acquired by smuggling. E-waste will be generated from all the financial strata in changing volumes, sort, and level of brokenness (Mesfin *et al*., 2014). Thus, manufacturers, government workplaces, organizations, businesses, and families are generators of e-waste. For example, Ashfaq and Khatoon (2014) wrote that around 1,050 tons of electronic piece is being created by producers in a solitary year and half of the PCs which are sold everywhere throughout the nation are fundamentally from the auxiliary market and are reassembled on the old segments. Also, manufacturers and constructing agents projected to create around 1200 tons of electronic pieces every year (Jhariya *et al*., 2014).

The shopper thinks that it's advantageous to purchase another PC as opposed to update the old one because of the evolving setup, innovation and the appealing offers of the producers (Ramesh and Joseph, 2006). As Jhariya *et al*. (2014) specified, there is a project that 2 million tons of total out of date (obsolete) PCs are created from government workplaces, business houses, ventures and family units. In addition, partners, for example, IT ventures, government workplaces, open and private segment foundations, instructive organizations, business and corporate houses and so on are primarily in charge of the creation or generation of the electronic waste (Borthakur and Sinha, 2013).

2.5. THE MAJOR FACTORS BEHIND THE PROLIFERATION OF E-WASTE

Over the most recent two decades, the universal development of electronic and electrical gear creation and consumption has been exponential. This is to a countless magnitude because of escalating market infiltration of items in developing nations and improvement of a substitution platform in advanced nations (UNEP, 2007). Rising salaries and falling costs have guaranteed that more individuals can manage the cost of electronic gear. Besides, quick advances in technology have come about in a huge

number of new electronic items as well as lessened their life expectancy by making items too out of date speedier. Electrical and electronic items, especially electronic gadgets, turn out to be mechanically outdated in a matter of months because of nonstop advancement of new models. Likewise the movement from simple to computerized advancements and to level screen TVs, screens, conservative and multi-entrusting gadgets, for example, the iPad, iPhone and Kindle, are fuelling the expansion of electronic waste (Kalana, 2010; Tengku-Hamzah, 2011; Adediran and Abdulkarim, 2012; Benedicta, 2012; Lundgren, 2012; Devin *et al*., 2014; Managing e-waste in Victoria, 2015; Veit and Moura, 2015).

So also, researches affirmed that fast equipment advancement, scaling down and substitution; particularly for Information Communication Technology (ICT) items and purchaser gear are fuelling the expansion of e-waste. Fast innovation advancement and regularly shortening item life expectancies are among the elements adding to the developing measure of e-waste (Baldé *et al*., 2015).

Technological development can be seen as the main reasons behind the global proliferation of e-waste. With developing a number of advancements in EEE models; the number of old and unused gadgets has likewise expanded, henceforth contributing towards e-waste. The quick advances and development in the innovation, electronic gadgets have presently made such gadgets more accessible to customers at a reasonable cost thereby expanding their purchasing power. Presently shoppers may supplant their gadgets to be tech refreshed and some way or another nowadays it has additionally turned into a grown-up toy to utilize most recent electronic items (Tyagi *et al*., 2015). So also, as announced by (Managing e-waste in Victoria, 2015), fast development in both existing and new hardware can make an apparent need or yearning in buyers to refresh and move up to an item that might be more productive, more appealing or more sturdy than their present model. Shoppers are subsequently disposing of their electronic items at a quicker rate to guarantee they have the "most recent" item.

Other than that, because of the expansion in affordability of new items and mechanical headways, it is anything but difficult to buy as opposed to repair outdated hardware (Kalana, 2010). As unmistakably revealed by Managing e-waste in Victoria (2015), a reduction in the life expectancy of electronic items brings about items (or their parts) to work over shorter and shorter periods. Buyers tend to buy substitutions as opposed to repairing their current item. It is additionally getting to be noticeably less demanding and more helpful to change hardware than to repair or fix them (Adediran and Abdulkarim, 2012).

The generation and utilization of EEE keep on developing in the unindustrialized nations and overall in this way expanding the volume of WEEE at its End-of-Life (EoL). The quick development and advancement of the Information and Communications Technology industry have worsened the circumstance with the expansion of PCs and cell phones to address the mounting interest (Otieno and Omwenga, 2015). As it is mentioned before, the interest for economical second-hand equipment and crude materials in unindustrialized nations is the utmost motorist for the interregional and worldwide exchange of e-waste (Baldé *et al*., 2015).

The infiltration of the second-hand market in a large number of African nations can be considered as a reason for the production of electronic waste. As per an investigation led by Sivaramanan (2013), for example, around 4 million tons of wastes are conveyed to Ghana from Antwerp and different parts of the western world. E-waste entry is still there as the general population of Ghana could not afford to buy new electronic merchandise because of their neediness. They are sold for shabby cost, however, no guarantee for its use, while unusable things are signed and dumped there. Others likewise affirmed that the significant value distinction between the new and utilized EEE makes the customer go for the buy of the second hand EEE in developing nations (Borthakur and Sinha, 2013).

Production of e-waste is related with urbanization. For example, Malaysia is confronting issues with the fast development of residential e-waste volume. This is because of the expanding size of the populace living in urban regions and practicing

present-day ways of life (monetary change from farming based to the mechanical grounded socio-economic way of life in the 1980s). Additionally, the creation of household e-waste relies upon the socio-economic developments (Tengku-Hamzah, 2011).

A standout amongst the most critical components influencing the creation and rapid growth in the volume of e-waste are capital level, mindfulness level, and tastes of the general population. In such manner, Feras *et al*. (2012) affirmed that family unit size and income level influences the expectations for everyday comforts and utilization design. The author included family unit mindfulness level is an imperative factor in deciding the preparation of the general population to manage distinctive environmental issues.

The absence of specific strategy or policy to manage electronic waste will give rise to generation and accumulation of electronic waste. As reported by Feras *et al*. (2012), most of the consumers believed in storing e-waste for a certain time and that they can dispose of with the municipal solid waste (MSW). This deficiency occurs because there is no management system to handle e-waste in the country. For instance, India at present generates about 4, 00,000 tons of e-waste per annum of which only 19,000 tons is getting recycled according to data by provided by hardware manufacture association (Jhariya *et al*., 2014).

2.6. GLOBAL E-WASTE GENERATION AND TRENDS

Nowadays, electrical and electronic waste (which grows at about 4 percent per annum) is the fastest growing solid waste stream (Lundgren, 2012; Namias, 2013; StEP, 2014). It is growing at a much higher rate compared to most other or normal municipal solid waste. According to a report, it had been projected that 93.5 million tons of e-waste would generate globally by the end of 2016 compared to what was 41.5 million tons in 2011. As such the report indicated that with a compound annual growth of almost 18% it would become one of the biggest challenges to handle. An examination, from Greenpeace, assessed that internationally 20–50 million tons of

WEEE (waste electrical and electronic equipment) are disposed off yearly, with Asian nations alone contributing arranging up to 12 million tons per annum (Schluep *et al*., 2009; Devin *et al*., 2014; Veit and Moura, 2015; Tyagi *et al*., 2015).

As indicated by Baldé *et al*. (2015) it was estimated that the aggregate sum of e-waste created in 2014 was 41.8 million metric tons (Mt). The same author states that it is estimated to increase to 50 Mt of e-waste in 2018 with a yearly growth rate of 4 to 5 percent. This e-waste is consisted 1.0 Mt of lights, 6.3 Mt of screens, 3.0 Mt of small IT gadgets, (for example, cell phones, stash adding machines, PCs, printers, and so on.), 12.8 Mt of little gear, (for example, vacuum cleaners, microwaves, toasters, electric shavers, camcorders, and so on.), 11.8 Mt of substantial hardware, (for example, clothes washers, garments dryers, dishwashers, electric stoves, photovoltaic boards, and so forth.) and 7.0 Mt of cooling and solidifying hardware (temperature trade hardware). It was likewise uncovered that the cumulative quantities of the few poisons found in e-waste stream would result in landfills or recycling centres influencing the natural surroundings or the human being (Gaidajis *et al*., 2010).

As illustrated in Figure 2.1, the global quantity of e-waste generation in 2016 was around 44.7 million metric tonnes (Mt), or 6.1 kg per inhabitant. It is estimated that in 2017, the world e-waste generation will exceed 46 Mt. The amount of e-waste is expected to grow to 52.2 Mt in 2021, with an annual growth rate of 3 to 4% (Baldé *et al*., 2017).

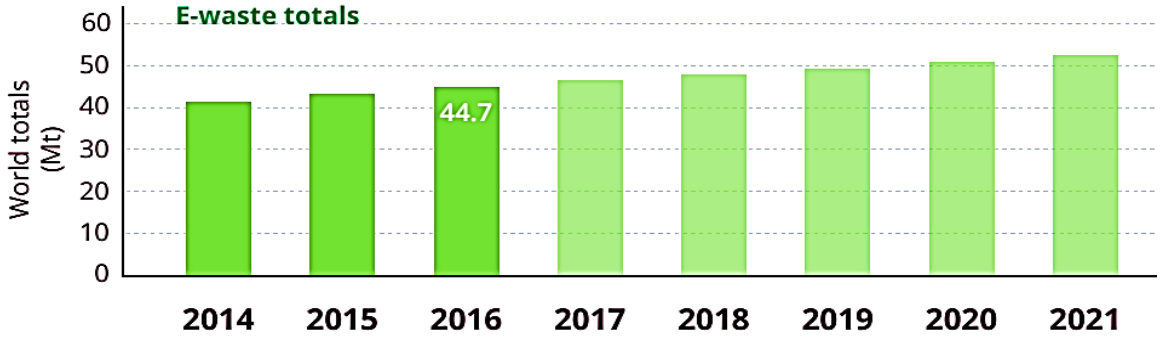

Figure 2.1. Global e-waste generation
Source: Baldé *et al*. (2017) **NB**: 2017-2021 are estimates

The generation of e-waste indicates variety among nations of the world. As indicated by Namias (2013), disposed off consumer gadgets (also called e-waste) contain the rapidly growing waste stream in the Unified States and the rapidly growing part of the Municipal Solid Waste (MSW) stream around the world. The same author reported that Europeans deliver around 20 kilograms of e-waste/individual/year, while the US creates roughly 7.2 kilograms of e-waste/individual/year. By correlation, the US produces the largest volume of e-waste yearly, amounting to about 3 million tons, trailed by China (2.3 million), as indicated by a 2010 UN report (YSFES, 2014).

Despite the presence of some e-waste data as described in the previous pages, studies also claimed that the data were not complete. For instance, Devin *et al*. (2014) claim that around 25% (2.1 million tons) of the assessed 8.7 million tons of e-waste created in the European Union (EU) every year is gathered and reused in formal handling plants. Then the remaining 75% is added to the "hidden flow" of unreported and untraced e-waste. Essentially, 80% of e-waste produced in the US purportedly adds to the worldwide "hidden flow" of e-waste; it is not enlisted meaning it is either informally sent out, deserted into landfills, or burned (Devin *et al*., 2014).

In light of EU e-waste category, Lundgren (2012) expressed that substantial family unit apparatuses represent the biggest extent (around 50 percent) of e-waste, trailed by information and communications technology equipment (around 30 percent) and customer gadgets (around 10 percent). Also, more than 20 million PCs wound up noticeably out of date in 1998. Just 13 percent were reused or recycled. Numerous regions are confronting the situation of what to do with developing measures of resigned electronic items (Kumar *et al*., 2013).

Likewise, electronic waste is alarmingly generated in the higher educational institutions including universities. John *et al*. (2010), for instance, asserted that the e-waste administration in UKM is still at its early stages and directly there are more than 8,000 waste PCs inside the college. The global quantity of e-waste in 2016 is mainly comprised of Small Equipment (16.8 Mt), Large Equipment (9.1 Mt), Temperature Exchange Equipment (7.6 Mt), and Screens (6.6 Mt). Lamps and Small IT represent

a smaller share of the global quantity of e-waste generated in 2016, 0.7 Mt and 3.9 Mt respectively (See Figure 2.2).

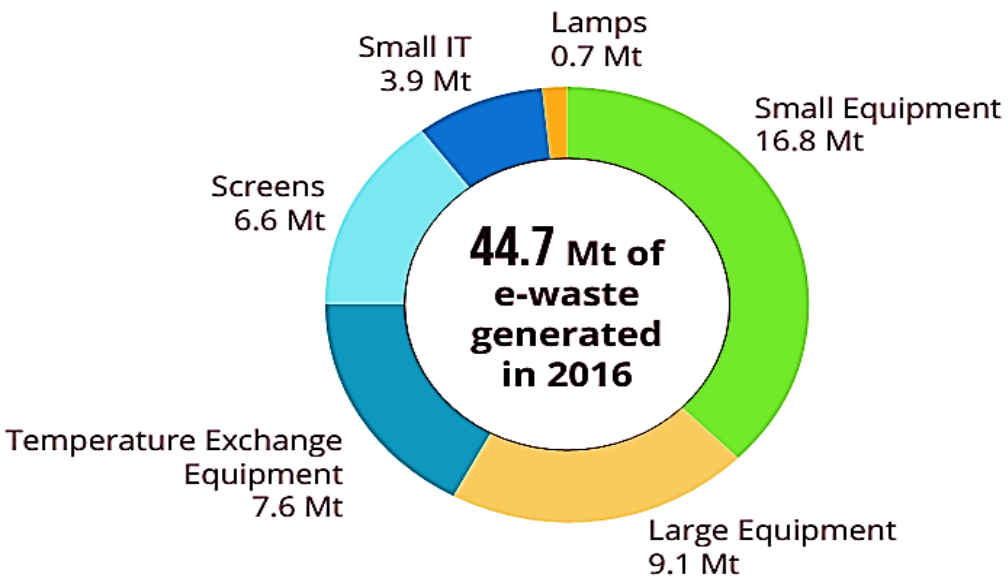

Figure 2.2. Estimates of e-waste totals per category in 2016

Source: Baldé *et al.* (2017)

In 2016, Asia was the region that generated by far the largest amount of e-waste (18.2 Mt), followed by Europe (12.3 Mt), the Americas (11.3 Mt), Africa (2.2 Mt), and Oceania (0.7 Mt). While the smallest in terms of total e-waste generated, Oceania was the highest generator of e-waste per inhabitant (17.3 kg/inh), with only 6% of e-waste documented to be collected and recycled. Europe is the second largest generator of e-waste per inhabitant with an average of 16.6 kg/inh; however, Europe has the highest collection rate (35%). The Americas generate 11.6 kg/inh and collect only 17% of the e-waste generated in the countries, which is comparable to the collection rate in Asia (15%). However, Asia generates less e-waste per inhabitant (4.2 kg/inh). Africa generates only 1.9 kg/inh and little information is available on its collection rate (Baldé *et al*., 2017).

UNU estimates that in 2016, domestic e-waste generation in Africa was approximately 2.2 Mt, with contributions from Egypt (0.5 Mt), South Africa and Algeria (each 0.3 Mt) ranking highest. The top three African countries that have the highest e-waste generation per inhabitant are Seychelles (11.5 kg/inh), Libya (11 kg/inh), and Mauritius (8.6 kg/inh). Currently, little information is available on the amount of e-waste documented that is collected and recycled by the formal sector in Africa (Ibid).

Africa, though produce moderately amount of e-waste, is a commonly a dumping ground for electronic waste from different countries. Crosswise over Africa, a mix of populace development and expanded access to cell phones and other innovation will deliver a surge in e-waste throughout the following five years (YSFES, 2014). As far as e-waste creation in Ethiopia is concerned, the utilization of many sorts of EEE is for the most part confined to urban areas, as the absence of power and acquiring power in the rural centres regularly hampers the commonness of gadgets, for example, TVs, refrigerators and PCs (Baldé *et al*., 2015).

When it comes to the generation level and legislations obtained, as indicated in Table 2.5, Egypt, Republic of South Africa and Nigeria are the leading e-waste generators followed by Kenya, Ethiopia and Democratic Republic of Congo. However, as indicated in Table 2.3, in terms of the enforcement of national regulation towards e-waste only Nigeria has enforced e-waste legislation.

Table 2.3: Domestic e-waste generation in some African countries in 2014

Countries	Kg/inh. (Kilogram per inhabitant)	Kt (kilo tonnes)	National Regulation in enforce till 2013	Population (1000)
Burundi	0.2	2	No	9201
Comoros	0.7	1	No	724
Djibouti	1.2	1	No	939
Eritrea	0.3	2	No	6000
Ethiopia	0.5	43	No	90982
Malawi	0.2	4	No	17604
Madagascar	0.3	6	No	23537
Kenya	1.0	44	No	44572
Nigeria	1.3	219	Yes	173938

South Africa	6.6	346	No	52433
Egypt	4.3	373	No	85833

Source: Baldé *et al*. (2014)

2.7. E-WASTE COMPOSITION AND CHARACTERISTICS

E-waste varies synthetically and materially shrewd from urban or industrial waste. It contains both perilous and profitable materials demanding special dealing and reusing practices to maintain a strategic distance from unfriendly ecological effect and unsafe effect on human well-being (Gaidajis *et al*., 2010; Baldé *et al*., 2015). The organization of e-waste is exceptionally assorted and contrasts crosswise over product offerings and classifications. By and large, it encompasses more than 1000 distinct materials which fall into "perilous" and "harmless" classifications; essentially, the harmfulness of a significant number of the elements in e-waste is obscure.

Comprehensively, electronic items comprise of ferrous and non-ferrous wood and plywood, plastics, metals, glass, printed circuit sheets, cement and earthenware production, elastic and different things. Iron and steel constitutes around 50 percent of e-waste took after by plastics (21 percent), non-ferrous metals (13 percent) and different constituents (UNEP, 2007). Likewise Lundgren (2012) asserted that electronic items frequently comprise a few tenacious, bio aggregate and lethal materials including heavy metals, for example, lead, nickel, chromium and mercury, and persistent organic pollutants (POPs, for example, polychlorinated biphenyls (PCBs) and brominated fire retardants.

According to Widmer *et al*. (2005), as cited by Tengku-Hamzah (2011), a detail account of e-waste content, produces a list of more than one thousand chemical substances. These substances are grouped into three categories based on their relative amount in e-waste, such as: bulk elements (such as lead, tin, copper, silicon, carbon, iron and aluminium), in small quantity (such as cadmium and mercury), and trace elements (such as platinum, arsenic, silver, gold, lithium, titanium, cobalt, manganese and many others).

While electronic items may contain reusable and important materials, the majority of the segments in e-waste are however risky and poisonous, henceforth dangerous to nature. Basic perilous constituents found in e-waste are weighty metals, (for example, lead, mercury, cadmium and so on.) and chemicals (chlorofluorocarbon). Notwithstanding unsafe materials, e-waste likewise contains numerous profitable materials, (for example, copper, plastics and aluminum) and valuable metals (like silver, gold, palladium, and platinum) that can be reused. Truth be told, up to 60 components from the periodic table can be found in complex hardware, and a hefty portion of them are recoverable, however it is not generally economical to do as such directly (Adediran and Abdulkarim, 2012; Namias, 2013; Baldé *et al*., 2015).

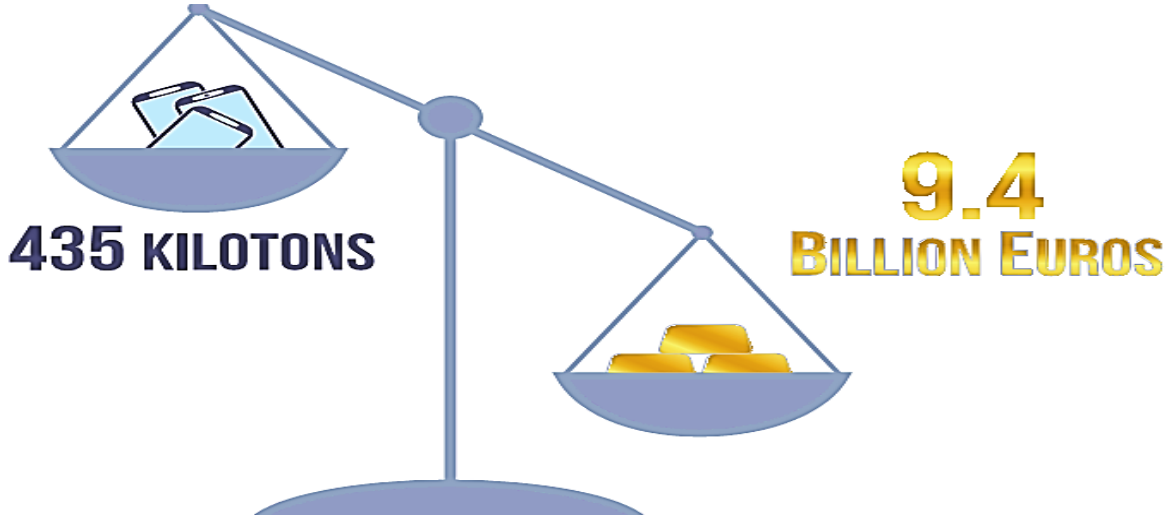

Figure 2.3. Potential value raw materials in mobile phone waste

Source: Balde *et al*. (2017)

As illustrated in Figure 2.3, in 2016, around 435 kilotons (kt) of wasted mobile phones were generated across the globe. This means that the value of raw materials in wasted mobile phones was 9.4 Billion €. However, if all phones had a longer lifespan and could enter a second-hand market, the value could be even higher (Balde *et al*., 2017).

As referred to by Joseph (2007), the division including iron, copper, aluminium, gold and diverse metals in e-waste is more than 60%, while plastics represent around 30%

and the unsafe toxins involve just around 2.70% (Widmer *et al*., 2005). Tengku-Hamzah (2011) claimed that e-waste is viewed as an asset, which ought to and could be recovered. The same author further states that electrical items contain profitable metals, for example, gold and silver and additionally of many materials.

The largest effect of EEE on significant metals assets must not be ignored. Tengku-Hamzah (2011) mentioned for instance, a cell phone can contain more than 40 components including base metals (copper (Cu), tin (Sn), uncommon metals (cobalt (Co), indium (In), antimony (Sb), and valuable metals (silver (Ag), gold (Au), palladium (Pd). The author further asserted the lithium-particle battery contains around 3.5 grams of cobalt. This has all the earmarks of being very negligible yet with the use of 1.2 billion cell phones sold comprehensively in 2007 this prompts a huge metal request. For instance, 80% of the world indium request is utilized for LCD screens, more than 80% of ruthenium is utilized for hard plates and half of the overall interest for antimony is utilized for fire retardants. Considering the profoundly powerful development rates of EEE, it turns out to be evidence that they are noteworthy drivers for the advancement of interest and costs of specific metals (Tengku-Hamzah, 2011). Thus, careful end-of-life administration of e-waste is basic so as to recoup profitable parts and legitimately oversee unsafe and harmful segments (Namias, 2013).

2.8. E-WASTE HANDLING AND DISPOSAL METHODS

Electronic waste treatment varies among developed and developing nations. Baldé *et al*., (2015) disclosed that in industrialised nations, e-waste is likewise gathered by singular waste merchants or organizations and after that exchanged through different channels. The principle highlight of this situation is that e-waste is exchanged uninhibitedly, and typically, its amount is not efficiently archived or answered by experts, because of the absence of particular detailing system or necessities. The same author points out in most developing nations, there are a tremendous number of independently employed individuals occupied with the accumulation and reusing of e-waste. After the informal gathering, when electronic items don't have any reuse esteem, they are for the most part reused by through "backyard recycling" or

substandard techniques, which can make serious harm to the environment and human well-being.

As environmentally careful waste administration alternatives are exceptionally innovative and require high-monetary speculation, there is presently an abnormal state of trans-limit, regularly unlawful, e-waste movement into unindustrialized nations for less expensive recycling (Lundgren, 2012). Baldé *et al*., (2015) contends in Africa in spite of the fact that there are a few clues that e-waste is discarded in an unrestrained way, the larger part of outdated EEE is as of now put away inside government structures, workplaces, global associations and family units or anticipating future measures (Manhart *et al*., 2013). As referred to by Kalana (2010), various consumers don't instantaneously discard or reuse unused appliances since they visualize that the objects still have value (Babu *et al*., 2007).

Adediran and Abdulkarim (2012) states, the most prescribed moves made to e-waste is to recycle. Recycling is a compelling and temperate answer for overseeing electronic waste. It is one of the parts of the 3R choices of reducing, reuse and recycle e-squander. There are many advantages to be gotten from recycling e-waste. Among these is the accompanying:

- Most electronic appliances comprise a collection of materials, including metals that can be recouped for future utilization.
- Intact regular assets are rationed by disassembling and giving reuse conceivable outcomes.
- Air and water contamination that could be caused by risky disposal is maintained a strategic distance from.
- It prompts diminishment in the amount of ozone-depleting substance emanations caused by the assembling of new items.

The best choice for managing e-waste is to lessen the volume. Creators ought to guarantee that the item is worked for re-utilize, repair as well as upgradeability. Stress ought to be laid on the utilization of less dangerous, effectively recyclable and

recoverable constituents which can be reclaimed for renovation, remanufacturing, dismantling and reuse (Joseph, 2007). In spite of the reality, the most well-known practices embraced for transfer of e-waste are corrosive showers, land filling, and incineration (Jhariya *et al*., 2014).

In the greater part of the cases, the whole handling of e-waste is being done in an unregulated domain in the informal division, where there is no control on discharges. For example, there are entrenched systems of waste authorities/merchants, dismantlers, and recyclers in India, the greater part of which have a place in the informal sectors. Each such unit works on a little scale, as way to-entryway waste gatherers/merchants, referred to locally as "kawariwalas. Therefore, 95% of the e-waste in India is being reused in the non-formal segment and five level of the e-waste volume are taken care of informal unit (Borthakur and Sinha, 2013). Osibanjo and Nnorom (2007), as cited by Abenezer (2015), stated that the lion's share of second-hand gadgets sent out to developing nations are unusable throws out, untreated and illegal recycling exercises are pervasive. Likewise, the disposed of e-waste is arranged an indistinguishable route from conventional wastes, and there is no different taking care of and treatment for e-waste.

Because of the mind-boggling arrangement of profitable and perilous substances, specific, regularly "cutting edge" techniques are compulsory to process e-waste in ways that amplify asset recuperation and limit latent damage to people or the environment (Tengku-Hamzah, 2011). Sadly, the utilization of these specific strategies is uncommon, with a significant part of the world's e-waste voyaging extraordinary separations, for the most part to developing nations, where rough procedures are regularly used to extricate valuable materials or reusable parts for additional utilization. These "back-yard" methods pose risks to ineffectively ensured labourers and their neighbourhood regular habitat. Additionally, they are exceptionally ineffective regarding resource recuperation as reusing in these occurrences, for the most part, concentrates on a couple of profitable components like gold and copper (with frequently poor reusing yields), while most different metals are disposed of and unavoidably lost (Tengku-Hamzah, 2011).

According to CIWMB (2012), e-waste best management practices dictate that the waste is processed in the most environmentally desirable method. It further states that environmentally desirable means that none of the waste will be handled in such a way as to contaminate the environment. If handled improperly, toxic components found in e-waste can find their way into the water or air and potentially cause serious illness or disease in animals and humans.

Electronic waste management is diverse in advanced and less-advanced nations. Veit and Moura (2015) asserted that there are two sorts of sectors in advanced nations occupied with the recycling chain, as indicated by the idea of the strategies included. The main group comprises the facilities that are chiefly occupied with the disassembling and mechanical handling of e-waste for the recuperation of crude materials. The second group utilizes metallurgical procedures to recuperate metals. Conversely, the e-waste recycling division in less developed nations is generally unregulated, and e-waste is frequently handled to recoup important materials in little workshops utilizing elementary recycling techniques (Veit and Moura, 2015).

As referred to by Borthakur and Sinha (2013), the vast majority of less developed nations including India and China are still to discover an answer that guarantees to limit the negative ecological and human wellbeing effects of e-waste treatment and reuse. What's more, the authors projected that 75% of electronic waste is put away because of susceptibility of how to oversee it. The greater part of the buyers are uninformed of the dishonourable transfer of e-waste and keep on discarding their end-of-life apparatuses with consistent family waste.

Additionally, Skinner (2010) claimed that India does not have a far-reaching direction managing e-waste administration. The author further explained that a noteworthy issue in India is that as the majority of the general population associated with the recycling business are unskilled and poor, they are absolutely unconscious of the dangers to their wellbeing and the overall environment from e-waste recycling processes. The most widely practiced e-waste disposal methods are landfilling,

incineration, recycling, buying green, waste prevention and reduction, reusing, and donating.

2.8.1. Landfilling

Landfilling remains the most popular means of final disposal for most waste types, including e-waste, especially those are not captured by the informal recyclers for further processing (Carisma, 2009). It is the oldest form of waste treatment and the least desirable option because of the many potential adverse impacts it can have. The most serious of these is the production and release into the air of methane, a powerful greenhouse gas 25 times more potent than carbon dioxide. Methane can build up in the landfill mass and cause explosions. In addition to methane, the breakdown of biodegradable waste in landfill sites may release chemicals such as heavy metals resulting in run-off called leachate. This liquid can contaminate local groundwater and surface water and soil, which could pose a risk to public health and the environment (EU, 2010).

Similarly, Borthakur and Singh (2012) discovered that when brominated flame retardant plastic or cadmium containing plastics are landfilled, both polybrominated diphenyl ethers (PBDE) and cadmium may leach into the soil and groundwater. It has been found that significant amounts of lead ion are dissolved from broken lead-containing glass, such as the cone glass of cathode ray tubes, gets mixed with acid waters and is a common occurrence in landfills. For instance, it is assessed that around 430 tons of WEEE are every year landfilled at the Gamodubu site (in Gaborone, Botswana), which compares to 1.9 kg/capita/year. Just about 50 wt% of this sum is ICT hardware, 40 wt% is little family unit machines, and the rest of different sorts of lights (Mesfin *et al*., 2014).

Landfilling gadgets are unwanted for some reasons, counting the way that follows measures of valuable metals including silver, gold, and palladium, and bigger amounts of metals and composites including aluminium, copper, and steel utilized as a part of hardware are not recouped (Namias, 2013).

2.8.2. Incineration

It is a disposal system in which solid organic wastes are exposed to burning in order to transform them into more manageable deposits and/or gaseous items. It is a controlled and entire ignition process, in which the waste material is scorched in extraordinarily composed burners at a high temperature (900-1000oC).

The merit of the burning of e-waste is the lessening of waste volume and the use of the vitality substance of ignitable materials. By incineration, some environmentally hazardous organic substances are converted into less hazardous compounds. The disadvantage of incineration are the emission to air of substances escaping flue gas cleaning and the large amount of residues from gas cleaning and combustion (Guidelines for Environmentally Sound Management of E-waste, 2008). Similarly, Borthakur and Singh (2012) reveals that it is in fact, the most dangerous form of burning e-waste is the open-air burning of plastics in order to recover copper and other metals. The toxic fall-out from open air burning affects the local environment and broader global air currents, depositing highly toxic by-products in many places throughout the world.

2.8.3. Recycling

Several studies revealed recycling is the most important e-waste disposal methods. In spite of its unsafe potential, e-waste contains significant measures of valuable materials which give a beneficial business opportunity. In this manner, for both ecological and monetary reasons, various nations overall receive recycling and material recuperation system to oversee e-waste (Tengku-Hamzah, 2011). The current dumping grounds in numerous nations of the world are full and teeming beyond the limit and it is hard to get new dumping destinations because of a shortage of land. In this manner recycling is the ideal alternative for the administration of e-waste (Arora, 2008).

USEPA (2001) reported that recycling electronics avoids pollution and the need to extract valuable and limited virgin resources. It also reduces the energy used in new

product manufacturing. Much of the waste the people throw away can be recycled. Recycling reduces the amount of waste that ends up in landfill sites while cutting down on the amount of material needed from the natural environment (EU, 2010). The e-waste recycling division in developing nations is to a great extent unregulated and the way toward recuperating important materials happens in little workshops utilizing straightforward recycling strategies (Lundgren, 2012). With the exception of South Africa, where an expansion in material recuperation exercises has been accounted for, information on the recycling of WEEE in Africa is rare (Veit and Moura, 2015).

As referred to in Kumar *et al*. (2013), Hagelüken (2006), expressed that if donation for reuse is not a feasible alternative, family units and organizations can send their utilized hardware for recycling. Recycling gadgets maintain a strategic distance from contamination and the need to extricate significant and restricted virgin assets. It additionally decreases the vitality utilized as a part of new item fabricating. Likewise, open and private associations have developed that receive PCs and different hardware for recycling. As per Namias (2013), the main thrusts behind recycling e-waste are financial, environmental, general wellbeing and information security. A depiction of these components can be found underneath:

2.8.3.1. Economic factors

According to Namias (2013), electronic appliances comprise up to 60 distinct constituents, a number of which are important, for example, cherished and extraordinary metals, and some of which are dangerous. Valuable metals are uncommon, normally trendy metallic components which generally have a higher dissolving point, and are more pliable than different metals. They have high financial values, as exhibited by the two most surely understood valuable metals; gold and silver. Exceptional metals incorporate nickel, nickel base amalgams, cobalt base combinations, titanium, and titanium base composites. Electronic item is an essential and valuable product and uncommon metals and consequently, it is crucial that a joint

effort made with a specific end goal to recoup these metals and profitable components. Ventures are being made to treat e-scrap and recover the important metals, particularly as crude materials turn out to be all the more rare and costly. Recycling not only has large environmental benefits but also financial benefits. As cited in Marques and Silva (2017) for instance, a ton of used cell phones (6000 phones) yields more than 14,000 € in precious metals and proper recycling of 1 million cell phones can recover 24 kg of gold, 250 kg of silver, more than 9 kg of palladium and 9 kg of copper (Electronics Take-Back Coalition, 2016).

2.8.3.2. Environmental/resource factors

Notwithstanding recouping valuable metals, recycling hardware likewise diminishes the environmental effect related to essential generation of electronic items. The essential generation of valuable and uncommon metals, including vitality escalated stages, for example, mining and purifying, significantly affects carbon dioxide emanations. Reuse and recuperation of hardware diminish the environmental effect of these items, and in addition, the effect from the essential creation of metals and parts found in the gadgets (Namias, 2013).

2.8.3.3. Public health factors

Disposed of electronics contain an assortment of dangerous metals, including lead, cadmium, mercury, chromium, and polyvinyl chlorides, and in this way, the disposal of gadgets represents a remarkable environmental and wellbeing hazard when not appropriately dealt with. Despite the fact that e-waste represents to under 2% of landfill mass, it contains 70% of the dangerous waste in heavy metals.

2.8.4. Reuse

Otengo-Ababio (2012) stated that reuse of older electronic products is the most environmentally preferable option in dealing with e-waste. It is also economically the means through which many people can access electronic products. It further

conserves energy and raw materials needed to produce new once and reduces pollution associated with energy use and manufacturing. Unfortunately, since most used electronic imports are rarely tested for functionality, there is a high level of refurbishment and repair, and this serves as a disincentive and time-consuming.

CIWBM (2004) also disclosed that in the waste management hierarchy, the best management method is direct reuse, where someone else can use the electronic equipment without change. A very small percentage of residential electronic waste is likely to fall into this category because people tend to store old equipment for a couple of years before thinking about recycling. Additionally, repairing and refurbishing have emerged as important segments of e-waste (mis)management. Refurbishers transform old/non-functioning products by replacing defective components. They engage in cleaning and repairing activities in order to make the refurbished product more appealing and affordable to the populace (Otengo-Ababio, 2012).

2.8.5. Prevention and Reduction

It is in accordance with the hierarchy of waste (reduce, reuse, recycle) and furthermore environmentally best that working EEE equipment are not disposed of as waste, yet rather given an open door for reuse either specifically by the proprietor, who may give or offer the product, or by an authority association that may give or offer the product following a practical test, information wipe, assessment process or repair (StEP, 2014). Good waste management begins with preventing waste being produced in the first place – after all, what is not produced does not have to be disposed of. Waste prevention is becoming more and more important as the global population increases and waste are generating. One of the key tools being used to encourage waste prevention is eco-design, which focuses on environmental aspects during the conception and design phase of a product (EU, 2010). Waste prevention is closely linked to improving manufacturing methods and influencing consumers so that they demand greener products and less packaging (EU, 2010). USEPA (2001) claimed that preventing waste in the first place is usually preferable to any waste management option including recycling.

As per Nandkumar (2011), an indispensable approach for waste administration is the deterrence of waste material being made, otherwise called waste decrease. Strategies for avoidance include reuse of second-hand items, mending broken equipment as opposed to purchasing new, designing items to be recyclable or reusable. Electronic item's reuse, refurbishment or repair is most attractive since this choice builds the life expectancy of the electronic item and higher resource effectiveness. Recycling of hardware takes into attention cherished and extraordinary metals to be recouped, lessens the ecological effect related with electronic assembling from crude materials, and guarantees that perilous and harmful substances are dealt with suitably (Namias, 2013).

For instance, resources and organizations to benefit and maintain EEE's, however, the bigger upkeep is done by UKM PC section (John *et al*., 2010). The same author showed that the majority of the PCs which were sent to the PC section were repaired. At the point when the PCs were repaired they were reused inside UKM and now and again gave to religious schools (Chibunna *et al*., 2012).

By and large, the answer to the e-waste issue is not just the prohibiting of trans-limit movements of e-waste, as household generation represents a huge extent of e-waste in all nations. What is more, answers for the worldwide e-waste issue include awareness raising among the purchasers and e-waste recyclers in the informal sector, mix of the informal sector with the formal, making green employment, authorizing enactment and work standards, and taking out practices which are destructive to human well-being and the environment (Lundgren, 2012).

2.8.6. Donation

Donation of EE for reuse increases the lives of important items and keeps them out of the waste administration framework for a more prolonged time (Kumar *et al*., 2013). Chibunna *et al*. (2012) asserted that the activity of reducing, re-utilize and recycle inside the waste administration chain of command accept specific significance (Oskamp, 1995; Hamburg *et al*., 1997), particularly with regards to e-waste management framework. (Kelly *et al*., 2005) demonstrated that recycling program

depends on innovation, as well as on the participation of individuals, and environmentally friendly techniques. The most protected technique is recycling constituents including metals and reusing them, which incorporates industry-wide framework for the accumulation of electronic waste (Sivaramanan, 2013).

Giving reusable equipment to non-profits or schools can provide tax deductions to the donor and assist in bridging the digital divide. It is important to determine if the potential donation will be usable to the recipient and that they will have a mechanism to manage the equipment at the end of its extended life (CIWMB, 2004). Donating electronics for reuse extends the lives of valuable products and keeps them out of the waste management system for a longer time. Reuse, in addition to being an environmentally preferable alternative, also benefits society. By donating your used electronics, you allow schools, non-profit organizations, and lower-income families to use equipment that they otherwise could not afford (USEPA, 2001).

Other issues concerning donations are software licensing and adequate removal of data to ensure donor privacy. The enhanced alternative is to keep away from its creation. To accomplish this, purchase back of outdated electronic hardware should be made obligatory. Vast organizations should buy the utilized gear over from the clients and guarantee appropriate treatment and disposal of e-squander by approved procedures. This can impressively diminish the quantity of e-waste generation. (CIWMB, 2004).

2.8.7. Buying green

Naturally capable gadgets utilize includes not just legitimate end-of-life disposition of outdated gear, yet in addition obtaining new hardware that has been composed of ecological properties. Search for EE that is made with less toxic elements, utilize reused content, are energy proficient, intended for simple updating or dismantling are environmentally sounding. The chemical structure of WEEE is to a great degree heterogeneous, changing as indicated by the kind of gear, year of make, manufacturer, and the nation of inception, among different elements. Truth be told, polymers, earthenware production, and metals can be recouped from electronic

waste. The diverse metals exhibit draw the best considerations due to their monetary value. These metals might be available in various sorts of segments, in factors sums, pure or as composites. (Veit and Moura, 2015).

Environmentally responsible electronics use involves not only proper end-of-life disposition of obsolete equipment but also purchasing new equipment that has been designed with environmental attributes (USEPA, 2001). The study further stated that households, companies, and governmental organizations can encourage electronics manufacturers to design greener electronics by purchasing computers and other electronics with environmentally preferable attributes and by requesting takeback options at the time of purchase. What is more, the study has to encourage the consumers to look for electronics that: (a) are made with fewer toxic constituents (b) use recycled content (c) are energy efficient (e.g., showing the “Energy Star” label) (d) are designed for easy upgrading or disassembly (e) utilize minimal packaging (f) offer leasing or take-back options and (g) have been recognized by independent certification, groups (such as the Swedish TCO or Blue Angel) as environmentally preferable (USEPA, 2001).

2.9. THE CHALLENGES IN E-WASTE MANAGEMENT

Electronic waste is a worldwide, interregional, and local issue (Devin *et al*., 2014). Otieno and Omwenga (2015) asserted that the major issue is that the storage, accumulation, exchange, and disposal of WEEE in developing nations have not been streamlined and overseen in a compelling way to guarantee re-utilization; preservation of the environment; and security of the general population included. The same author further notes that the foundation and assets required to oversee WEEE are non-existent or ineffectual. Agreeing with the study led by Askari and Ghadimzadeh (2014), revealed that e-waste disposal is performed in an exceptionally complicated and uncontrolled way in many parts of the world. These authors further stated that absence of information in dealing with e-waste and the lack of conducive policies and rules at the state level are essential reasons for e-waste bungle.

By its nature, the disposal of e-waste is more complicated than normal household waste because of its hazardous content; and is more than just lack of space as commonly the case of solid waste management. Lack of appropriate facilities, weak enforcement (or lack of) law and regulation, and low level of awareness among the society may lead to indiscriminate or improper disposal (such as disposing of e-waste together with household's solid waste) (Tengku-Hamzah, 2011; Chibunna *et al.,* 2012).

Adediran and Abdulkarim (2012) affirmed that there was no policy to control the stream of utilized consumer electronic items; utilized electronic items are not viewed as stash by the Nigeria Customs Service insofar as suitable obligations and expenses are gathered on them; there was no public mindfulness on the characteristic perils of taking care of e-waste which, for instance, is viewed as a business opportunity, with the exception of refining of scrap metals; there were no e-waste recycling services in the nation; and ultimately, poor (assuming any) corporate social duty with respect to enterprises on e-waste. However, it was clearly reported in Balde *et al*. (2014) that Nigeria is the only African country to enforce the e-waste legislation.

The other challenges are associated with lack of skill and knowledge towards the handlings and treatments of e-waste. In this regard, Tyagi *et al*. (2015) admitted that informal sector is managing the major e-waste in India. The collection has been done by the local scrap vendors. After collection, recycling process involves segregation and dismantling the products. Primitive techniques are used in this process, which may include (i) disassembling of electronic equipment; (ii) heating or manual dismantling of printed circuit boards; (iii) recovering metals by opening or cutting cables; (iv) breaking or melting plastics; (v) toner sweeping; (vi) metals recovery by open acid leaching of e-waste. The author points out that most of the scrap vendors are not much educated; moreover, the people working under them are also not skillful and educated. They also do the repair and refurbishment of old products, which will be sold in second-hand market. They just use their older and traditional illegal methods of burning the products to extract the metals – in many cases, they are not aware of the health risks involved.

Studies show the challenges identified with (i) the low-level of resident consciousness on the unsafe effects of e-waste on the environment, their wellbeing, and protection (ii) the government sector offices managing waste administration have constrained ability to manage e-waste administration and are not working in an organized way that could assemble cooperative energy. E-waste administration has not been given the attention it merits among government authorities (iii) insufficient assets and duty towards tending to the issues and difficulties related with it and (iv) satisfactory formal training has not been given to the issues of WEEE administration (Otieno and Omwenga, 2015).

Also, Lundgren (2012) featured that there is by and large low public familiarity with the perilous idea of e-waste and the unrefined waste administration methods utilized as a part of developing nations. It was confirmed that data towards electronic waste management is lacking particularly on the volume of e-waste produced and the sources, and on where it is going to. The same author further admitted that this condition is exacerbated by the present information gathering system, in which utilized, second-hand and waste products are all things considered, undetectable to national insights on generation, deal and exchange goods.

The other principal challenge is lack of e-waste policies or legislations poses serious problems on e-waste administration in a large portion of the developing nations. Principally in Africa, studies have revealed that only Cameroon and Nigeria have authorized national e-waste related policy, while Ghana, Ethiopia Kenya still have legislations pending endorsement. In Africa, the electronic waste challenge is on the political concern in the recent years, however, there is by and large an absence of e-waste administration framework, which is reflected by the lack of e-waste administration laws (Baldé *et al*., 2015).

Table 2.3: Percentage of population covered by legislation per-sub region

	2014 (in %)	**2017 (in %)**
World	44	66
East Africa	10	10
Middle Africa	14	15

Caribbean	12	12
Southern Africa	0	0
Northern Africa	0	0
Western Africa	49	53
North America	98	100
Western Asia	37	38
Northern Europe	99	100
Southern Europe	100	100

Source: Balde *et al*. (2017)

The sub-regions where e-waste legislation is most developed are found in Europe. In Europe, the e-waste amounts documented to be collected and recycled are also highest. Other countries with developed e-waste recycling and collection are in Northern America, Eastern Asia, and Southern Asia. As indicated in Table 2.4, in several regions, national e-waste legislation is completely absent, such as in large parts of Africa, Caribbean, Central Asia, Eastern Asia (Balde *et al*., 2017).

Indeed, even a portion of the Asian nations confront difficulties to oversee e-waste. The examination led by Borthakur and Sinha (2013), uncovers while a few nations have sorted out frameworks for the gathering, isolation, reusing, transfer and follow up of e-waste (as, Switzerland), different nations (for the most part developing nations like India and China) are still to discover an answer that guarantees limiting the negative ecological and human wellbeing effects of e-waste treatment and recycling. Similarly, Namias (2013) asserted that the problem is normal notwithstanding for developed nations. Absence of national legislation has been appeared to altogether block recycling rates in different countries (StEP, 2009). E-waste recycling in the U.S. is restricted because of: (i) deficient gathering (ii) no government enactment or strategy commanding e-waste reusing (iii) absence of reusing and recuperation innovations, and unlawful export of perilous e-waste to developing nations where reusing forms exert genuine dangers to human wellbeing and the environment (Namias, 2013).

Several authors have likewise thought of difficulties in e-waste administration. For example, Mesfin *et al*. (2014) states, there is no organized structure to address the expanding streams of old items aside from some sporadic endeavours by a modest

bunch of organizations, government workplaces, and people to deal with their own e-waste. The authors admitted that there is low associations of the private divisions and NGOs in e-waste administration. Moreover, individual and group level consciousness of e-waste both as a peril and potential asset is by and large low. Just an extremely constrained amount of e-waste have been repaired and given to schools and the rest of the items away are unrecoverable because of serious harm, absence of professionals, and budgetary assets.

Electronic waste management is the most difficult assignment, because of its quickly expanding volume, as well as more essentially as a result of its perilous nature (Tengku-Hamzah, 2011). It has been affirmed that limited e-waste legislations, regulations, policies, safeguards and enforcement of the safe disposal of imported e-waste and electronic products have prompted genuine human and ecological problems (Kiddee *et al*., 2013). So also, Osibanjo and Nnorom (2007) states, the greater part second-hand hardware sent out to developing nations are unusable junk. Likewise, these gadgets are disposed of e-waste arranged indistinguishable route from customary squanders, and there is no different taking care of and treatment for e-squander. The authors additionally call attention to the absence of facilities for proper waste administration, lack of policy managing particularly with e-waste, the absence of any structure for end-of-life (EoL) item or usage of EPR as the principle challenges for overseeing e-squanders. As a result of the absence of administrative enactment on e-waste, disposal regulations, appropriate component for taking care of these harmful hi-tech items, for the most part wind up in landfills or somewhat recycled in unhygienic conditions and incompletely tossed into waste streams (Jhariya *et al*., 2014).

The deficiencies of numerous administrations in developing nations are constrained capacity of the government to manage e-waste. Absence of facilitated approach crosswise stakeholders involvement and the facilities to manage e-waste, no administrative and arrangement structures to protect the human wellbeing, ecological and social impacts of e-waste (Were *et al*., 2014). Widmer *et al.* (2005) recognised problems specific to unindustrialized and industrializing countries in e-waste

administration after evaluating management issues from China, India, and South Africa.

These complications are several; the first one is the growing quantity of e-waste smuggled illegally into the unindustrialized countries. Second-hand EEE introduced into the unindustrialized countries are infrequently tested for functionality. Thus, noteworthy amounts of used EEE imports projected at between 25–75% are unusable junk (e-scrap). Secondly, there is lack of consciousness in government and public circles of the potential threats of the present EoL management of e-waste in the unindustrialized countries to human health and the environment. Those involved in the hazardous unpolished recycling actions are also ignorant of the implications of these activities and/or are forced to choose between 'poverty and poison'. Thirdly, there is absence of infrastructure for the recycling or suitable management of e-waste following the principles of maintainable consumption/ development. In Africa, formal recycling facilities for e-waste exists only in South Africa (Finlay, 2005)

Fourthly, lack of capital and venture to finance profitable improvements in e-scrap recycling. There is a loss of resources, energy wastages and environmental pollution because of the crude 'backyard' recycling activities. Absence of e-waste legislation that deals specifically with e-waste management. Others include absence or ineffectual implementation of existing regulations/legislation relating to the control of trans-boundary movement of hazardous wastes and recyclables. Besides, absence of authorised or effective voluntary take-back program (EPR) for end-of-life EEE in the unindustrialized nations. Furthermore, there is also the reluctance of customers and enterprises to hand out their old-fashioned EEE or pay for WEEE recycling. Finally, Corruption and unsuccessful data collection and propagation on material flow of EEE and WEEE are also challenges to overcome in the less industrialized countries especially in Africa.

A portion of the proposals recommended towards e-waste administration featured that public education and effort is the most imperative part of the administration of e-waste. Sinha *et al*. (2005) admitted that is on account of regardless of what facilities are accessible and fulfilled, what the laws are, and what the alternative is, nobody will

know about it without intensive awareness creation program. In addition, for the maintainable administration of e-waste, nations need to grow such an adaptable and versatile framework that can deal with the changeability in amount and nature of e-waste stream (Sinha *et al*., 2005). The enactment should be changed to dynamic arrangements which will clear path for a brighter contamination free future in the nation.

Realizing appropriate directions to make it mandatory to wear protecting masks and gloves and safety glass when pull to pieces could be essential to minimize the threats of e-waste. In addition to this, avoiding easy methods of extraction such as burnings which results in damaging fumes, avoid dumping and avoid using acid baths, and applying stringent rules against dumping e-waste in landfills should also be encouraged. Actualizing legitimate capacity framework for the collected and separated e-waste until the point when it is reused as items, fortify the usage of concurred policies of Basel Convention and executing powerful laws to counteract political attacks or weights. Furthermore, it is the obligation of governments to assign adequate grants and ensuring the universally concurred ecological regulations inside their outskirts (Sivaramanan, 2013; Jhariya *et al*., 2014). The widespread, intricately complex and risky nature of e-waste demands calls for close policy attention at all levels of society, and between government and non-governmental actors (Tengku-Hamzah, 2011).

2.10. GLOBAL E-WASTE MANAGEMENT DECLARATIONS AND CONVENTIONS

Because of the unsafe nature of e-waste and trans limit movement of WEEE, various conventions, controls, strategies, and rules have been set up to deal with this hazard. Before, most e-waste directions have been incited by and concentrated on ecological assurance. As of late, e-waste rules have been received and implemented due to human wellbeing concerns (Devin *et al*., 2014). The worldwide policies trying to control the delivery of waste are the Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and their Disposal (1989), Rotterdam

Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998) and Stockholm Convention on Persistent Organic Pollutants (2001) (Lundgren, 2012; Otieno and Omwenga, 2015).

2.10.1. The Basel convention

As referred to by Benedicta (2012), the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (hereinafter alluded to as "the Basel Convention") appeared in 1989 because of dangerous deposits in Africa and different parts of the developing nations. This activity, prompted by the consciousness acquisition on the long haul impacts of inappropriate transfer of perilous waste by the developed nations brought about strident directions on the transfer of risky waste. Looking for elective sites for the expanding e-waste collection, enterprises and administrators alike looked for modest transfer choices in Eastern Europe and the developing countries where awareness towards the environment was low and strident directions and its implementation was deficient (Basel Convention, 2011).

The Basel Convention was received on March 22, 1989, and came into action on May 5, 1992. The 1989 Basel Convention, which has been endorsed by 181 nations, restricts the fare of e-waste (Devin *et al*., 2014). It manages the control of trans-limit boundary of perilous waste and its stores. This Convention stipulates that unsafe waste must be discarded in the nation of the starting point. The Basel Convention considers electronic waste as unsafe and its fare could be permitted just under unique conditions (Veit and Moura 2015).

The Basel Convention is the main skillet worldwide universal agreement made to lessen the transfer of risky waste between countries. Specific underline is set on the shipment of dangerous or unsafe waste from the advanced or industrialized countries to the less industrialized or developing countries. The Basel Convention plans to guarantee environmental duty of waste by the nation of origin and additionally support the decreased volume of waste creation and harmfulness by nations who are

signatories to the settlement. It likewise guarantees that administration of unsafe waste or its trans-limit movement is reliable with the security of human wellbeing and the environment where it is discarded. The convention additionally advances sound ecological waste administration among developing countries (Basel Convention, 2011).

The agreement on Basel Convention concentrates on worldwide generators of electronic waste and recyclers of electronic waste alike. As shown in the past segments, electronic waste contains unsafe substances which impose short and long-term risk to human well-being and the environment. In this way, the worldwide electronic industry is influenced by the BAN (Basel Action Network) convention. Basically, nations who are signatories to the BAN convention are obliged to guarantee that e-waste creation and different dangerous waste is lessened to the barest least. The convention likewise guarantees that signatory nations have adequate disposal infrastructures to guarantee appropriate administration of e-waste and different risky waste created. It lays particular accentuation on guaranteeing that waste administration is reached out to the point or place of transfer (Benedicta, 2012).

In spite of export directions, this convention has a provision that licenses e-waste exportation on the loophole that it is expected for "re-utilization. This detail prompts an expansive amount of close end-of-life EEE being traded. These functional items have short life expectancies, if any whatsoever, once they achieve the fare nations. Thus, the e-waste assigned for "re-utilization" only end up adding to the problem of e-waste in the developing nations (Devin *et al*., 2014).

It is highly likely that a nation, for example, the US would be capable and willing to satisfy and execute this call for national independence in waste administration. To date, however, the United States is the leading advanced nation that has not sanctioned the Basel Convention. Thus, the US authorities as indicated by (Puckett *et al*., 2002) have effectively attempted to annihilation, and after that weaken the Basel waste export ban.

The US government approaches appeared to be intended to energize exportation of their waste to different nations that would have them. Reports have demonstrated that authorities at the US Environmental Protection Agency (USEPA) have conceded under scrutinizing that fare is especially a piece of the U.S. e-waste transfer methodology and the main issue of worry for the US may be the means by which to guarantee negligible ecological norms abroad (Puckett *et al*., 2002). The Basel Convention is intended to keep advanced nations from unlawfully dumping waste in deviceloping nnations, where recycling facilities are ordinarily missing (Baldé *et al*., 2015).

Basel Action Network is presently working taking care of business to stop or control trans-limit e-waste movements. Likewise, they are engaged in directing public awareness creation projects to inform the global society and open up research regions to discover better strategies or choices (Sivaramanan, 2013). Sotelo *et al*. (2016) asserted that although the Basel agreement objectives, countries that were added to this agreement must be into the rules established for trans-boundary movements control of hazardous wastes, their still some gaps in some areas. The same author's further states that electronic waste is subject of interest or this agreement, one of it is major problems with authorities is to establish a clear definition in order to distinguish between secondhand equipment to be repaired, refurbish or direct reuse and those they are an e-waste.

2.10.2. The Rotterdam convention

The Rotterdam Convention advances shared duty amongst importing and exporting nations in ensuring environment and human well beings, and accommodates the trading of data about possibly unsafe chemicals that might be sent out and imported. The Convention makes restricting commitments to the execution of the PIC strategy lawful. It covers pesticides and modern chemicals that have been prohibited or extremely controlled by Parties (Lundgren, 2012).

2.10.3. The Stockholm convention

The Stockholm Convention on Persistent Organic Pollutants (POP) was embraced in 2001 and gone into compelling in 2004. The Convention expects the members to take actions to kill or decrease the arrival of POPs on the earth (Bell and McGillivray, 2006). E-waste includes numerous chemicals named POPs. The Convention intends to shield human wellbeing and the earth from chemicals that stay determined in the land for long times, are disseminated all around and collect in the greasy tissue of people and creatures. There are three distinguished classes of POPs: pesticides, mechanical chemicals, and inadvertently created results. To date, 176 nations are Parties to the Convention (Lundgren, 2012).

2.10.4. The Montreal protocol

The Montreal Protocol on substances that exhaust the ozone layer authorized in 1987 with the goal of shielding the ozone layer from chemicals that pulverize it. Ninety-six chemicals are as of now controlled by the Montreal Protocol. These chemicals are regularly available in the household articles, for example, old refrigerators (Lundgren, 2012).

2.10.5. The Bamako convention

The Bamako Convention also called the Bamako Convention on the ban on the import into Africa and the Control of Trans-limit Movement and Management of Hazardous Wastes inside Africa, is an agreement of African countries forbidding the importation of any risky waste (counting radioactive waste). The Convention was consulted at Bamako, Mali in January 1991 by twelve African countries and came into the drive in 1998 (Organization of African Unity (OAU), 1991).

The Bamako Convention appeared from the acknowledgment that the wealthy countries were sending out harmful squanders to Africa and from the disappointment of the Basel Convention to adequately disallow the exchange of dangerous waste to developing nations. The Bamako Convention shares a few similitudes in organization

and utilization of languages as the Basel Convention, however, it is more fearless in denying all imports containing unsafe waste without any special cases, (for example, radioactive materials) pardoned by the Basel Convention. Nigeria endorsed the Basel Convention on May 24, 2004; restricting the movement of risky waste into its shores yet has not approved the Bamako Convention (Benedicta, 2012).

This Convention plans to restrict the import of all dangerous waste, for any reason, to Africa from non-contracting parties. Indeed, even gatherings which are not signatories to the Basel Convention are denied from sending out e-waste to Africa. The Convention was actualized keeping in mind the end goal to force a more grounded message about the exchange of dangerous waste and its administration inside Africa (Lundgren, 2012).

Be that as it may, implementation remains challenging in view of the absence of sufficient and unsurprising assets. Besides, the degree to which the instrument has been streamlined inside national enactment has not been formally archived and there is a requirement for more grounded cross-fringe participation (Munyua, 2010). As indicated by the African Union, in 2010, 24 of the 52 member states of African Union have endorsed the Bamako Convention (Lundgren, 2012).

2.10.6. The Durban declaration

The 2008 Durban Declaration on e-waste administration in Africa took after the 2006 Nairobi ministerial assertion on e-waste created from COP of the Basel Convention. It expects nations to take after their own particular procedure to characterize their reactions and plan activities in connection with the e-waste issue (Marriott, 2011). It requires the foundation of an African local stage and additionally an e-waste discussion in collaboration with setting up African systems and universal bodies. It expects nations to audit existing enactment, enhance consistence with the existing enactment and revise existing waste administration enactment to take into consideration control of electronic waste administration (Durban Declaration, 2008). Therefore, a few African nations are drawing up strategies with respect to e-waste. In any case, arrangements centering on forbidding or controlling imports or practices,

for example, open burning have so far been pitifully implemented (Marriott, 2011; Lundgren, 2012).

2.10.7. The EU waste framework directive

The general point of the European Union Waste Framework Directive of 2008 (Directive EU2008/98/EC) is that the EU wind up noticeably independent in waste transfer limit (European Environment Agency, 2009; Lundgren, 2012). The Policy might address all issues going from generation and exchange to conclusive disposal, including innovation exchanges for the reusing of electronic waste. Clear administrative instruments, sufficient to control both legitimate and unlawful fares and imports of e-waste and guaranteeing their environmentally sound administration ought to be set up. There is likewise a need to address the escape clauses in the predominant lawful edge work to guarantee that e-waste from advanced nations is not achieving the nation for transfer. The Port and the Custom experts need to screen these angles. The controls ought to restrict the disposal of e-waste in metropolitan landfills and support proprietors and generators of e-waste to legitimately reuse the wastes. Fabricates of items must be made monetarily, physically and legitimately in charge of their items (Joseph, 2007).

2.10.8. E-waste certification standards and e-waste recycling initiatives in the U.S.

With a developing number of choices for recycling electronic waste, it is imperative to have a rating framework set up to guarantee the best possible disposal of electronic waste. Presently there are two voluntary electronic waste confirmation gauges that are authorized by the American National Standards Institute (ANSI) American Society for Quality (ASQ) National Accreditation Board (ANAB). These are E-Stewards and Responsible Recycling (R2) Practices Standard (Namias, 2013).

2.10.8.1. E-Stewards certification

The E-Stewards Initiative is a venture of the Basel Action Network (BAN), an altruistic association which concentrates on "standing up to the worldwide environmental

injustice and financial wastefulness of poisonous exchange (harmful squanders, items and innovations) and its staggering effects" (Basel Action Network, 2011). The E-Stewards Initiative attempts to guarantee that fares of perilous electronic waste to developing nations are abolished, and bolsters greener enactment and producer responsibility. The E-Stewards Initiative has not just uncovered the electronic waste dangerous exchange issue to the world, yet it has additionally created market-based answers for dependably recycling hardware. The E-Stewards Pledge program was propelled in 2003, which confirmed 40 e-recyclers with 100 areas over the U.S. who promise to just utilize all around responsible means and best practices to process e-waste. These confirmed that e-recyclers are not permitted to discard gadgets in landfills or incinerators, send out e-waste, or utilize shoddy work to process waste (ibid).

2.10.8.2. Responsible recycling (R2) practices standards

The R2 Standard is an intentional electronic waste affirmation standard that intends to make a market-based system for guaranteeing capable recycling of gadgets. One of the real contrasts between R2 and E-Stewards is concerning import laws in creating nations. R2 takes into consideration the fare of poisonous e-waste to less-developed nations, among different recompenses. R2 additionally underpins the utilization of municipal landfills and incinerators for e-waste, and the utilization of jail work for preparing e-waste (ibid).

2.10.8.3. Step Initiative

The Solving the E-waste Problem (StEP) Initiative, was propelled by the United Nations University (UNU) in 2007 and today has more than 60 members comprising of organizations, the scholarly world, and legislative and non-administrative associations. There are five teams of StEP; policy, re-design, re-use, re-cycle, and capacity building. These teams concentrate on all inclusive acknowledged standards, practices and principles (ibid).

2.10.8.4. EPA's plug-in to e-cycling

The American Environmental Protection Agency (AEPA) is at present supporting various activities keeping in mind the end goal to expand the national recycling rate by 35%, one of its objectives for empowering the reuse, recycling and acquiring of greener hardware. These activities, incorporating the Plug-In to recycling Campaign and the Federal Electronics Challenge, intend to get the message out about chances to reuse and recycle old hardware, and also work with partners, for example, gadgets makers, retailers and organizations to diminish the environmental impression of gadgets amid all life cycle stages (ibid).

2.10.8.5. Consumer electronic association's recycling leadership initiative

The Consumer Electronic Association's recycling Leadership Initiative (ELI), which was declared in April 2011, is a national activity which means to recycle one billion pounds of gadgets every year by 2016, up from the roughly 300 million pounds of hardware recycle by customer gadgets producers and retailers in 2010. ELI tries to expand familiarity with industry supported accumulation destinations, increment the measure of gadgets recycled dependably, and give straightforward measurements on recycling's endeavours (ibid).

2.11. E-WASTE MANAGEMENT MODELS AND TOOLS

Broad research is as of now under route into e-waste management to moderate issues at both the national and worldwide levels. A few apparatuses have been created and connected to e-waste administration, including Life Cycle Assessment (LCA), Material Flow Analysis (MFA), (Multi-Criteria Analysis) and Extended Producer Responsibility (EPR). Each model has particular components when connected to e-squander administration (Veit and Moura, 2015).

2.11.1. Life Cycle Assessment (LCA)

Initially, LCA presents different favourable circumstances to help e-waste administration. It evaluates the impacts of materials utilization that effects on eco-

plan items and item advancement and designates the effects of the inspected item or procedure of ecological intrigue. Life Cycle Assessment is a device used to plan naturally inviting electronic gadgets and to limit e-waste problem. It likewise assesses the ecological and financial perspectives identified with the end-of-life disposal of electronic gadgets and empowers better basic leadership for disposal of e-waste. In view of distributed writing, LCA is a prevalent apparatus presently being utilized for e-waste administration including an outline and item advancement and ecological basic leadership in numerous nations including Columbia, Germany, Japan, Korea, India, Switzerland, Taiwan, Thailand, and United Kingdom (Kiddee *et al*., 2013). The LCA utilizes a "cradle-to-grave" way to deal with consider the ecological and aggregate effect of a particular item. Snags emerge from the absence of stock information, especially in developing nations, which is required to finish this appraisal (Devin *et al*., 2014).

2.11.2. Material Flow Analysis (MFA)

MFA has a few unmistakable focuses for the management of e-waste. MFA is a device utilized to anticipate the progression of material (e-waste) spilling into recycling locales, or transfer regions and loads of materials, in time and space. It links sources, pathways, and the middle of the road and last goals of the material (Kiddee *et al*., 2013). The MFA follows a substance from creation to application to reusing and transfer. Not surprisingly, it can be trying to follow items (Devin *et al*., 2014).

2.11.3. Multi-Criteria Analysis (MCA)

MCA is a basic guidance tool created for seeing vital choices and taking care of complex multi-criteria issues that integrate quantitative/subjective parts of the issue. It is not generally utilized for e-waste administration; it is regularly utilized for strong waste (Kiddee *et al*., 2013). The MCA is a basic investigation device for basic leadership as it contributes a total picture of option situations and arrangements (Devin *et al*., 2014).

2.11.4. Extended Producer Responsibility (EPR)

Expanded Producer Responsibility (EPR) doles out gathering and recycling obligation to the producer. EPR is characterized as "an ecological security procedure to achieve a natural target of a diminished aggregate environmental effect of an item, by making the producer of the item in charge of the whole life-cycle of the item and particularly for the reclaim, reusing and last transfer" (Lundhqvist, 2000). The reason for EPR is to advance social duty by urging makers to consider end-of-life administration amid the item configuration stage. As of now, the EPR approach is utilized as a part of all European Union nations, and twenty-three of the twenty-five States in the U.S that have authorized e-waste enactment. In the U.S., the absence of government enactment is one of the biggest impediments to across the board selection of this idea (Namias, 2013).

In developing nations, the potential use of EPR is being investigated hypothetically particularly in making it operational by considering the interesting elements of gadgets division (Liu *et al*., 2006; Manomaivibool, 2009). EPR is a domain arrangement approach that credits obligation to producers in reclaiming items after utilize and depends on polluter-pays standards (Kiddee *et al*., 2013). As indicated by Liu *et al*. (2006), the insufficiencies in the control, moderate usage and development of reusing facilities, and imperfect gathering framework all added to the insufficient management of the finish of-life of electronic items. Likewise, the material and money related stream of e-waste, the part of informal recycling, and the hesitance of subjects to pay recycling expense made the administration more confused and troublesome. In India, in spite of the fact that an EPR Program is yet to be actualized, (Manomaivibool, 2009) discovered two primary impediments that can undermine EPR component which are huge dark market for some electronic items and the unlawful importation of WEEE. In a more advanced nation like South Korea, the execution of EPR in 2003 has prompted expanded recycling and item reclaim as electronic producers are commanded to gather and reuse a doled out amount in light of the level of hardware sold (Yoon and Jang, 2006).

Without a doubt, EPR might be most suitable for all nations so as to limit the creation of electronic waste given that the obligation regarding electronic waste created post Basel Convention is passed back to the makers (Kiddee *et al*., 2013). EPR is hard to actualize given the resistance of monetarily invested makers (Devin *et al*., 2014). The extended producer responsibility can be implemented under several forms, like mandatory take-back programs, voluntary take-back programs, or with the support of economic instruments like Advance Recycling Fee –ARF (Rudareanu, 2013).

2.12. THE EFFECTS OF IMPROPER DISPOSAL OF E-WASTE

Tengku-Hamzah (2011) notes that with the advent of information technology, there has been a diverse increase in the leap of all activities of human life. While on one hand electronic communication has saved the environment by dramatically reducing paper usage, it has additionally caused far-reaching ecological harm because of the utilization of toxic materials in the fabricate of electronic products. The author further states e-waste contain various perilous substances which may posture risk to the human health and the environment on the off chance that they are not discarded in the right way. All things considered, 9% of the heaviness of electronic waste is made of unsafe substances, for example, lead, cadmium, mercury and other lethal metals (Tengku-Hamzah, 2011).

Conversely, Veit and Moura (2015) admitted that the electrical and electronic improvement influences the environment in two courses: first through the huge and developing measure of hardware that is disposed of yearly and second through the extraction of characteristic crude materials to supply the request of the new gear industry. Both can be measured by the measure of hardware that is delivered and disposed of every year by numerous nations.

More strongly, studies note that e-waste disposal affect human well-being in two ways which include: (a) food chain aspects: tainting by poisonous substances from transfer and primitive reusing forms that outcome in side-effects entering the evolved way of life and in this manner exchanging to people; and (b) direct effect on specialists who

work in primitive reusing ranges from their job activities to dangerous substances. There is adequate confirmation now to show that landfills tolerating electronic gadgets or old landfills containing e-waste will cause groundwater tainting (Schmidt, 2002; Yang, 1993). Poisons can possibly relocate through soils and groundwater inside and around landfill destinations (Kiddee *et al*., 2013). Likewise, Joseph (2007) and Managing e-waste in Victoria (2015) disclosed that numerous electronic items contain risky materials such as phosphor, liquids and refrigerants. Leif in landfills, (especially those that don't meet current models), or put away improperly, these materials can filter into groundwater and soil issues and human medical problems.

An investigation uncovers that individuals occupied with a customary electronic waste reusing exercises that they attempted to isolate copper from wires after burning them. In this procedure, Plastic and PVC codes create toxic smoke which is bad-tempered to eyes and cause respiratory issues. Additionally, there are odds of mischances like cuts and consumes amid the disassembling, destroying, corrosive showers and cremation process, what's more, introduction to the e-waste chemicals have some long haul impacts (Sivaramanan, 2013).

Because of inappropriate disposal of e-waste, where electronic waste is normally discarded together with city solid waste and finished in a non-risky landfill or being burned, and some are quite recently dumped unpredictably. In these cases, the dangerous components in e-waste may enter the dirt and sully the groundwater, or enter the environment as lethal exhaust if consuming is utilized as a method for transfer. In the USA, it is assessed that 70% of mercury and cadmium contamination and 40% of lead contamination in landfills are caused by spillage of electronic waste (Tengku-Hamzah, 2011; Adediran and Abdulkarim, 2012).

Unsafe materials, for example, lead, mercury, and hexavalent chromium, in circuit sheets, batteries, and shading cathode ray tubes (CRTs) are found in electronic waste. For example, Televisions and CRT screens contain four pounds of lead, all things considered (the correct sum relies upon size and piece). Mercury from gadgets has been referred to as the main wellspring of mercury in city waste. What's more,

brominated fire retardants are ordinarily added to plastics utilized as a part of gadgets. In the event that they are dishonourably took care of, these toxics can be discharged into the environment through incinerator slag or landfill leachate (Kumar *et al*., 2013).

E-waste winding up as landfills are portrayed as a poisonous time bomb. They may release to the environment following quite a long while by characteristic means, and there is a plausibility of draining of squanders, for example, batteries discharge acids and substantial metals mercury, nickel, and cadmium, electronic circuits have the lead, zinc, Nickel, Copper, Mercury and cadmium. These may reach the groundwater and reaches creatures and people, and blends with other new water sources, for example, waterways and streams (Sivaramanan, 2013; StEP, 2014).

At the point when the electronic gear is scorched, they discharge bounteous vapour which is perilous for environment path past our estimation and imagination (Jhariya *et al*., 2014). There are three fundamental teams of substances that might be discharged amid recycling and material recuperation, and which are of concern: unique constituents of gear, for example, lead and mercury; substances that might be included amid some recuperation forms, for example, cyanide; and substances that might be shaped by recycling forms, for example, dioxins (Lundgren, 2012).

All the more particularly, cadmium can bio-accumulate in the environment and is to a great degree poisonous to people, antagonistically influencing kidneys and bones. It is additionally one of the six poisonous substances that have been prohibited in the European Restriction on Hazardous Substances (RoHS) Directive (StEP, 2010). Past CRT screens, plastics, including polyvinyl chloride (PVC) cabling is utilized for printed circuit sheets, connectors, plastic covers, and links. Whenever consumed or arrive filled, these PVCs discharge dioxins that have dangerous affect human reproductive and immune frameworks. Mercury (Hg), which is utilized as a part of lighting gadgets in level screen shows, can harm the sensory system, kidneys, and cerebrum, and can even be passed on to babies through breast milk (Tengku-Hamzah, 2011; Tyagi *et al*., 2015).

As referred to by Tengku-Hamzah (2011), Qiu *et al*. (2005), in Zhang, (2009) contends that the negative wellbeing impacts of labourers in the electronic recycling and recuperation industry are higher contrasted with specialists in different businesses by these rates; migraine (47.7%), tingle (15%), sickness (11.1%), a sleeping disorder (9.7%), hypomnesia (5.3%) and conjunctiva clog (4.8%). In this way, to remove the metals, deliberate disposal and reusing is required on the grounds that just by burning or by some perilous extraction techniques, dangerous materials including mercury, lead, lithium and cadmium which are extremely hurtful to the earth and thus for the human wellbeing are created (Tyagi *et al*., 2015).

2.13. THE CONCEPTUAL AND THEORETICAL FRAMEWORKS

2.13.1. Conceptual framework

Rapid technological changes shorten the lifespan of electronic equipment. Thus, older, broken and unserviceable e-waste is going to be generated. In the environments where there is poor maintenance, repair, and recycling activities and in areas with limited success of reuse and refurbishment, there will be high rates of generation and accumulation of e-waste in households and organizations.

The issue of e-waste management has presently become one of the leading issues of human and environmental concern throughout the world due to three main reasons. First, it contains valuable spare parts and precious materials. Secondly, it encompasses several dangerous materials, which may pose a threat to the environment and human health if they are not disposed of in the right method. Thirdly, as stated above, the volume of e-waste is presently growing at a rate which is three times as much as the growth rates of other types of solid waste.

E-waste management is not an easy task and it requires a group of different actors to realize proper management. Stakeholders such as manufacturers, distributors, waste dealers, users, and governments are responsible organs in the management of e-waste. The main activities performed in the e-waste management process are prevention and collection, inventory, structuring and organization, formulation and implementation of legislation, recycling and reusing of e-waste. However, there are various challenges to practice effective e-waste management. These challenges include financial constraints, shortage of facilities, lack of skilled manpower and the paucity of stakeholders with a meaningful interest in the management of e-waste.

Unless effective e-waste management is set in place, the toxic substances in e-waste may pose serious threats to the overall well-being of human beings and the physical environment. Moreover, proper e-waste management is recognized as a key area in environmental protection and human health protection. This is due to the fact that outputs of production, circulation and consumption interface with the natural environment like soil, air, water, and climate as well as human and animal health.

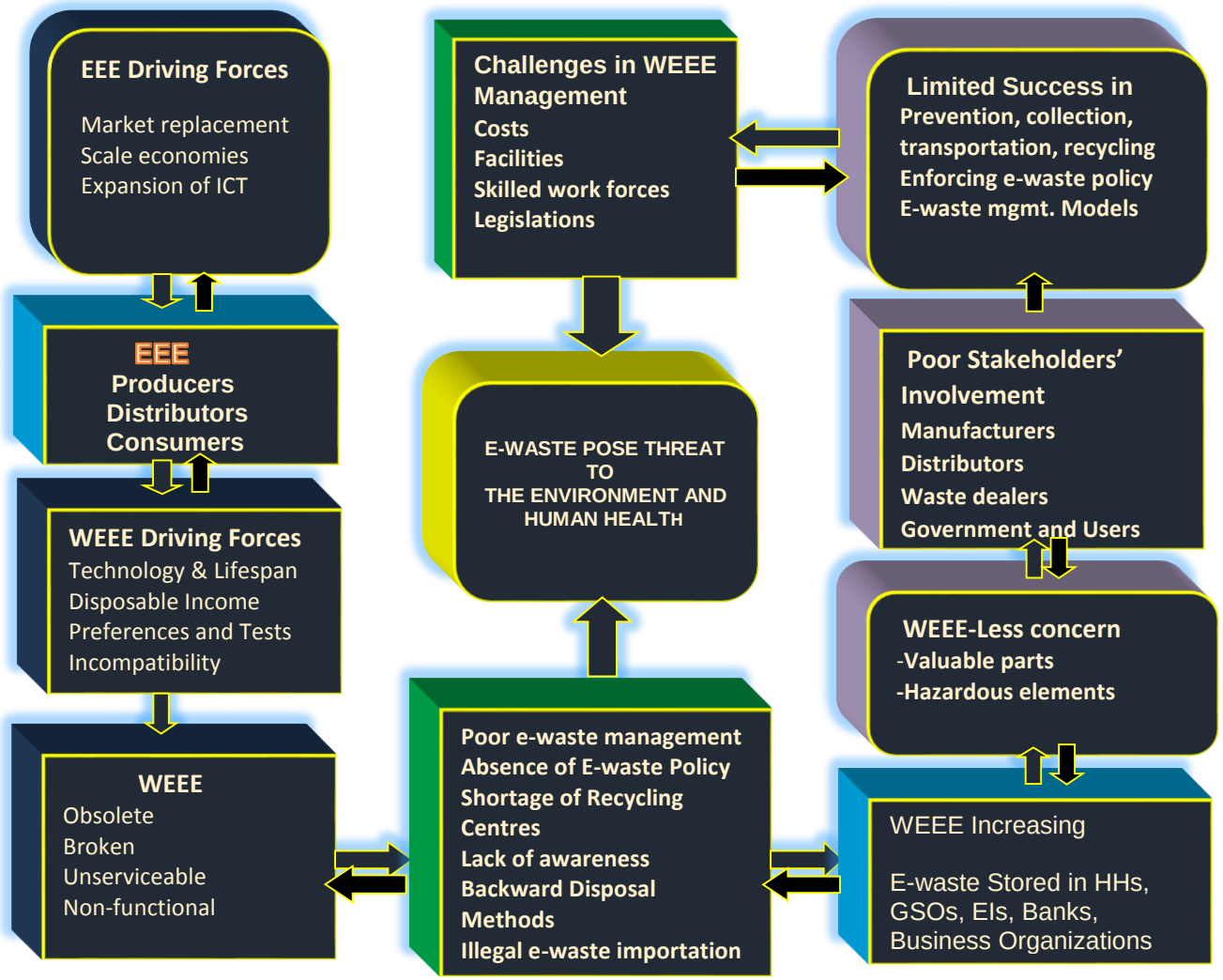

Figure 2.4: E-waste Management conceptual framework

Source: Abenezer (2012)

2.13.2. Theoretical frameworks

So far most of the previously conducted studies on e-waste and e-waste management lack theoretical frameworks. Some of the theoretical frameworks that guide this study were Actor-Network Theory (ANT), Game theory, Extended Producer Responsibility (EPR), and Pollution Haven theory. However, ANT has been extensively used in studying electronic waste management in Addis Ababa due to its strong efficacy in assessing the role of various actors in the network.

2.13.2.1. Actor-Network Theory

Cressman (2009) admitted that regardless of its ontological multifaceted nature, Actor-Network Theory (ANT) has spread over various controls. The author further states that from its unassuming beginnings in the humanism of science and innovation, the ANT diaspora has spread to human science, management, geography and organization, anthropology and philosophy.

ANT is considered as a heterogeneous amalgamation of literary, theoretical, social, and technical actors. Systems portrayed by an abnormal state of merging are those that exhibit assertion because of interpretation. That is, met systems are those that are both exceedingly adjusted and composed.

Applying this theory to the study of electronic waste management is both possible and useful. There are many actors in e-waste management of which the leading ones include the consumers, governments, manufacturers, refurbishes and recyclers. Since managing e-waste is a complex task, it requires these actors to work jointly and interdependently. Their action, intention, subjectivity, interest, and perception towards the electronic equipment purchase, consumption, generation, and disposal is very crucial to design a strategy or strategies to manage e-waste.

It also requires a strong network of these actors to realize effective and efficient management of e-waste. The degree to which actors are networked shall determine the success and failure of e-waste management. In short, the theory helps to show

the extent to which the networks of the actors are convergent or divergent. In addition to this, it helps to assess the degree to which there is coordination among the actors to enable them to adopt, implement and abide by the rules and regulations that they formulate.

2.13.2.2. Game Theory

Game theory is the formal investigation of contention and collaboration. These theoretic ideas apply at whatever point the activities of a few specialists are related. These operators might be people, gatherings, firms, or any blend of these. The most punctual case of a formal theoretic examination is the investigation of a duopoly by Antoine Cournot in 1838. The mathematician Emile Borel recommended a formal game theory in 1921, which was promoted by the mathematician John von Neumann in 1928 out of a "hypothesis of parlour recreations."

The game hypothesis was built up as a field in its own right directly after the 1944 production of the momentous volume. Theory of Games and Economic Behaviour by von Neumann and the financial expert Oskar Morgenstern. In the 1960s, this theory was expanded hypothetically and connected to issues of war and governmental issues. Since the 1970s, it has driven an unrest in the monetary hypothesis. Also, it has discovered applications in human science and brain science and built up joins with development and science.

As a mathematical tool for the decision-maker, the strength of the game theory is the methodology it offers for arranging and examining problems of strategic choice. The process of officially modelling a situation as a game requires the decision-maker to count overtly the players and their premeditated options, and to consider their favourites and reactions.

Numerical plan of the issue considers a case of electrical/electronic gear transfer with four partners, to be specific, government, maker or producer, recycler, and shopper. Each of these four players has two systems. Government can have two methodologies either to charge the producer for not having the correct accumulation

and transfer framework or give some monetary help with the name of appropriation to the recycler to energize the reusing of e-squander. A maker can have two systems, either to take the additional instalment as an Advanced Recycling Fee (ARF) at the season of procurement from the shopper for the sake of an e-squander administration expense, or to gather as a shrouded charge incorporated into the cost of the gear as an Extended Producer Responsibility (EPR) charge. The recycler can choose the e-waste gathering framework in two ways, either accumulation by the producer or direct gathering from shoppers named as accumulation by the recycler. A buyer can have two systems, either picking the land disposal or recycling alternative. Along these lines, it is critical to choose how to acquire a balance technique for each of the partners.

2.13.2.3. Extended Producer Responsibility (EPR)

There is no uncertainty the idea of Extended Producer Responsibility (EPR) has been making strides as a strategic alternative for overseeing electronic waste. The idea of EPR, as first instituted by Lindhqvist (2000), alluded to it as natural strategy rule. As an arrangement rule, it fills in as a guide or provides guidance to settle on educated decisions of a strategy blend from an arrangement of approach instruments to achieve certain destinations (Manomaivibool, 2009). It could likewise be comprehended as arrangement technique, strategy approach or strategy worldview (Manomaivibool, 2009). EPR is likewise in some cases alluded to as "reclaim", yet misnomer, since makers are considered mindful to reclaim and assume the responsibility of the last disposal of their items after they are disposed of by the end-clients.

According to Lindhqvist (2000), EPR is defined as:

> “A strategy rule that advances add up to life cycle ecological changes of item frameworks by expanding the obligations of the producer of the item to different parts of the item's life cycle, and particularly to the reclaim, recuperation and last transfer of the item”

While OECD (2001) defines EPR as:

> An environmental strategy approach in which a maker's duty regarding an item is stretched out to the post-customer phase of an item's life cycle. There are two related elements of EPR strategy: (1) the moving of duty (physically or potentially financially; completely or mostly) upstream toward the maker and far from regions, and (2) to give motivations to makers to consolidate environmental contemplations in the outline of their items.

It additionally illuminates the makers' part and duties in the item life cycle underlining reclaim (physical), recycling (instructive) and last transfer (budgetary). A definitive objective of EPR, accordingly, is reasonable improvement through naturally dependable item advancement and item recuperation. The hypothesis is that by making makers pay to remediate the waste and contamination they make, they will have a motivating force to join a more extensive scope of natural contemplations into their item configuration, bundling and selection of materials. As indicated by OECD (2001), there are four central objectives of EPR, in particular; Source decrease (normal asset preservation/materials protection), squander anticipation, plan of all the more ecologically good items and enclosure of materials-utilize circles to advance feasible development.

2.13.2.4. Pollution Haven Theory

This is straightforwardly connected to the "race-to-the-bottom" hypothesis yet particularly respects ecological law and principles. It expresses that contamination intensive economical movement will have a tendency to relocate to those purviews where costs identified with ecological control are most minimal (Lepawsky and McNabb, 2010). This hypothesis covers with globalization and north–south issues, the level headed discussion over the unique ramifications for the developed and less developed nations, and whether globalization will prompt "modern flight" from the north and the development of "contamination shelters" in the south (Medalla and Lazaro, 2005). On account of e-waste, the "contamination safe house" is in creating

nations where, by and by, squander handlers confront strong motivating forces to keep away from charges and directions and discard their waste unlawfully (Lundgren, 2012). It is evident that this theory is directly linked to the trans-boundary movement of hazardous wastes including e-waste from developed to developing countries in the form of donations and second-hand equipment.

2.14. CONCLUSION

E-waste is sourced from both developed and developing countries. Industrialized and innovatively propelled countries, for example, the USA, the UK and other developed nations produce a tremendous volume of the world's electronic items and in this way produce the vast majority of the e-waste and sending out the e-waste to the third world nations particularly Africa and Asia in the appearance of 'second hand' hardware.

Several causes make e-waste to create. Together with a reduction in costs and the development in web utilize, rapid advances in technology, the monetary development of the nation, population development, advertise infiltration, innovation, shopper appealing plans, calculability issues and out of date quality rates. The e-waste treatment varies among advanced and developing countries. In most developing nations, the treatment takes place through a "backyard recycling" or substandard techniques, which can make serious harm the environment and human wellbeing.

The major challenges in e-waste management are the absence of information in dealing with e-waste and the lack of conducive policies and rules, lack of skill and knowledge towards the handlings and treatments of e-waste, its rapidly growing volume, its hazardous components, lack of capitals and facilities. Because of the unsafe nature of e-waste and trans limit movement of WEEE, various conventions, controls, strategies and rules have been set up to deal with this hazard.

Some of the theoretical frameworks that guide this study were Actor Network theory, Game theory, Extended Producer Responsibility and Pollution Haven theory.

However, both EPR and ANT were extensively used in studying electronic waste management in the study area due to its strong efficacy in assessing the role of various actors in the network.

CHAPTER THREE

DESCRIPTION OF THE STUDY AREA AND BACKGROUND THEMATIC AREAS

3.1. INTRODUCTION

This chapter presents the description of the study area and backgrounds thematic areas. The first section describes Addis Ababa; its foundation, location, economy and population review. In the next section, the chapter discusses several background thematic areas that help to become familiar with the solid waste management of Ethiopia and Addis Ababa in general and e-waste management in particular. The chapter further appraised the regulatory frameworks, the actors and challenges of e-waste management in the country and the city of Addis Ababa.

3.1. DESCRIPTION OF THE STUDY AREA

3.1.1. Addis Ababa; its foundation and location

Addis Ababa was founded as the capital city of Ethiopia in 1889 (Tolon, 2008). Ali (2002) also stated that the city was established in the late 19th century as the permanent capital of the then emerging modern Ethiopian state. Pankhurst, 1961; Tufa, 2008, as cited in The State of Addis Ababa (2017), point out that Emperor Menelik II and his wife Empress Taitu founded the City of Addis Ababa (Addis Ababa means 'New Flower' in English and 'Finfinne' in Afan Oromo) in the late 19th century. The emperor selected the Finfinne area for its fertile land, mild climate, geographically strategic and defensive position, and ancestral history. It is alleged that the royal couple was attracted to the 'Filwuha', hot springs which were believed to possess curative powers.

Addis Ababa is just over one hundred years old. Ever since its foundation, the city has been serving as the seat of the central government. Establishment of Addis as the permanent seat of central government made a turning point in the long history the shifting of capital cities in Ethiopia (Ali, 2002). According to Tolon (2008), there were three main factors that helped Addis Ababa to remain as a permanent capital city of Ethiopia: the introduction of eucalyptus (an exotic tree that grows very fast and provides a lot of wood for construction as well as for cooking purposes), the proclamation for legalizing private ownership of urban land in 1907 and the completion, mainly by the French, of the Addis Ababa – Djibouti railway in 1917.

Addis Ababa is a chartered city and as such, is considered both a city and a state. It is the largest city in the world located in a landlocked country (World Population Review, 2018). It serves both as the country's political and economic centre (Manhart *et al.,* 2013). Besides, UN-HABITAT (2008) stated Addis Ababa is one of the largest and oldest cities in Africa. It is a capital of a non-colonized country in Africa, it is playing a vital role in accommodating the regional organizations (UN-HABITAT, 2008).

Addis Ababa is the biggest as well as the dominant economic, political, historical and cultural city of the country. It plays a pivotal role in the economic, social and political life of the country. The city houses representatives of not less than 22 important international organizations including FAO, WHO, UNESCO, UNFPA, UNDP and World Bank, some of them have regional missions beyond the Ethiopian territory and others with missions limited to Ethiopia (Ali, 2002). Further, the current African Union formerly named as the OAU is based in this city. Besides the city hosts headquarters of the United Nations Economic Commission for Africa (UNECA) and several meetings from continental and inter-continental organizations (CGAA, 2011/12; Daniel, 2011; Manhart *et al.,* 2013). What is more, there are more than a hundred embassies, international hotels and conference centres in the city which is also a major transportation hub and the homes of the leading airlines in Africa, the Ethiopian Airlines (AACPPO, 2012). Consequently, Addis Ababa is the third highest city in the world, after La Paz and Quito in Latin America (CGAA, 2011).

Geographically, Addis Ababa is located between 8 55'and 9 05'N Latitude and 38 40' and 38 50' E Longitude. The city is located at the geographic centre of Ethiopia and it has an area of 540 km^2 of which 18.174 km^2 is rural (Nigatu *et al*., 2011). As it also indicated in Mikyas (2011), it is found in the central part of Ethiopia at an elevation of 2440 meter above sea level. The mean precipitation rate of the city is around 1188.27 mm per annum and the annual mean maximum and a minimum temperature of the city for the year 2007 were 23.8 ^{0}C and 10.2 ^{0}C respectively (Daniel, 2011). Similarly, CGAA (2011) asserted that the city is located in the central part of the country, with altitude ranging from 2,100 meters above sea level at Akaki in the south to 3,000 (9,800 ft) meters above sea level at Entoto Hill in the North. Its time zone is categorized in East Africa Time (UTC+3).

Settled in the late 19th century, today the city is comprised of three government levels, including the formal city government at the top, ten sub-city administrations in the middle, and 99 kebele – roughly equivalent to a neighbourhood – at the bottom (Cheever, 2011). However, very recently the city was governed by three administrative levels: Addis Ababa city administration (top administrative level), 10 sub-cities (second administrative level) and 116 Woredas (third administrative level) (Schleicher *et al.,* 2015). The ten sub-cities comprises Bole, Addis Ketema, Lideta, Kolfe Keraniyo, Kirkos, Akaki Kaliti, Nefas Silk Lafto, Gulele, Arada, and Yeka. In terms of areal coverage, Bole sub-city is the largest sub-city followed by Akaki-Kality and Yeka sub-cities. Addis ketema is the smallest and followed by Lideta and Arada Sub-cities (CGAA, 2011).

3.1.2. Addis Ababa; its population and economy

Several studies were conducted regarding the demographic characteristics of Addis Ababa. Accordingly, various estimations and results were made on the city's national share of population and its growth rate within the different time period. In this regard, The State of Addis Ababa (2017) reported that there is no reliable comprehensive statistical data to show Addis Ababa's population trends since its establishment. The

first census data was obtained only in 1961. However, several researchers have provided estimated population numbers for the city since 1889.

According to the CSA (2015) estimate, Ethiopia's total population is about 90 million people. Of the total population, 19.5% (17.5 million people) live in urban areas. This number is rising fast due to an annual urban population growth of 4.89%. Ethiopia's urban population is expected to triple by 2037 (World Bank, 2015). According to The State of Addis Ababa (2017), reported that Addis Ababa hosts an estimated 3.238 million people, which is a 17% share of Ethiopia's total urban population and is ten times bigger than the second biggest cities in the nation. The city has through recent years seen a strong annual growth rate, and population counts as of 2017 are growing closer to 4 million (World Population Review, 2018). Currently, Addis Ababa is experiencing an annual growth rate of 3.8% and is estimated to reach 4.7 million inhabitants by 2030. It was anticipated that in the following fifteen years, the populace is assessed to develop every year by 3.8% and it will achieve ten million and more individuals following fifty years (AACPPO, 2012; Mikyas, 2011; Daniel, 2011).

Table 3.1: The population size and population growth of urban centres

Urban centres	Population size	Urban Population growth rate over the last 10 years
Mekele	273,601	6.2
Hawassa	212665	6.1
Dire Dawa	262884	4.3
Bahir Dar	191016	3.7
Adama	271562	4.2
Addis Ababa	3040740	2.1

Source: CSA (2014)

Adjacent to its biggest offer of the urban population, Addis Ababa is Ethiopia's financial focus. It is all around associated with all major overland courses inside the nation and leader of the railroad line that interfaces Ethiopia with the port nation Djibouti (Manhart *et al*., 2013). It is one of the quickest developing urban communities in Africa. It is the development motor for Ethiopia and a noteworthy column in the

nation's vision to end up noticeably a centre wage, carbon-nonpartisan, and versatile economy by 2025. Addis Ababa's economy is developing every year by 14%. The city alone as of now contributes roughly half towards the national GDP, featuring its key part inside the general monetary advancement of the nation (The World Bank Group, 2015).

According to UN-HABITAT (2008), Addis Ababa, the capital of Ethiopia and the discretionary focus of Africa, is one of the quickest developing urban communities on the mainland. Its population has almost multiplied each decade. In 1984 the population was 1, 412, 575, in 1994 it was 2,112, 737, and it is presently thought to be 4 million. It additionally assesses that this number will keep on rising, reaching 12 million by 2024. The accelerated population growth of Addis Ababa has been putting pressure on municipal services.

The populace size of sub-cities changes in space. Thus Kolfe Keranyo (15.66%), Yeka (12.65%), Nefas Silk (11.55%) and Bole (11.28%) have the biggest offer of the populace of the city individually (CGAA, 2011). The suburban areas do not exclusively fluctuate as far as population size and land area are concerned, however they display varieties regarding wage status. Along these lines, in the course of the most recent three decades, a couple, dominatingly high-salary, locations have risen, particularly in the Bole and Old Airport regions. Another upper white collar class location additionally is by all accounts really taking shape in the eastern peripheries of the city (Tolon, 2008). Subsequently, it has an implication in examining e-waste management and this is the motivation behind why high and middle-income locations were picked as the study units over the others.

In terms of the economy, Addis Ababa is very diverse. Trade and commerce are the most popular industries, followed by manufacturing and industry, homemaking, and civil administration. Tourism is a growing industry in the area as more shopping centres, restaurants and attractions are built. In fact, the city is becoming known as the “spa capital of Africa.” (World Population Review, 2018). The State of Addis Ababa (2017) further reported over the last five years the services sector has

persistently dominated the urban economy and there is no sign of a changing trend. Within the services sector, transport, communications, trade, the hospitality industry (hotels and restaurants) and financial intermediation constitute the largest shares, in descending order. Booming construction activity also significantly contributed to Addis Ababa's industry sector, followed by manufacturing.

3.2. BACKGROUND THEMATIC AREAS

3.2.1. Solid waste management in Ethiopia

Yami (1999) point out that like urban communities of most developing nations, the arrangement of essential administrations lingers behind the need and advancement of settlements in urban areas of Ethiopia. The author also stated that the arrangement of solid and liquid waste gathering and transfer is found at the lowest status (most urban zones do not have the administration). As solid waste generation increases with financial advancement and population development, the sum in these urban territories will twofold inside a comparable time run (Yami, 1999).

According to MUDHCo (2012), in Ethiopia, an expected of 30 to 50 percent of solid waste generated in urban zones are not collected. In substantial number of urban regions of the nation, solid waste administrations are either missing or lacking. It further sates solid waste management in Ethiopia is for the most part in a poor state. For instance, the collection services are regularly wasteful and don't cover all regions. As a rule, the unapproved and a large portion of the approved dump destinations are inadequately overseen causing critical ecological effects. Throughout the most recent couple of years, numerous micro and small scale enterprises have been set up to do squander pre-accumulation benefit, getting instalment either from the individual recipients or districts to gather waste and transport to the civil waste compartments, and fills the made crevices in gathering and transporting squanders. The role of these enterprises could be considered as a decent beginning stage for building private division support and understanding the related advantages (MUDHCo, 2012).

According to Yami (1999), for example, a review of present status of the framework in 15 haphazardly chosen large (Dessie, Bahir-Dar, Debre-Zeit, Gondar, Mekele, Nazareth) and medium sized urban centres (Woldiya, Axum, Adigrat, Robe, Gimbi, Adwa, Arbaminch, Wolayita Sodo, Debremarkos) demonstrates that from the sample urban territories examined 13, i.e. 86.6% utilized open dump to arrange squander, while the rest utilized holes. Most of the other urban areas in Ethiopia are believed to use open dump for disposal (Yami, 1999).

Municipalities throughout Ethiopia are not free of problems and they are facing major challenges with solid waste collection and landfill management. EPA/WB (2004), as cited in Daniel (2011), stated that the per capita measure of waste produced in Ethiopia range from 0.17 to 0.48 kg/individual/day for urban centres to around 0.11 to 0.35 kg/capita/day for rustic zones. The range relies upon a few factors, for example, salary and period. The aggregate solid waste in Ethiopia in 2003 was estimated to be 2.8 to 8.8 million tons. This can be part to roughly 0.6 to 1.8 million tons from urban areas and 2.2 to 7 million tons from rural regions (EPA/WB, 2004).

A few studies have demonstrated that exclusive 43% of waste is gathered in the nation are appropriately gathered and arranged in open landfills. The staying waste is aimlessly arranged off in seepage lines, open spaces, road sides or is casually scorched (Daniel, 2011). In Addis Ababa and other secondary towns, family units have the propensity for isolating out specific sorts of solid waste that have coordinate an incentive for reuse or reusing, for example, plastic compartments, however generally there is no waste division at family unit and almost no at institutional level (PAN-Ethiopia, 2012).

With respect to waste management responsibility in the urban areas of Ethiopia, Mazhindu *et al*., (2012) stated that it is the obligation of the City Division of Health. All regions – with the exception of the chartered urban areas of Addis Ababa and Dire-Dawa who have cabinet representation – practice some independence in dealing with their own particular undertakings. All the chartered urban areas and the affirmed littler urban focuses are ordered "to give, keep up and direct ecological

wellbeing administrations alongside different exercises in their own particular ranges". However, the part of the district in reusing is missing as the region concentrates on the accumulation, stockpiling, transportation and transfer of waste. The greater part of the accumulation of recyclable waste in the city is carried out by the informal waste dealers. The recyclable waste materials are utilized by the neighbourhood plastic, shoe, and metal industrial facilities (Mazhindu *et al*., 2012).

3.2.2. Solid waste management in Addis Ababa

The fast and generally uncontrolled population growth and spatial extension of substantial urban communities in third world nations regularly brings about impressive harm to the environment (Tolon, 2008). While urban areas are producing a regularly expanding volume of waste, the adequacy of their solid waste gathering and transfer frameworks are declining. Mohamed and Elsa (2003), as cited in Nigatu *et al*. (2011) stated that in urban centres all through African locales, not as much as half of the solid waste created is collected, and 95 percent of that sum is either unpredictably discarded at different dumping destinations on the fringe of urban centres, or at various temporary destinations, regularly purge parcels scattered all through the city.

Addis Ababa, as the biggest city in the nation, and additionally other smaller urban areas have been thought about as an undeniably developing urban waste management issue. It is one of the quickest developing urban communities in Africa and the city is at present experiencing the issues that run with fast population growth and urbanization: a deficiency of better housing and an absence of essential infrastructures and public amenities, for example, water, power and sewerage (Daniel, 2011). Apparently, the quick population growth and extension of Addis Ababa – for the most part due to the in-migration of individuals originating from all sides of the nation looking for better work conditions and urban facilities - represent the city with many difficulties of waste management (Mazhindu *et al*., 2012).

The administration of solid waste can't meet evolving needs. The solid waste gathering administration is inadmissible, and scenes of scattered waste are regular

in most areas of the city (Nigatu *et al*., 2011). Regardless of its initial foundation, Addis Ababa has begun its solid waste administration later after its foundation with the point of guaranteeing the wellbeing of its inhabitants. However the city is as yet confronted with various waste administration issues (Hayal *et al*., 2014). Furthermore, Ayenew (1999), as cited in Selamawit (2006), revealed that solid waste management service is one of the basic urban services that have mistreated most. WHO (1996) and (Sue) 2010, in Mohammed and Elias (2017) argued that regardless of increasing volume of waste generated, the performance of the city‘s solid waste collection and disposal system is poor.

On the other hand, the built-up range of Addis Ababa – including ultra-present day structures nearby slums - exists in the huge Akaki and little Akaki river basin which has a catchment zone of around 540 square kilometres. The enormous and little Akaki waterways, with their dendritic tributaries, drain the city out of north to south. The unseemly practices of dumping of wastes from family unit and industries in the waterway catchments has brought about the spread of anthropogenic ailments in the city (Mazhindu, *et al*., 2012).

As per city government BSC study group supposition, (2011) of the aggregate solid waste created was 76% from private, 9 % from business regions, 6% from road clearing, 5%from enterprises, 3% from hotels and 1% from hospitals. The per capita solid waste generation rate is 0.34 Kg/cap/day. Recently, it was 0.45kg/cap/day and as an aggregate 1,020,000 kg or 3,063.06 m^3 with density of waste every year and 330 kg/m^3 every day. There is 5% rise urban waste generation every year (AACG, 2011; Hayal *et al*., 2014).

Around 20% to 30% of the waste created in Addis Ababa stayed uncollected and made the city condition stylishly unpleasant and influenced the city's general wellbeing (Nigatu *et al*., 2011). The city committee recognizes six noteworthy sources of solid waste: family units, roads, business establishments, enterprises, hotels and health centres including hospitals. The greater part of the solid waste materials delivered by family units are arranged without sufficient care. This uncovers a

noteworthy bit of the solid waste produced was arranged unlawfully and in this way expediting much weight the city's environment and the health of its occupants (AACG, 2011). As indicated in Table 3.3, an investigation made by the Addis Ababa City Organization demonstrates that, the collection scope has been continually expanding from 38 percent in 2011 to 40 in 2012, 53% in 2013, and 53.9% in 2014 (Mesfin and Van Dijk, 2014).

The assessed physical structure is as per the following: vegetables 4.2%, paper 2.5%, elastic/plastics 2.9%, wood 2.3%, bone 1.1%, materials 2.4%, metals 0.9%, glass 0.5%, combustibles leaves 15.1%, non-burnable stones 2.5% and all fines 65% (Daniel, 2011). The author further reveals that from the day by day solid waste generation in Addis Ababa, 65% is gathered, 5% recycled and 5% treated as compost. The rest 25% is essentially dumped on open destinations, seepage channels, streams and valleys and in the city (Nigatu *et al*., 2011).

Prabu (2009) examined the poisonous overwhelming metal defilement of Akaki Waterway by measuring the concentration levels of seven chose metals Cd, Cr, Cu, Zn, Mn, Fe and Ni that might danger the human wellbeing and environment. Accordingly, the outcome demonstrated that the amount of these metals in the stream surpassed as far as possible set by the nation's Environmental Protection Authority (EPA, 2003). The research centre tests completed uncovered differing extents of the nearness of all the chose substantial metals in the waterway – Cd (40%), Cr (64), Cu (15%), Zn (13%), Mn (4%), Fe (2%) and Ni (2%). The nearness of poisonous overwhelming metal fixation in the Akaki waterway is because of the collection of both harmful liquid and solid waste produced by households, industrial and municipal exercises in the areas (Mazhindu *et al*., 2012). The same author added the cramped living conditions and the presence of pathogens in the home environments due to the lack of basic infrastructure; the dangerous and unhealthy sites of some neighbourhoods due to the irregular or non-collection of garbage and the city-wide problems of toxic or hazardous waste disposal pose the major threats to the health of most residents in city (Mazhinda et. al. 2012).

Table 3.2: Solid waste generated, collected and disposed

Description	2011	2012	2013
Average amount of solid waste generated m^3/day	2585	5367	5613
Number of vehicle in charge of solid waste disposal	79	99	78
Capacity of vehicle in collection of waste product in m^3	943518	1178935	1304340
Waste disposal in m^3	60225	72570	*
Amount of waste disposed used for composite in m^3/day	2749	3450	3574
Number of institutions engaged in charge of waste disposal(Gov't, MSEs and Private)	529	527	539

Source: AACG (2013) * not estimated

The UN-HABITAT (2008) reported that waterway, soil, air and water contamination because of industrial waste, are ineffectively overseen, and are getting to be noticeably growing attention in Addis Ababa. The city is home to significant landfill locales; Repi Landfill and Koshe Dump are the two generally noticeable. The two landfills are open, unlined dumps. The Koshe dump is found adjoining the group of Koshe, home to nearly 80,000 of the city's poorest individuals: numerous in this group allegedly utilize the landfill as a sustenance source (Cheever, 2011). Mohammed and Elias (2017) claimed that the city is still dependent on 'Reppi' landfill site that receives over 750 tons of solid waste per day. As illustrated in Figure 3.1, about 31.9% of the generated solid waste in the city is thrown away.

In sum, the management of sewage and solid waste in Addis Ababa is worrisome and radical measures are needed to reverse the on-going ecological decline of the city. Failure to do so will have huge economic consequences and, in the long-term, increasingly will affect the well-being of the residents of the city (The State of Addis Ababa, 2017).

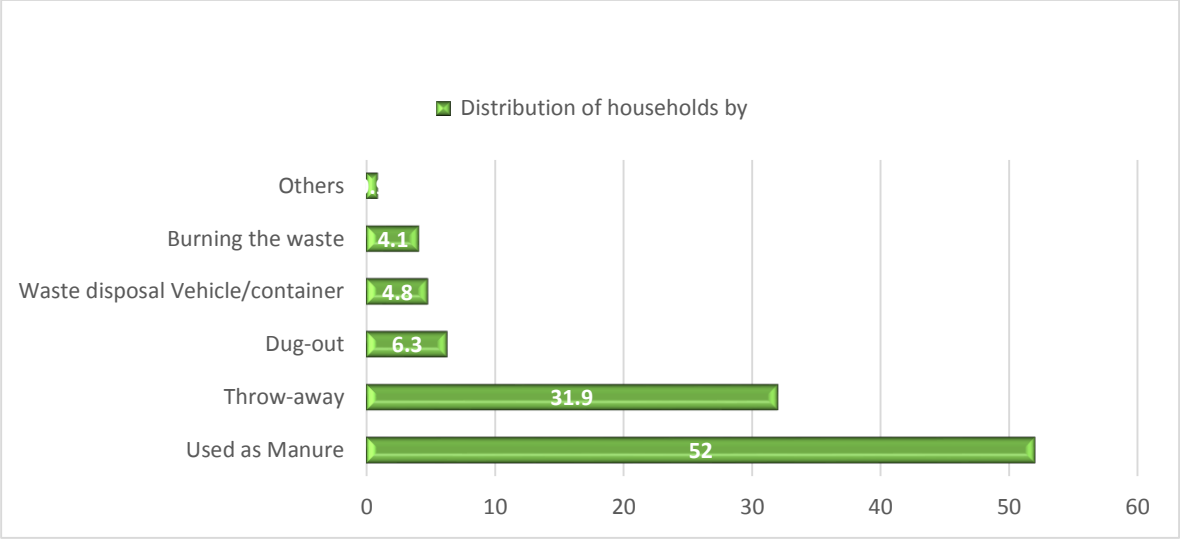

Figure 3.1. Distribution of households by waste disposal

Source: Tolon (2008)

3.2.4. E-waste management and the regulatory frameworks in Ethiopia

Knowingly, compared with other challenges of waste management in the fast expanding urban areas of the country, e-waste could hardly be considered a critical problem. Ethiopia, in common with other developing countries, is now seen as an 'open' market for passing on old, almost obsolete electronic equipment. Although it may be done with genuine good intentions, equipping a school or office with old computers and printers without having them checked and given some sort of guarantee that they will work effectively for a few years, not months, is really only passing on the problem of safe disposal and recycling of such equipment from a developed country or organization in the developed world to us here in the Third World (Tadesse, 2010).

Ethiopia, for the development of schools, health and research institutions, and universities and for other infrastructure development, needs ICT materials. According to Leulseged (2014), EEE is the second imported item in volume to the country. The same author further states that though, there is no research done in the sector, particularly in the recycling area, it is obvious that from the level of import of the

commodity (legal and illegal imports of EEE), high amount of electrical and electronic wastes are generated.

The application of computers, and thereby the development and information technology in Ethiopia, is closely related to the introduction of computers into by foreign suppliers. Computer usage started in Ethiopia around 1960s in relation to the major suppliers, namely IBM, NCR, SERIC Ethiopia, and Burroughs (Theodros, 2010). So as to lay a strong establishment for the advancement of Ethiopia's e-waste administration system, it was considered important to produce dependable information on e-waste volumes and current administration practices and choices, and additionally to examine potential outcomes for enhanced e-waste management and other pertinent perspectives. These markers recommend that Ethiopia's e-waste generation is still generally low. As government bodies and different sorts of workplaces (e.g. banks, organizations, NGOs) have as of not long ago been the predominant purchasers of electrical and electronic hardware, they are as of now the most huge origins of e-waste in the nation. Nevertheless, the fast entering of ICTs in Ethiopian community will soon modify this picture to a more heterogeneous e-waste circumstance (Manhart *et al*., 2013).

Gudeta *et al.* (2015) asserted that since Ethiopia has adopted a pathway to progress exploring Information and ICT possibilities, e-waste or the waste generated out of electronic and electric gadgets have emerged as a major constituent among the solid wastes. Likewise, PAN-Ethiopia has watched unpredictable e-waste dumping in open unregulated spaces in some Ethiopian towns (PAN-Ethiopia, 2012). In provincial Ethiopia, there is no sort of waste administration l*et al*one e-waste accumulation. Harmful e-waste delivered, especially light and radio batteries are discarded absolutely uncontrolled (Tadesse and Sue, 2013).

UNIDO (2010), as cited in Tadesse and Sue (2013), notes that it has been accounted for that more than 300 million dry cell batteries are used in Ethiopia every year. Further the study stated that numerous families not associated with a power supply make utilization of low-cost non-rechargeable standard batteries. These batteries

regularly have short lifetimes and contain substantial metals, for example, lead and additionally cadmium.

Though, Ethiopia is not one of the e-waste destination countries, the volume of electronic equipment import is the second largest commodity for the country (See Figure 3.2). Some of the imported materials applied directly for consumption and some getting reconditioned and consumed after importing, but the destination of these materials is removed as a waste (Leulseged, 2014).

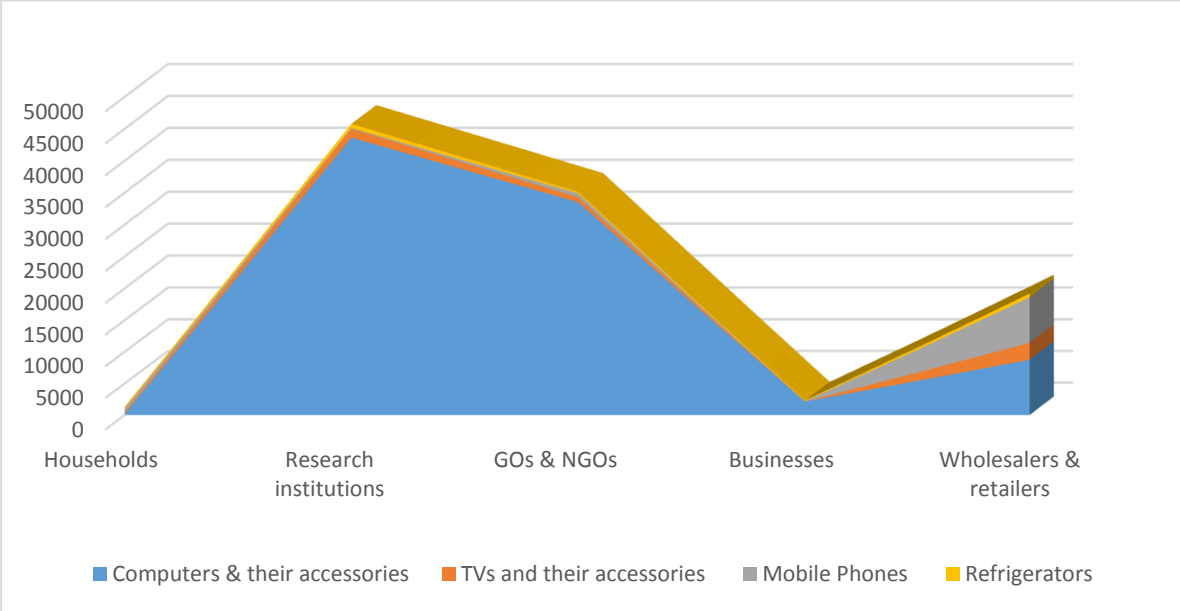

Figure 3.2. Electronic equipment volume in selected urban areas
Source: PAN-Ethiopia (2012)

Tadesse and Sue (2013) admitted that e-waste administration in Ethiopia is portrayed by (i) extended storage in family units, workplaces and government distribution centres (ii) formal accumulation from government workplaces and conveyance to DMF (iii) casual restoring and reusing in and around scrap metal markets (iv) unpredictable dumping (especially of a wide range of batteries, lights, and massive things, for example, coolers) (v) transfer with family unit waste.

Concerning the regulatory frameworks that govern waste management, at the higher level the Constitution of Federal Democratic Republic of Ethiopia recognised the citizen the right to live in clean and healthy environment and the state obligation of allocating resources to provide health, education and other social services to citizens under the provision of Article 44.1 and 44.4 of The Constitution of the Federal Democratic Republic of Ethiopia (FDRE, 1994).

The next federal level legal instrument governing the waste management is the Environmental Policy of Ethiopia (EPE), which was approved in 1997 (Selamawit, 2006).The EPA is responsible for federal level environmental protection by formulating the national environmental policy (Forum for Environment, 2010; Kuma, 2004). The EPA issued the Environmental Policy of Ethiopia which refers to waste management in three different articles, either directly or indirectly:

- Article 3.7 addresses issues related to human settlement, urban environment and environmental health;
- Article 3.8 addresses issues related to the control of hazardous Materials and pollution from industrial waste; and
- Article 3.9 addresses atmospheric pollution and climate change.

BOX 1: Article 3.8, in EPA, addresses issues related to the control of hazardous materials and pollution from industrial waste. Some of the policies are:

- To establish clear linkages between the control of pollution and other policy areas including water resources, agriculture, human settlements, health and disaster prevention and preparedness;
- To review and develop guidelines for waste disposal, public and industrial hygiene, and techniques to enable the cost-effective implementation of defined standards of control, and to issue regulations to enforce them;
- To formulate and implement a country-wide strategy and guidelines on the management of wastes from the medical, agriculture and other sectors that may use potentially hazardous biological organisms, their fragments or chemicals, and to issue the necessary regulations to enforce them;
- To establish a system for monitoring compliance with land, air and water pollution control standards and regulations, the handling and storage of hazardous and dangerous materials, mining operations, public and industrial hygiene, waste disposal, and water quality;
- To promote waste minimization processes, including the efficient recycling of materials wherever possible;
- To prohibit from importation to and from transit through Ethiopia hazardous materials, organisms or fragments of organisms as agreed by African states in Bamako.

Source: FDRE, Environmental Policy of Ethiopia, 1997

It can be seen from the box, nothing discuss particularly about e-waste and its management. Even the statements are too general and fail to consider e-waste as hazardous waste that require special handlings and treatments. In addition to this policy, As showed in Table 3.3, Ethiopia is a signatory of a large portion of the worldwide conventions including the Basel, Bamako, Rotterdam, Stockholm and different conventions for the greater part of which the EPA is the Designated National Authority (DNA) (Tadesse and Sue, 2013; Cheever, 2011). However, according to the forum for environment (Ethiopia) and the FDRE Waste Policy, there is no specific policy, regulation and principle in the area of electronic waste removal in Ethiopia (Leulseged, 2014).

Table 3.3: International conventions ratified by Ethiopia on hazardous waste

Proclamation Number and Date	Convention
Proclamation No. 192/2000	Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal
Proclamation No. 278/2002	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

Source: Cheever (2011)

Despite the fact that Ethiopia endorsed the Basel convention and has set up some start up measures for the administration of e-waste, notwithstanding, the rate of e-waste generation in Ethiopia was not surely documented and understood so a stock was expected to comprehend the current circumstance so as to decide additionally measures expected to guarantee its environmentally sound management (Tadesse and Sue, 2013).

3.2.3. E-waste management and regulatory frameworks in Addis Ababa

Addis Ababa as a focal point of political and economy of the nation there is a high rate of populace agglomeration joined by rural–urban relocation brought about the creation of enormous amount of solid waste. If not legitimately oversaw, it would turn into a wellspring of health and other related issues (AACG, 2013). In addition, the study stated that as of late, e-waste is evolving as one of the predominant ecological and health concerns to Addis Ababa with the issue disposal of waste or utilized items. The expanding out of obsolescence rates of electronic items added to the enormous import of garbage hardware from abroad will make complex situation for solid waste administration in Addis Ababa (Theodros, 2010).

As per a current Green Paper reported by the UNU-facilitated Solving the E-waste problem (StEP) activity, the stored volume of e-waste in Ethiopia is still moderately little (an expected 4,300 tons of non-working PCs, TVs, cell phones and refrigerators) and by and large bound to urban regions, especially the city of Addis Ababa (UNU, 2013). Likewise, PAN-Ethiopia, (2012), as cited in Tadesse and Sue (2013) disclosed that there is no huge informal e-waste accumulation created in Ethiopia may be because of the way that general e-waste volumes, specifically from private family units are still moderate, combined with the common consumer behaviour of not giving away obsolete devices as they are considered still having value.

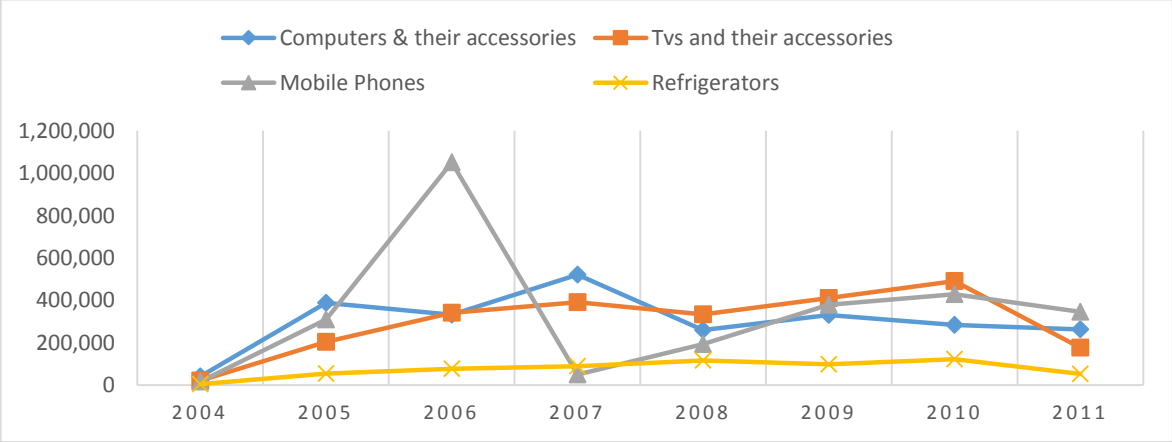

Figure 3.3. Imported products through AA Customs Authority, 2004-2011
Source: PAN-Ethiopia (2012)

What is more, with its large population and partly as a political and economic focus, Addis Ababa is additionally the city with the most astounding interest for EEE and creates the most e-waste in Ethiopia (Manhart *et al*., 2013). Despite the fact, however, e-waste collection and recycling activities are found at low level. On the other hand, Schleicher *et al.,* (2015) claimed that it is quite difficult to estimate incoming e-waste volumes that have to be handled by future collection systems. Nevertheless, the e-waste stocks (TVs, PCs, Refrigerators and Mobile Phones) in secondary cities such as Bahir Dar, Dire Dawa and Hawassa have been assessed to be in a range between 100 and 300 metric tons (See Figure 3.3). This would result in annual collection volume ranging from 20 t to 240 tons per secondary cities. For Addis Ababa, no data for e-waste stocks and generation exist so that no predictions can be made on potential collection volumes (Schleicher *et al.,* 2015).

In the effort to manage the solid waste of the city, the municipality plans to install three waste transfer stations in Addis Ababa (in Bole Arabsa, Repi and Akaki Kaliti). These locations will not only act as transfer points for solid waste from pre-collectors to the municipality, but also to sort waste and to carry out recycling activities. However, there is currently no formal collection of e-waste from households and businesses in Addis Ababa (Schleicher *et al.*, 2015).

On the other hand, the Ethiopian Information and Communication Development Agency (ICTDA) in collaboration with international organizations established a computer refurbishment centre in Addis Ababa which is capable of handling 2,000 computers per month. The centre also conducts trainings in courses of computer software and hardware. The centre de-manufactures old computers and separates plastics, metals, CRTs and mother boards so as to sale these items to those who can reuse or recycle. Most of the items are indicated to be used by different factories but CRTs and mother boards are still stored and there is no clue what to do with these hazardous items (Tadesse, 2010). PAN-Ethiopia (2012) noticed that the vast majority of the institutions additionally store non-practical e-items since they are in the organizations' property enlists as resources. The study further shows the possession by family units of electrical and electronic hardware supposedly cut over all pay levels.

Selamawit (2006) stated that the waste management regulatory frameworks in Addis Ababa, the main known authoritative archive with respect to solid waste management services was Public Notice no 25/1944. This Notice denied the burning and disposal of waste at open spots and on roads. In 1954, the city district was given the duties regarding controlling the cleanliness conditions and giving waste administration services in light of the General Notice No.172/1954. Sanitation service was presented without precedent for Public Notice No. 148/1958 by the Ministry of Health. What is worth bearing here is that landfill site has been and still utilizing was set aside for this purpose built up in 1965.

Despite the fact that it is far from adequate to accommodate the extremely large and ever-growing volume of all sorts of solid waste produced in the city, it is as yet serving the city as the main waste dumping site. All these infer that the strong waste administration has remained darkened. Regardless of the early acknowledgment of the significance of the administrations, it was not given due concern until 1994. At this point the solid waste administration duties were substituted to the recently settled Sanitation Service Team under the city's Health Bureau (Selamawit, 2006).

The reorganization of the city in 2003 by the Declaration Number 2/2003 has acquired noteworthy change status of the solid waste management services. This Announcement decentralized the solid waste management to the authorities at the Sub-city and Kebele levels. Also, it permitted the foundation of the Sanitation, Beautification and Park. It is issued by the Addis Ababa City Government to implement the Environmental Policy of Ethiopia. The targets are protection of human health, protection of the environment and fostering rational utilization of natural resources. The strategies are collection, recycling and disposal. The instruments of implementation are penalty and prescription, incentive, and public participation.

BOX 2: Addis Ababa City Waste Management, Collection, and Disposal Regulation,

- made responsible individuals and any other waste generating organisation for proper management of solid wastes
- made responsible solid waste service organisation for proper collection and safe keeping and transporting of wastes and prohibited disposal of waste in unauthorised place
- made provision for proper handling and disposal of hazardous wastes
- made provision for privatisation of the sanitation services
- described the power and responsibility of SBPDA, Sub-City, Kebele and other relevant organs regarding solid waste management tasks
- provided legal basis for establishment sanitation fee
- provided penal code on offences related disregard of sanitary regulations sanitary

Reference: Addis Ababa City waste management, collection and disposal regulation, No. 316/2004

Waste management collection and disposal regulations (i.e. Regulation No. 13/2004) of the Addis Ababa is issued because it is found appropriate to manage collect, transport and dispose waste generated from the city in a manner that does not pollute the environment and harm health of the society. It also required amending the existing hygiene regulations No. 1/994 by harmonizing with the current situation so as to make the city cleaned and ensure that its natural resources' balance is maintained (Theodros, 2010).

On perceiving the upsides of participatory association in service conveyance, the city administration of Addis Ababa acquainted directions with advance the contribution of private organizations in the waste administration sector. In its acknowledgment of the

essential part of the private division in waste administration, the Addis Ababa city government proclaimed "“Waste Management Collection and Disposal Regulations” No. 13/2004. The directions stipulate that "administration gave by government in the accumulation, transportation and discarding solid waste may, through various participatory or exchanging strategies, be given to private segment speculators (Mazhindu *et al*., 2012).

3.2.8. Actors of e-waste management in Addis Ababa

In Addis Ababa, there are diverse stakeholders who are specifically associated with an extensive variety of solid waste management actions including Non-Governmental Organizations (NGOs), privately owned businesses, people/youths from poor family units are the pioneers in giving door-to-door solid waste pre-collection benefit in the city (Nigatu *et al*., 2011). They provide the service of gathering and transporting solid waste from family units to impermanent accumulation sites. It is from that point forward the administration authorities saw the part as one of the business producing fields. Waste accumulation has progressively pulling in the considerations of the authorities as one of the un-tapped work producing job opportunities. Presently government arranges those private sectors and all are circuitously government employed (Nigatu *et al*., 2011).

Similarly, Leulseged (2014) disclosed that households, governmental and nongovernmental organizations, academic and research institutions, wholesalers and retailers of electronic equipment, electronic equipment maintenance shops and other businesses (like restaurants, cafeteria, hotel) as stakeholders of e-waste management. While these stakeholders are generators of e-waste and at the same time they could influence its management. Furthermore, according to the report made by MUDHCo (2012) both solid and liquid waste collection is undertaken by governmental and private organizations in this city. On the other hand, Stephanie (2013) identified key players in e-waste management in the city of Addis Ababa. These include;

- Ethiopian organizations: – Government – Environmental Protection Authority, Ministry of Communication and Information Technology, Standards Authority.
- Civil Society – PAN-Ethiopia, Forum for the Environment, Institute for Sustainable Development, ENDA Ethiopia.
- Academia – Addis Ababa University
- Industry - Ethiopia Plastic, Ethiopia Iron and Steel Factory
- International Organizations: StEP, UNIDO, UNU, Cascade Asset Management LLC, University of Limerick, Oeko Institute, IBLF, USEPA.

Behind this, local activities play a decisive role to make urban solid waste management sustainable. Regarding formal sector service conveyance, changes have concentrated on decentralization of solid waste gathering service to nearby government and the presentation of private part service conveyance. At the neighbourhood, group based activities are additionally winding up progressively noticeable as a methods for tending to the lacks of the formal framework (Mesfin and Van Dijk, 2014).

More recently, the solid waste collection policy in Addis Ababa has been chosen by the city administration. As per the current arrangement, solid waste are gathered by the administration workers, privately owned businesses depends on some legally binding understandings and micro and small enterprises (MSE). In any case, the guideline expressing that the waste generators are liable to put their wastes into various compartments in light of particular sort of waste is not rehearsed in the city (Hayal *et al*., 2014).

Then again, the key players in the waste administration segment in Addis Ababa are formal and informal administrators in the procedures of accumulation, partition, reusing, recycling and transportation of waste for definite disposal at the city dumping site of "Koshe". Formal administrators are those enrolled and authorized to work subject to tax and space controls. These administrators incorporate metropolitan cleaners and private administrators approved by government, though informal operators are not enlisted and have no legitimate base for the operation of their

business. The last classification incorporates foragers, unregistered recyclers and re-usable article dealers (Mazhindu *et al*., 2012).

With exclusion of e-waste, the generated waste is to be collected in two different collection phases; primary and secondary collection systems. Initially, primary collection is done by micro and small enterprises. These enterprises have formal agreement with sub-city administrations to collect waste from households or business establishments and dump them in designated containers. There are about 750 micro and small enterprises organized to pre-collect waste from households. The majority operate in the middle and high-income residential houses. They collect solid waste using a door-to-door method. Secondary collection is a system whereby solid wastes are transported from containers to the final dumping site. This is usually undertaken by the municipality which represents the highest level in transportation system. The role of the private sector on transportation of solid waste in this system is limited. Currently in the city administration collects 85% of the waste from containers and dumps it in the city's one and only open dumpsite which is known as ''Rappi'' or ''Koshe'' (Daniel, 2011).

There are some positive aspects of the existing system in Addis Ababa, such as informal recycling, composting initiatives and in particular the introduction and expansion of private sector enterprises that carry out pre-collection service from households. These enterprises play an important role in improving waste collection and reducing unemployment at local and regional level (MUDHCo, 2012). E-waste collection from federal government sector offices is organized by the Public Procurement and Property Disposal Service (PPPDS) under the Ministry of Finance and Economic Development (MOFED). In 2011 it issued a circular letter to all federal government sector offices to hand over e-waste to the De-manufacturing Facility (DMF). Following this circular, various federal government sector offices delivered obsolete equipment to the DMF. It is the most relevant initiative, which is located 30 km south of Addis Ababa in Akaki (Manhart *et al.,* 2013; DMF, 2014).

This E-waste Recycling and Computer Refurbishment and Training (CRTC) or Computer De-manufacturing Facility (DMF) receives donations from the UK and pre-processing of obsolete ICT equipment through dismantling and sorting (Stephanie, 2013).

The DMF is overseen by the Ministry of Communication and Information Technology (MCIT), gathered 17,162 gadgets, for example, PCs, typewriters, printers and duplicate machines from government workplaces between October 2011 and December 2012. The gathered gadgets have somewhat been dismantled and the DMF is as of now looking for downstream markets and answers for the different yield parts (steel, aluminium, links, printed wiring sheets, plastics (Manhart *et al*., 2013). Be that as it may, DMF has no yield to downstream markets yet, for the most part put away (18 tons of steel scrap and 6.8 tons of blended plastic at office). In addition, no perilous waste dump site or waste incinerator in Ethiopia (Stephanie, 2013).

In addition, various other institutions such as the African Development Bank (ADB), World Bank (WB), the World Food Program (WFP) as well as several NGOs located in Addis Ababa have handed over used and end-of-life EEE (Manhart *et al.,* 2013, DMF, 2014). What is more, as informal e-waste collectors, the so called “Quorales or petty traders”, who move from door to door to buy specific types of mainly household solid waste such as used bottles, tin cans, small metallic objects including bits and pieces or parts of electronic waste with the clear intent of selling such collections to recyclers or other interested customers. However, repair shops also purchase used and EoL EEE that were acquired by Quorales. They plays an important role in the current e-waste collection in Addis Ababa and other cities in Ethiopia. The ‘qourales’ operate in small villages, in the regions and cities, as well as in the Ethiopian capital, Addis Ababa. Their contribution in the waste management sector is, however, not well documented at a national level (Schleicher *et al.,* 2015). The same author added, quorales purchase both, used and EoL EEE (e.g. used and end- of-life TVs, computers, refrigerators etc.) as well as scrap metals (such as copper, steel aluminium). Repair shops typically focus on acquiring used and EoL EEE from households rather than scrap metals and components. This is motivated by the

consideration, that such devices can either be repaired and sold as second-hand product, or be used as a source of spare parts for other repairs.

Beside this, as cited in Schleicher *et al*. (2015), “the pre-collector enterprises reported that e-waste is also collected from households and businesses together with mixed solid waste.” The collected volumes are small as households give most used electrical and electronic equipment (EEE) to repair shops so that it does not enter the municipal waste collection system (Bole pre-collectors, 2014).

As per the study carried out by PAN-Ethiopia (2012), there is a noteworthy stream of electrical and electronic devices to informal repair shops. The greater part of the repairing procedure is done manually by repair shops utilizing normal hand apparatuses, for example, screw drivers, voltmeter, hot weapons, fans or suckers and fastening instruments. At the point when the repair has been done, the gear is then tried before being reassembled to be come back to the proprietor. On the off chance that the item can't be repaired, the repair shops ordinarily consult to get it from the proprietors to utilize it as a sources of extra parts for other gear. The main strategy for dealing with non-useful PCs and other electrical and electronic gear that couldn't be utilized any longer was either to keep it put away or discard it with municipal squanders.

3.2.10. Solid waste and e-waste management challenges in Addis Ababa

The consistently expanding volume and structure of solid waste in Addis Ababa has turned into a significant issue that ought to be given due consideration by the occupants, environmental associations and government bodies (Selamawit, 2006).

Urban waste administration has been a challenge for municipalities and urban governments in the third world countries, to a great extent because of poor foundation, bureaucratic skill and constrained institutional limit of the regions (Daniel, 2011). This issue is regularly amplified in urban communities where a thick centralization of individuals prompts a significant measure of waste generation (Cheever, 2011). The circumstance of deficient waste management is unavoidable in

many developing nations (Nicolas Escalante, 2011). The problem is exacerbated by migration of individuals moving to urban areas (Montgomery, 2008). Densely populated zones are more defenceless to health dangers as illness can be spread rapidly (Cheever, 2011).

In light of these, increasing populace development and high rural-urban relocation put numerous environmental threats for Addis Ababa city. One of these difficulties is identified with solid waste administration. Further the study highlighted that the solid waste management has continued to encounter problems associated with improper organisation, lack of innovative approaches and insufficient resources (SBPDA, 2004).

The inadequate solid waste management framework has brought about the dumping of waste on open grounds, in streams and storm drainage around sites where municipal garment collection bins are kept. This has caused immense inconvenience particularly because of water and soil contamination and the burning of waste (air contamination), blockage of storm drainage channels, and thus provoking the spread of sicknesses. This circumstance is accepted to bring about poor urban environmental conditions and a constant danger of pandemics, which thus display an imposing risk to wellbeing and efficiency of the occupants of the city (AACG, 2011). Additionally, Cheever (2011) notes that with an ever increasing number of individuals moving to urban areas in Ethiopia, urban communities like Addis Ababa and Bahir-Dar are under expanding weight to oversee waste viably keeping in mind the end goal to maintain to avoid occurrences of diseases.

Besides, some of the main challenges that the city administration currently faces in solid waste collection and landfill management are: poor infrastructure, which makes most part of the city inaccessible, lack of properly designed collection route system and time schedule, lack of proper collection of containers and lack of emptying containers when full, lack of proper truck maintenance, poor condition of the final dumpsite as well as lack of promotion on waste reduction, recycling and composting (Daniel, 2011).

Henceforth, this issue is by all accounts associated with absence of actualizing waste administration strategy, absence of sound institutional association, insufficient spending budget and poor usage of human asset. In addition, the information accumulated from the archives of the concerned associations, group pioneers, occupants and individual perception demonstrate that the solid waste administration in Addis Ababa is as yet a difficult issue that requires a joint exertion of both the group and the city government (Selamawit, 2006).

In this specific circumstance, waste administration in urban areas in developing nations, for example, Addis Ababa, still stays one of the biggest difficulties that public organizations confront due to the expanding amounts of various materials streams, which turn out to be increasingly intricate and differing as demographic and financial development rise. The city has been confronting different issues which incorporate inadequate and sub-standard infrastructure arrangements, lacking open spaces, intense deficiency and weakening of houses, poor sanitation, and joblessness (AACG, 2011).

Other investigation has likewise affirmed that the city confronts challenges with strong waste administration. Tolon (2008) declared the per capita generation of solid waste in the city is far beneath reality, it is by all accounts working below standards. The implementation is truly obliged by two fundamental elements: (i) deficiencies in its own particular administration; and (ii) a significant bit of the city stays outside its degree, owing either to poor access to a few neighbourhoods, or to lacking participation by families, or both. Next to this, developing movement blockage likewise ruins waste gathering truck capacity to make the same number of round excursions as alluring between city lanes and the dumping grounds.

Concerning the association of operations and administration structure, gathering and disposal are parts that are ineffectively composed. A transfer site arranged at one corner of the city is likewise the fundamental deciding variable for accumulation and transfer of waste in the city. Dump destinations and trucks for solid waste transfer are inadequate. With setting to handling and reusing of social waste, little is done at all level of its administration i.e. there is no source partition or arranging and this occurs

at transfer destinations as well. A few groups get close to nothing (now and again no) strong waste gathering administrations since nearby governments have no assets to cover all family units. Therefore, without collection services, families utilize types of disposal the greater part of which are intensely contaminating (Nigatu *et al*., 2011).

The other challenge is identified with families' readiness and collaboration in waste administration. Studies show that most family units were hesitant to pay for the district administrations rendered for solid waste removal. This concurred with the basic routine with regards to occupants dumping all scope of solid waste materials on stream banks, open sewers in the surroundings of their living regions (Mazhindu *et al*., 2012). The populace has the conclusion that the metropolitan solid waste gathering service is not working appropriately. Accordingly, the ability of the population to collaborate with improper gathering operation and to pay for the administration is low (Nigatu *et al*., 2011).

The capacity, technology and knowledge influences e-waste management. The repair shops receive mostly obsolete electric and electronic equipment (EEE) to restore functionality. In case the equipment proves to be beyond repair, the repair shops typically keep the devices and use them as a source of spare parts. Similarly, due to the limited storage capacity of the DMF the facility had to slow down collection efforts recently. Municipal government sector offices are not affected by the circular letter dispatched from the FDRE Public Property Disposal Service (PPDS) and the Ministry of Finance, Economic Development (MoFED). As a result, currently they have no strategy to manage e-waste from their offices. As all equipment owned by municipal government sector offices is registered, all disposal efforts require deregistration. To date, obsolete EEE from municipal government sector offices is commonly stored awaiting future management strategies (Schleicher *et al.,* 2015).

A few campaigns, projects and tasks have been started to mitigate this issue. In any case, their exertion neglected to yield any economical answer for the issue. The variables for the disappointment may be numerous. Yet, the significant ones are: powerlessness of both government and NGOs waste supervision tasks to include CBOs and the informal sectors operatives. Besides, the absence of organized private

institutions and active community that supplement the impact, and inadequacy of most city inhabitants to pay cost recuperation service charge (Selamawit, 2006).

To challenge these issues, then again, a colossal effort has so far been practiced by the city government, despite the fact that they are not satisfactory. While there is no completely functional e-waste administration framework set up yet, some encouraging endeavours can fill in as essential beginning stages for growing environmentally stable e-waste management frameworks (Manhart *et al*., 2013). Thus, satisfactory arrangement of waste administration is basic if groups and all essential and optional urban communities are to effectively address the test of a maintainable improvement, including asset preservation, climate protection, and contamination avoidance (Nicolas Escalante, 2011).

Other key legislations related to waste management include Environmental Pollution Control Proc. No. 300/2002 and Environmental Impact Assessment Proc. No. 299/2002, Amendment of the Basel Convention Proc. No. 356/2003, Ratification of Kyoto Protocol Proc. No. 439/2005, Environmental Protection Organs Establishment Proc.No.295/2002 and Establishment of the Environmental Protection Authority Proc. No. 9/1995, which is recently reorganized under a new Ministry for Environment and Forests. However, the existing SWM proclamation does not provide a comprehensive framework for sustainable SWM. Existing legislations do not elaborate on all principal waste streams, namely municipal, industrial, construction, biomedical, agricultural and e-waste as well as all phases of integrated solid waste management (Mohammed and Elias, 2017).

Consequently, as e-waste volumes quickly increment and disposal propensities are probably going to change, the present circumstance ought to be viewed as a one of an opportunity to plan careful fitting collection and reusing frameworks (Tadesse and Sue, 2013). Gudeta *et al*. (2015) further stated that gradual but conspicuous growth of e-waste demands early planned strategies for dealing with it. Improper e-waste management is an escalating problem all over Ethiopia, but eluding necessary attention. According to UNU (2013), as Ethiopia is one of Africa's most speedily growing nations, the accessibility of electrical and electronic items will clearly

increment in the coming years, and the relative cost of obtaining it will diminish. Besides, the study reveals that as this happens, it is anticipated that decreased ability by Ethiopians to store non-working hardware, along these lines expanding the volume of e-waste and introducing extensive social and natural challenges identified with its reusing, recycling and final dumping (UNU, 2013).

Tadesse and Sue (2013) highlighted that as government bodies and also different sorts of workplaces (banks, organizations, NGOs) have up to this point been the overwhelming shoppers of electrical and electronic items, they are presently the most essential wellspring of e-waste in the nation. The authors further reveals the quick entrance of electrical and electronic equipment in the Ethiopian culture will soon change this data to a more heterogeneous e-waste circumstance, especially concerning cell phones in number, and PCs and their spare-parts in volume and weight. Even though vastly growing, there is no sufficient data on the type and quantity of e-waste in Ethiopia in general and even in the capital city, Addis Ababa, in particular. Now is a good time for Ethiopia to give serious consideration on how to deal with the emerging mass of electronic waste before it starts to contaminate the environment, as has and is still continuing to happen in the developed countries (Tadesse, 2010).

MUDHCo (2015), as cited in Mohammed and Elias (2017), noted the solid waste management (SWM) strategy mentions lack of strong political commitment for SWM; challenges to streamline existing legal and regulatory frameworks; absence of mechanisms that would ensure inter-institutional collaboration; limited managerial and technical competencies in municipal SWM operations; and lack of service delivery standards as gaps in waste management.

3.3. CONCLUSION

As the capital city of Ethiopia, Addis Ababa is just over one hundred years old. It was established in the late 19th century as permanent capital of the then emerging modern Ethiopian state. Ever since its foundation, the city has been serving as seat of the central government. Solid waste management has been expanding all over Ethiopia in leaps and bounds. Since Ethiopia has adopted a pathway to progress exploring Information and Communication Technology (ICT) possibilities, e-waste or the waste generated out of electronic and electric gadgets have emerged as a major constituent among the solid wastes. Solid Waste Management in Ethiopia is for the most part in a poor state. For instance, the collection services are regularly wasteful and don't cover all regions. Municipalities throughout Ethiopia are not free of problems and they are facing a major challenges with solid waste collection and landfill management. As government bodies and also different sorts of workplaces (banks, organizations, NGOs) have up to this point been the overwhelming shoppers of electrical and electronic items, they are presently the most essential wellspring of e-waste in the nation. Ethiopia, for the development of schools, health and research institutions, and universities and for other infrastructure development, need ICT materials. Electronic equipment is the second imported item in volume to the country. According to the forum for environment (Ethiopia) and the Ethiopian federal government's waste policy, there is no specific policy, regulation and principle in the area of electronic waste removal in Ethiopia. In Addis Ababa, there are diverse stakeholders who are specifically associated with an extensive variety of solid waste management actions including Non-Governmental Organizations (NGOs), privately owned businesses, people/youths from poor family units are the pioneers in giving door-to-door solid waste pre-collection benefit in the city.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1. INTRODUCTION

A detailed research design is of paramount importance and is the most crucial step in the research process. It helps a researcher to focus on the study and holds all the parts and phases of a research project together. This chapter presents the methodological aspects of the study in detail. Accordingly, the chapter elucidates the nature of geographical research, research design and approach, sources of data, data collection tools, sampling techniques and sample size, the variables affecting e-waste management, data analysis, and presentation techniques, validity and reliability test, and ethical considerations.

4.2. THE BROAD GEOGRAPHICAL RESEARCH AREAS

Geography is a broad discipline that deals with various aspects of human life. Most recently, geographers have attempted to involve themselves in rigorous researches. The broad research areas that are discovered in geography, for instance, are feminist geography, political geography, economic geography, physical geography, GIS, development planning, urban geography, environmental sciences/studies and so on. Then, each of these broad fields has several research topics. Therefore, in light of this, the study has selected urban geography, urban planning, and environmental science as its broad research area.

Urban geography, for example, is a branch of human geography concerned with the various economic, social, political, cultural, demographic, technological processes and their consequences in relation to the city and between cities. The major research areas in urban geography include housing, transportation, employment, waste management, land-use, public space, green space, urban tourism, environment etc.

Thus, among the identified thematic areas of urban geography, the study has chosen waste management.

It is evident that various types of wastes are generated, segregated, collected, transported and handled in urban areas. The major categories embrace municipal, domestic, chemical waste, e-waste, liquid waste, industrial waste etc. Among these urban management pressing issues, this study has attempted to investigate the waste electrical and electronic equipment management and disposal methods in Addis Ababa, Ethiopia. The fact that the magnitude of challenges in e-waste have been dramatically growing while those of the challenges posed by most other municipal solid waste were lessening has particularly been the main factor that aroused the researcher's interest to address the issue of e-waste management in Addis Ababa.

4.3. RESEARCH DESIGN AND APPROACH

This study employs both descriptive and explanatory research designs based on the nature, types, and purpose of the data. It employs a triangulation research approach. Thus, the researcher has studied the cases of selected HHs (households) EIs (Educational Institutions) and GSOs (Government Sector Offices) of Addis Ababa.

With regards to descriptive research design, it was intended to describe the e-waste management and disposal methods in Addis Ababa. According to Kothari (2004), descriptive research design is describing characteristics of a particular individual, or of a group and situations and it also concerned with specific predictions, with the narration of facts and characteristics concerning an individual, group or situation. The same author argues that most of the social research approaches under this category of studies.

On the other hand, the study has also employed explanatory research design to explain the e-waste management particularly in the households of Addis Ababa. What is more, it has tried to identify the variables that affect the volume of electronic waste in households. The reason for selecting a mixed method research approach came out of the desire to acquire qualitative and quantitative data. It was also chosen on

the ground that the strengths in one method could help to lessen the limitations of the other method as is also buttressed by Creswell (2012).

4.4. SOURCES OF DATA AND DATA COLLECTION TOOLS

4.4.1. Data sources

This study utilizes both primary and secondary data sources to acquire relevant information that is required to analyse, discuss and present the data. The primary data sources were acquired through questionnaire surveys, in-depth and semi-structured interviews, and observations. On the other hand, secondary data sources used in this study were obtained through review of documents, books, websites, conference papers, and journals, relevant published and unpublished materials.

4.4.2. Data collection tools

Since the study has laid its foundation on a mixed methods research approach, data were acquired through both qualitative and quantitative data collection methods. As such it had two phases of data collection. First, the quantitative data were collected through a questionnaire survey and review of relevant documents. In the second phase, qualitative data were obtained through interviews and observations to complement data obtained through quantitative data collection tools.

4.4.2.1. Quantitative data collection tools

4.4.2.1.1. Questionnaire survey

It is one of the essential quantitative data collection tools that was widely used for this study. The purpose of the questionnaires was to assess the electronic waste management in households, educational institutions, and government sector offices of Addis Ababa. To achieve the study objectives in this regard, close-ended, open-ended and open response questions were designed and administered. For government officials, the questionnaires were administered in English but it was

communicated in the local language for the residents in order not to miss valuable information.

Thus, there were three forms of questionnaires designed to collect the requisite data. These included questionnaires intended for households, for GSD (general service department) personnel of EIs and GSOs and for HGOs (higher government officials).

4.4.2.1.1.1. Questionnaire surveys for households

Questionnaires for households were designed in a way that the HHs could react to the e-waste management in their home. The questionnaire had four parts. The first part attempted to generate information on the backgrounds of the HHs such as gender, sub-city, monthly income, family size, and educational status. The second part of the questionnaire consisted of eleven question items that sought to generate information on the households' awareness of electronic waste and its management. These part of the questionnaire were developed on the basis of 'yes', 'no' and 'uncertain' response options to assess whether or not the households know e-waste, whether or not they are aware of volume of e-waste they generate, laws/legislation governing the management of e-waste, its safe disposal of e-waste and the like. Thirdly, nine questions that focused on the causes, management methods and disposal of e-waste were included. Here the main issues raised were the causes of e-waste, reasons to replace old electronic equipment, e-waste management methods, and actions taken on non-functional, broken and old electronic equipment. Finally, the last part of the questionnaire attempted to generate information on engagement level of HHs in some electronic waste management. This part of the questionnaire had seven questions that were constructed based on the three-point Likert scale ranging through 'always', 'sometimes', and 'never'.

4.4.2.1.1.2. Questionnaire surveys for GSD personnel

As far as questionnaires for GSD personnel of both EIs and GSOs are concerned, questionnaires which consisted five parts were designed. The first part of the questionnaire had four question items that sought to explore profile of the study participants such as gender, educational status, position, and the identified

institutions/offices. In a manner that was similar to the questionnaires intended for households, then, the second part of the questionnaires comprised of twelve question items that attempted to generate information on awareness towards electronic waste management. These part of the questionnaire were developed on the basis of ‘yes’, ‘no’ and ‘uncertain’ response options to assess whether or not the GSD personnel have known e-waste, whether or not they were aware of the volume of the e-waste they generated and the laws/legislation governing e-waste management and other related issues. Unlike questionnaires for households, the third part composed of nine question items that sought to gather information on the activities performed in EIs and GSOs as regards e-waste management. The fourth part of the questionnaires had twenty-three items that were designed to generate information on the causes, management methods, challenges, stakeholders and disposal methods of e-waste. The last part of the questionnaires consisted of seven questions that aimed at collecting information on engagement level of GSD personnel in some e-waste management activities. Besides, the items were constructed on a three-point Likert scale ranging through ‘always’, ‘sometimes’ and ‘never’.

4.4.2.1.1.3. Questionnaire surveys for higher government officials

Similar to HHs and GSD personnel, the questionnaire surveys were designed for HGOs who were responsible for e-waste management. However, very few questions were employed for HGOs. Hence, an in-depth interview had to be conducted with them. Thus the questionnaires which consisted of two parts were designed. The first part of the questionnaire had four question items that sought to explore the profiles of the study participants such as their gender, educational status, position, organizations/offices. Similar to the questionnaires for GSD personnel, the second part of the questionnaire comprised of twelve question items that attempted to generate information on awareness towards electronic waste management. These part of the questionnaire were developed on the basis of ‘yes’, ‘no’ and ‘uncertain’ response options to assess whether or not the HGOs have known e-waste, whether or not they were aware of the volume of e-waste they generated, the laws/legislation governing e-waste management and other related issues.

4.4.2.1.2. Review of documents

In addition to questionnaire surveys, the quantitative data for this study was acquired through a review of documents to generate data on quantities, levels and types of e-waste generation in HHs, EIs, and GSOs. Two kinds of document review were designed one for HHs and the other for EIs and GSOs. With regards to the HHs, the document review has two parts. The first part of the review document attempted to generate information on the total volume of electronic waste that enables to know the quantities of e-waste, the most and the least frequently generated types of e-waste as well as to solicit practical information on the types of e-waste (outdated, non-functional and broken items). The second part of the review document consisted of information on the purchase year, service, and storage years of electronic equipment. This was helpful to examine generation level, the influence of technology, people's tastes and preferences as well as the economy for the past two or three decades.

The review documents as regards EIs and GSOs, it had four parts. The first part of the review of documents consisted of information on the total amounts of electronic equipment (such as newly purchased, received from donating organizations and purchased from second-hand market), which was essential to identify the sources of e-waste. The second part focused on information regarding the quantities of e-waste in such a way that it could help to examine types of e-waste (such as broken, obsolete and non-functional). The third part of the review document aimed at generating information on the ways in which e-waste was managed or disposed of (such as donating, storing, selling, recycling, dumping, and incinerating). Finally, the last part of the review document attempted to solicit information on the e-waste generation levels in the last five years. However, it was impossible to get actual data on this part due to mainly poor data management methods.

4.4.2.2. Qualitative data collection

4.4.2.2.1. Interview guides

In order to complement data obtained through questionnaires and review of documents, interview guides were employed. The interview guide has two parts; for GSD personnel and for HGOs. Regarding the interview guides for GSD personnel, an in-depth interview comprising eleven questions were prepared. They focused on activities performed in relation to e-waste management, e-waste storage and facilities, major challenges in e-waste management, stakeholder's involvement in e-waste management, efforts to minimize e-waste generation, and general recommendations and suggestions.

On the other hand, in-depth interviews were designed for HGOs. It was composed of nine important questions which were focused on the role of the offices in e-waste management, activities performed, the purchase and procurement of electronic equipment, e-waste policy, e-waste recycling centres, challenges in e-waste management, stakeholder's involvement, and future plans and recommendations. In both cases, during the interviews, the GSD personnel and HGOs were informed to freely and openly describe their views, ideas, and suggestions towards electronic waste management in their real situations. The interviews were conducted in English however translated into Amharic based on the preferences of the participants. An interview guide was prepared in a scientific and logical manner and the key informants were contacted to arrange a fitting place and time for the interview sessions. It took 50-60 minutes to conduct the interview for each of individual participant. It was conducted in person with the assistant of audio recording material.

4.4.2.2.2. Observations

This data gathering instrument was essential to practically observe what is there and what is not there. Besides, observation offers researchers the opportunity to confirm data acquired through other instruments. Therefore, it was one of the data gathering tools employed in this study to examine the e-waste storage areas, facilities within

the storerooms, types of e-waste stored, conditions in which e-waste was stored etc. During the observations, the researcher and investigators were stuck to the observation checklists or guideline to carefully observe and record the overall setting of electronic waste storage and the status of junks or storerooms with the help of a photograph. The observation took place in EIs and GSOs.

4.5. SAMPLE SIZE DETERMINATION AND SAMPLING PROCEDURES

Based on the research design (where data collection methods have been determined) the relevant research questions were prepared, appropriate sampling units were identified and various types of respondents were selected. The study employed multiple sampling strategies so as to obtain and generate nearly accurate data from the concerned groups.

The aim of the study was to investigate the electronic waste management and disposal methods in Addis Ababa. The significance of choosing of Addis Ababa as a study area can be explained in terms of three justifications. Firstly, there is an extremely large number of public and private organizations in Addis Ababa. It goes without saying that these organizations are handling an enormous amount of physical resources. There are also a large number of higher educational institutions that are managed by both the private and public sectors in the city. In addition to this, industries, business enterprises and public institutions that are found in the city could be major sources of e-waste. In other words, this simply means that they are using large volumes of electronic items and gadgets.

Secondly, there is widespread use of electronic equipment and related household appliances in the hundreds of thousands of dwelling units that are found in the city. Almost all activities are technology-driven in a city like Addis Ababa where the role of electronic equipment in making tasks easier is immense. What is more, the human development index of the city is relatively higher than those of the other urban areas in the country. In fact, the generally higher disposable income and relatively improved lifestyle that is observable in Addis Ababa can be an evidence of considerable dependency on the use of various electronic products.

Finally, the fact remains that a city is a place where new technologies and improved working and living styles are first adopted and then replicated in the regional capital, secondary cities and small towns of the country. Therefore, all these and other related factors have contributed much in prioritizing Addis Ababa as the site of the study**.** However, due to time, capacity and financial constraints, it was difficult to carry out the study in all households, business organizations, government and non-governmental organizations, educational institutions, industries, and companies.

Therefore, using a systematic random sampling mainly using a skip interval, the household heads were selected. For the qualitative aspects of the research, purposive sampling method was employed to select the respondents from Educational Institutions, and Governmental Sector Offices. This is done based on the presumption that EIs, GSOs, and HHs are among the leading producers of e-waste in Addis Ababa as tried to show in the previous survey conducted by the same writer. On the other hand, the study was conducted among the of households who typically have high disposable incomes and the willingness to spend their money on consumer gadgets. Beside this, HGOs were included in filling questionnaires and interviews.

Regarding the selection of the study sites, beyond its role of serving as 'the political capital of Africa' in large and Ethiopia in particular, Addis Ababa is a centre for numerous private and public educational institutions, NGOs and governmental organizations. Therefore, after identifying where the study should have to be carried out, then, the researcher had purposively selected eight PREIs, eight PUEIs, and eight GSOs. In addition, out of the total (10) sub-cities of Addis Ababa, the study purposively selected two well-known affluent sub-cities, namely Bole and Nefas Silk Lafto (NSL) sub-cities (See Table 4.1).

With regards to the study participants, similarly using a non-probability sampling technique, key respondents for this research were selected based on their intimate links with the issue under investigation and they were specifically approached as 'key informants'. Hence the sampling technique adopted was purposive sampling. Thus, EIs and GSOs (which the key informants are representing) such as property

administration directors, procurement officials and storekeepers hereinafter named as “GSD personnel” (General Service Department) were selected. Then, three GSD personnel from each of the EIs and GSOs were included in the study. This constitutes seventy-two (72) sample respondents, of which 48 were selected to fill the questionnaires while 24 interviewed.

In case of households, using a sampling frame of the population, the study selected fifty households from each sub-city as case study groups through a systematic random sampling, which made a total of one hundred. Finally, six (6) HGOs were purposively selected in filling the questionnaire and interviews. Table 4.1 presents selected HHs, EIs, and GSOs.

Table 4.1: Sample EIs, GSOs and sub-cities of Addis Ababa

S.N	PREIs	PUEIs	GSOs
1	Unity University (UU)	Ethiopian Civil Service University (ESCU)	Ministry of Education
2	Admas University	AAU FBE campus	Ministry of Health
3	Orbit IT College	EiABC	Ministry of Trade
4	Rift Valley University(RVU)	Kotebe Metropolitan University (KMU)	Ministry of Revenue
5	St. Marry University	AAU (Main Campus)	Ministry of Finance and Economic Development
6	PESC Information System College	Entoto TVET College	Ministry of Science and Technology
7	CPUC	Addis Ababa Science & Technology University (AASTU)	Ministry of Information and Communication
8	New Generation University	AAU Science Faculty (4KILO)	Ministry of Agriculture
HIGHER GOVERNMENT OFFICIALS/OFFICES CONSULTED			
FDRE, PPPAA		FDRE, PPDA	FDRE, MCIT
CRTC, Ethiopia		AA, CA	AA, SWRRDO
SUB-CITIES/HOUSEHOLDS			
BOLE SUB-CITY		NEFAS SILK LAFTO SUB-CITY	

Source: Survey, 2016

4.6. THE VARIABLES

As indicated in Table 4.2, the study identifies some of the variables to compute the independent t-tests, partial correlations, Pearson's Product Moment Correlation, Ordinal, Poisson and Multiple regression models.

Table 4.2: The selected variables of e-waste management

Independent Variables (IV)	Dependent Variables (DV)
➢ **Household Size** ➢ **Education Level** ➢ **Monthly Income** ➢ **Gender** ➢ **Organizations**	• Electronic Waste Generation Level • Electronic Waste Management Methods • Electronic Equipment Purchase Year • Types of Electronic Waste • Electronic Equipment Ownership • E-waste Management Practices

Source: Field Survey, 2016

4.7. DATA ANALYSIS METHODS

As discussed earlier, the study employed a mixed method approach. Thus before going into the analysis, the data collected through questionnaires, interviews, review of documents and observations were carefully organized. The data were checked and crosschecked in terms of quality, accuracy, and completeness of the responses. Then, description of data parameters and variables, determination of relationships between variables, and identification of important variables were carried out. The data were coded and tabulated so as to assist data entry. Thus, IBM Statistical Package for Social Sciences (IBM SPSS 21) version 21 was used to analyse the data systematically and scientifically by applying descriptive and inferential statistics. The qualitative data mainly interviews were analysed using ATLAS. Ti. 7 software.

4.7.1. Quantitative data analysis

4.7.1.1. The descriptive statistics

Descriptive statistics were widely used to analyse the data. This involved computation of simple frequency tables, mean, and standard deviations. It was used to summarize a group of data using a combination of tabulated description (i.e., tables), graphical description (i.e., graphs and charts) and statistical commentary (i.e., a discussion of the results).

4.7.1.2. Inferential statistics

4.7.1.2.1. Chi-square test

The chi-square test for independence also called Pearson's chi-square test or the chi-square test of association, is used to determine if there is a relationship between two categorical variables. It allows the researcher to determine whether variables are independent of each other or whether there is a pattern of dependence between them. It was tested at a significant level of 0.05. If the value computed from this statistics is less than 0.05, it indicates a significant association between the variables. Whereas if the value comes greater than 0.05, it indicates there is no association between the categorical variables. With this understanding, the chi-square test was employed mainly for households' e-waste management. For example, it was aimed to know whether gender (male/female) is associated with study locations (Bole/NSL), education level with study locations, awareness towards e-waste with education level, e-waste management methods with income, engagement level with monthly income etc.

4.7.1.2.2. Independent samples t-test

The independent-samples t-test compares the means between two unrelated groups on the same continuous, dependent variable. It was used in this study to determine the variations in the households' volume of electronic waste based on gender, income, and education level. Besides, the variations in the households' volume of

electronic equipment purchased in the different period of time year based on the income of the households were computed. It was tested at a significant level of 0.05.

4.7.1.2.2. Partial correlation and Pearson's product moment correlation

Partial correlation is a measure of the strength and direction of a linear relationship between two continuous variables whilst controlling for the effect of one or more other continuous variables (also known as 'covariates' or 'control' variables). It was used in this study to measure the relationships between electronic waste volume and monthly income whilst controlling for family size. On the other hand, the Pearson's product-moment correlation also known as the zero-order correlation between was computed to see the strength of the relationship between the volume of e-waste "and "monthly income" and between monthly income and obsolete e-waste generation of the households.

4.7.1.2.3. One way ANOVA

The one-way analysis of variance (ANOVA) is used to determine whether there are any statistically significant differences between the means of two or more independent (unrelated) groups. In light of this, using this test statistics, the study attempted to determine whether the total quantity of electronic equipment, newly purchased electronic equipment, second-hand equipment, and those owned from donating organizations differed PREIs, PUEIs, and GSOs. Besides, it was computed to check whether total electronic waste, broken, obsolete and non-functional e-waste differ among PREIs, PUEIs, and GSOs. Furthermore, the ANOVA table was also produced to check whether there is a significant difference among selected EIs and GSOs in terms of the management actions taken towards e-waste (donating, selling, storing, incinerating, dumping, and recycling). They all were tested at 0.05 significant levels.

4.7.1.2.4. Ordinal logistic regression model

Ordinal logistic regression is a statistical technique that is used to predict the behaviour of ordinal level dependent variables with a set of independent variables. The dependent variable is the order response category variable and the independent variable may be categorical or continuous. It is used to predict the ordinal dependent variables given one or more independent variables. Thus, an ordinal regression model was carried out to predict the effects of gender, educational status and monthly income of the households on the ordinal dependent variables i.e. the households' level of engagements in some of the e-waste management related activities/practices asked on three-point Likert scale ranging from "never" to "always". Similarly, it was also conducted to predict the ordinal dependent variables i.e. the institutions' level of engagement in some of the e-waste management practices based on institution type. These were also asked on three-point Likert scale ranging from "never" to "always".

4.7.1.2.5. Multiple linear regression models

A multiple linear regression models is used to predict the value of a variable based on the value of another variable. The variable we want to predict is called the dependent variable (or sometimes, the outcome variable). The variable that is using to predict the other variable's value is called the independent variables (or sometimes, the predictor variable). Thus, a multiple regression was computed to predict the volume of household's electronic waste based on gender, monthly income, family size and educational status. The R, R squares, ANOVA tables, coefficients, and residuals were all computed. Consequently, the volume of e-waste was predicted based on the independent variables identified in this study. The assumptions of linearity, homoscedasticity, and normality have met for multiple regression.

4.7.1.2.6. Poisson regression model

Poisson regression is used to test for associations between predictor and confounding variables on a count outcome variable when the mean of the count is higher than the variance of the count. Poisson regression is interpreted in a similar fashion to logistic regression with the use of odds ratios with 95% confidence intervals.

4.7.2. Qualitative data analysis

The qualitative data were acquired through the interviews and observation. The data were first checked and cross-checked to increase accuracy and identify incomplete responses. Those audio recorded data were transcribed verbatim. Then, a qualitative analysis software named ATLAS.ti.7 was used by creating a Hermeneutic Unit (HU) or a project. An HU contains all of the documents, quotations, codes, memos, and associated files that make up the interview results. Then, various codes, quotations, categories and thematic areas were identified. For the sake of clarity and simplicity, for all of the data obtained through interview, first, the interview topics along with core interview results and codes were prepared in the form of a table. Then, based on the table, discussions were made for each result by applying direct quotations. On the other hand, results obtained through observations were analysed both in tables and pictures. All that has been observed using observation guides and photographs were carefully described in tables and depicted in pictures respectively. Finally, detail explanations were provided for both of the results in the table and pictures.

4.8. DATA PRESENTATION TECHNIQUES

Finally, the presentation is the last stage where all the managed, classified and interpreted data are presented and reported. The research points out the analysed data to the research question, objectives and the related literature. Intensive discussions were made. The quantitative data was then presented using various techniques including bar graphs, pie charts, histograms, tables and etc. The data

included raw data or direct quotations from participants particularly those that were qualitative in character.

4.9. THE VALIDITY AND RELIABILITY TESTS RESULTS

In this study, the validity and reliability of the findings were ensured through various methods. The validity of the findings from the study was computed by employing a mixed methods research approach that enables researchers to integrate multiple data sources and methods. The quantitative and qualitative data collection instruments were employed to collect the requisite data.

The Cronbach's Alpha Coefficient (also known as coefficient alpha technique) is statistical test used to determine the reliability or internal consistency of the questionnaires. The researcher conducted a pilot test before the actual data collection phase to determine the internal consistency among the question items. Based on the results from the pilot test, some modifications were made to the questionnaires that lacked the consistency to obtain high-quality data. Consequently, after collecting the data for this study, the researcher checked the reliability of the items. The reliability tests were computed independently for the questionnaires that were designed for HHs and for the EIs and GSOs.

Table 4.3: The result of reliability statistics of the data

S.N	Cases	Number of Items	Cronbach's Alpha
1	Households	35	.789
2	Educational Institutions and Government Sector Offices	51	.706

Source: Field Survey, 2016

Thus, the reliability test result was obtained (See Table 4.3). According to Saunders *et al.* (2003), alpha values greater than 0.70 are an indication of acceptable internal reliability. The value of Cronbach's Alpha for the items is all within 0.789 and 0.706 range respectively for HHs, and EIs and GSOs. Therefore, the result established

good justification for employing or administering these instruments to undertake the study.

4.10. ETHICAL CONSIDERATIONS

It is essential to consider important ethical aspects before, during and after data collection phases. Throughout the whole research process including during the phases of data analysis and dissemination of findings to ensure that the final report of the thesis provides an honest, fair and unbiased account and does not negatively affect those who participated in the research. In fact, in order to undertake the study in the study area, a permission letter was required from one of the government authorities such as the Addis Ababa City Administration and the Ethiopian Public Property and Procurement Agency.

Beside this, to ensure that no key informants should suffer as a consequence of their involvement with the research, strict confidentiality and anonymity of respondents were guaranteed. What is more, to ensure that the interests of all parties are protected, the respondents kept informed about the aim of the research and objectives of the questionnaire, interview, and observation. Last but not least, they were required not to participate in the study unless they have formally consented to partake in the study.

4.11. CONCLUSION

This study employs both descriptive and explanatory type of research designs based on the nature, types, and purpose of the data. It employs a triangulation research approach. Data were obtained from primary and secondary data sources. The data collection tools were questionnaires, interviews, document reviews, and observations. The study has attempted to investigate the cases of selected HHs, EIs, and GSOs of Addis Ababa. It employs both systematic random sampling and purposive sampling technique to select the respondents of the study. As far as the EIs and GSOs are concerned, three GSD personnel from each of the EIs and GSOs

were included in the study. This constitutes seventy-two (72) sample respondents. On the other hand, in case of households, the study selects fifty (50) HHs from each sub-cities as a case study area, which gives hundred (100) HHs using a systematic random sampling. Finally, six (6) HGOs were participated in filling the questionnaire and interviews. Some of the variables were identified to compute independent t-tests, partial correlations, Pearson's Product Moment Correlation, Ordinal, Poisson and Multiple regression models. The data were coded and tabulated so as to assist data entry. Thus, IBM Statistical Package for Social Science version 21 (IBM SPSS 21) was used to analyse the data systematically and scientifically by applying descriptive and inferential statistics. On the other hand, for a qualitative data analysis, ATLAS.ti, 7 software was computed by creating a Hermeneutic Unit (HU) or a project. Before the administration of the final version of the questionnaire, the reliability test result was obtained. Accordingly, the value of Cronbach's Alpha for the items is all within 0.789 and 0.706 range respectively for HHs and EIs and GSOs. The next two consecutive chapters present the findings of the study obtained from the HHs, EIs, and GSOs of Addis Ababa.

CHAPTER FIVE

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT MANAGEMENT IN THE HOUSEHOLDS OF ADDIS ABABA

5.1. INTRODUCTION

The aim of this study was to investigate the electronic waste management and disposal methods in Addis Ababa, Ethiopia. It attempted to examine e-waste management in HHs, EIs, and GSOs of Addis Ababa. To this end, data were acquired through questionnaires, in-depth interviews, document reviews and observations. This chapter, therefore, presents the results of the study obtained from the households of two affluent sub-cities of Addis Ababa such as Bole and NSL sub-cities. Accordingly, 100 households were involved in the study. Since the survey was carried out in the face-to-face method of data collection, all the participants filled and returned the questionnaires. This makes a high response rate.

In general, for the sake of clarity and simplicity, the results were organized and structured as sub-topics. The first sub-topic presents and discusses background profile of the study participants. Secondly, households' awareness as regards e-waste and e-waste management are also presented. Then, e-waste generation level, types, and characteristics are discussed. Fourthly, the causes, management methods and disposal of electronic waste management are addressed. What is more, the households' engagement level in e-waste management practices has also been presented. Finally, results from the independent t-tests, correlations, ordinal, Poisson and multiple regression models are presented.

5.2. BACKGROUND PROFILE OF THE HOUSEHOLD RESPONDENTS

Table 5.1 provides the background profiles of the sample households that participated in this study. As mentioned earlier, the study establishes sample respondents of households from two affluent neighbourhoods of Addis Ababa city such as Bole and Nefas Silk Lafto (NSL) sub-cities. Profoundly, the study investigates the demographic and economic characteristics of the sample respondents with the assumption that they are among the determinants of e-waste management. Accordingly, the households' demographic characteristics such as gender, educational status, and family size were described. Besides, the households' economic characteristics mainly the monthly income was presented.

Concerning the gender composition of the participants, as shown in Table 5.1, male-headed household accounted 59% while female-headed household constituted 41%. With regard to the monthly income of the households, the study selected household heads of Bole and NSL sub-cities on a systematic random sampling basis with the assumption that they have high disposable income to rely on electronic and electrical equipment. Thus, the majority of the participants (77%) earned monthly incomes that were greater than 25,000ETB. This particularly the case mainly among Bole residents. Comparatively the remaining, 23% of the respondents had monthly incomes that fell between 10,000 and 25,000ETB. Most of those who fell in this income category were NSL residents. The mean income of the total respondents was 35,550.00ETB. As far as family sizes are concerned, the majority of the households (58%) had a family size ranging from 1-5, and 41% are ranged from 6-10. The mean household size of all of the respondents was 5.22 per household. This indicates that the majority of the participants have large family sizes, a phenomenon which might have an implication on the volume of e-waste they generate.

Lastly, the educational qualification of the respondents varied from certificates for completing high school or some form of pre and post grade 12 training to Ph.D. of which 30% of them held the BA or BSc. degree. Comparatively, about 14% of the respondents had educational qualifications that ranged from the completion of grade 6 to grade 10, which constitutes relatively equal proportion with respondents holding

a certificate (13%), diploma (13%), M.A/M.Sc. (17%) and Ph.D. (13%). Similar to monthly income, the findings of the study shows the selected household heads were educated sample households, hence, 86% of the sample respondents held the educational qualification above diploma.

Table 5.1: Profile of sample respondents

Variables	Description/Category	Count	%	Total
Gender	Male	59	59	100
	Female	41	41	
Sub-city	Bole	50	50	100
	NSL	50	50	
Monthly income	10,000-25,000ETB	23	23	100
	>25,000ETB	77	77	
Family size	1-5	58	58	100
	6-10	41	41	
	11-15	1	1	
Educational qualification	Certificate	13	13	100
	Diploma	13	13	
	Degree	30	30	
	M.Sc./M.A.	17	17	
	PhD	13	13	
	Other	14	14	

Source: Field Survey, 2016

With regard to the gender-educational status aspects in respect of the two sub-cities as indicated in Table 5.2, the "Pearson Chi-Square" results are χ^2 (1) = 7.509, *p* = .185, which is p>0.05, for Bole Sub-city and χ^2 (2) = 3.214, P = .667, which also have a p-value of greater than 0.05 for NSL sub-city. This indicates that there is no statistically significant association between gender and educational status of the sample respondents in both sub-cities. Likewise, the educational qualification of the respondents depicts no significant difference among the educational qualification of the respondents in both sub-cities as a χ^2 test is 2.18, p = .824.

On the other hand, the study attempted to examine whether any associations were existed between the educational qualifications and monthly incomes of the respondents as well as between the gender and monthly incomes. Accordingly, the χ^2 test revealed that there is no a systematic association between households educational status and monthly income (χ^2 = 219.163, p=.503). Besides, the study also reveals there is no significant association between gender and monthly income of the households (χ^2=37.829, p=.732). However, there were significant associations between the monthly income and the sub-cities (χ^2 = 61.210, p=.044), and between educational status and family size of the households (χ^2 =69.270, p=.037).

Table 5.2: The Chi-square test results on the associations among variables

S.N	Crosstab	Valid	X^2	Sig.
1	Gender-educational status	100	6.002	.306
2	Gender-monthly income	100	37.829	.732
3	Educational status-monthly income	100	219.163	.503
4	Gender-sub-cities	100	.041	.839
5	Monthly income-sub-cities	100	61.210	.044
6	Family size-sub-cities	100	8.357	.594
7	Educational status-sub-cities	100	2.181	.824
8	Educational status-family size	100	69.270	.037

Source: Field Survey, 2016

5.3. AWARENESS OF THE E-WASTE AND ITS MANAGEMENT

E-waste is a recently growing waste and its concept was not widely understood by the people. Borthakur and Singh (2012) stated that the lack of public awareness regarding the disposal of electronic goods and inadequacy of policies to handle the issues related to e-waste increase the problem. The authors further asserted that due to the lack of awareness, some people discard e-waste with regular municipal solid waste which is an extremely dicey practice. One of the objective of the study was concerned with households' awareness of the existence of e-waste and e-waste management related aspects. To this end, data was gathered from households

through close and open-ended questionnaires. The focuses of the questionnaire include households' awareness about the concepts of e-waste, volume they generate, the environmental and health impacts of e-waste, local or international laws and activities towards e-waste, and safe disposal of e-waste. Therefore, this section presents the findings of the study acquired from the households in this regard. Further discussions were presented to this particular sub-section under chapter seven.

5.3.1. E-waste concept

The study verified that the majority of the respondents (60%) known what does it mean by e-waste. About 23% had no knowledge of e-waste while 17% were uncertain about what exactly was (See Figure 5.1). Based on the understanding that educational status might influence peoples' awareness, the researcher was interested in looking at their association.

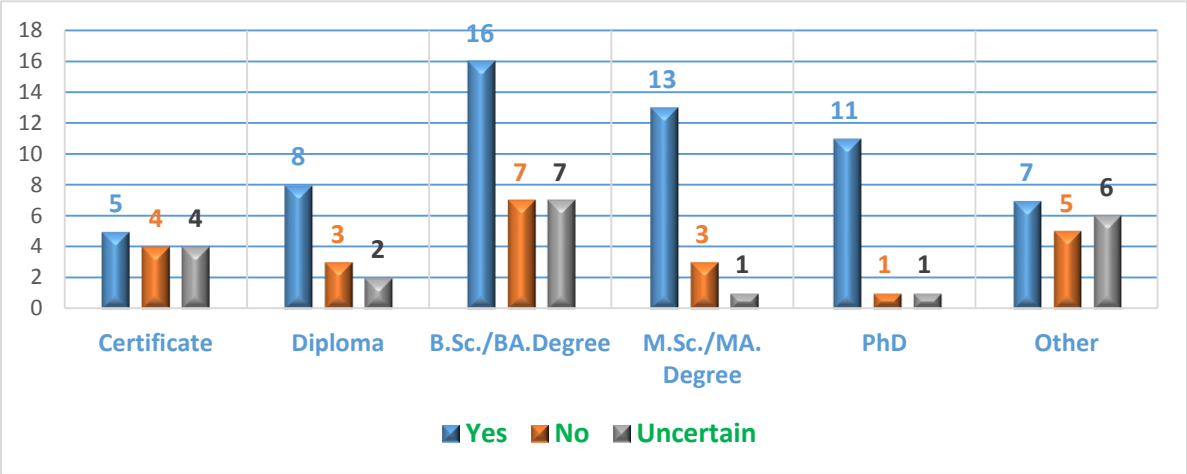

Figure 5.1. Concepts of e-waste based on educational qualifications

Source: Field Survey, 2016

Accordingly, the chi-square test result produced from the statistics χ^2 was 10.547 while p was .394 (P>0.05). Therefore, there is no significant association between educational qualification of the respondents and their awareness about the existence of e-waste as an element of municipal solid waste. The symmetric measures' results

of Phi was .325 while Cramer's V was .230 indicating the existence of a strong association between the variables is very weak.

5.3.2. Consciousness on the volume of e-waste generated

The study explores whether households are conscious of the volume of e-waste that they generate. As illustrated in Figure 5.2, it was found that majority of the respondents (46%) were not conscious of the volume of e-waste they generate, while 30% were uncertain about it. The χ^2 test result to see whether there is a significant difference between the two sub-cities is χ^2 =3.148, p =.207. Hence, p>0.05, there is no significant difference between Bole and NSL households regarding the extent they are conscious of the volume of e-waste they generate.

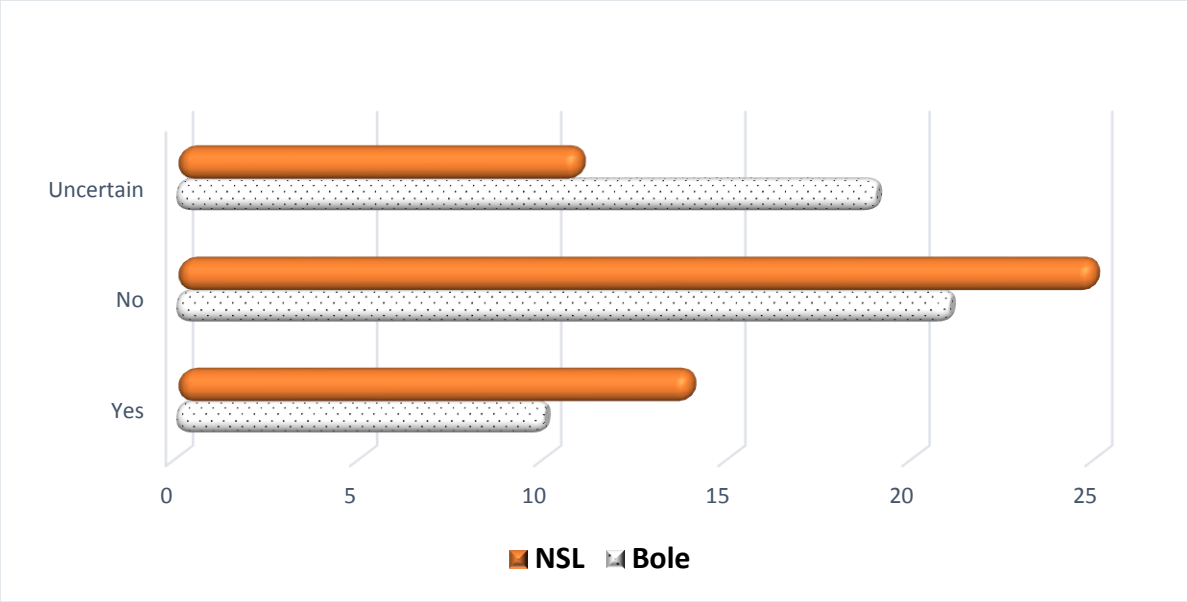

Figure 5.2. Consciousness of electronic waste generated

Source: Field Survey, 2016

5.3.3. The environmental threats of e-waste

Peoples' awareness's and understandings about the environmental impacts of e-waste have considerably influenced its management. In light of this, the questionnaire requested the household participants whether e-waste poses a threat to the

environment. Accordingly, 45% of the respondents agreed that e-waste poses a threat to the environment. About 36% were uncertain about this issue while 19% stated that e-waste has no environmental impacts (See Figure 5.3). This indicates that the respondents were aware of the environmental impacts of e-waste. In addition to this, an attempt was made to find out if educational qualification had any impact on the responses made concerning the impact e-waste on the environment. The result of the chi-square test on this issue was 23.334 with $p = .010$, $p<0.05$, which is statistically significant that indicating that the educational status influences the respondent's understanding of the impact of e-waste on the environment.

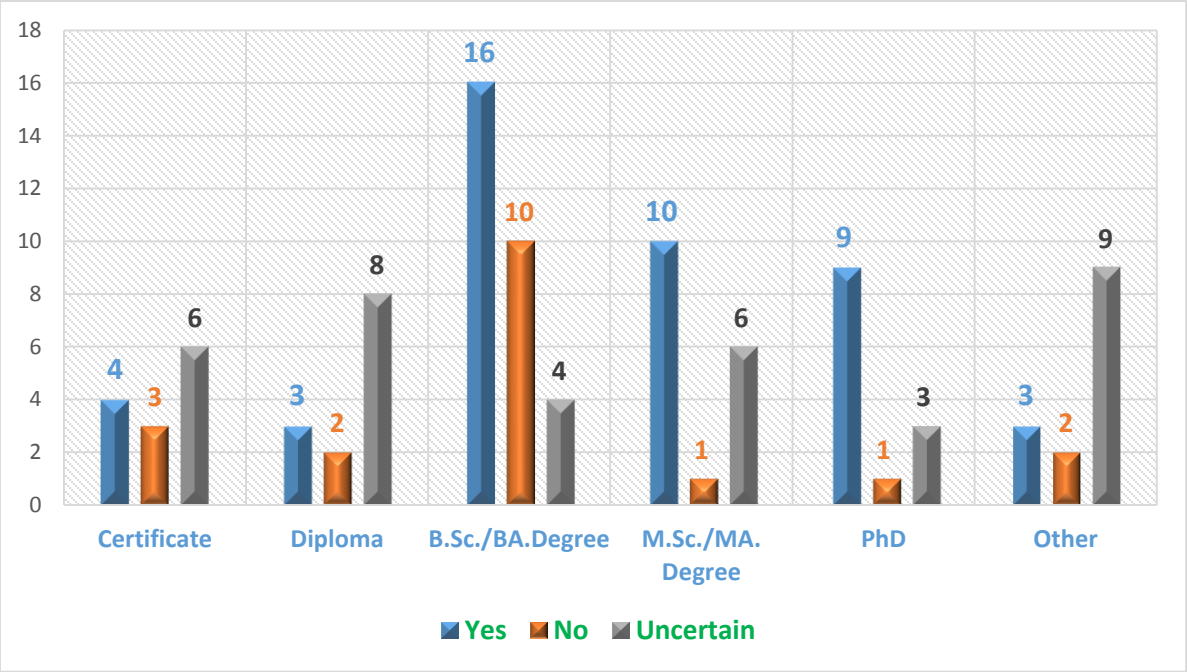

Figure 5.3. Environmental threats of e-waste and educational qualifications

Source: Field Survey, 2016

5.3.4. Health risks of e-waste

Similarly, awareness about the health risks associated with improper disposal of e-waste might embolden the households to take care of themselves and their families from inappropriate disposal and handlings of e-waste. In this regard, the study

highlighted that half of the respondents (50%) were not aware of health risks associated with e-waste, whilst 13% of them were uncertain about it. The χ^2 test result (1.073, p=.585) was not statistically significant. Therefore, in both sub-cities, the awareness of the respondents about the health risks of e-waste was found to be very low.

5.3.5. The safe disposal of e-waste

By its nature, e-waste is composed of hazardous materials. The disposal associated with electronic waste need special care and should only be performed with great care. In this aspect, among 100 households who responded to this particular question, the majority of the respondents (44%) claimed to be not aware that some hazardous fractions of e-waste needed a special treatment in order to be safely disposed of.

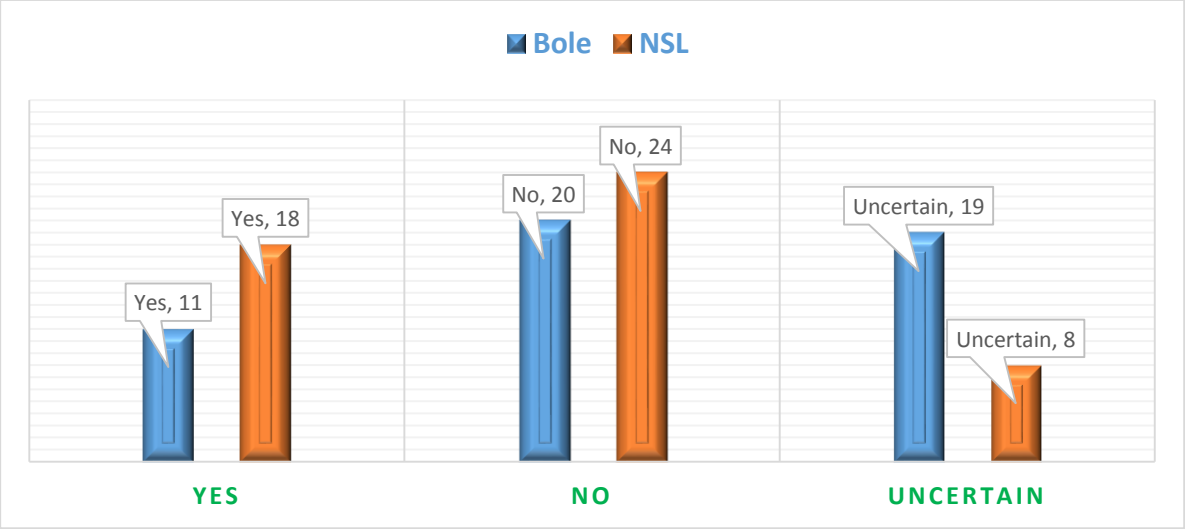

Figure 5.4. Awareness of the safe disposal of e-waste

Source: Field Survey, 2016

About 29% of the respondents were aware of the need to dispose of hazardous wastes safely while the remaining 27% were unsure whether or such a precaution was necessary when disposing of e-waste (See 5.4). Thus, it can be seen that most of the respondents were not aware of the need for the safe disposal of e-waste, and

it is needless to say that such a lack of awareness would negatively affect the proper e-waste management. The chi-square test to see whether there was a significant difference between the two sub-cities showed a significant difference. The result is $X^2 = 6.535$, p = .038 since p-value is less than 0.05, it can be determined that awareness regarding this item was highlighted the significant difference that NSL sub-city's respondents were more aware of it.

5.3.6. The safe disposal of used dry-cell batteries

Studies indicate that mobile phone is one of the fast growing types of e-waste in the world due in part to its very short lifespan. Besides, due to its relative affordability and rapid obsolescence rate, it would add a significant volume of e-waste. Moreover, the disposal of cell phone batteries needs special attention because if thrown down with other domestic wastes, it might pose a threat to the environment. In light of these, the responses obtained through a questionnaire, revealed that the majority of the respondents (56%) were aware of the fact that used dry cell batteries needed to be disposed of as safely as possible. Comparatively, about 33% of them were not aware of this reality. The X^2 test made to check whether or not the respondents from the two sub-cities responded differently showed that there was no significant difference in their levels of awareness of this particular issue. Hence, $X^2 = .649$, p=.723.

5.3.7. Local or international laws toward e-waste

Unlike other types of waste, e-waste management is a complex and challenging task due to its hazardous components. Therefore, it requires the formulation and enforcement of laws, legislation, and guidelines that specifically deal with it to minimize the impacts it might pose to the environment and health. What is more, awareness creation program should address this component so that customers/users

should abide by those laws and guidelines during the purchase, operate, recycle and disposal of the electronic equipment.

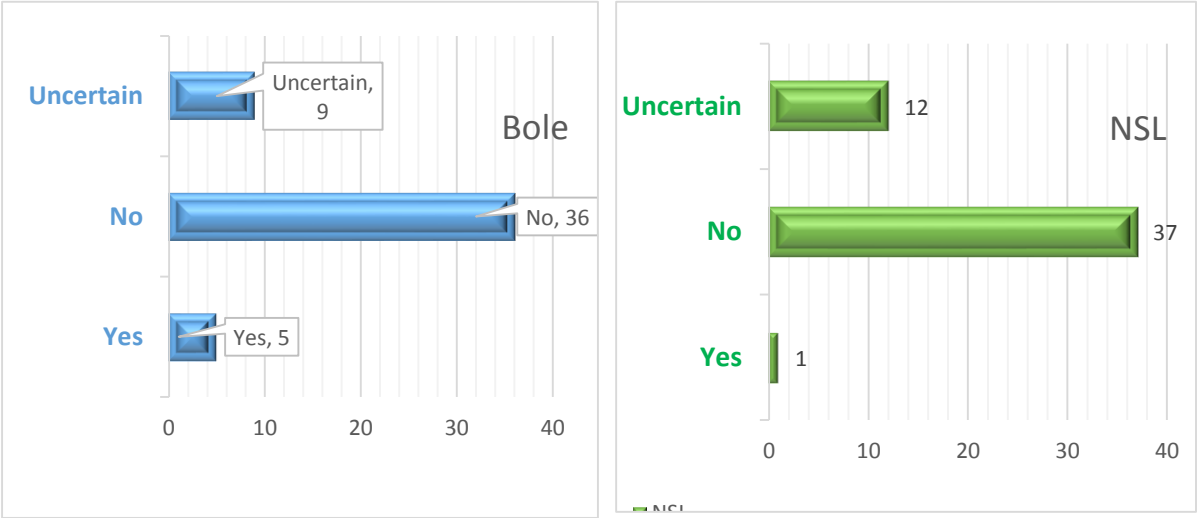

Figure 5.5. Awareness of local or international laws governing e-waste

Source: Field Survey, 2016

In this sense, the study explores whether the selected households were aware of any local or international laws pertaining to e-waste. The study found, as it can be observed from the Figure 5.5, that the majority of the respondents (73%) did not know any local or international laws or regulations pertaining to e-waste management. The chi-square result (χ^2=3.109, p=.211) indicated that no significant difference existed between the respondents of Bole and NSL sub-cities concerning the awareness of e-waste management laws.

5.3.8. Local programs and projects pertaining to e-waste

E-waste management has put up formidable challenges to developing countries. The governments should involve multi-stakeholders by launching various programs and projects to create awareness, to collect, dismantle, refurbish, recycle and dispose of electronic waste. As far as the awareness of the households is concerned, the respondents were asked a question regarding this issue. Thus, it was verified that their awareness of the local programs, projects, and activities pertaining to e-waste

management was very low. As it is indicated in Figure 5.6, the majority (65%) of the respondents were not aware of local activities or projects concerning e-waste management while 21% were uncertain about it.

Figure 5.6. Awareness of programs and projects in e-waste management

Source: Field Survey, 2016

5.3.9. Selling off parts of e-waste

E-waste has not only containing hazardous chemicals but it contains valuable parts which can be vented to the market. Thus, awareness creation in this regard will embolden the households to appropriately handle and dispose of e-waste. The result obtained from the survey showed that the majority of the respondents (48%) were not aware of some electronic parts that could be profitably sold to recyclers, whereas only 29% were aware of it. The χ^2 test was computed to see whether any difference between Bole and NSL respondents in responding to this question. The result of the chi-square test (χ^2 = 6.708, p = .013) showed statistically significant. In general, the respondents of NSL sub-city were found to be more aware of the fact that some electronic parts could be profitably sold to recyclers than Bole residents.

5.4. E-WASTE GENERATION LEVEL, TYPES, AND CHARACTERISTICS

This section presents the households e-waste generation level, types, and characteristics of e-waste. The study attempted to investigate about twenty types of household e-waste. To this end, data were acquired through a review of documents and questionnaires. Accordingly, the overall volume, types, characteristics, the purchasing periods, lifetime and storage years of the items were presented.

The data obtained from the households described the existence of differences in e-waste generation level among Bole and NSL sub-cities. Accordingly, Bole sub-city has the highest mean value of 104, maximum 176, and minimum 56 with high variation from the mean SD, 29. Whereas, NSL sub-city is with the lowest mean value 54, maximum 77, minimum 34, and SD of 11.616 as compared to Bole (See Figure 5.7).

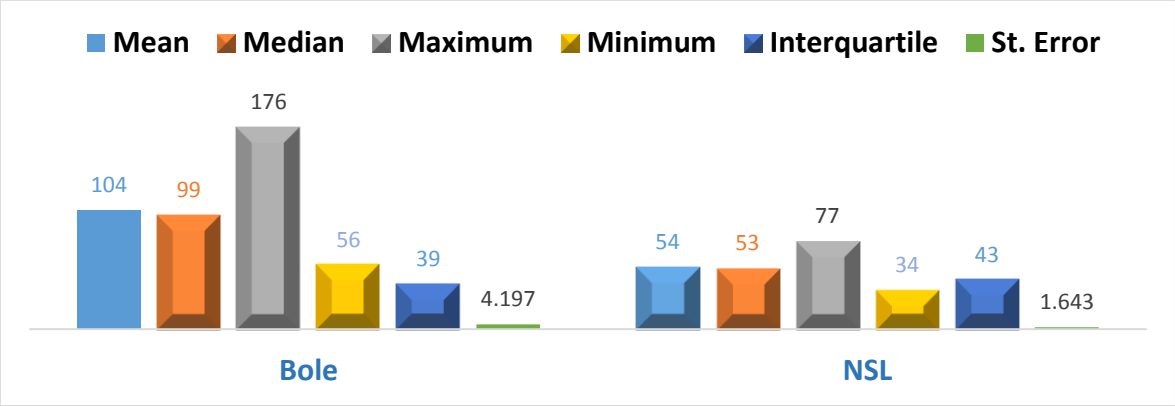

Figure 5.7. Comparison of e-waste generation level
Source: Field Survey, 2016

The Table 5.13 and Figure 5.8 depicts a total volume of e-waste generated by households of Bole and NSL sub-cities. It was found that a total of 7,943 e-waste were generated in both sub-cities. This number constitutes all broken (not to mean broken parts of an electronic equipment), obsolete and non-functional e-waste. It should be clear that this number includes not only e-waste currently available at home but includes that e-waste sent for maintenances and refurbishments.

A total of 4,010 (non-functional), 2,077(obsolete), and 1,856 (broken) e-waste were generated. Non-functional (NF) electronic waste accounts for 51% of the total e-waste while obsolete (O) and broken (B) makes 26% and 23% respectively. In this aspect, we can see that the volume of non-functional electronic waste is very high followed by obsolete and broken e-waste. However, a high share of non-functional electronic waste is associated with the inclusion of a maximum number of CDs/VCDs/DVDs, headsets/earphones and fluorescent lamps within this category. What is more, there are differences in volume of e-waste among the households based on their location. Accordingly, Bole sub-city has generated the highest volume of e-waste (5,211) which accounts for about 65% of the total e-waste than NSL sub-city (2,732), which makes 35% of the total e-waste generated by the respondents in this two sub-cities.

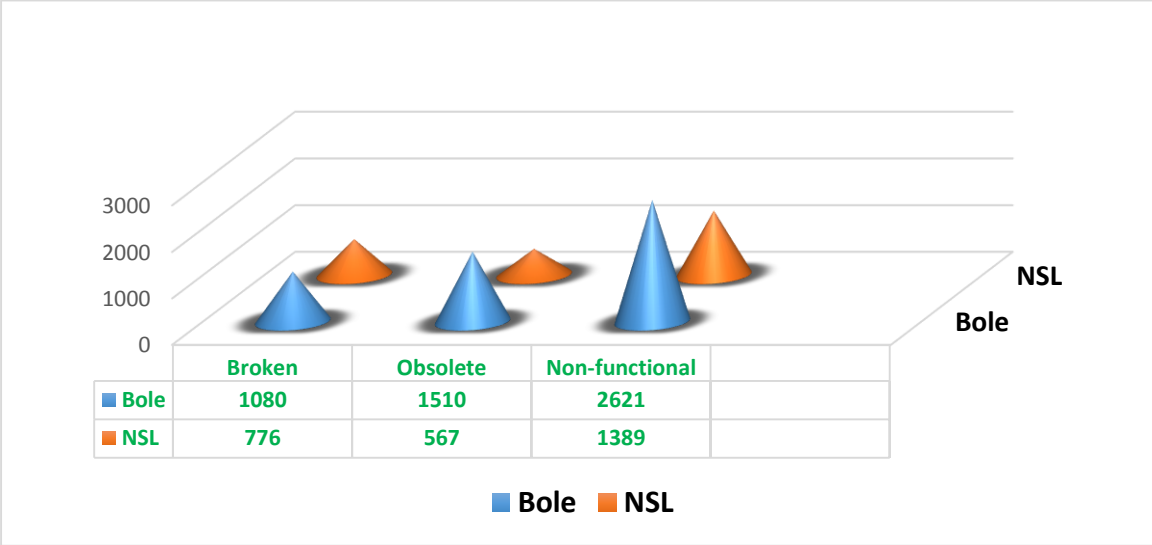

Figure 5.8. Quantities and types of e-waste generation

Source: Field Survey, 2016

Figure 5.8, shows the types of electronic waste generated by the respondents both in Bole and NSL sub-cities. Accordingly, the study identifies the most generated types of electronic waste in both sub-cities. This includes batteries of different categories, CDs/VCDs/DVDs, fluorescent lamps/bulbs, headsets/earphones, cell phones. There are also a significant number of tape recorders, MP3/VCD/DVD Players, television sets and computers/laptops were generated. As it was said non-functional and

obsolete electronic waste is the predominantly generated types of e-waste. Accordingly, the most frequently generated non-functional e-waste were CD/VCD/DVDs, washing machines, MP3/MP4 players, printers/cartridges, headsets/earphones, flat iron, air conditioner, fluorescent lamps, and microwave/ oven. On the other hand, computers/laptops, cameras, tape-recorders, cell phones, television sets, radio sets and VCD/DVD players were found to be the most obsolete types of e-waste (See Table 5.3 and Figure 5.9).

Table 5.3: The quantities and types of e-waste

S. N	Electronic Items	E-waste Generation Level (Bole)				E-waste Generation Level (NSL)			
		B	O	NF	Total	B	O	NF	Total
1	Computer/Laptop	32	67	41	140	0	20	25	45
2	Camera	35	122	55	212	0	61	28	89
3	Tape Recorder	38	64	34	136	16	56	33	105
4	Cell phone	32	103	45	180	31	54	61	146
5	Television	18	75	9	102	32	25	13	70
6	Mp3/Mp4 Player	27	15	31	73	8	14	0	22
7	Radio/Hi-Fi Set	42	64	35	141	28	14	18	60
8	CDs/VCDs/DVDs	270	321	943	1534	138	0	234	372
9	Printer + Cartridges	16	7	19	42	0	7	7	14
10	VCD/DVD/CD Player	47	67	42	156	31	14	58	103
11	Headset/Earphones	132	125	223	480	89	49	287	425
12	Batteries	127	143	546	816	75	111	322	508
13	Telephone	8	87	18	113	9	28	13	50
14	Microwave/Oven	21	3	32	56	21	0	32	53
15	Refrigerator	23	16	23	62	42	12	26	80
16	Flat Iron	11	14	33	58	7	4	14	25
17	Washing Machine	21	9	31	61	28	0	25	53
18	Air-Conditioner	8	12	31	51	9	7	33	49
19	Electric Fan	27	21	23	71	11	12	35	58
20	Fluorescent Lamps/Bulbs	145	175	407	727	201	79	125	405
Total		1080	1510	2621	5211	776	567	1389	2732

Source: Field Survey, 2016

NB: B=Broken, O=Obsolete NF= Not functional

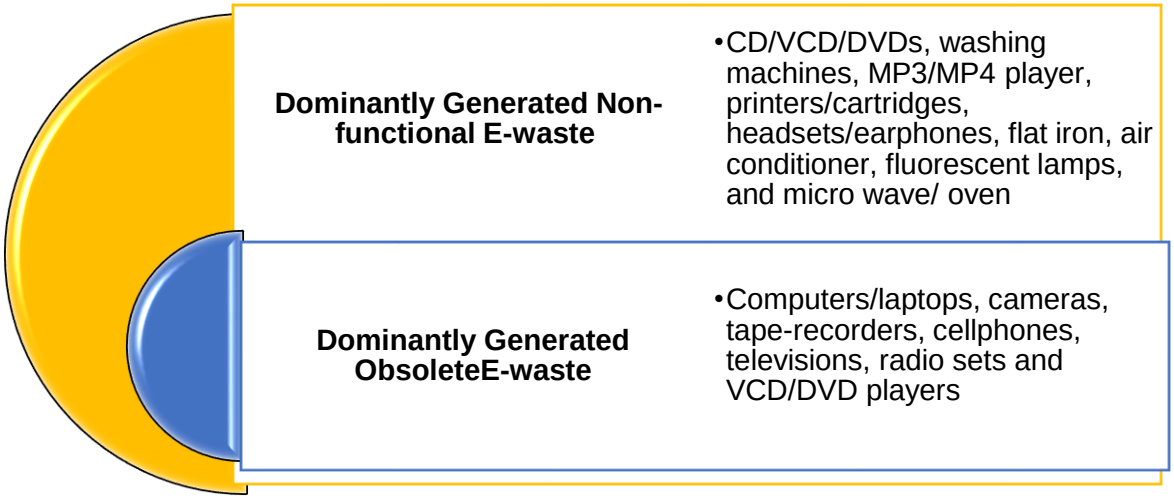

Figure 5.9. Dominantly generated non-functional and obsolete e-waste

Source: Field Survey, 2016

Figure 5.10, Figure 5.11 and (Table 8.1 under appendixes) present the lifetime and storage years of households' electronic equipment in both Bole and NSL sub-cities. For instance, in Bole sub-city, out of the total 5,211 electronic waste, about 3,203 or 62.5% were gadgets that served less than a year. In addition, about 1,297, which accounted for 25%, have served from one up to five years. Furthermore, 530 (10%) and 181 (3.5%) served from five to ten years and above ten years respectively.

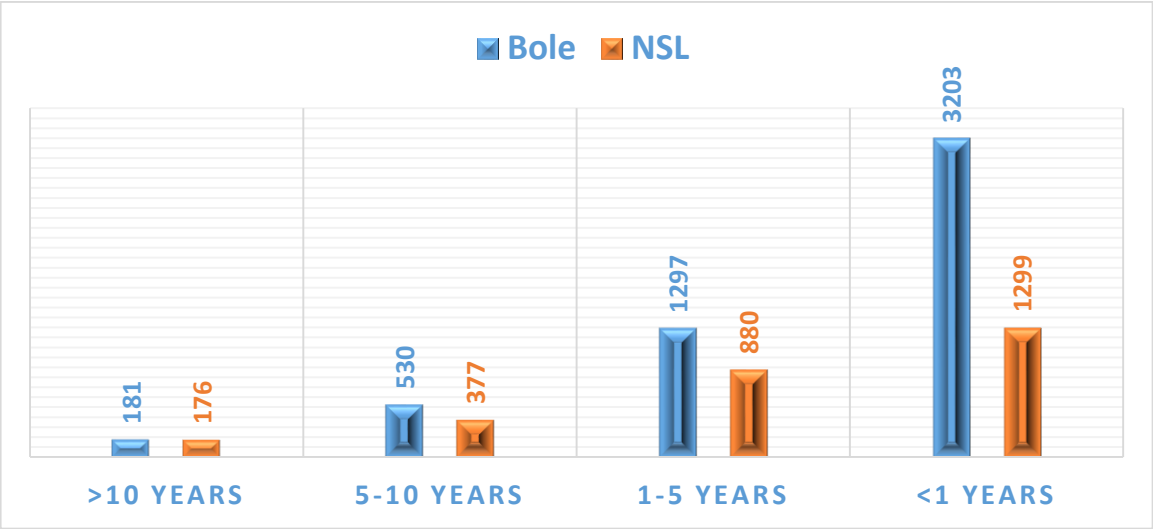

Figure 5.10. Electronic equipment service years

Source: Field Survey, 2016

When we look at NSL sub-city, out of 2,732 total e-waste, about 1,299 (47.5%) served less than a year, while 880 (32.2%) served from one up to five years. The remaining 377 (13.8%) and 176 (6.5%) served from 5-10 and greater than 10 years respectively. In both cases, the largest value is for electronic equipment, which served less than a year. In fact, this was due to the fact that the greater number of CDs/VCDs/DVDs, fluorescent lamps, headsets/earphones, and batteries, which have the shortest lifespan. From this result, it can be observed NSL sub-city households served relatively longer year than those of Bole sub-city households.

When it comes to the storage years of electronic waste, for instance, in Bole sub-city, out of 5,211 total e-waste, 363 (7%) of them were stored for more than 10 years, 976 (18.7%) stored for 5-10 years, 2,268 (43.5) stored from 1-5 years and 1,604 (30.7%) stored less than a year. As far as NSL sub-city is concerned, out of 2,732 total e-waste, 105 (3.8%) stored for more than ten years, 252 (9.2%) stored from 5-10 years, 1,646 (60.2%) stored from 1-5 and 729 (26.6%) stored less than a year.

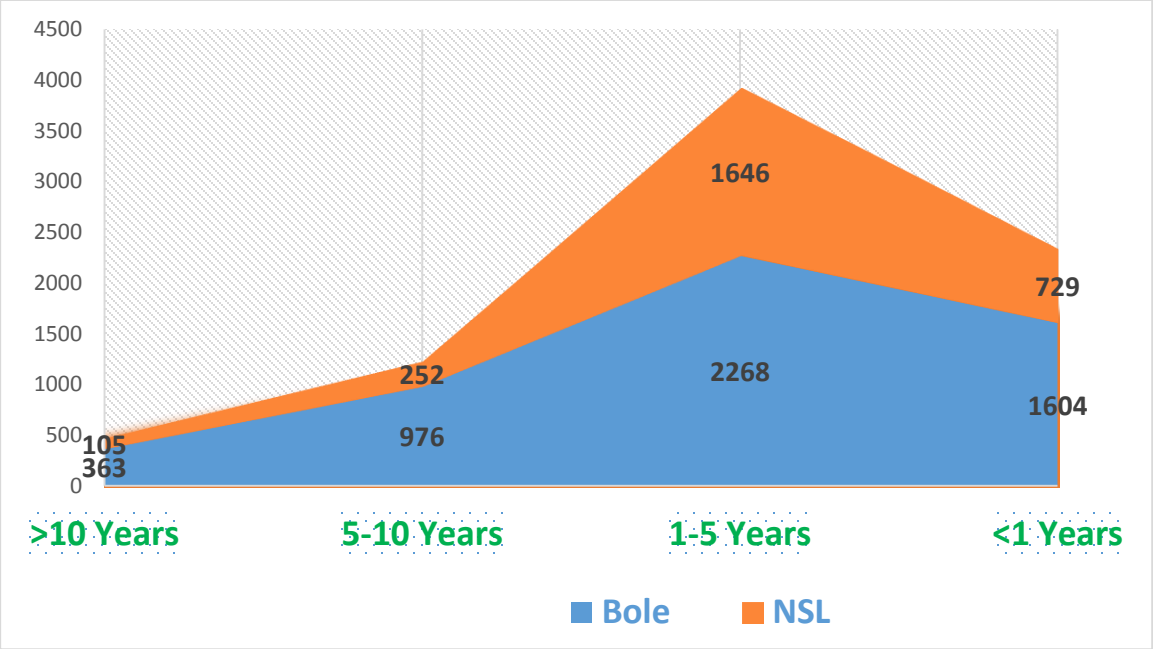

Figure 5.11. E-waste storage years

Source: Field Survey, 2016

As indicated in (Table 8.1 under appendixes), electronic items such as camera, tape-recorder, radio, television, refrigerators and telephones have a service year of greater than ten while CDs/VCDs/DVDs, batteries, headsets/earphone, fluorescent bulbs have relatively a shortest lifespan that most of them have served less than a year.

The study examines the purchase year of households' electronic equipment in the selected sub-cities to see the effects of scale economies, technologies, and tests of the people towards electronic appliances consumption. As depicted in the Figure 5.12, of the 7,943 total electronic waste the maximum purchase which accounted 3,609 (45.4%) took place between 2005 & 2015, and 2,574 (32.4%) were purchased after 2015. It can be understood that the purchase of electronic equipment was increasing from time to time and the highest number took place in the years between 2005 & 2015 and the lowest volume was before 1993.

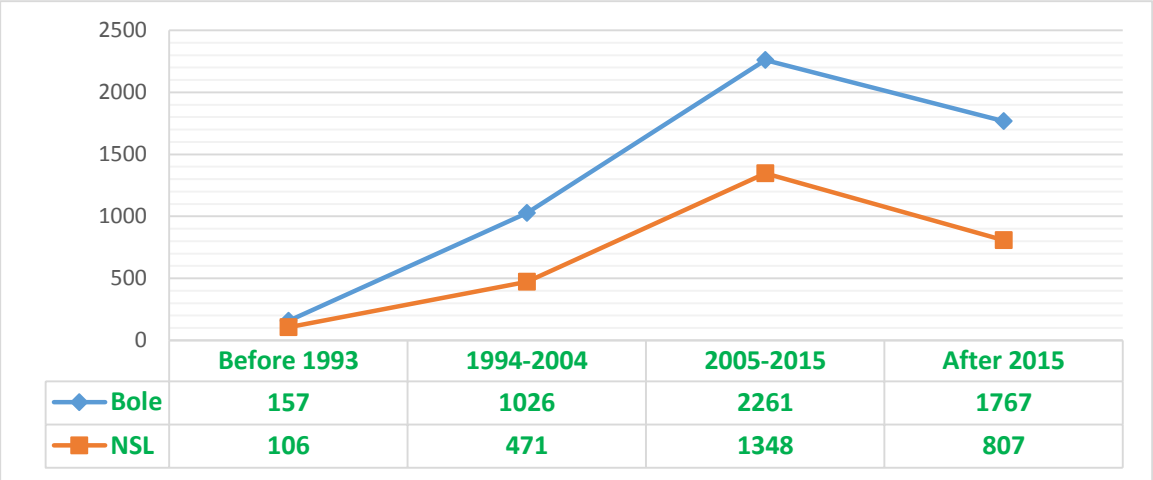

Figure 5.12. Quantities of e-waste in terms of year of purchase

Source: Field Survey, 2016

More explicitly, in Bole sub-city, about 2,261 (43.3%) electronic gadgets were purchased between 2005 & 2015, and 1,767 (34%) were purchased after 2015. When it comes to households of NSL sub-city, about 1,348 (49.3%) were purchased between 2005 & 2015 while 807 (29.5%) were purchased after 2015. From this report, we can understand that there is no significant variation in the percentage of purchased electronic equipment among the two sub-cities.

Table 8.1 under appendixes, presents purchase year of electronic items of both higher income groups (Bole) and middle-income groups (NSL). It was found that electronic items such as cameras, radios, tape-recorders, televisions, and telephones were mostly purchased before 1993. These were common for the majority of Ethiopians at that time. Whereas equipment such as cell phones, laptops, computers, Mp3/Mp4 players, electric fan, washing machines, air conditioners are the most dominantly purchased in between 2005 & 2015 in both sub-cities.

5.5. E-WASTE CAUSES, MANAGEMENT METHODS, THE CHALLENGES

Households are one of the main generators of e-waste. They contribute a significant proportion of e-waste volume. Moreover, since various e-waste categories are generated from households due attention should also be paid to household e-waste management. The categories of e-waste from households include large and small household appliances such as washing machines, clothes dryers, electric stoves, video cameras, electric shavers, electric kettles, radio sets, etc.; screens and monitor equipment such as televisions, computers, laptops, tablets and notebooks, small IT and telecommunication equipment such as mobile phones, personal computers, printers, GPS, pocket calculators etc. Above all, the disposal methods adopted and practiced by the households should not be ignored.

On the other hand, it is apparent that e-waste management comprises the tendency of the people towards the purchase of second-hand or original/new equipment. Factors such as the incomes, tastes, and preferences toward cutting-edge technologies substantially affect the volume of e-waste generated. What is more, the management strategies followed and promoted in each household also contributes towards the reduction of health and environmental impacts of e-waste. Based on these conceptions, therefore, this section presents the causes of e-waste, reasons for replacing old electronic equipment, e-waste disposal methods, e-waste management actions are taken on old, broken and non-functional electronic equipment and reasons for storing of e-waste.

5.5.1. Sources to purchase EE

Studies highlighted that electronic equipment selling shops, companies, and factories are contributing a significant role in e-waste management through the production and marketing of original and environmentally friendly electronic appliances. Basically, the purchase and procurement of electronic equipment are affected by levels of peoples' awareness as regards identifying reputable and original equipment, affordability, incomes, function, purpose, tastes, and preferences. However, the electronic equipment shopping companies might determine the supply of original and durable equipment. Regarding this, questionnaire was distributed to examine the sources from which households make a purchase of electronic equipment. Accordingly, as depicts in Figure 5.13, the majority of the households (75%) claim to purchase most of the electronic appliances from retail shops followed by general distributors which constitute 20% of the sample respondents.

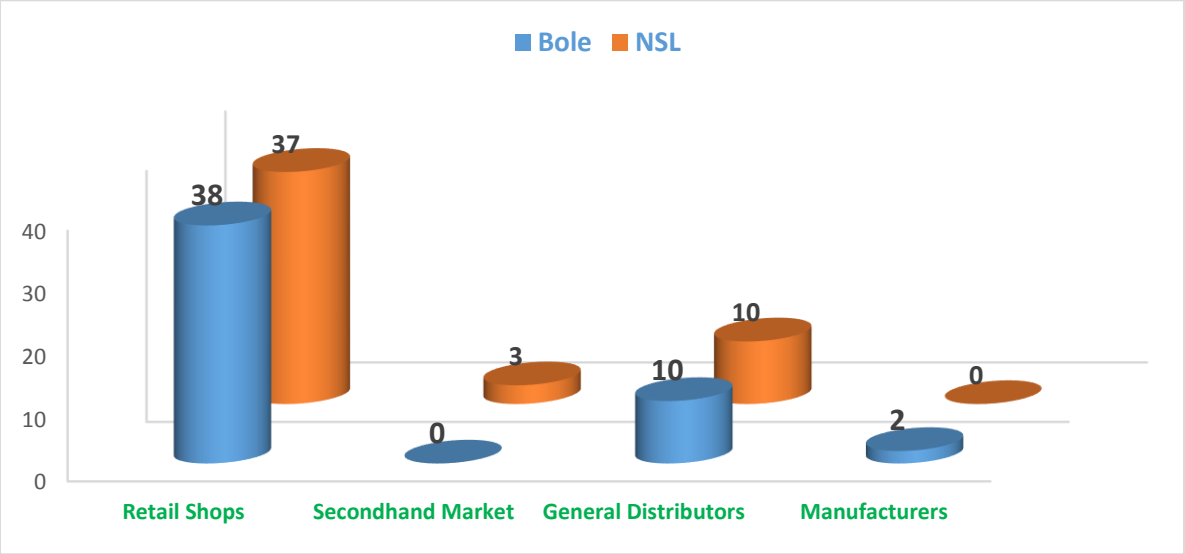

Figure 5.13. Sources of electronic equipment to purchase

Source: Field Survey, 2016

Households who purchased from the second-hand market and directly from manufacturers is very low. Indeed, the low number of households who are relying on the purchase of second-hand market is associated with the purposive selection of the household heads from the two affluent sub-cities. The chi-square test result (χ^2 =

5.013, p=.171) show statistically insignificant differences between Bole and NSL sub-cities in terms of the sources from which the respondents purchase electronic appliances.

5.5.2. E-waste generation causes

Increase in the end-of-life of electrical and electronic products depends on the economic growth of the country, population growth, market penetration, technology upgrading, and high obsolescence rates of electronic gadgets. In addition to that, due to the growing economic accessibility of new products and technological advancements, it is easy to purchase rather than repair outdated equipment (Kalana, 2010). The total amount of e-waste is produced is exponentially increasing because of multiple factors. Consumer demand and high obsolescence rates lead to more frequent and unnecessary purchases of electronic equipment (Devin *et al.,* 2014).

One of the major concerns of the study was to identify the leading factors behind the generation of e-waste in the surveyed households. The results of the study show that the high rates of breakage or malfunctioning of electronic goods accounts for 36% the e-waste that the surveyed households generate whereas high obsolescence rates of such goods also account for more or less a similar proportion, i.e, 35% the e-waste they generate. It is also interesting to take note of the fact, that the demand for newly designed products which normally encourages to purchase additional equipment accounts for about 27% of (the electronic goods that are disposed of as waste (See Figure 5.14). However, the fact remains that these factors have been rated differently by causes are differently ranked among the households of the two sub-cities. The result of the study disclosed that the major causes of household e-waste generation are breakage (36%) high obsolescence rate (35%), the demand for a new design which encourages purchase of additional equipment (27%) (See Figure 5.14).

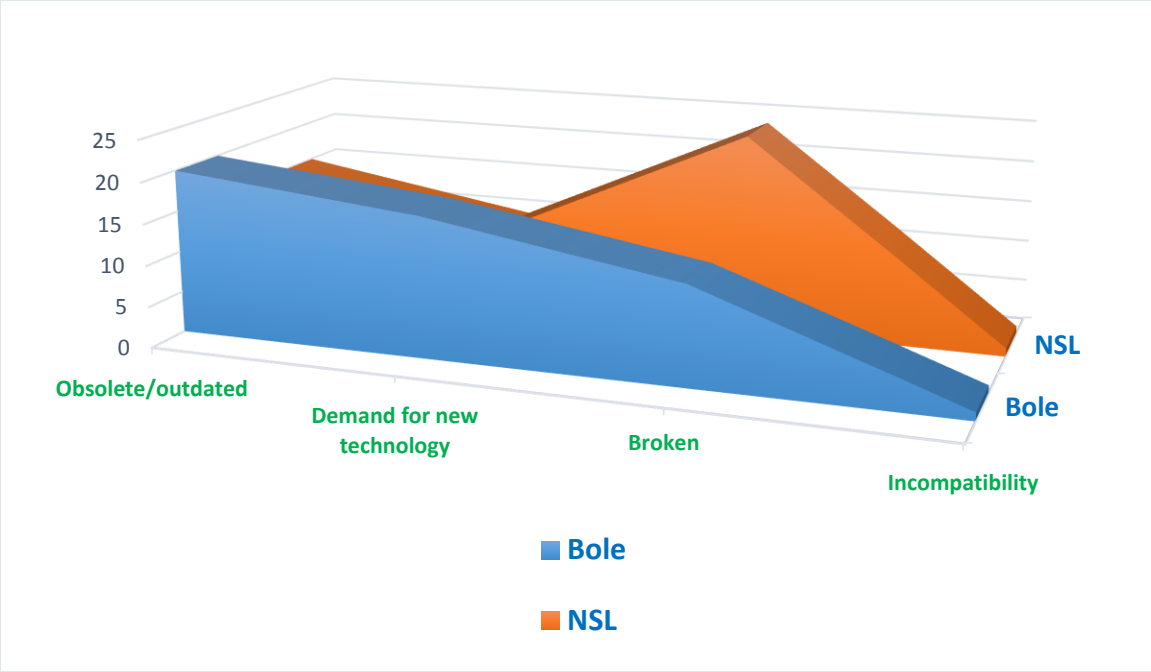

Figure 5.14. E-waste generation causes

Source: Field Survey, 2016

However, the causes were differently ranked among the respondents of the two sub-cities. In Bole sub-city, the respondents claimed that the major causes were rapid obsolescence rate, high demand for new design, breaking of electronic equipment which ranked from 1st to 3rd respectively. On contrary, breakage of electronic equipment, rapid obsolescence rate, and the demand for the new design are ranked from 1st to 3rd. respectively for NSL households. Finally, it was found that in both cases of the respondents the incompatibility of old appliances with a new one was not considered as a cause of e-waste.

5.5.3. Conditions of bringing EEs to their End-of-Life

People could bring various electronic equipment to their end-of-life in different forms. While some do based on the degree of technological sophistication of electronic gadgets to label them as 'obsolete' or 'modern', others similar decisions based on an equipment's status as 'operational' or 'non-operational' equipment. Furthermore, they might categorize on the basis of age as 'old' or 'new'. We are raising this issue here chiefly because the ways in which electronic equipment are registered or considered

as waste would affect the overall electronic waste management practice and the strategies designed to address the fast-growing problem of e-waste generation in the city.

The findings of the study have revealed that the largest portion of the participants (38%) designates an electronic equipment as e-waste based on its functional attributes i.e. whether or not it is 'operational' or 'non-operational', whilst about 28% of them arrive at the similar conclusions based on the serviceability or non-serviceability of broken equipment (See Figure 5.15). On the other hand, a significant number of participants didn't apply any of the e-waste categorization options. The chi-square test result to investigate this issue showed that there was no significant difference between the surveyed households as regards their ways of declaring electronic gadgets

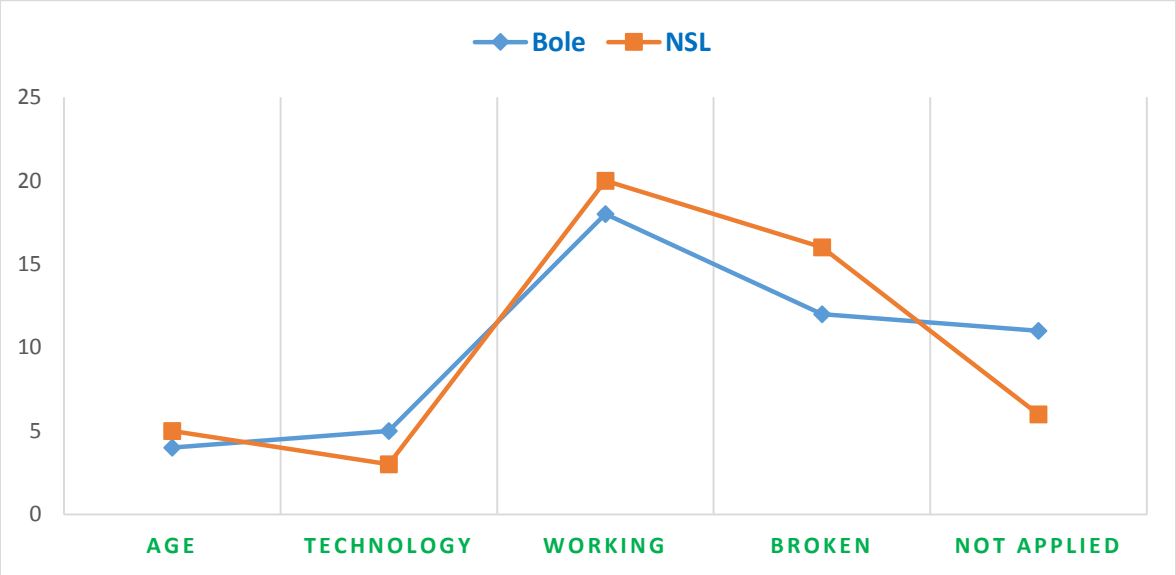

Figure 5.15. Condition of making EE at end-of-life

Source: Field Survey, 2016

5.5.4. Reasons for replacing old EE

Several reasons might drive the households to replace old, broken and unserviceable electronic equipment. Whereas some of them might replace old electronic appliances in order to have newer technology others could be looking for features not available on old electronic equipment. In this regard, the results of the study reveal that the majority of the respondents (51%) reported that they replace old electronic equipment because they are wanting newer technology or design. Comparatively, about 29% reported that they replace old equipment wanting additional appliances while 16% were looking for features not available on old electronic equipment (See Table 5.4).

Table 5.4: Reasons for replacing of old electronic equipment

		Sub-City		Total
		Bole	NSL	
Reasons to replace old electronic equipment	Too slow	2	1	3
	Wanting newer technology/design	26	25	51
	Wanting features not available on old electronic equipment	9	7	16
	Wanting additional equipment	13	16	29
	Incompatible with the existing electronic equipment	0	1	1
Total		50	50	100

Source: Field Survey, 2016

5.5.5. Electronic disposal methods practices

As indicated in Figure 5.16, concerning the e-waste disposal methods practiced by the households, the data obtained through questionnaire discovered that the highest proportion of the participants (61%) are promoting storing/disposing of as the only e-waste disposal method. Comparatively, about 29% of the respondents reported that they believed in reusing the appliances or their parts. As discussed below, there are justifications why the majority of the respondents store e-waste. We can see from their responses that the lack of better disposal methods has left them without any

other alternatives. A chi-square test was computed to measure the differences in the e-waste disposal methods practiced by the households. The result ($\chi^2 =$ 5.650 and, $p < 0.001$) shows that there exists a significant difference between the e-waste disposal methods that the participants are practicing. As shown in the cross-tab, about 40% of the respondents from Bole reported that storing was the only option for managing e-waste while the majority of NSL respondents were reusing and storing.

This finding in a way suggests that higher income groups (like those who live in Bole sub-city) have the will and the economic ability to stow away either non-functional or old electronic equipment while households that largely belong to the middle-income category (like those living in NSL sub-city) have a strong tendency to reuse such equipment

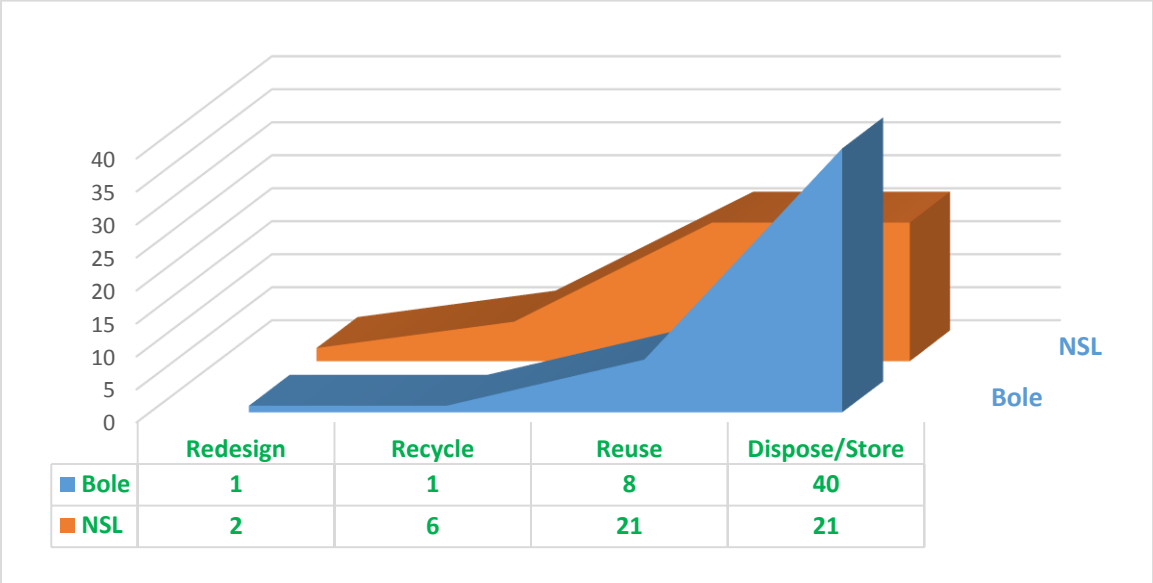

Figure 5.16. E-waste disposal methods practiced

Source: Filed Survey, 2016

5.5.6. Reasons for storing unused EE

In line with the e-waste disposal methods practiced among the households, the study must respond to why people practice some e-waste disposal methods over the other. In general, people might store e-waste due to several reasons, which include they may not consider it appropriate to throw it in the garbage or they may not know what to do with it. While others have not found good disposal methods or recycler to reuse and recycle. What is more, others want to donate or sell such appliances to other users. The respondents were asked why they were storing of e-waste. Accordingly, the study reveals as indicated in Table 5.5, the majority of the participants (35%) store e-waste because they have not found good disposal methods/recycler to recycle and reuse the equipment. About 27% reported that they wanted either sell or donate such gadgets to other users. About 20% of the household respondents store unused electronic equipment simply because they did not either upgrade or repaired them. Moreover, a chi-square test result was produced to see if any significant differences exist among the various households in each group. The results of the analysis came out to be statistically significant at 0.035 which was less than p-value (0.050). The X^2 test result was 10.340.

Table 5.5: Reasons for storing unused electronic equipment

		Sub-city		Total
		Bole	NSL	
Major reasons for storing unused electronic equipment	We don't consider it appropriate to throw it as garbage	9	1	10
	We don't know what to do with it	3	5	8
	We want to donate it/sell it	16	11	27
	We have not upgraded/repaired it	9	11	20
	We have not found good disposal methods or a recycler	13	22	35
Total		50	50	100

Source: Field Survey, 2016

5.5.7. E-waste management actions on unserviceable EE

People's e-waste management action towards the old, broken and unserviceable electronic equipment are among the essential elements of e-waste management. In fact, the actions taken by the households might be constrained by several factors that include absence of recycling, maintenance and refurbishment centers. Concerning this, households were requested to respond on what they did to electronic equipment which is unserviceable or beyond repair. Accordingly, it was found that the majority of the sample respondents (35%) store used or broken electronic appliances while 31% sell such equipment. Comparatively, about 27% of the participants reported that throwaway electronic waste just like any other types of solid waste. The study found a significant difference between the respondents from two sub-cities in this regard as shown by the χ^2 test result (11.858), p = .008 which is less than 0.05. Furthermore, 7% of the respondents from Bole threw unserviceable e-waste to other institutions and organizations which are looking for the equipment, while none of the NSL sub-city residents did this.

5.5.8. Actions on broken EE

Similar to the e-waste management action taken to unserviceable equipment, the households were asked what actions are taken to broken e-waste. Accordingly, the study reveals that 47% of the sample respondents reported they sold broken electronic equipment to scrap dealers or e-waste businesses. Nearly a similar proportion of the respondents (about 44%) reported they stored such gadgets at home (See Table 5.6). As noted earlier, the increase in the production of electronic appliances, the rise in their consumption rates and consequently the rapid growth in the numbers of either non-repairable or obsolescent electronic gadgets leads to the creation of a considerable volume of electronic waste. Therefore, care should be taken in handling old or outdated, broken or non-repairable electronic equipment in order to ensure their proper management.

Table 5.6: Measures taken to broken electronic equipment

		Sub-City		Total
		Bole	NSL	
Actions were taken to broken electronic equipment	Store	16	28	44
	Sell to scrap dealer/e-waste business	27	20	47
	Throw them to other institutions and organizations	2	0	2
	Give them back to the company for servicing	1	0	1
	Other	4	2	6
Total		50	50	100

Source: Field Survey, 2016

5.6. ENGAGEMENT LEVEL IN E-WASTE MANAGEMENT PRACTICES

Table 5.7 depicts households' responses on the extent to which they have engaged in certain electronic waste management practices. For the sake of clarity, the researcher has divided the presentation of this section into three parts. The first section is concerned with providing an explanation on the mean score. Then, it presents the frequencies and percentages and finally the chi-square test results. As far as the mean score is concerned, it ranged from 1.08 to 2.86, which means it ranges between 'always' and 'never'. Explicitly, the mean score highlighted that households' engagement level in electronic management ‟ ranged from 'always' to 'never'. However, there were some differences in the mean score between Bole and NSL sub-cities. The respondents were 'always' engaged in buying new electronic gadgets even if the older one were working and buying gadgets with brands that are reputable for their durability and longer life over other brands. On the contrary, they 'never' recycle electronic gadgets which can still be recycled. Furthermore, the respondents 'never' observed proper waste segregation practices.

As far as a percentage is concerned, half of the households (50%) were 'sometimes' keeping inventories of the equipment they discard/store while 45% 'never' keep records. As indicated in Table 5.7, the majority of the respondents (63%) from both sub-cities have 'never' recycled electronic equipment which was and still is recyclable. As regards this issues, the chi-square test result produced no significant

difference between the two groups of respondents. About 53% of the total respondents ‘always’ buy new electronic equipment even if the older once are still working. Comparatively, about 35% of the respondent buy new electronic appliances now and then. It can be understood from these findings that respondents’ total e-waste generation have also been more influenced by their tastes and preferences than by their monthly incomes. A chi-square test was produced to see if there was significant variation between the two groups of respondents as regards to their frequency of purchase of new electronic gadgets even if the older ones were working.

Table 5.7: Engagement level in e-waste management practices

S.N	Items	Sub-city	Engagement Level			Mean
			Always	Sometimes	Never	
1	How often do you keep inventories of the equipment you discard/store?	Bole	3	27	20	2.34
		NSL	2	23	25	2.46
2	I recycle electronic products/gadgets which can still be recycled.	Bole	1	19	30	2.58
		NSL	1	16	33	2.64
3	I buy new electronic gadgets even if the older ones are still working.	Bole	35	9	6	1.42
		NSL	18	26	6	1.76
4	I buy gadgets with brands that are reputable for their durability and longer life over other brands.	Bole	46	4	0	1.08
		NSL	36	9	5	1.38
5	I observe proper waste segregation practices.	Bole	2	7	41	2.78
		NSL	3	10	37	2.68
6	I buy second-hand gadgets and/or “re-assembled” gadgets.	Bole	0	7	43	2.86
		NSL	1	22	27	2.52
7	I trade or sell used electronic gadgets	Bole	6	23	21	2.30
		NSL	3	23	24	2.42

Source: Field Survey, 2016

The result of the test (13.710, p = .001, hence p<0.05), showed that there was a statistically significant difference between the two groups of respondents as regards this issue. Thus, the majority of the respondents from Bole sub-city have ‘always’ buy new electronic equipment even if older ones are still working than respondents from NSL. Likewise, the majority of the respondents from Bole sub-city (82%) ‘always’ buy electronic equipment with brands that are reputable for their durability and longer life over other brands than that of NSL. The χ^2 test result is (8.143 and p = .017) which was statistically significant.

The majority of the respondents (78%) reported that they ‘never’ been involved in proper waste segregation practices, while 17% reported that they were ‘sometimes’ engaged in proper waste segregation practices. This finding is very much indicative of the fact the practice of e-waste segregation in the city is still at its stage of infancy. Moreover, the majority of the respondents (70%) have ‘never’ bought second-hand gadgets or re-assembled electronic items while 27% of them bought these kinds of electronic gadgets now and then. The chi-square test computed to see the differences between the respondents from Bole and NSL sub-cities, the results showed statistically significant (χ^2 = 12.416, p = .002).

Therefore, as it can be understood from the results, compared to the respondents from Bole sub-city, the majority of the respondents from NSL sub-city ‘sometimes’ buy second-hand gadgets. Finally, with regards to households level of engagement in trading or selling used electronic gadgets, the study revealed that about 46% of the respondents ‘sometimes’ trade used electronic gadgets while 45% of them ‘never’ trade used electronic items.

5.7. THE ORDINAL REGRESSION MODEL OUTPUTS

An ordinal regression was carried out to predict ordinal dependent variables given one or more independent variables. Accordingly, gender, monthly income, and educational level were considered as independent variables that will affect the ordinal dependent variables ranging from “never” to “always” for all items. It was understood that gender and educational level didn’t affect the households’ engagement level towards e-waste management related actions. While monthly income did affect some aspects. The summary result is presented in Table 5.8 and Table 5.9 as follows.

Table 5.8: The Ordinal Regression output 1

								95% Confidence Interval	
		Estimate	**Std. Error**	**Wald**	**df**	**Sig.**	**Exp(β)**	Lower Bound	Upper Bound
Threshold	[Q24 = 1.00]	.029	.812	.001	1	.972	1.029	.210	5.055
	[Q24 = 2.00]	1.500	.882	2.890	1	.089	4.480	.795	25.245
Location	Income	-4.511E-005	2.255E-005	4.002	1	.045	1.000	1.000	1.000
	[Gender=1.00]	-.071	.546	.017	1	.896	.931	.319	2.716
	[Gender=2.00]	0[a]	.	.	0	.	1.000		

Source: Field Survey, 2016

The Table 5.8 depicts an increase in a monthly income (expressed in ETB) was associated with an increase in the odds of the households buying gadgets with brands that are reputable for their durability and longer life over other brands, with an odds ratio of 1.000 (95% CI, 1.000 to 1.000), Wald X^2 (1)=4.002, $p < .045$.

Table 5.9: The Ordinal Regression output 2

		Estimate	Std. Error	Wald	df	Sig.	Exp(β)	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	[Q26 = 1.00]	-3.320	1.188	7.805	1	.005	.036	.004	.371
	[Q26 = 2.00]	.559	.694	.650	1	.420	1.750	.449	6.819
Location	Income	4.951E-005	1.862E-005	7.072	1	.008	1.000	1.000	1.000
	[Gender=1.00]	-.333	.477	.488	1	.485	.716	.281	1.826
	[Gender=2.00]	0[a]	.	.	0	.	1.000		

Source: Field Survey, 2016

Table 5.9 shows an increase in a monthly income (expressed in ETB) was associated with a decrease in the odds of the households buying second-hand gadgets and/or "re-assembled" gadgets., with an odds ratio of 1.000 (95% 1.000 to 1.000), Wald X^2 (1)=7.072, p < .008.

5.8. E-WASTE GENERATION AND THE LOCATION OF PLACES

The independent samples test were used to measure the differences in the households' volume of electronic waste that might exist among households based on their location and family size. Where independent samples test was used to examine differences, the equal variance was assumed as Levene's test for the variables was not significant if P>0.05. As shown in Table 5.10, there is a significant difference between the means of the respondents' total electronic waste generation based on their location. In general, the respondents from Bole sub-city have higher mean values than those from NSL sub-city. In addition, the test results revealed p-values .000, which are less than 0.05 level of significance, showing that there is the statistically significant difference in respondents' total electronic waste generation based on their location. Overall the participants from Bole have higher e-waste volume (104 ± 29.674) compared to those from NSL (55 ± 11.616) at t(98) =

11.002, p = 0.000. Table 5.10 also presents the actual results from the independent t-test. Thus in view of the well-known fact, the respondents from Bole tend to have markedly higher average household incomes than the respondents from NSL, the results of this study strongly suggest household income has a positive relationship with rates of e-waste generation. The table also presents the actual results from the independent t-test. Therefore, this study found that high-income participants (Bole residents) had statistically significantly higher e-waste volume (104 ± 29.674) compared to middle-income groups of NSL residents (55 ± 11.616), $t(98) = 11.002$, $p = 0.000$.

Table 5.10: Independent sample t-test on e-waste generation based on location

	Sub-City	**N**	**Mean**	**SD**	**t**	**Sig (2-tailed)**
E-waste volume	Bole	50	104.22	29.674	11.002	.000
	NSL	50	54.64	11.616		

Source: Field Survey, 2016

The study examines the overall purchase of electronic equipment before 1993, between 1994 and 2004, between 2005 and 2015 and after 2015 for both sub-cities. As can be understood from the t-test Table 5.11, Bole sub-city has greater mean scores than NSL sub-city in all-time dimensions. The greatest volume of electronic equipment was purchased between2004-2015 and after 2015 because of mean and standard deviation scores of (45 ± 19.003) for Bole and (27 ± 7.730) for NSL sub-city, and (35 ± 13.164) for Bole and (16 ± 6.312) for NSL sub-city respectively. On the contrary, both sub-cities held much less volume of electronic equipment before 1993 with the mean value of 3 ± 1.565 for Bole and the mean value of 2.12 ± 1.023 for NSL sub-city. This implies that the volume of e-waste in both sub-cities was substantially growing. This might be linked to the scale economies Ethiopia has registered in the recent past and the tastes of the people have been developing towards the utilization of technologically advanced devices.

Similarly, the t-test results highlighted that there is a statistically significant difference between the respondents from the two sub-cities as regards the purchase year of electronic equipment. Where independent samples test was used to examine the differences, the equal variance was assumed as Levene's test for the variables was not significant if P>0.05. However, the test shows statistically significant at p<.001 level in all purchase years. Therefore, there is a significant difference between the numbers of electronic equipment purchased in different years.

Table 5.11: Independent sample t-test on EE purchase year based on location

Sub-City		**N**	**Mean**	**SD**	**t**	**Sig (2-tailed)**
purchased before 1993	Bole	50	3.14	1.565	t(98)=3.857	.000
	NSL	50	2.12	1.023		
purchased between 1994-2004	Bole	50	20.52	5.870	t(98)=12.097	.000
	NSL	50	9.42	2.763		
purchased between 2005-2015	Bole	50	45.22	19.003	t(98)=6.294	.000
	NSL	50	26.96	7.730		
purchased after 2015	Bole	50	35.34	13.164	t(98)=9.300	.000
	NSL	50	16.14	6.312		

Source: Field Survey, 2016

The independent t-test was employed to look whether there is a significant difference in the volume of e-waste among the sample participants based on their education level. To compute this, initially, the data was transformed into different categories to obtain two independent groups in terms of educational qualification of the respondents which ranged from "less than grade 10 to post-secondary school diploma" and from "B.Sc. or B.A. degree to Ph.D.". The results of this independent sample test, t (98) = .096, p = .924 reveal that p-value is quite greater than 0.05, thus proving that there is no significant difference in total e-waste volume of the respondents when examined based on their educational qualifications. Therefore, the results of this indicate educational qualification has no noteworthy contribution to the rates at which the respondents' generate (See Table 5.12).

Table 5.12: Independent sample t-test on e-waste based on education Level

	Education	N	Mean	SD	t	Sig. (2-tailed)
E-waste volume	<Grade 10 to Diploma	40	79.83	31.349	t(98) =.096	.924
	B.Sc./B.A. Degree to PhD	60	79.17	35.145		

Source: Field Survey, 2016

The study computed an independent sample test whether there is a significant difference in the volume of e-waste among the respondents based on their gender. As shown in Table 5.13, the results of the independent sample test *t* (98) = -1.454, *p* = .149 revealed that the p-value was markedly greater than 0.05. These results thus, proved that there was no significant difference between male and female respondents with regard to the volume of the total in total e-waste that they generate. Therefore, this indicates gender difference has less contribution in households' electronic waste generation (See Table 5.13).

Table 5.13: Independent sample t-test on e-waste volume based on gender

	Gender	N	Mean	SD	t	Sig. (2-tailed)
E-waste volume	Male	59	75.39	30.812	t(98) =-1.454	.149
	Female	41	85.24	36.674		

Source: Field Survey, 2016

The independent t-test was employed (See Table 5.14) to find out if there was a significant difference in the rate of e-waste generation between broken, obsolete, and non-functional e-waste among Bole and NSL residents. Accordingly, this study found that high-income participants (Bole residents) had statistically significantly higher obsolete e-waste volume (30 ± 16.748) compared to middle-income groups of NSL residents (11 ± 11.616), *t* (98) = 7.561, *p* = 0.000. This is attributed mainly to the differences between the respondents with regard to their attitudes toward the purchase and use of modern technology as influenced by their differences income as

well as their tastes and preferences. Similarly, it was also found that respondents of Bole sub-city have produced significantly more non-functional e-waste (52 ± 21.161) than NSL sub-city which had a mean and SD value of (27±8.155), at t (98) =7.681, p< 0.001. There is also a significant difference in the volumes of broken e-waste between the respondents from two sub-cities as the figures t (98) = 4.053, p< 0.001 indicates. Arguably, these results would be influenced by the total volume of e-waste generation in each sub-city.

Table 5.14: Independent sample t-test on e-waste types based on location

	Sub-City	**N**	**Mean**	**Std. Deviation**	**t**	**Sig (2-tailed)**
Broken	Bole	50	21.60	8.079	t(98) = 4.053	.000
	NSL	50	15.52	6.873		
Obsolete	Bole	50	30.20	16.748	t(98)=7.561	.000
	NSL	50	11.34	5.531		
Non-functional	Bole	50	52.42	21.161	t(98)=7.681	.000
	NSL	50	27.78	8.170		

Source: Field Survey, 2016

5.9. DETERMINANT FACTORS AFFECTING THE AMOUNT OF E-WASTE

A multiple regression models was computed to predict the volume of household's electronic waste based on monthly income, education status, gender, and family size. Table 5.15 presents the regression result.

Table 5.15: Model summary of the multiple linear regression

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.944[a]	.891	.886	11.296

Source: Field Survey, 2016

This table (Table 5.15) provides the R and R^2 values. The R value represents the simple correlation and is 0.944, which indicates a high degree of correlation between the independent variables and volume of e-waste that households are generating. The R2 value (the "R Square" column) indicates how much of the total variation in e-waste volume, can be explained by independent variables. In this case, it was found that household income explains about 0.89% the variation in the amount e-waste generated.

Table 5.16: The ANOVA table of multiple regression outputs

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	99090.271	4	24772.568	194.139	.000[b]
	Residual	12122.239	95	127.603		
	Total	111212.510	99			

Source: Field Survey, 2016

The ANOVA table result indicates that the regression model predicts the dependent variable significantly well (See Table 5.16). The table shows that the independent variables statistically significantly predict the dependent variable, $F(4, 95) = 194.139$, $p < .0005$ (i.e., the regression model is a good fit of the data).

The coefficients table (Table 5.17) provides us with the necessary information to use income a predictor for the volume of e-waste from independent variables, as well as determine whether the independent variables contribute statistically significantly to the model. Thus the findings show household income explains 89% of the variation in the volume of e-waste generated.

Table 5.17: The coefficients of the multiple regression outputs

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	12.105	5.398		2.242	.027	1.388	22.822
	Gender	1.814	2.356	.027	.770	.443	-2.862	6.491
	Monthly Income	.002	.000	.941	27.386	.000	.002	.002
	Family Size	-.086	.572	-.005	-.150	.881	-1.223	1.050
	Educational Status	-.027	.739	-.001	-.036	.971	-1.494	1.440

Source: Field Survey, 2016

The general form of the equation to predict Household e-waste generation from gender, monthly income, family size and education status is: predicted Household's Total E-waste Generation (HTEWG) = 12.105 + (1.814 x gender) + (0.002 x monthly income) – (0.086 x family size) - (0.027x education status). The model predicts that for a 1 unit increase in gender (from male to female), the e-waste volume will increase by 1.814 holding the other variables constant. It predicts a 1 unit increase in the monthly income of the households, the e-waste volume will increase by .002, a 1 unit increase in family size and educational status, the e-waste volume will decrease by -.086 and -.027 respectively holding other variables fixed.

Table 5.18: Poisson regression model output

Parameter	B	Std. Error	95% Wald Confidence Interval		Hypothesis Test			Exp(β)	95% Wald Confidence Interval for Exp(β)	
			Lower	Upper	Wald Chi-Square	df	Sig.		Lower	Upper
(Intercept)	4.422	.0360	4.351	4.492	15076.698	1	.000	83.238	77.566	89.325
[Gender=1.00]	-.120	.0229	-.165	-.075	27.615	1	.000	.887	.848	.927
[Gender=2.00]	0[a]	.	.	.	.	.	.	1	.	.
Family size	.004	.0057	-.007	.015	.563	1	.453	1.004	.993	1.015
(Scale)	1[b]									

Source: Field Survey, 2016

Similar to the results obtained from multiple regression models, a Poisson regression was run to predict the number of e-waste that household has generated based on gender and family size (See Table 5.18). The result indicates that as we move from female-headed household to male-headed household, .887 (95% CI, 0.848 to 0.927) times decrease in e-waste generation, statistically significant result, $p < .001$. This means moving from female to male household heads, we will expect an 11.3% decrease in the number of e-waste that the household is generating. With regards to family size, the result was statistically not significant ($p = .453$).

5.10. THE CORRELATION RESULTS

Table 5.19 presents the partial correlation between electronic waste volume and monthly income while controlling for family size. The results of the partial correlation shows there is a high positive partial correlation between the dependent variable, "households' e-waste volume", and the independent variable, "Households' monthly income", while controlling for "family size", which was statistically significant ($r(97) = .943$, $n = 100$, $p = .000$).

However, when we refer to the Pearson's product-moment correlation – also known as the zero-order correlation – between ‘Households’ E-waste Volume’ and ‘Households’ monthly income’, without controlling for "family size", we can see that there was also a statistically significant, high positive correlation between "Households’ E-waste Volume" and "Households’ Monthly Income" (r(98) = .944, n = 100, p = .000). This suggests that "family size" had very little influence in controlling for the relationship between "e-waste volume" and "income".

Table 5.19: Correlation result 1

Control Variables			Monthly income	E-waste volume	Family size
-none-[a]	Monthly income	Correlation	1.000	.944	.046
		Significance (2-tailed)	.	.000	.652
		df	0	98	98
	E-waste volume	Correlation	.944	1.000	.042
		Significance (2-tailed)	.000	.	.679
		df	98	0	98
	Family size	Correlation	.046	.042	1.000
		Significance (2-tailed)	.652	.679	.
		df	98	98	0
Family size	Monthly income	Correlation	1.000	.943	
		Significance (2-tailed)	.	.000	
		df	0	97	
	E-waste volume	Correlation	.943	1.000	
		Significance (2-tailed)	.000	.	
		df	97	0	

Source: Field Survey, 2016

One of the major causes of rapid e-waste generation is obsolescence rate associated with a short lifespan of the equipment, technological progressions and the changing in tests and preferences of the people. The study has also tried to find out if there was a correlation between household obsolete e-waste generation and monthly income. It has an implication for the overall management of e-waste and some household with high monthly income will make active/functional electronic equipment at the end-of-life. This produces a considerably large volume of e-waste in the city. The study found that there was a strong positive correlation between monthly income

and obsolete e-waste generation of the households. The Pearson correlations result shows .691 nearly .70 and p<0.01, which establishes a significant correlation between the two variables. We can understand that high-income group of people could decide to bring functional electronic equipment to its end-of-life before its lifetime is over (See Table 5.20).

Table 5.20: Correlation result 2

		Monthly Income	Obsolete E-waste
Monthly income	Pearson Correlation	1	.691**
	Sig. (2-tailed)		.000
	Sum of Squares and Cross-products	29148750000.000	18319650.000
	Covariance	294431818.182	185046.970
	N	100	100
Obsolete e-waste	Pearson Correlation	.691**	1
	Sig. (2-tailed)	.000	
	Sum of Squares and Cross-products	18319650.000	24135.710
	Covariance	185046.970	243.795
	N	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			

Source: Field Survey, 2016

The study identifies if there is a difference in obsolete e-waste generation between high income and middle-income groups. From the Figure 5.20, we can understand that Bole sub-city has produced a high volume of obsolete e-waste than NSL sub-city. This was consistent with the results obtained through questionnaire that obsolescence was the major cause for e-waste generation is obsolescence)

5.11. CONCLUSION

This chapter presents the results of the study obtained from the households of Bole and NSL sub-cities of Addis Ababa. Basically, the chapter deals with study sample backgrounds, awareness towards e-waste, e-waste generation level, causes of e-waste, e-waste management and the households' engagement level in some e-waste management activities. The households' awareness about the concepts of e-waste, the volume they generate, the environmental and health impacts of e-waste, local or international laws and activities towards e-waste, and safe disposal of e-waste vary among the households of Bole and NSL sub-cities. Besides, it was realized that the educational status of the households significantly influences the awareness of the sample respondents.

The sub-cities generated a significant volume of non-functional, broken, obsolete and e-waste yet Bole sub-city has produced the highest volume of e-waste than NSL sub-city. The most generated non-functional e-waste are CD/VCD/DVDs, washing machines, MP3/MP4 player, printers/cartridges, headsets/earphones, flat iron, air conditioner, fluorescent lamps, and microwave/ oven. On the other hand, computers/laptops, cameras, tape-recorders, cell phones, televisions, radio sets and VCD/DVD players are the most obsolete types of e-waste.

The chapter also presents the service and storage years of e-waste that it varies among the two sub-cities as well as between the different e-waste types. The purchase of electronic equipment was increasing from time to time and the highest number takes place in the year between 2005 and 2015 and the lowest volume was before 1993. The study found that the major causes of household e-waste generation are breaking of electronic equipment, obsolescence nature of e-waste, the demand for new design, which encourages the purchase of additional equipment. Majority of the participants are promoting storing/disposing of as the only disposal method followed by reuse.

The independent t-test revealed that income status of the households significantly affects the e-waste volume generated whereas gender and educational status had

no effect on the volume of e-waste. The multiple regression model result obtained indicates a high degree of correlation between income and volume of e-waste that households are generating.

CHAPTER SIX

E-WASTE MANAGEMENT IN THE EDUCATIONAL INSTITUTIONS AND GOVERNMENTAL SECTOR OFFICES OF ADDIS ABABA

6.1. INTRODUCTION

The aim of this study was to investigate the waste electrical and electronic equipment management and disposal methods in Addis Ababa. It attempted to examine e-waste management in the HHs, EIs, and GSOs of Addis Ababa. To this end, data were acquired through questionnaires, interviews, document reviews, and observations. In the previous chapter, the study has attempted to present the results obtained from the household heads of Bole and NSL sub-cities. This chapter, however, presents the results of the study obtained from Private Educational Institutions (PREIs), Public Educational Institutions (PUEIs) and Governmental Sector Offices (GSOs) of Addis Ababa. Besides, it presents the results obtained from Higher Government Officials (HGOs).

In general, to avoid any confusions, the results were organized and structured as sub-topics. As such, this chapter has been broadly classified into three major sections. The first part deals with data obtained through questionnaire surveys and review of relevant documents. The second part presents results obtained through interviews. The final section of the chapter presents findings it obtained from observation.

The analysis of data obtained through questionnaires and review of documents has again been divided into six sub-topics. Accordingly, the first sub-topic presents and discusses the findings of the surveyed EIs and GSOs. In the next section, the profiles of the study participants are presented and discussed followed by a section on the levels of the awareness of the GSD personnel as regards electronic waste management. In the following section, e-waste generation level and e-waste types are raised and discussed. In the next section of the chapter, it presents the causes,

management methods, challenges and disposal of electronic waste management. What is more, the last sub-topic presents the GSD personnel's engagement level in some e-waste management practices. As far as results from the interview are concerned, it has broadly classified into two parts. The first section presents results obtained from GSD personnel of EIs and GSOs. The second section presents the results obtained from HGOs. Finally, findings from observations are presented and discussed.

6.2. SAMPLE EDUCATIONAL INSTITUTIONS AND GOVERNMENTAL SECTOR OFFICES

Table 6.1 shows the list of the sample EIs and GSOs involved in this study. The EIs were comprised of both private and public educational institutions. As far as the Private Educational Institutions (PREIs) were concerned, the study has select Unity University, Admas University, Orbit IT College, St. Marry University, New Generation University College, PESC College, CPU College and Rift Valley University. As regards Public Educational Institutions (PUEIs), the study covered Addis Ababa University (AAU)-the Main Campus, the FBE Campus, and Science Faculty. It also included the Entoto TVET College, the Kotebe Metropolitan University (KMU), the Ethiopian Civil Service University (ECSU), AAU southern campus for the Ethiopian Institute of Architecture, Building, and Construction (EiABC) and the Addis Ababa Science and Technology University (AASTU).

On the other hand, the study selected Governmental Sector Offices (GSOs) at ministerial level. These were the Ministry of Education (MoE), the Ministry of Health (MoH), Ministry of Finance and Economic Development (MoFED), Ministry of Trade (MoT), the Ministry of Revenue (MoR), the Ministry of Science and Technology (MoScT) and the Ministry of Communication and Information Technology (MoCIT).

Table 6.1: Sample educational institutions and governmental sector offices

	PUEIs	PREIs	GSOs
1	AAU, Main Campus	Admas University	Ministry of Health
2	Kotebe Metropolitan University	Orbit IT College	Ministry of Education
3	Entoto TVET College	St. Marry University	Ministry of Agriculture
4	AAU, FBE Campus	NGU College	Ministry of ICT
5	AA Science and Technology University	Rift Valley University	Ministry of Trade
6	Ethiopia Civil Service University	PESC College	Ministry of Revenue
7	Ethiopia Institute of Architecture, Building, and Construction	Unity University	Ministry of Science and Technology
8	AAU, Science Faculty	CPU College	Ministry of Finance and Economic Development

Source: Field Survey, 2016

6.3. BACKGROUND CHARACTERISTICS OF STUDY SAMPLE

The study was intended to investigate e-waste management in Addis Ababa the case of HHs (Bole and NSL sub-cities), EIs and GSOs. It also purposively includes HGOs to obtain data through in-depth interviews. This section, as indicated in Table 6.2, presents the background characteristics of study sample such as gender, educational status, and their institutional affiliation. In light of this, the gender characteristics of the participants showed that the majority of the sample study were male accounting for 70.8%, whereas female constitute 29.2%. As it was clearly noted in the methodology part, a total of 72 sample respondents were purposively selected from PREIs, PUEIs, and GSOs of which 48 were selected to fill the questionnaires. Finally, regarding the educational qualification of the sample respondents, it varied from certificate to Ph.D., of which the majority of the sample respondents (56.3%) hold

BA/BSc. degrees followed by diploma holders which accounts (22%) of the total sample respondents. There were also respondents holding a certificate of two years post grade 12 training (10.4%), M.A/M.Sc. (8.3%) and Ph.D. (2.1%). This indicates the study has involved relatively educated sample respondents. Since the survey was carried out in the face-to-face method of data collection, all the participants filled and returned the questionnaire. This makes a high response rate.

Table 6.2: Background information on sample respondents

Variables	Category	Count	%	Total
Gender	Male	34	70.8	100
	Female	14	29.2	
Institution	PUEIs	16	33.3	100
	PREIs	16	33.3	
	GSOs	16	33.3	
Educational Status	Certificate	5	10.4	100
	Diploma	11	22.9	
	B.Sc/B.A	27	56.3	
	M.Sc./M.A.	4	8.3	
	PhD	1	2.1	

Source: Field Survey, 2016

The study has computed a chi-square test to see whether any associations might exist between the three variables (gender, educational status, and affiliation) (See Table 6.3). With regards to the gender-educational status, the "Pearson Chi-Square" results is χ^2 = 8.946, *p* = .062, which is P>0.05. This indicates that there is no statistically significant association between gender and educational status of the sample respondents in all sample groups. Concerning to the educational qualification of the respondents, there is no significant difference among the educational qualification of sample respondents in the three cases as a χ^2 test is 13.946, P = .083. However, the majority of the participants belong to those who hold either college degrees or diplomas. Similarly, χ^2 test result (.807, p = .668) shows there is no

significant difference between PREIs, PUEIs, and GSOs in terms of gender distribution.

Table 6.3: The Chi-square test result among the variables

S.N	Cross tabulations	Valid	X^2	Sig.
1	Gender-institutions	48	.807	.668
2	Gender-educational status	48	8.946	.062
3	Educational status-institutions	48	13.946	.083

Source: Field Survey, 2016

6.4. AWARENESS OF E-WASTE AND ITS MANAGEMENT

E-waste is a topical issue and a rapidly growing waste stream in the world. Studies have indicated that e-waste management is a complex task because it contains hazardous elements. Therefore, awareness about e-waste management might have its own implications in the whole process of e-waste management from generation to up to its final disposal. In this sense, the study was concerned with awareness of e-waste and its management. To this end, data were gathered through a questionnaire survey. Accordingly, the study formed two major awareness related items; awareness of e-waste and its impacts, and awareness of legislation, policies and activities or projects related to e-waste. In both of the categories, the fundamental questions were accentuated around the concepts of e-waste, e-waste volume generated, the environmental and health impacts of e-waste, local or international laws and activities towards e-waste, and the safe disposal of e-waste. Therefore, this section presents the findings of the study obtained from the sample participants in this regard.

6.4.1. Awareness of e-waste and its impacts

As far as the GSD personnel's awareness about e-waste and its impacts are concerned, as it is shown in Table 6.4, the study found that majority of the respondents (85.4%) claims knowing what it is meant by e-waste, while 14% have

not known what it means by e-waste. The χ^2 test result (2.341), p=.310, shows no significant difference among the three cases. Then, the study attempted to explore if the respondents were conscious of the volume of e-waste that they generated. It was found that the majority of the sample respondents (52.1%) were conscious of the volume of e-waste they generated, while 39.6% were not. The χ^2 test result was computed to see whether there was a significant difference among the three cases. Accordingly, the computed result came out as (χ^2 =5.763, with p =.218). Thus it was found that there was no significant difference between the GSD personnel of the PREIs, PUEIs, and GSOs regarding their consciousness of the volume of e-waste they generated.

Thirdly, having awareness about the health risks associated with electronic waste could also make the educational institutions and government offices to take better care of themselves, as well as the environment when they collect, store and dispose of the discarded electronic waste. In this regard, the study divulges that the highest proportions of the respondents (60.4%) were aware of the health risks associated with electronic waste. Comparatively, about 31.3 % of them either did not know about the issue while and 8.3% were uncertain about it. The χ^2 test result (3.980, p=.408) was statistically not significant. Therefore, in the three cases, awareness of the health risks of e-waste was relatively high. Similarly, the study reveals that the majority of the participants (66.7%) agreed that electronic waste posed a threat to the environment, while an equal percentage of participants (16.7%) were uncertain about the issue. Interestingly a similar proportion of respondent (16.7%) did not believe that e-waste had no environmental impacts. Irrespective of this, however, these findings confirm that the proportion of respondents have adequate awareness about the environmental impacts of e-waste is reasonably in all surveyed organizations. What is more, the study has attempted to find whether there is a significant difference among various EIs and GSOs in responding to this question. As it was understood from the χ^2 test result (11.250, and p = .024), $p<0.05$, which was statistically significant shows there were statistically significant different levels of the awareness of the impacts of e-waste among the three types of organizations.

Table 6.4: Summary of responses to e-waste and its impacts

ITEMS		Institution's Name			Total	χ^2	Sig. (2-tailed)
		PREI	PUEI	GSO			
Do you know electronic waste?	Yes	25	31.3	29.2	85.4	2.341	.310
	No	8.3	2.1	4.2	14.6		
	uncertain	0	0	0	0		
Are you conscious/aware of the volume of electronic waste that you generate?	Yes	20.8	10.4	20.8	52.1	5.763	.218
	No	10.4	20.8	8.3	39.6		
	uncertain	2.1	2.1	4.2	8.3		
Are you aware of any health risk/s associated with electronic waste?	Yes	22.9	20.8	16.7	60.4	3.983	.408
	No	10.4	10.4	10.4	31.3		
	uncertain	0	2.1	6.3	8.3		
Does electronic waste pose a serious threat to the environment?	Yes	20.8	25	20.8	66.7	11.250	.024
	No	0	8.3	8.3	16.7		
	uncertain	12.5	0	4.2	16.7		
Do you aware that used dry cell batteries need to be disposed of as safely as possible?	Yes	14.6	22.9	22.9	60.4	10.461	.033
	No	6.3	8.3	10.4	25		
	uncertain	12.5	2.1	0	14.6		
Are you aware that some hazardous fractions in e-waste need a special treatment in order to be safely disposed of?	Yes	25	16.7	27.1	68.8	7.273	.122
	No	8.3	8.3	4.2	20.8		
	uncertain	0	8.3	2.1	10.4		

Source: Field Survey, 2016

Moreover, the disposal of cell phone and other types of batteries need special attention that if thrown down with other municipal wastes it might pose a threat to human health and the environment. In this regard, the responses obtained through a questionnaire, as depicted in Table 6.4, the majority of the respondents (60.4%) were aware that used dry cell batteries needed to be disposed of as safely as possible. Whereas, 25% were not and about 14.6%of the participants were uncertain about it. The results of the χ^2 test made to examine if the respondents from the three cases

responded differently to the question posed (which was χ^2 = 10.461, p=.033), proved that there was a significant difference between them in this regard. Overall, a statistically significant percentage of respondents from PREIs were uncertain about the issue, while the majority of the respondents from PUEIs and GSOs were aware of the need for the safe disposal of dry cell batteries.

Lastly, the study highlighted that the majority of the respondents (68.8%) claimed the fact that some hazardous fractions of e-waste needed a special treatment in order to be safely disposed of. About 20.8% were not aware of it. The remaining 10.4% of the respondents were uncertain about it. The chi-square test result (χ^2 = 7.273, p = .122) to see whether there is a significant difference among the three cases showed no significant difference.

6.4.2. Awareness of e-waste legislation, policies, and recycling

Table 6.5 depicted the responses obtained from the respondents on legislation, policies and recycling activities. When questioned whether the respondents were aware of recycling or trading fairs for electronic waste, it was confirmed that half (50%) of the respondents reported that they were aware of it. Whereas, about 31.3% of the respondents were not aware of it while the remaining 18.8% were uncertain about it. The χ^2 test result (3.200, p= .525) shows no statistical difference among the three cases concerning their awareness levels about recycling or trading fairs for e-waste. Similarly, the respondents were asked whether they have been aware of the possibilities to sell some parts of e-waste to recyclers. Accordingly, as it was shown in Table 6.5, the majority of the respondents (58.3%) were aware of it, while 35.4% were not aware. The remaining 6.3% were uncertain about it. Therefore, in both questions, it can be seen that about half the respondents were not aware of possibilities of recycling and selling of parts of electronic waste.

Unlike other types of waste, e-waste management require specific legislation, guidelines or regulations that deal with e-waste. Regarding this, the majority of the respondents (62.5%) were not aware of any local or international laws pertaining to e-waste management. Besides, about (75%) of the respondents also contended that

they were not aware and uncertain about any policy/legislation on e-waste management at the federal/state level. The chi-square test result for both of the questions was statistically not significant. With regard to the programs, activities, and projects in relation to e-waste, as it is shown in Table 6.5, about 58.3% of the respondents reported that they were not aware of this aspect, while 22.9% were aware of programs, activities and projects towards e-waste management.

Table 6.5: Responses to e-waste legislation, policies, and recycling

ITEMS		Institution's Name			Total	χ^2	Sig. (2-tailed)
		PREI	PUEI	GSO			
Are you aware of recycling/trading fairs for electronic wastes?	Yes	16.7	16.7	16.7	50	3.200	.525
	No	12.5	6.3	12.5	31.3		
	uncertain	4.2	10.4	4.2	18.8		
Are you aware that some electronic parts may be profitably selling to recyclers?	Yes	20.8	22.9	14.6	58.3	3.752	.441
	No	12.5	8.3	14.6	35.4		
	uncertain	0	2.1	4.2	6.3		
Do you know of any local or international laws pertaining to electronic waste management?	Yes	8.3	8.3	6.3	22.9	1.925	.750
	No	18.8	18.8	25	62.5		
	uncertain	6.3	6.3	2.1	14.6		
Is there any policy/legislation on e-waste management at the state/federal level that your institution is aware of?	Yes	0	14.6	10.4	25	9.461	.051
	No	22.9	10.4	12.5	45.8		
	uncertain	10.4	8.3	10.4	29.2		
Are you aware of local programs, projects or activities pertaining to electronic waste management?	Yes	6.3	6.3	10.4	22.9	1.465	.833
	No	18.8	20.8	18.8	58.3		
	uncertain	8.3	6.3	4.2	18.8		
Are there e-waste recycling sites in Addis Ababa or elsewhere in the country that you know?	Yes	6.3	16.7	12.5	35.4	3.795	.434
	No	20.8	14.6	16.7	52.1		
	uncertain	6.3	2.1	4.2	12.5		

Source: Field Survey, 2016

Finally, as far as recycling sites in Addis Ababa were concerned, participants were asked whether they knew e-waste recycling centres in Addis Ababa or elsewhere in the country. As a result, the study found that more than half of the respondents (52.1%) didn't know e-waste recycling sites in Addis Ababa or elsewhere in the country, while 35.4% were aware of it. The chi-square test results in both cases did not produce statistically significant results.

6.5. E-WASTE GENERATION LEVEL, TYPES, AND CHARACTERISTICS

This section presents the e-waste generation level, types, and characteristics and the major management measures taken on e-waste among the EIs and GSOs. These data deemed essential to know the current status of e-waste generation level that helps to develop appropriate e-waste management strategies. To begin with the functional electronic equipment, GSOs have the highest mean value of (7,043), maximum (10,092), and minimum (3,129) with standard deviation (SD of 2339) followed by PUEIs with the mean value of (5,255), maximum (20,472), minimum (1,511), and highest SD value of 6,270. The PREIs were with a mean value of (3,081), maximum (9,506), minimum (482) and SD value of (3,008).

Figure 6.1 depicts a total volume of functional electronic equipment that was currently providing services in PREIs, PUEIs, and GSOs. Accordingly, in all selected cases, it was found that a total of 123,041 different functional electronic equipment were providing services. Besides this, the study attempts to identify how many of them were received through donations, newly purchased and from second-hand markets. As a result, the majority of the functional equipment, which accounts 112,062 were newly purchased from general distributors and retail shops, whereas 5,697 electronic equipment was purchased from the second-hand market, and finally about 5,282 of the total functional electronic equipment were received from donating organization.

As far as a percentage is concerned, newly purchased equipment accounts the highest value (91%), electronic equipment from donating organization accounts (5%), and about (4%) of the total functional electronic equipment was purchased from

second-hand markets. What is more, there are differences in the volume of functional electronic equipment among the three cases. Accordingly, GSOs account for the highest volume of functional e-waste (56,349) followed by PUEIs which hold a total functional electronic equipment of 42,043 and PREIs have 24,649 functional electronic equipment.

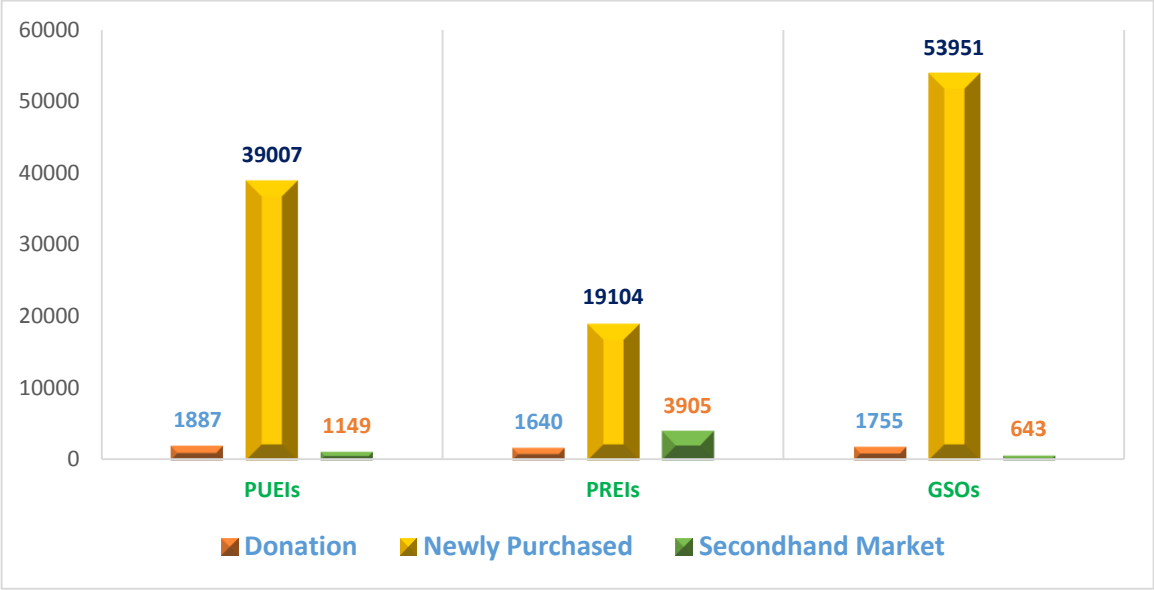

Figure 6.1. Quantities and sources of functional electronic equipment

Source: Field Survey, 2016

Furthermore, a one-way ANOVA was carried out to see whether there is statistically significant difference in terms of the volume of functional EE, newly purchased, second-hand, and those owned from donating organizations among PREIs, PUEIs, and GSOs. Accordingly, the results indicated that there was no statistically significant difference between the three cases (See Table 6.6).

Table 6.6: ANOVA results on the types of functional electronic equipment

ANOVA						
Functional Electronic Equipment		Sum of Squares	df	Mean Square	F	Sig.
Total EE	Between Groups	63004286.333	2	31502143.167	1.755	.197
	Within Groups	376935730.625	21	17949320.506		
	Total	439940016.958	23			
Through donation	Between Groups	3819.083	2	1909.542	.011	.989
	Within Groups	3653514.750	21	173976.893		
	Total	3657333.833	23			
Newly purchased	Between Groups	76406914.750	2	38203457.375	2.420	.113
	Within Groups	331475313.750	21	15784538.750		
	Total	407882228.500	23			
From second-hand markets	Between Groups	770509.000	2	385254.500	1.890	.176
	Within Groups	4280540.625	21	203835.268		
	Total	5051049.625	23			

Source: Field Survey, 2016

The bar graph and the table (Figure 6.3) and (Table 6.7) respectively demonstrated categories of functional electronic equipment, which were available in selected EIs and GSOs.

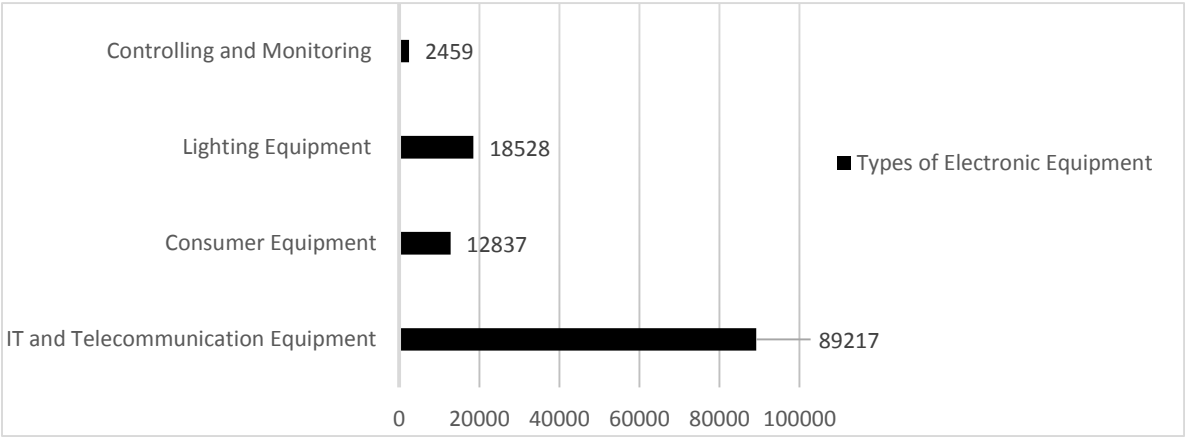

Figure 6.2. Types owned electronic equipment

Source: Field Survey, 2016

Thus, it was found that the most dominantly available category was IT and telecommunication equipment, which constitutes 73% of the total functional electronic equipment. The types of electronic equipment that fall under this category are computers, printers, photocopy machines, scanners, fax machines, phones (land lines). Next, to this, lighting equipment accounts for about 15%, which includes fluorescents and luminaries. Thirdly consumer equipment also shares 10% which includes projectors, cameras, DVD players, radios, televisions sets, audio-amplifiers, UPSs, and tape-recorders. Lastly, controlling and monitoring equipment such as smoke detectors, heating regulators, and laboratory equipment were also identified in the EIs and GSOs.

Given the newly purchased electronic equipment, the study tries to compare categories of electronic equipment owned through donations and from second-hand markets. As depicted in the graph IT and telecommunication equipment (ITTE) shares the highest number followed by consumer equipment (CE). Both lighting (LE) and controlling and monitoring equipment (CME) accounts the least share. This is true that most of the donating organizations throw IT and telecommunication equipment to the developing countries (See figure 6.4).

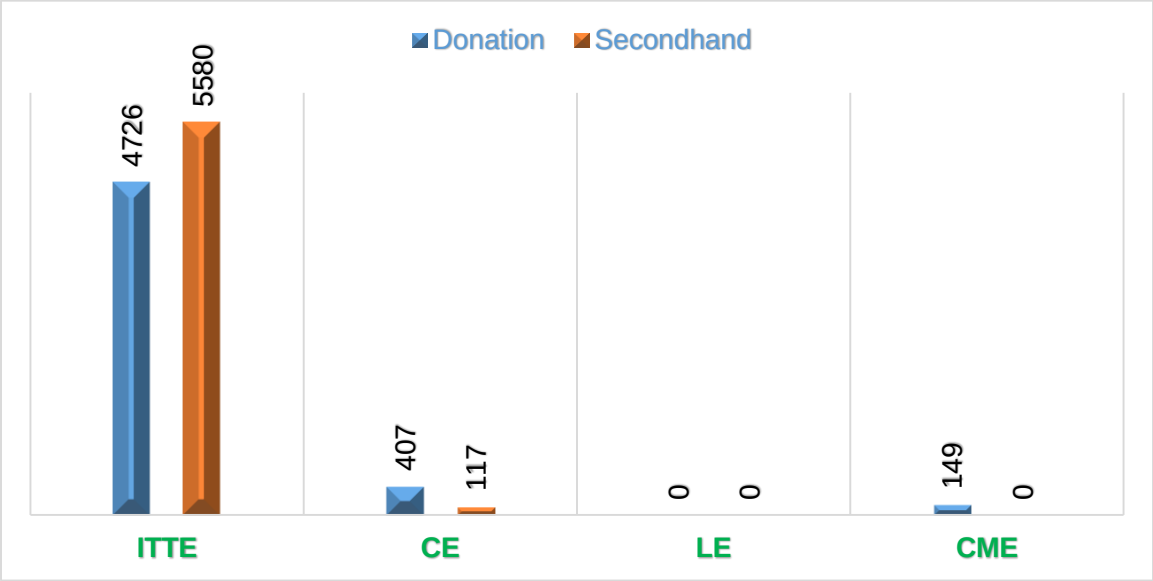

Figure 6.3. Electronic equipment owned from donors and second-hand market
Source: Field Survey, 2016

One of the main objectives of this study was to investigate the e-waste generation level among EIs and GSOs. Accordingly, data were acquired through a review of the documents. Figure 6.5 depicts a total volume of e-waste generated by EIs and GSOs of Addis Ababa. It was found that a total of 38,424 (in number) e-waste was generated. This number constitutes all broken, obsolete and non-functional e-waste. Specifically, a total of 11,153 (non-functional), 15,911(obsolete), and 11,360 (broken) e-waste were generated. As far as a percentage is concerned, obsolete electronic waste accounts for 41% of the total e-waste while non-functional and broken e-waste makes 29% and 30% respectively. Pertaining to the volume of e-waste generated among EIs and GSOs, PUEIs have generated the highest volume of e-waste (16,833) which accounts for about 43.8% of the total e-waste followed by GSOs which shares (11,958) or (31%). Lastly, the PREIs accounted for 9,633 or (25%) of the total e-waste.

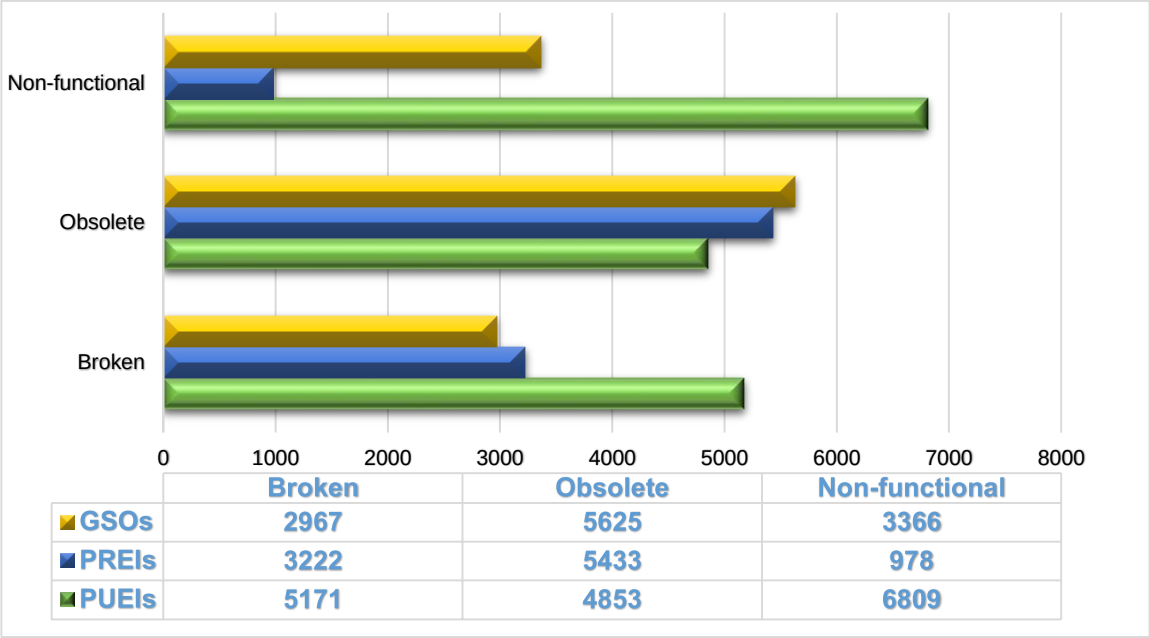

Figure 6.4. E-waste quantities and types generated

Source: Field Survey, 2016

Furthermore, a one-way ANOVA was computed to see whether total volume of e-waste, broken, obsolete and non-functional e-waste differed among PREIs, PUEIs, and GSOs. Accordingly, the ANOVA result which was tested at a significance level of 0.05 reveals no statistically significant differences in total e-waste, broken and obsolete e-waste generated in EIs and GSOs. However, it was found that the test was significant at 0.05 in terms of non-functional electronic equipment as (F= 8.432, and p=.002) (See Table 6.10).

From the results so far, it is known that there are statistically significant differences between the groups as a whole in terms of non-functional e-waste. Thus, to see which group differed, the Tukey post hoc test was conducted. As indicated in Table 6.11, the result shows there is a statistically significant difference in terms of the non-functional electronic waste between PREIs and PUEIs (p = 0.001). However, there were no differences between PREIs and GSOs (p = 0.239) and between PUEIs and GSOs (p = 0.62).

Table 6.7: ANOVA results on e-waste types

		Sum of Squares	df	Mean Square	F	Sig.
E-waste (Total)	Between Groups	3375468.750	2	1687734.375	1.095	.353
	Within Groups	32356341.250	21	1540778.155		
	Total	35731810.000	23			
E-waste (Broken)	Between Groups	363385.083	2	181692.542	.717	.500
	Within Groups	5319814.250	21	253324.488		
	Total	5683199.333	23			
E-waste (obsolete)	Between Groups	40385.333	2	20192.667	.017	.983
	Within Groups	24724431.625	21	1177353.887		
	Total	24764816.958	23			
E-waste (non-functional)	Between Groups	2148223.083	2	1074111.542	8.432	.002
	Within Groups	2675133.875	21	127387.327		
	Total	4823356.958	23			

Source: Field Survey, 2016.

The study also identified, as depicted in Table 6.8 and Figure 6.6, the most frequently generated types of e-waste in EIs and GSOs. Accordingly, IT and telecommunication equipment which includes computers, photocopy machines, scanners, fax machines, printers, laptops, phones, and typewriters were the most generated e-waste types followed by lighting equipment such as straight fluorescent, compact fluorescent and luminaries.

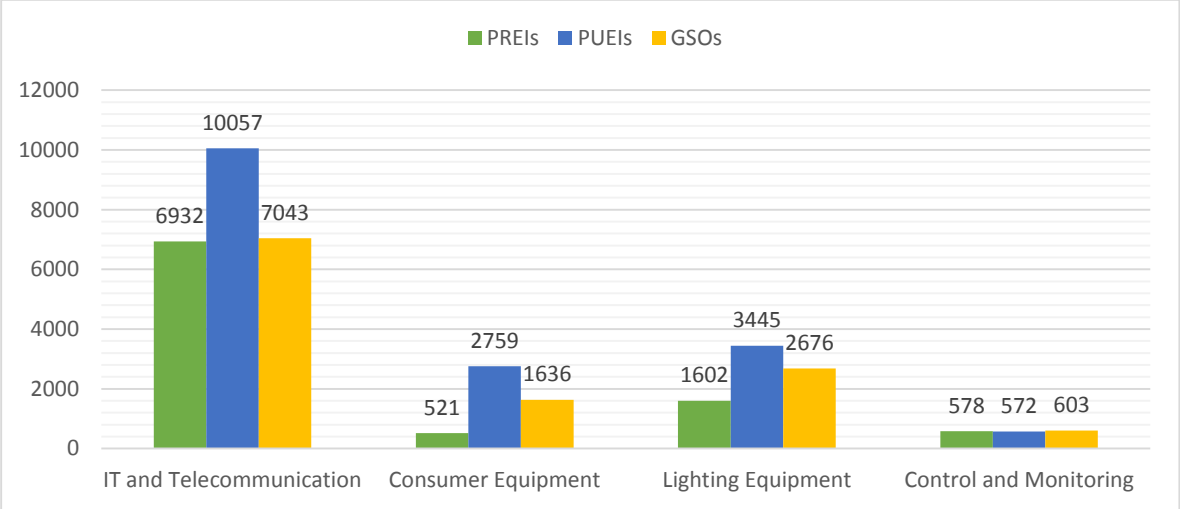

Figure 6.5 E-waste categories

Source: Field Survey, 2016

Concerning the e-waste disposal methods majority of electronic waste are stored in the each of the selected EIs and GSOs due to various reasons mentioned earlier which have discussed in the next section. Meaning, less number of e-waste were possibly recycled, donated, incinerated, sold and dumped. In fact, it might be impossible for the EIs and GSOs to properly manage the e-waste in the absence of policy/legislation that specifically deals with e-waste. The other determinant factors include costs, facilities, and skilled manpower. Thus, the ultimate disposal method was storing. This result was consistent with the results obtained through questionnaires.

The following Figure 6.8 depicts the e-waste disposal methods practiced in PREIs, PUEIs, and GSOs.

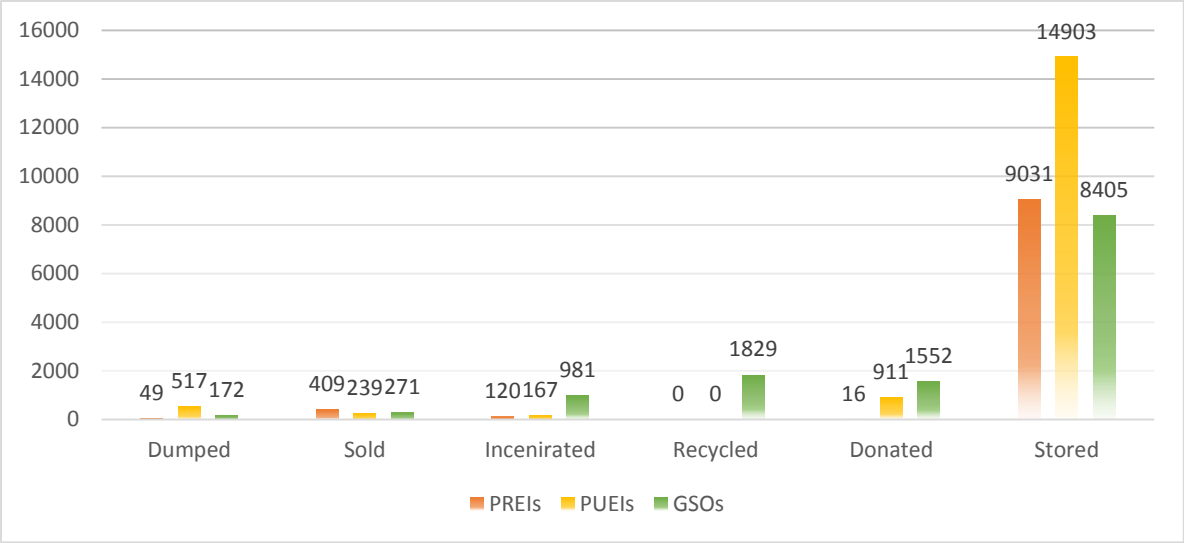

Figure 6.6. E-waste disposal methods

Source: Field Survey, 2016

Similarly, the study computed a one-way ANOVA to see whether there is a significant difference among the selected EIs and GSOs in terms of the e-waste disposal methods. As the ANOVA table reveals, there is no statistically significant difference in e-waste disposal methods such as dumping, donating, storing, incinerating, selling and recycling of e-waste.

Table 6.8: ANOVA results of e-waste disposal methods

		Sum of Squares	df	Mean Square	F	Sig.
E-waste (dumped)	Between Groups	14715.750	2	7357.875	2.791	.084
	Within Groups	55368.750	21	2636.607		
	Total	70084.500	23			
E-waste (donated)	Between Groups	148800.083	2	74400.042	.812	.457
	Within Groups	1923010.875	21	91571.946		
	Total	2071810.958	23			
E-waste (stored)	Between Groups	3212344.333	2	1606172.167	1.152	.335
	Within Groups	29291273.625	21	1394822.554		
	Total	32503617.958	23			
E-waste (incinerated)	Between Groups	58588.583	2	29294.292	2.124	.144
	Within Groups	289568.750	21	13788.988		

	Total	348157.333	23			
E-waste (sold)	Between Groups	2040.333	2	1020.167	.098	.907
	Within Groups	218796.625	21	10418.887		
	Total	220836.958	23			
E-waste (recycled)	Between Groups	278770.083	2	139385.042	2.319	.123
	Within Groups	1261989.875	21	60094.756		
	Total	1540759.958	23			

Source: Field Survey, 2016

6.6. E-WASTE CAUSES, MANAGEMENT METHODS, AND THE CHALLENGES

This section attempts to analyse e-waste causes, disposal methods, and management practices in the selected EIs and GSOs of Addis Ababa. More specifically, the data sought to examine conditions under which electronic equipment was purchased, pre-testing for functionality or originality, purchasing sources, causes of e-waste, conditions of making EE at end-of-life, reasons for replacing old electronic equipment, e-waste disposal methods, reasons for storing e-waste, reasons for replacing obsolete, broken and unserviceable electronic equipment, types of e-waste frequently observed, electronic equipment maintenance, e-waste handling in the storage, e-waste recycling and the hindering factors, barriers to the adoption e-waste management policy, challenges, and the e-waste management practices.

6.6.1. Purchase of electronic equipment

Basically, it is essential to consider about conditions in which electronic equipment should be purchased. It was found that majority (79.2%) of the selected EIs and GSOs contended to purchase ‘new’ electronic equipment while 16.7% were argued to purchase ‘used’ electronic equipment. The remaining 4.2% contended to purchase ‘working’ electronic equipment (See Table 6.12). This indicates there are reasons for the institutions and offices to purchase used and working equipment which can considerably increase e-waste creation. Obviously, it is due to the fact that both used and working electronic equipment are affordable and found at a low price when compared to those of original or new equipment. As a result, a significant number of

the institutions and organization would rely on the purchase of second-hand equipment. The χ^2 test result (3.118, P=.538) shows no significant difference among the EIs and GSOs.

Table 6.9: Conditions under which EE purchased

			Institution's Name			Total
			PREIs	PUEIs	GSOs	
Conditions under which EE was purchased	Used	Count	3	4	1	8
		% of Total	6.3%	8.3%	2.1%	16.7%
	New	Count	13	11	14	38
		% of Total	27.1%	22.9%	29.2%	79.2%
	Working	Count	0	1	1	2
		% of Total	0.0%	2.1%	2.1%	4.2%
		% of Total				100.0%

Source: Field Survey, 2016

6.6.2. Pre-testing of electronic equipment

Some of the electronic equipment has remained non-functional and others experienced technical defects after the purchasing process has taken place. Therefore, there should be ICT technicians who may pre-testing for the status of the equipment before it is going to be utilized. Regarding this, the data gathered from the sample EIs and GSOs show that majority of them (68.8%) claimed to pre-test the status of the newly purchased equipment by 'ICT technicians', whilst (25%) of the respondents argued that there are 'purchasing teams' who can check it. About 4.2% replied the equipment are checked by 'distributors' and the remaining 2.1% did not implement the pre-testing process (See Figure 6.9).

The χ^2 test shows no significant difference among the three cases. Hence, χ^2 = 8.545, p=.201. Inevitably rapid technological advancements, affordability of electronic equipment and rapid obsolescence rate would enforce both EIs and GSOs to undertake to purchase of electronic equipment frequently.

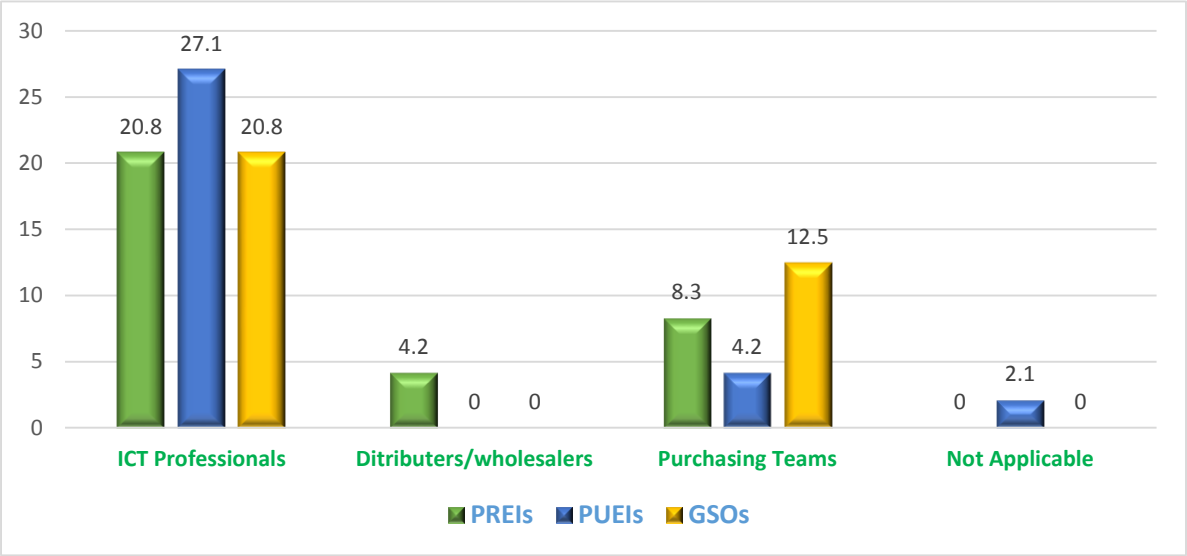

Figure 6.7. The pre-testing for functionality of electronic equipment

Source: Field Survey, 2016

6.6.3. Sources of electronic equipment

As mentioned earlier, arguably electronic equipment selling shops, companies, factories are contributing a significant role in e-waste management through the production and provision of original and environmentally friendly electronic appliances. Fundamentally, the purchase of electronic equipment and their sources would be affected by the economic status, established linkages, availability, and accessibility of original and ecologically friendly products. There are various sources for the educational institutions and offices to make a purchase of electronic items; these are retail shops, wholesalers, second-hand market, and manufacturers.

Regarding the sources purchase of the electronic equipment needed for the institution as depicts in the Figure 6.10, the majority of the EIs and GSOs (70.8%) claimed to purchase most of the electronic appliances from general distributors followed by retail shops which constitute 18.8%. Whereas, few EIs and GSOs were purchasing the electronic equipment through lease and directly from manufacturers. This question was raised because the mechanism through which the electronic products purchased greatly influences the management of electronic wastes.

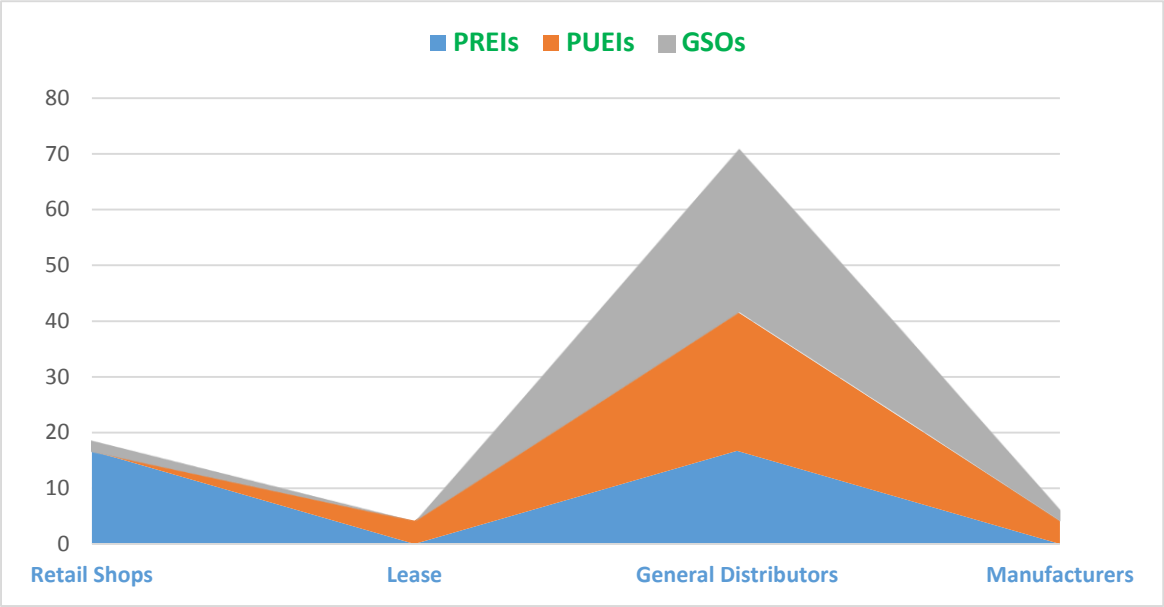

Figure 6.8. Purchasing sources of electronic equipment

Source: Field Survey, 2016

The χ^2 test result (20.314, p=.002) to see whether there is a significant difference in the sources of electronic equipment among the three cases, was statistically significant. It was confirmed that majority of the PREIs are making a purchase of electronic equipment from retail shops.

6.6.4. E-waste causes and conditions of making at end-of-life

One of the major concerns of the study was to identify the causes of electronic waste in those selected EIs and GSOs. Identifying the causes of e-waste generation would result in proper e-waste management. The study found that the major causes are breakings (39.6%) and obsolescence (39.6%), the demand for new design (16.7%) and incompatibility issues (4.2%). However, the causes are differently ranked among the EIs and GSOs. Accordingly, in PREIs the major causes are obsolescence and breaking of electronic equipment. Whereas, it is quite different for PUEIs that breaking of electronic equipment, obsolescence rate, and the demand for the new

design are ranked from 1st to 3rd. Finally, it was found that obsolescence, the demand for new design and breakings were caused for e-waste created in government sector offices (See Table 6.13).

Table 6.10: E-waste generation causes

Rank	The major causes of e-waste generation and the ranks					
	PREIs		**PUEIs**		**GSOs**	
	Causes	%	Causes	%	Causes	%
1st	Obsolescence	18.8	Breakings	16.7	Obsolescence	14.6
2nd	Breakings	14.6	Obsolescence	6.3	The demand for new technology	10.4
3rd	Demand for new Technology	0	Demand for new Technology	6.3	Breakings	8.3
4th	Incompatibility	0	Incompatibility	4.2	Incompatibility	0

Source: Field Survey, 2016

The χ^2 test (13.066, p=.042) result was statistically significant in terms of causes of electronic waste among EIs and GSOs. On the other hand, the study reveals that majority of the participants (68.8%) categorize e-waste based on the working status of the equipment i.e. as operational and non-operational, whilst 31.3 % make the electronic equipment at the end-of-life based on the age of the equipment i.e. as old and new (See Figure 6.11).

Besides, the χ^2 test was computed to see whether there is a significant difference among that selected area on how to identify/categorize e-waste. The result was not significant.

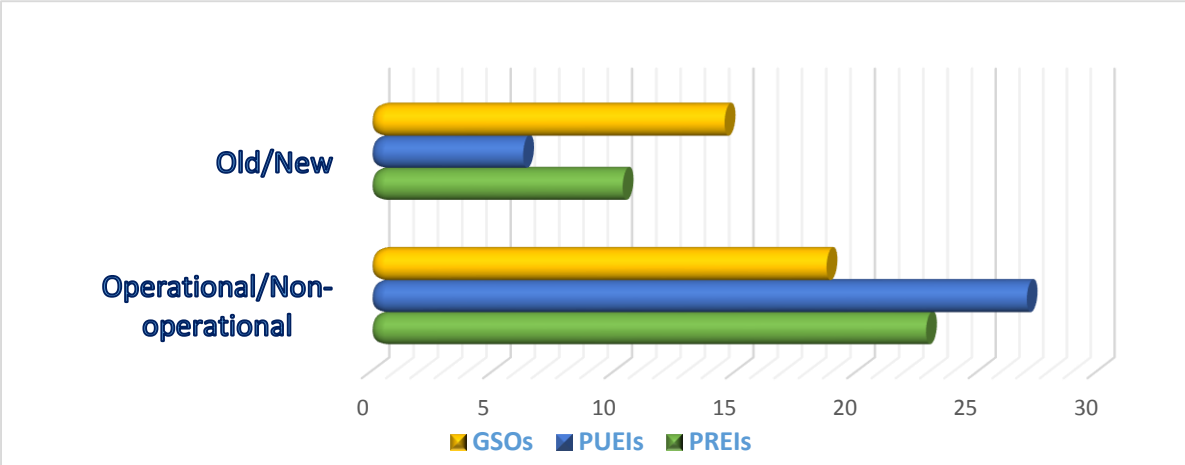

Figure 6.9. Conditions of making electronic equipment at their end-of-life

Source: Field Survey, 2016

6.6.5. Reasons for replacing old EE

It is obvious that consumers would replace old electronic equipment on the basis of several reasons. Where some of them might replace old electronic appliances in order to have newer technology others are wanting features not available on old electronic equipment.

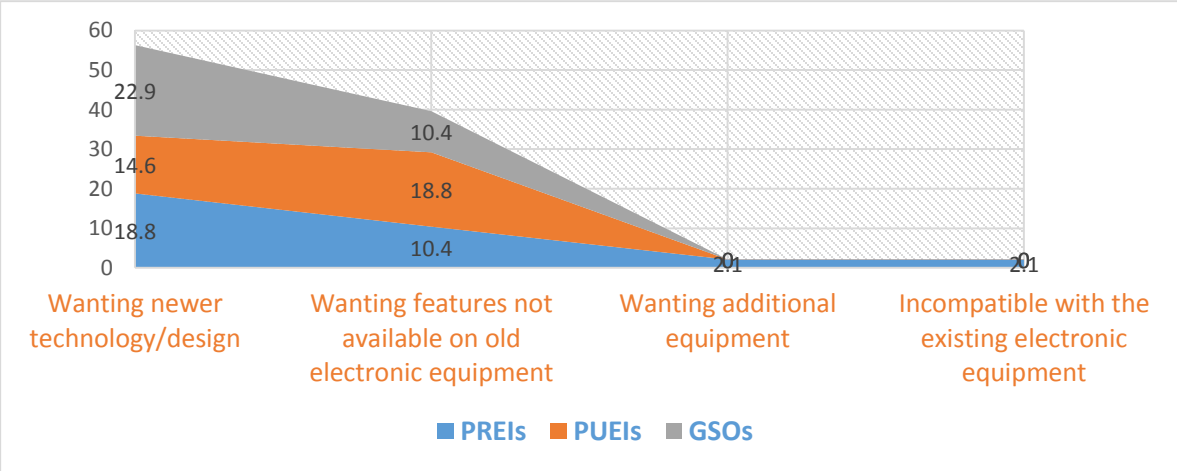

Figure 6.10. Reasons for replacing old electronic equipment

Source: Field Survey, 2016

In this regard, the results of the study reveal that majority of the respondents (56.3%) reported that they replace old electronic equipment wanting newer technology or design whilst (39.6%) of the sample respondents replied they replace old equipment wanting features not available on old electronic equipment (See Figure 6.12). The X^2 test result (6.573, P=.362) shows no significant differences among the selected areas in terms of reasons for replacing old electronic equipment.

6.6.6. E-waste disposal methods

Concerning to the disposal methods practiced by the EIs and GSOs, the data obtained through questionnaire revealed that majority of the participants (81.3%) are promoting storing/disposing of as the only disposal method e-waste followed by reuse which accounts (18.8%) of the respondents (See Figure 6.13). We can see from the response that other management practices such as recycling and refurbishing are not observed. The result of X^2 test is not significant in e-waste management strategy that selected EIs and GSOs are promoting. The result is $X^2 =$ .821 and, P = .663.

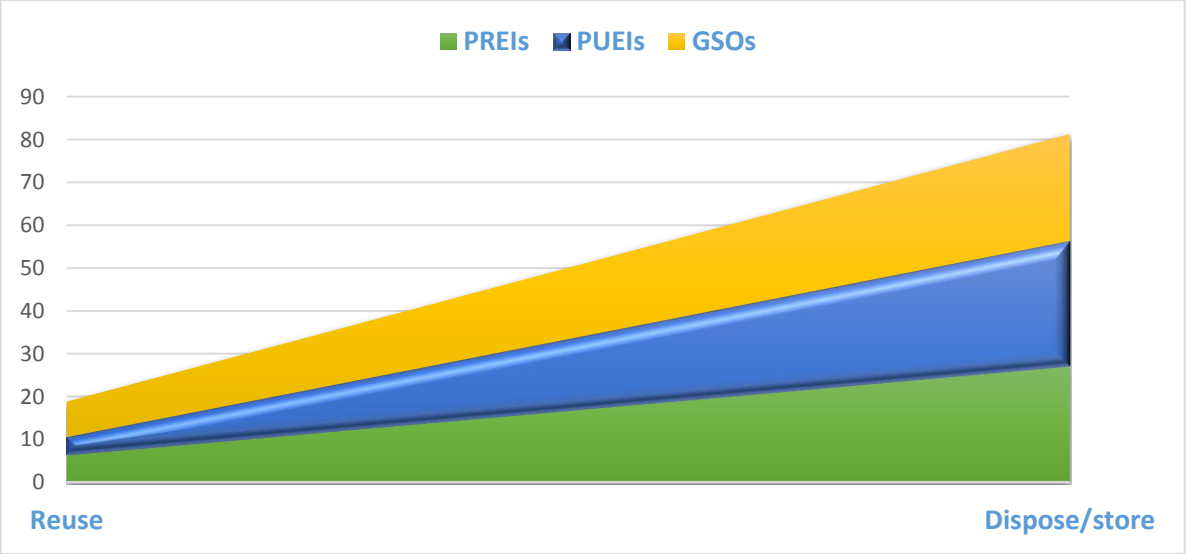

Figure 6.11. E-waste disposal methods practiced

Source: Field Survey, 2016

Respondents were asked why they are storing unused electronic equipment. The study reveals that majority of EIs and GSOs (45.8%) store e-waste because they are wanting to sell/donate it. The other 18.8 % stored unused electronic equipment because they don't know what to do with it. On the other hand, about 16.7% of them reacted that they store unused e-waste because of the absence of good disposal methods or recyclers. What is more, about 14% of the participants store e-waste because they have not repaired/upgrade it (See Figure 6.14).

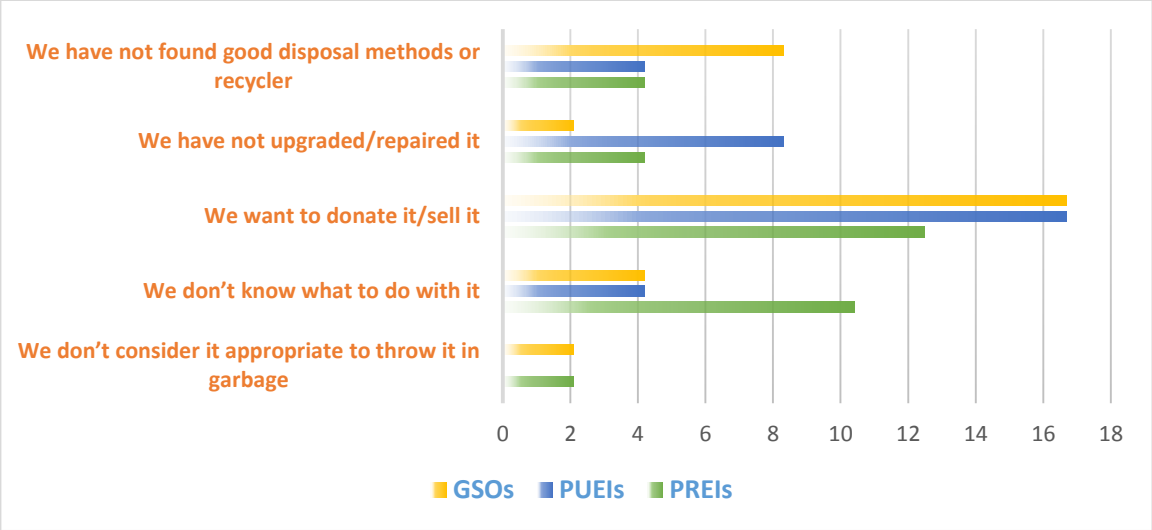

Figure 6.12. Reasons for storing electronic waste

Source: Field Survey, 2016

We can understand that there are very limited recycling centers, refurbishing and maintaining shops in the city. The χ^2 result (6.364, p=.607) shows no significant difference among the three cases.

6.6.7. Measures toward e-waste

One of the essential elements of electronic waste management is the actions and practices towards old, broken and irreparable electronic equipment. The generation of such types of waste is inevitable in EIs and GSOs. However, it is frequently observed in most of the institutions that there is less concern about e-waste. However, emphasis should also be given to the final destination of that electronic

equipment. In this regard, as shown in Table 6.11, the study result reveals that majority of the PREIs, PUEIs, and GSOs were storing old, broken and unserviceable electronic equipment. There were some EIs and GSOs which throw that equipment to other institutions and organizations in the form of donations (See Table 6.14). Finally, the study also found that a small number of institutions and governmental sector offices gives the old, broken and irreparable equipment back to the company (manufacturer) for recycling.

Table 6.11: Actions are taken on outdated electronic equipment

		PREIs (%)	PUEIs (%)	GSOs (%)	Total
Actions taken to old/outdated equipment	Store	22.9	18.8	25.0	66.7
	Sell to scrap dealer	10.4	6.3	4.2	20.8
	Throw them to other institutions	0	6.3	4.2	10.4
	Give them back to the company for servicing	0	2.1	0	2.1
Total					100.0%

Source: Field Survey, 2016

Table 6.12: Actions taken on broken electronic equipment

		PREIs (%)	PUEIs (%)	GSOs (%)	Total
Actions were taken to broken EE	Store	14.6	16.7	20.8	52.1
	Sell to scrap dealer	12.5	8.3	2.1	22.9
	Throw them to other institutions	0	2.1	8.3	10.4
	Give them back to the company for servicing	6.3	2.1	2.1	14.6
Total					100.0%

Source: Field Survey, 2016

Table 6.13: Action taken on irreparable electronic equipment

		PREIs (%)	PUEIs (%)	GSOs (%)	Total
Actions taken to irreparable electronic equipment	Store	16.7	18.8	20.8	56.3
	Sell to scrap dealer	16.7	12.5	12.5	41.7
	Throw them to other institutions	0	2.1	0	2.1
	Give them back to the company for servicing	0	0	0	0
Total					100.0%

Source: Field Survey, 2016

6.6.8. Waste collectors and EE maintenances

It is argued that formal and informal waste collectors have a significant role in electronic waste management through the collection of waste generated from all development sectors in the country. With regards to whether waste collectors come and collect e-waste from the selected EIs and GSOs, the study highlighted that the majority of the sample respondents (45.8%) confirmed that waste collectors didn't come and collect e-waste, while 39.6% of the respondents reported that they come to their institutions or offices to collect not e-waste but other types of waste. Furthermore, the remaining EIs and GSOs (14.6%) replied that waste collectors come to them to collect everything including e-waste (See Figure 6.15). The X^2 test result (4.960, p=.291) shows no significant difference among the three cases with regards to whether waste collectors collect e-waste. This indicates that there is lack of management system which allows waste collectors to collect electronic waste generated from EIs and GSOs.

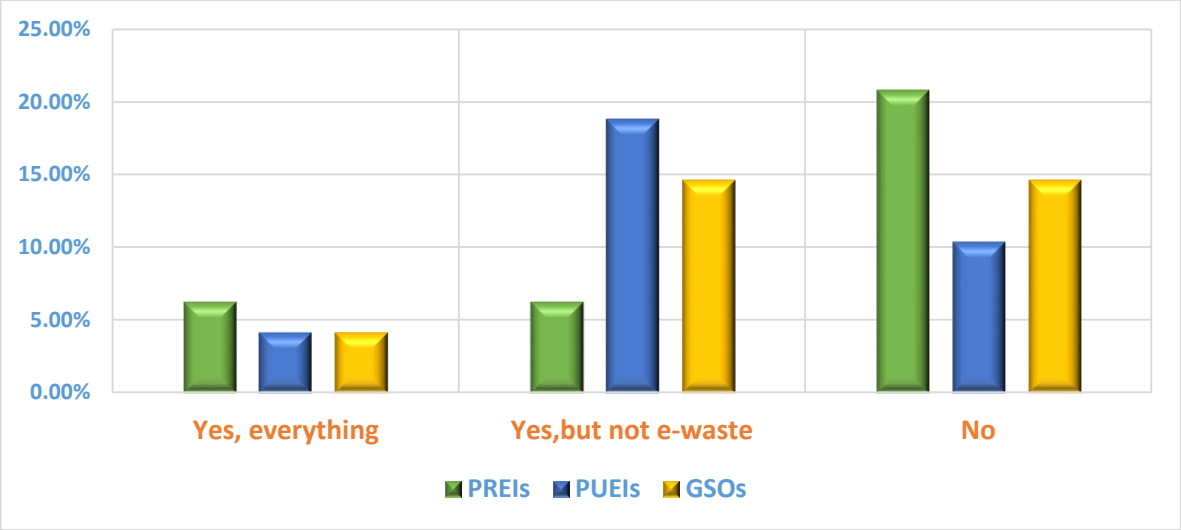

Figure 6.13. Whether waste collectors collect e-waste

Source: Field Survey, 2016

The role of electronic maintenance and refurbishment shops is decisive in electronic waste management through the collection and maintaining of broken and non-functional electronic equipment. Hence, it would encourage reuse of the equipment which ultimately reduces the number of e-waste generated. Paradoxically, if technicians in these shops or centres have limited knowledge and skills to maintain and refurbish electronic items, most of the electronic equipment will remain broken and non-functional.

Concerning this, the study was trying to identify whether EIs and GSOs get repaired the electronic equipment they send them for repairs. Accordingly, it was found that the majority of them (72.9%) confirmed that they got them repaired, while the remaining 27.1% of the respondents didn't get them repaired. Besides, for the question who does repair the broken and non-functional electronic equipment, the majority of the respondents (87.5%) claimed that they were repaired by certified professionals, while 10.4% repaired by their own the remaining 2.1% got repaired by untrained personnel. What is more, it was found that most of the repairing activities were done not at regular intervals rather on a case by case as confirmed by a majority of the respondents, which accounts (60.4%) (See Figure 6.16). This might imply a

limited number of e-waste maintenance and refurbishment shops in the city, as well as high volume of e-waste generation from EIs and GSOs, sent to these centres for repair. The chi-square test result shows no significant difference among the three cases with respect to e-waste repairing activities.

6.6.9. E-waste storage and facilities

With this regard, questionnaires were administered to the respondents to know how electronic waste was stored in the storerooms of selected EIs and GSOs. Accordingly, the majority of the respondents (52.1%) confirmed that e-waste was stored mixed with other types of waste in the same room, whereas about 29.2% said that e-waste was stored separately from other types of waste in different rooms. On the other hand, about 12.5% reported that e-waste was stored separately from other types of waste but in the same room, while 6.3% replied e-waste stored mixed with functional electronic equipment (See Figure 6.17).

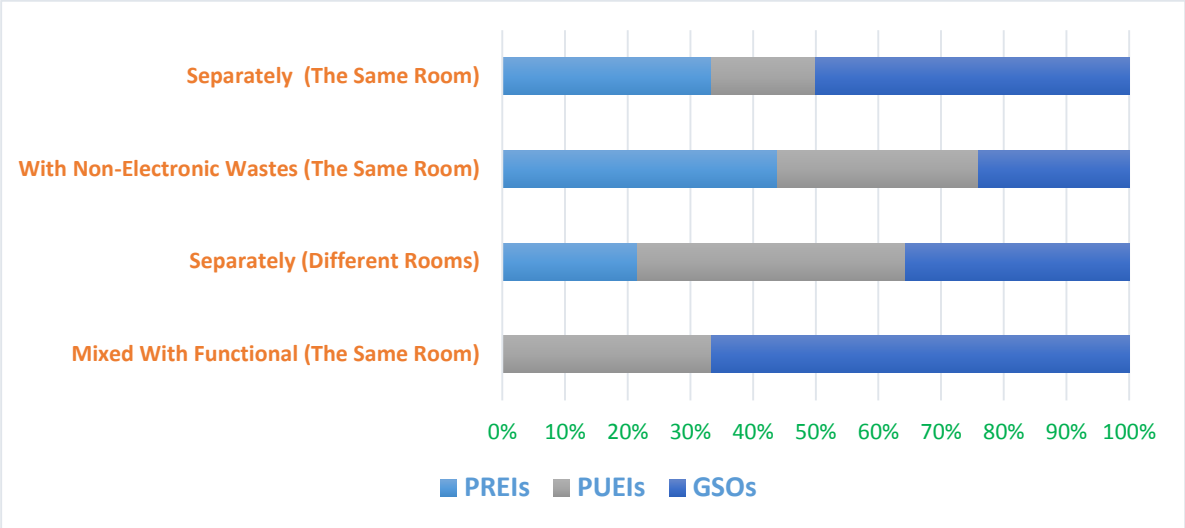

Figure 6.14. Conditions of e-waste in storerooms

Source: Field Survey, 2016

6.6.10. E-waste recycling and hindering factors

Recycling of electronic waste is one of the methods of e-waste disposal in which recycled materials can be used in developing new equipment, valuable materials are retrieved and help the environment by avoiding pollution. As discussed earlier, most of the selected EIs and GSOs never recycle e-waste. In this section, the study discusses factors hindering the recycling of electronic waste.

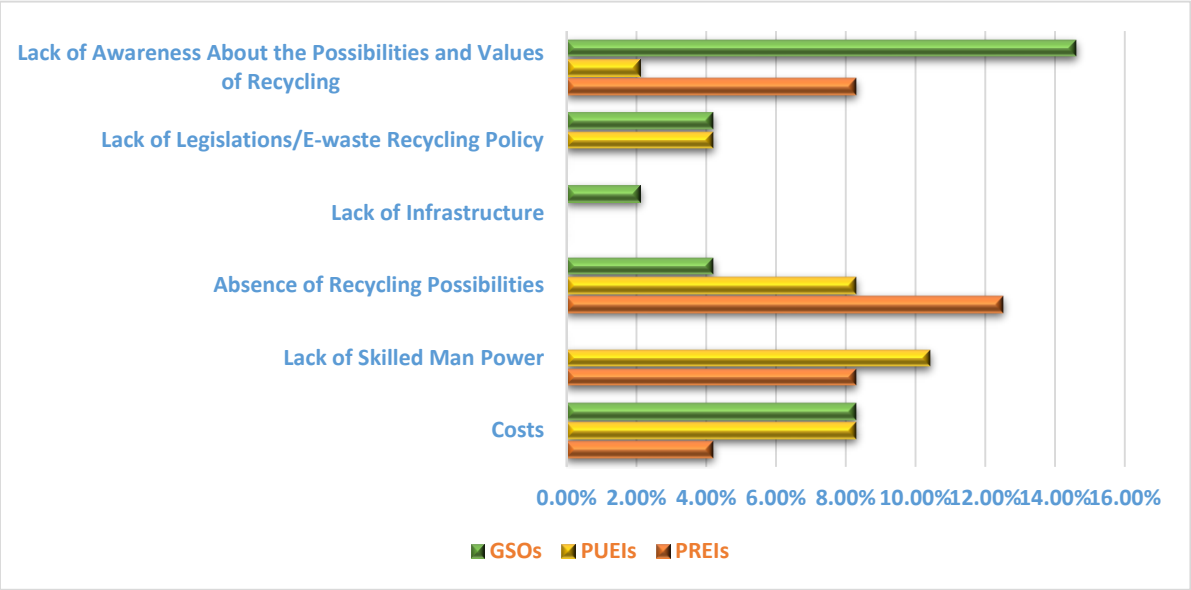

Figure 6.15. Factors hindering e-waste recycling

Source: Field Survey, 2016

As indicated in the Figure 6.18, about 25% of the respondents mentioned the absence of recycling possibilities as e-waste recycling hindering factor. An equal number of respondents which accounted 25% reported that the lack of awareness of the possibilities and values of recycling as a hindering factor for e-waste recycling. Whereas, about 20.8% points out costs of recycling and the remaining 18.2% reported a shortage of skilled manpower as hindering factor for e-waste recycling. More specifically, the majority of respondents from governmental sector offices (14.6%) mentioned lack of awareness about the possibilities and values of recycling while 12.5% of the respondents from private educational institutions stated the

absence of recycling possibilities as a hindering factor than others in the questionnaire alternatives. The Chi-square test result is not statistically significant (χ^2=15.967, p=.101). We can see that almost all of the factors have been noted by the EIs and GSOs as a challenge to recycle e-waste.

6.6.11. E-waste management challenges

Developing countries are facing several challenges in managing electronic waste generated from households, government sector offices, educational institutions, industries and business centres. Most of the developing countries didn't enforce policies or legislation that specifically deal with electronic waste management. In light of this, as indicated in Figure 6.19, the data gathered through questionnaire indicates almost equal percent of the selected EIs and GSOs confirmed barriers to the adoption of electronic waste management as weak enforcement of environmental consciousness laws (22.9%), policy barriers (lack of legislation or absence of framework) (20.8%), absence of appropriate e-waste management model (20.8%), e-waste management facility shortage (20.8%) and lack of skilled manpower (14%).

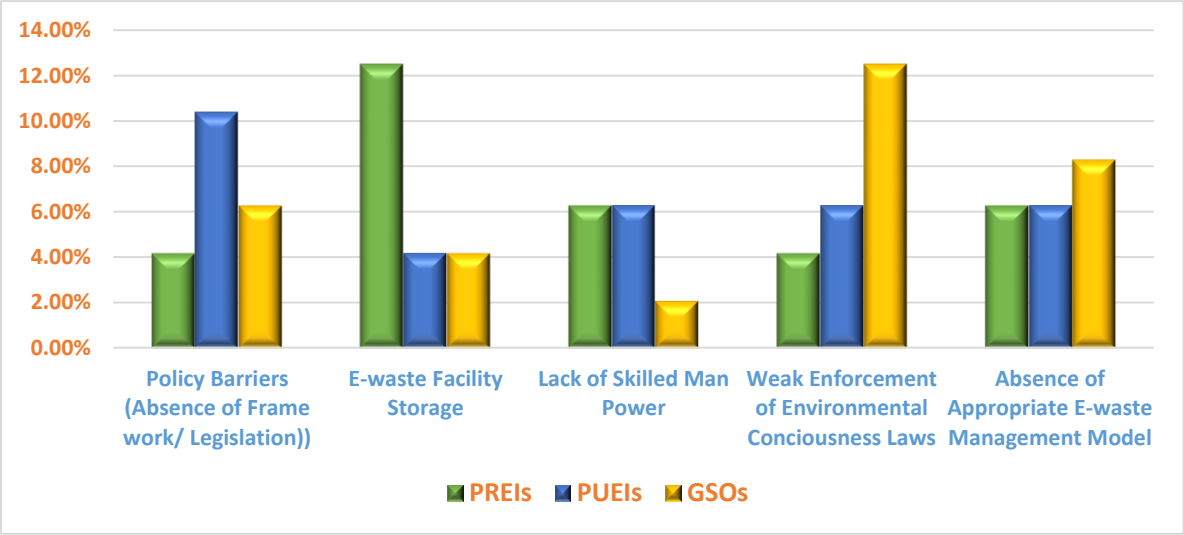

Figure 6.16. Barriers to the adoption of e-waste management strategies

Source: Field Survey, 2016

What is more, the barriers were different for different EIs and GSOs. For instance, PUEIs were mentioned absence of framework or e-waste policy as a big challenge, while PREIs stuck to e-waste management facility shortage and GSOs concerned with weak enforcement of environmental consciousness laws. Nevertheless, it indicates the e-waste management aspect in the city in particular and the country, in general, is lagging behind. Besides, from the χ^2 test result, it was understood that there is no significant difference between EIs and GSOs in terms of the barriers to the adoption of e-waste management.

6.6.12. E-waste management activities

Concerning the e-waste management related activities that the selected EIs and GSOs have been performing, questionnaire was administered to 48 respondents and results were obtained. Accordingly, as indicated in Figure 6.20, the majority of them (52.1%) were performing e-waste inventory only, while about 23% of them were doing nothing.

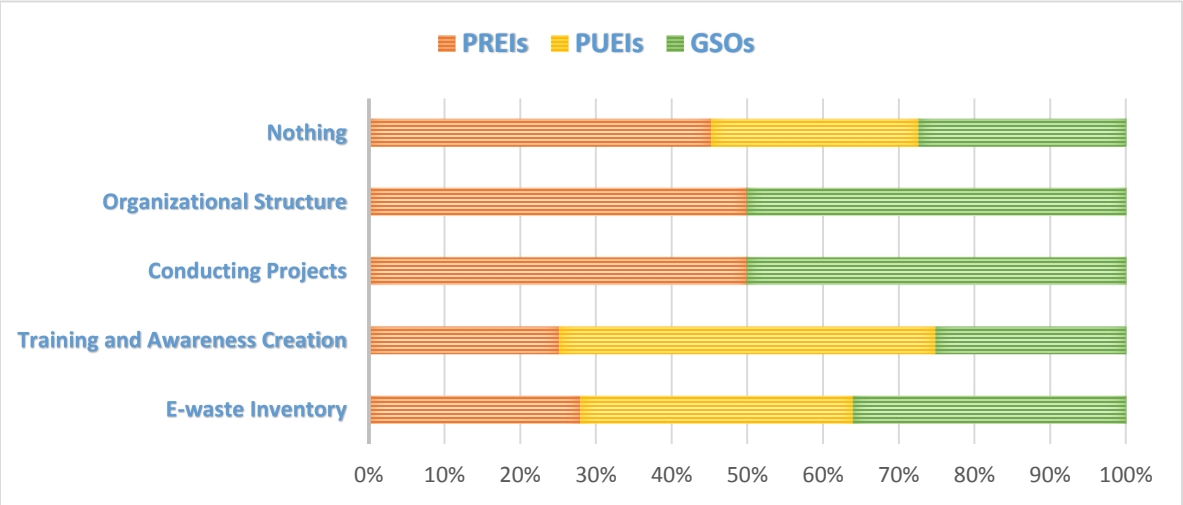

Figure 6.17. E-waste management activities performed

Source: Field Survey, 2016

On the other hand, about (16.7%) of the EIs and GSOs conducted awareness creation and training program on e-waste. Finally, a small percent of the respondents argued that their institutions and offices were involved in undertaking projects to recycle e-waste and revising the organizational structure that entertains e-waste management issue. The χ^2 test result (4.047, p=.853) indicates no significant difference regarding e-waste management activities performed among the three cases.

6.6.13. E-waste management stakeholders

Electronic waste management is not a simple task, it invites various actors to realize proper collection, transportation, recycling and disposal of electronic waste. Thus, their intervention influences the way in which e-waste is managed. After all, the researcher tried to assess this issue because creating links with these stakeholders is paramount in the management of e-waste. In light of this, the selected EIs and GSOs were asked if they have created partnerships with other stakeholders to manage e-waste. Accordingly, it was found that the majority of the respondents (60.4%) didn't make a partnership with stakeholders to manage e-waste, while 39.6% communicates with government bodies/agencies on how to manage e-waste. The χ^2 result (7.492, p=.024) shows significant difference among the selected EIs and GSOs in terms of partnership creation.

6.7. ACTIVITIES & ENGAGEMENT IN E-WASTE MANAGEMENT PRACTICES

6.7.1. Activities performed in electronic waste management

As per the objective of the study, in addition to attempting to gauge the awareness level of the respondents, the researcher was also aimed at identifying the overall activities of the selected EIs and GSOs in relation to e-waste (See Table 6.14). Thus, one of the major areas of emphasis in the questionnaire survey was to examine activities related to e-waste inventory, independent units handling e-waste, e-waste policy, e-waste recycling, storage of e-waste, and e-waste awareness creation programs. Accordingly, the results of the study revealed that the majority of the respondents (68.8%) have kept inventories of the electronic equipment they discarded while 25% of them have not. However, what the researcher noticed during document review was that almost all of the selected EIs and GSOs didn't have organized data regarding e-waste.

Electronic waste management, due to its nature, should be handled by special bodies who are knowledgeable and skillful with the basics of e-waste categorization, dismantling, refurbishing, and recycling. With regards to this, the study was seeking to identify whether there was independent unit /department which is responsible for e-waste management. Accordingly, the results of the study highlighted that the majority of the respondents (54.2%) reported that their organization did not have independent units for handling e-waste. Comparatively, about 41.7% of the respondents reported that their organizations had an independent unit for handling e-waste. What is more, interview results show that many institutions considered e-waste as other types of solid waste and as a result lacked independent units for the management of such types of wastes. Many of them also felt that there was a need to revise the organizational structures of their institutions in order to create independent departments/units for handling e-waste. The chi-square test result (7.962, p=.093) indicates that there is no significant difference among the EIs and GSOs regarding the presence or absence of independent units for handling e-waste. Basically, there should be policy or guidelines on how to manage e-waste before and

after their creation. Concerning this, about 45.8% of the respondents have argued they have a policy for the management of electronic waste while 41.5 % reported that they had no policies for guiding and controlling activities related to e-waste management. The remaining 12.5 were uncertain about the issue.

Table 6.14: Summary of the activities performed in e-waste management

ITEMS	Response	Institution's Name			Total	χ^2	Sig. (2-tailed)
		PREIs	PUEIs	GSOs			
Do you keep inventories of the equipment you discard/store?	Yes	25	22.9	20.8	68.8	2.682	.612
	No	8.3	6.3	10.4	25		
	uncertain	0	4.2	2.1	6.3		
Is there any unit that is specifically responsible for e-waste management in your institution/office?	Yes	10.4	20.8	10.4	41.7	7.962	.093
	No	22.9	12.5	18.8	54.2		
	uncertain	0	0	4.2	4.2		
Does your institution have a policy for the management of electronic waste management?	Yes	14.6	20.8	10.4	45.8	5.827	.212
	No	14.6	12.5	14.6	41.7		
	uncertain	4.2	0	8.3	12.5		
Does your office/institution have appropriate and sufficient storage to handle e-waste and discarded electronic items?	Yes	16.7	10.4	8.3	35.4	3.815	.432
	No	16.7	20.8	20.8	58.3		
	uncertain	0	2.1	4.2	6.3		
Are there types of electronic waste that you consider hazardous?	Yes	14.6	12.5	18.8	45.8	9.720	.045
	No	18.8	14.6	4.2	37.5		
	uncertain	0	6.3	10.4	16.7		
Is there any electronic equipment that is not giving service because of its design/size/features?	Yes	10.4	16.7	16.7	43.8	2.597	.565
	No	14.6	12.5	14.6	41.7		
	uncertain	8.3	4.2	2.1	14.6		
Is your institution currently addressing the growing need for knowledge and skills relating to resource consumption or electronic waste?	Yes	20.8	20.8	8.3	50	7.000	.136
	No	8.3	6.3	10.4	25		
	uncertain	4.2	6.3	14.6	25		

Source: Field Survey, 2016

As it can be seen from Table 6.14, the majority of the majority of EIs and GSOs (58.3%) did not have appropriate and sufficient storage facilities to handle discarded electronic waste. This is also one of the evidence that indicate the level of concern for e-waste management in most of the surveyed institutions was markedly low. This was particularly the case when it came to the proper handling of discarded appliances. Regarding the types of electronic waste that EIs and GSOs consider hazardous, the majority of the respondents (45.8%) reported that there were types of

electronic waste that they considered hazardous whilst about 37.5% of them stated their organization did not have any e-waste they considered as hazardous (See Figure 6.18). The remaining 16.7% were uncertain about it. In this aspect, the chi-square test result (χ^2= 9.720, p=.045) showed that there was statistically significant difference among the three cases in considering types of e-waste.

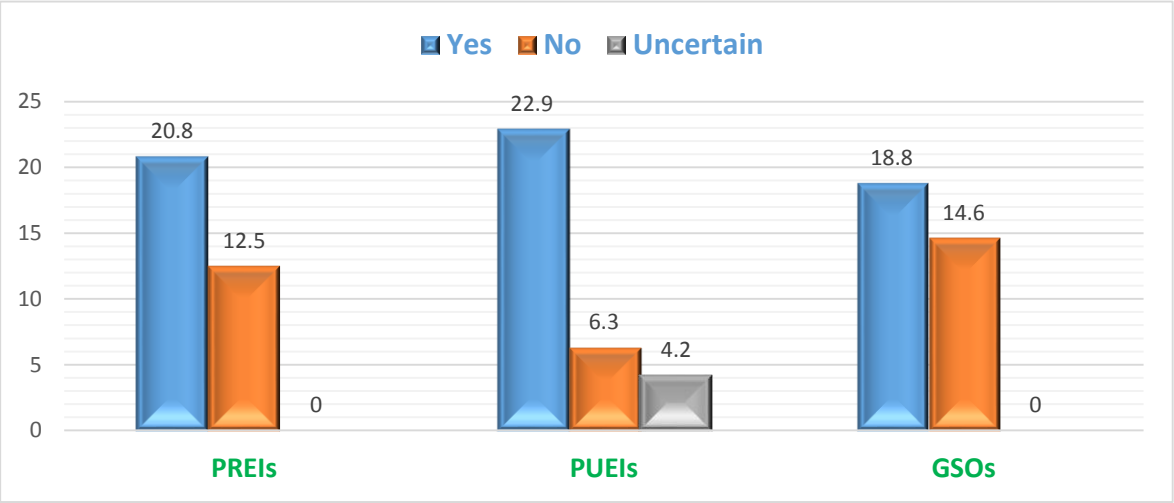

Figure 6.18. Whether electronic equipment owned form donors

Source: Field Survey, 2016

A significant number of electronic equipment imported or purchased were remaining non-functional not only due to their low capacities or faults but also because of the absence of manuals or lack of know-how to operate them. In this aspect, the study tried to investigate whether there was such kind of electronic equipment in the selected EIs and GSOs. Accordingly, the study found that the majority of the respondents (44%) replied that there was electronic equipment which is non-functional due to the absence of manuals, their sizes as well as designs and lack of knowhow to operate them. About 41.7% of the respondents reported that there was no electronic equipment which was not functional. Besides, the chi-square test result showed no significant difference between the three cases. Finally, the study revealed that about half (50%) of the selected EIs and GSOs were attempting to address the growing need for knowledge and skills relating to resource consumption or electronic waste during the survey (See Table 6.14).

Studies indicate that among the other causes of e-waste in developing countries like Ethiopia is the importation of second-hand electronic equipment in the form of donation. In this regard, the data were obtained through questionnaire surveys. As indicated in Figure 6.18, the study reveals that the majority of the selected EIs and GSOs (62.5%) have received electronic equipment from donating organizations or other institutions whilst 33.3% of them were not received. The remaining percentage was uncertain whether the institutions were receiving electronic equipment from donating organization.

With regards to whether the selected EIs and GSOs recycle electronic waste, as indicated in the Figure 6.19, the majority of them (66.7%) did not ever recycle e-waste, whilst 27.1% reported that they recycled e-waste discarded from their offices or institutions. The χ^2 test result shows no significant difference among the three cases. Hence, ($\chi^2 = 5.923$, p=.205).

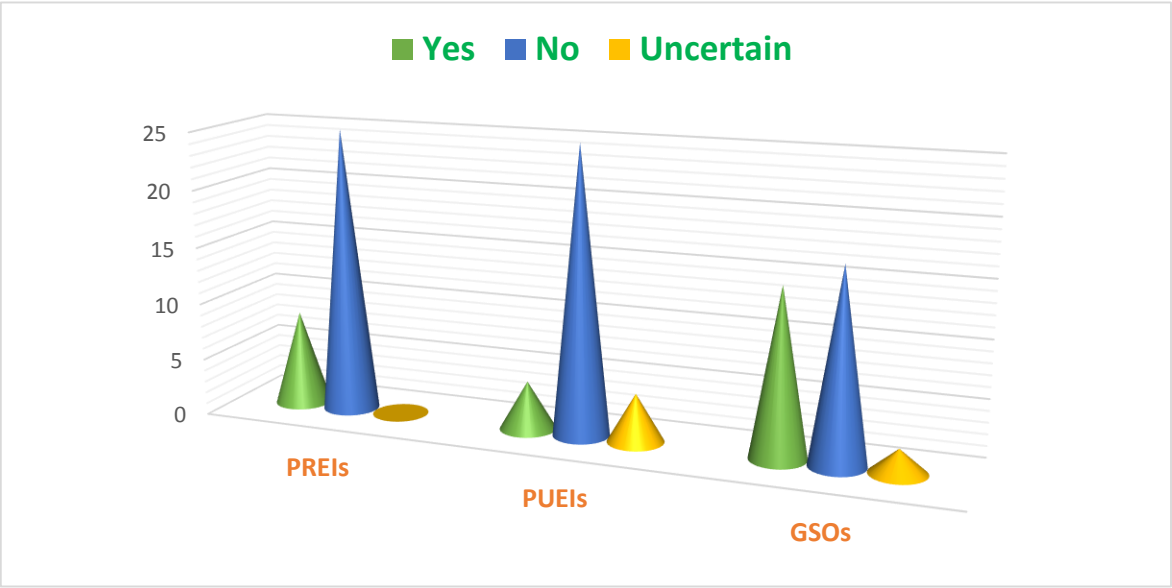

Figure 6.19. Whether or not recycle e-waste

Source: Field Survey, 2016

6.7.2. Engagement level e-waste management practices

This section presents the engagement level of the selected EIs and GSOs in some of the electronic waste management related activities. To this end, questionnaires were administered and employed on three-point scale as always, sometimes and never. As it was done for households, here there were three sections in the table (See Table 6.15); it depicts the mean score, percentages, and the chi-square test results. As far as the mean score is concerned, it ranged from 1.37 to 2.87. Explicitly, the mean score highlighted that engagement level of EIs and GSOs in electronic management " ranged from always to never. However, there are some differences in the mean score among the three cases. The majority of them were 'sometimes' engaged in all of the activities listed in the table, hence the mean value for the whole activities is 2.11.

The chi-square test results were significance at (p = .001, .007, .040), which indicates significance differences among EIs and GSOs in responding to questions such as "I observe proper waste segregation practices", "It buys electronic equipment with brands that are reputable for their durability and longer life over other brands" and "It traded or sells used electronic equipment" respectively.

Table 6.15: Responses on engagement level in e-waste management

Items	Institutions	Level of engagement			Mean	Sig.
		Always	Sometimes	Never		
It recycles electronic products/gadgets which can still be recycled.	PREI	2.1	12.5	18.8	2.31	.184
	PUEI	0	22.9	10.4	2.50	
	GSO	4.2	10.4	18.8	2.43	
It buys new electronic gadgets even if the older ones are still working.	PREI	6.3	27.1	0	1.75	.478
	PUEI	8.3	25	0	1.81	
	GSO	12.5	20.8	0	1.62	
It buys electronic equipment with brands that are reputable for their durability and longer life over other brands.	PREI	20.8	12.5	0	1.56	.338
	PUEI	14.6	18.8	0	1.37	
	GSO	12.5	20.8	0	1.62	
I observe proper waste segregation practices.	PREI	4.2	20.8	8.3	1.81	.001
	PUEI	12.5	14.6	6.3	2.12	
	GSO	0	6.3	27.1	2.81	
It buys second-hand gadgets and/or “re-assembled” equipment.	PREI	6.3	16.7	10.4	2.75	.007
	PUEI	2.1	4.2	27.1	2.12	
	GSO	0	4.2	29.2	2.87	
It traded or sells used electronic equipment.	PREI	14.6	14.6	4.2	2.12	.040
	PUEI	6.3	16.7	10.4	1.68	
	GSO	2.1	12.5	18.8	2.50	
It donates some old electronic equipment to other institutions	PREI	0	14.6	18.8	2.06	.170
	PUEI	8.3	14.6	16.7	2.56	
	GSO	8.3	16.7	8.3	2.00	
Average					2.11	

Source: Field Survey, 2016

6.7.3. The ordinal regression outputs

Moreover, in order to predict an ordinal dependent variable given one independent variable, the study conducts an ordinal regression. Accordingly, institution type (PREIs, PUEIs, and GSOs) was considered as an independent variable that might affect the ordinal dependent variables ranging from “never” to “always” for all items. The summary result is presented in Table 6.16, as follows.

Table 6.16: The ordinal regression output 1

		Estimate	Std. Error	Wald	df	Sig.	Exp_β	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	[Q49 = 1.00]	-4.055	.820	24.485	1	.000	.017	.003	.086
	[Q49 = 2.00]	-1.487	.644	5.339	1	.021	.226	.064	.798
Location	[PREIs]	-2.419	.825	8.608	1	.003	.089	.018	.448
	[PUEIs]	-3.361	.881	14.571	1	.000	.035	.006	.195
	[GSOs]	0[a]	.	.	0	.	1.000		

Source: Field Survey, 2016

The ordinal regression result shows that the odds of Private Educational Institutions and Public Educational Institutions in observing proper waste segregation practices was .089 (95% CI, .018 to .448) and .035 (95% CI, 006 to .195) times that of Government Sector Offices, a statistically significant effect, Wald $X^2(1) = 8.608$, $p = .003$ and Wald $X^2(1) = 14.571$, $p < .001$ respectively (See Table 6.16).

Table 6.17: The ordinal regression output 2

		Estimate	Std. Error	Wald	df	Sig.	Exp_β	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	[Q50 = 1.00]	-4.072	.945	18.583	1	.000	.017	.003	.109
	[Q50 = 2.00]	-1.965	.761	6.673	1	.010	.140	.032	.622
Location	[PREIs]	-2.698	.918	8.641	1	.003	.067	.011	.407
	[PUEIs]	-.543	.988	.302	1	.583	.581	.084	4.027
	[GSOs]	0[a]	.	.	0	.	1.000		

Source: Field Survey, 2016

The odds of Private Educational Institutions in buying second-hand gadgets and/or "reassembled" equipment was .067 (95% CI, .011 to .407) times that of Public Educational Institutions and Government Sector Offices, a statistically significant effect, Wald $X^2(1) = 8.641$, $p = .003$ (See Table 6.17).

Table 6.18: The ordinal regression output 3

		Estimate	Std. Error	Wald	df	Sig.	Exp_β	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	[Q51 = 1.00]	-2.550	.636	16.055	1	.000	.078	.022	.272
	[Q51 = 2.00]	-.270	.496	.297	1	.586	.763	.289	2.018
Location	[PREIs]	-2.281	.750	9.236	1	.002	.102	.023	.445
	[PUEIs]	-1.068	.694	2.368	1	.124	.344	.088	1.340
	[GSOs]	0[a]	.	.	0	.	1.000		

Source: Field Survey, 2016

As shown in Table 6.18, the odds of Private Educational Institutions in trading or selling used electronic equipment was .102 (95% CI, .023 to .445) times that of Public Educational Institutions and Government Sector Offices, a statistically significant effect, Wald X2(1) = 9.236, p = .002.

Table 6.19: The ordinal regression output 4

		Estimate	Std. Error	Wald	df	Sig.	Exp_β	95% Confidence Interval	
								Lower Bound	Upper Bound
Threshold	[Q52 = 1.00]	-1.159	.523	4.909	1	.027	.314	.113	.875
	[Q52 = 2.00]	1.159	.523	4.909	1	.027	3.186	1.143	8.881
Location	[PREIs]	1.525	.711	4.596	1	.032	4.594	1.140	18.518
	[PUEIs]	.182	.673	.073	1	.787	1.199	.321	4.482
	[GSOs]	0[a]	.	.	0		1.000		

Source: Field Survey, 2016

As indicated in Table 6.19, the odds of Private Educational Institutions in donating some old electronic equipment to other institutions was 4.594 (95% CI, 1.140 to 18.518) times that of Public Educational Institutions and Government Sector Offices, a statistically significant effect, Wald $X^2(1) = 4.596$, $p = .032$.

6.8. THE RESULTS FROM INTERVIEWS WITH GSD PERSONNEL

6.8.1. Introduction

This section presents the results of the study obtained through interviews. The interviews were conducted with twenty-four GSD personnel of EIs and GSOs and with eight HGOs. Using a phenomenographic approach described in the preceding chapter, the interviews were transcribed verbatim and analysed iteratively. From all of the interview guides, six major interview topics were identified. These were electronic waste management activities, challenges in e-waste management, storage areas and facilities of e-waste management, efforts to minimize e-waste, stakeholders in e-waste management and general recommendations forwarded towards e-waste management.

6.8.2. E-waste management activities

As shown in Table 6.20, the results of the interviews results made to solicit the views of GSD personnel regarding e-waste management activities done in EIs and GSOs confirmed that the majority of the GSD personnel viewed stock taking or making an inventory of e-waste as an activity. As such the activity included counting, categorizing and labeling of e-waste simply to identify functional and non-functional electronic equipment. The organization of e-waste management related training and the conception and execution of awareness creation programs were not widely designed and offered. Besides, most of the institutions reported that they have done nothing as regards training their personnel on any aspect of e-waste management. This implies less emphasis was paid to e-waste management among the EIs and GSOs. For instance, one GSD worker expressed the situation as follows:

> E-waste is simply stored in our office due to the absence of directives on what to do with them and lack of awareness of e-waste management. Therefore, we didn't go deeper into this aspect. What we have conducted is some elementary e-waste accounting in which we were able to identify e-waste from non-e-waste. The rest, the office didn't organize any training and

awareness creation programs on e-waste management until today (MoFED, GSD, interviewed in January 2016, verbatim).

This indicates that the attention given to e-waste was very low. Accompanied by lack of awareness and absence of directives, storing was the major action taken to e-waste. Thus, their actions and reactions were determined by these constraining factors.

Table 6.20: Theme I: Electronic waste management activities

Topics	Core Responses Obtained Via Interview	Codes
E- Waste Management Activities Implemented by EIs and GSOs	• Only e-waste accounting/inventory • provides no training and awareness creation program	MoR
	• e-waste accounting and kaizen training	AAUFBE
	• nothing b/c e-waste we don't consider e-waste problematic	AAUSF
	• E-waste accounting takes place but no training	MoT
	• Providing manuals for storekeepers and ICT professionals	MoScT
	• E-waste accounting and MoFED provides training on e-waste and other properties	Entoto
	• Nothing, no idea about e-waste	PESC
	• Provision of training on property management but not specific to e-waste	MoA
	• Nothing done	KMU
	• Some elementary e-waste accounting, no training b/c of lack of awareness about e-waste management.	MoFED
	• Training on property management	EiABC
	• Nothing on e-waste inventory, training on property management	Orbit
	• We have scientific method to handle e-waste, training provision to CRTC on how to store and handle e-waste	MoCIT
	• Nothing	Admas
	• Nothing	MoH
	• Nothing b/c we have small amount of e-waste	CPUC
	• No e-waste accounting and training only on customer handling topics	St.MU
	• E-waste accounting but not training	ECSU
	• Proper e-waste inventory-and we send for recycling to the centre called "daylight"	UU

Similarly, another GSD workers reported:

> Honestly speaking, the office has been involving in e-waste accounting. We have also engaged in e-waste collection from the departments and administrative offices. However, we put the majority of them to storerooms. We got some of them repaired and refurbished in electronic maintenance centres. We couldn't actively engage ourselves in e-waste management due to lack of attention and awareness about the economic values and impacts of e-waste (AAUSF, GSD, interviewed in January 2016, verbatim)

It can be seen from the above excerptions that the institution has attempted to engage in e-waste accounting, collection, and maintenances. The major challenge was associated with lack of awareness and attention about the e-waste management.

> I believe that our office didn't actively involve in e-waste management activities. In fact, it has prepared general directives that deals with other types of wastes but not e-waste, and the office has established committee who are responsible to identify, collect and store other types of waste but not e-waste. Regarding e-waste, what we did was providing manuals for storekeepers and ICT professionals to properly handle electronic equipment. However, it is very difficult for us to dispose of e-waste. E-waste has been treated like other waste (MoScT, GSD, interviewed in January 2016, verbatim).

This excerpt reveal that there was no general directives and activities on e-waste management. What they did was providing manuals that deal with how ICT professionals and storekeepers should have to utilize the electronic equipment. Therefore, e-waste has been treated just like other types of waste.

6.8.3. E-waste storage and e-waste handling facilities

One of the essential elements of e-waste management is to have appropriate and sufficient storages and facilities. In the absence of those e-waste handling facilities, obviously, the discarded electronic equipment might have damaged and exposed to rain, sprinkles, dust, and sunlight. This has implications in that it will reduce the service potential of the equipment thereby causing it to be recycled, donated or maintained. It could also ultimately affect the human health. In this regard, Meena (2008) disclosed that the storage areas should be covered areas for storage of e-waste till such time that the waste is recycled or treated. The same author added the storages could also be the warehouses hired for this purpose. Furthermore, the author asserted that appropriate containers should be used for storing different e-waste items separately and there should be no mixing of different kinds of e-waste. The purpose of the weatherproof covering for storage at treatment sites is to minimize the contamination of clean surface and rain waters, to facilitate the reuse of those whole appliances and components intended for recycling and to assist in the containment of hazardous materials and fluids.

The interview results indicated that the overall storage areas and the facilities within the storage area in the majority of the EIs and GSOs were very poor. Most of the GSD personnel reported that there were no sufficient and appropriate storage areas to handle e-waste in their storerooms. As a result, e-waste stored in combination with functional electronic equipment. What is more, facilities such as shelves, containers and other essential elements in the storage areas lacked (See Table 6.21). Here are some of the excerpts taken from the interviews that we conducted with GSD personnel:

> There is no sufficient and appropriate storage in our office to store e-waste except at the ICT centre to provide some maintenance services. What I observed was that functional electronic equipment was simply put in storerooms. They could be maintained and donated to other institutions if adequate concerns were given to e-waste management. However, most of the e-waste left in storerooms have begun to deteriorate and flout (MoT, GSD, interviewed in January 2016, verbatim).

In this particular excerption, the good aspect was the presence of ICT centre who provide some maintenance services. However, the problem was that functional electronic equipment was put in store considered as non-functional equipment. They claimed that the poor concerns toward e-waste management resulted in poor handlings of e-waste in the storage areas. Further, there was an opportunity to donate the equipment to other institutions which are requesting for.

> It could be said, to some extent, that our storerooms were sufficient and appropriate to properly handle e-waste generated from this university. However, we still lacked some e-waste facilities to refurbish and maintain broken and non-functional e-waste. The good thing was we had able to had three categories of e-waste in our storerooms. These were e-waste which needed maintenance, that could be donated and e-waste which was beyond repair (ESCU, GSD, interviewed in January 2016, verbatim).

According to this excerpts, the institution has attempted to classify the e-waste based on their status to facilitate e-waste management in the storage areas. However, it claims that the e-waste handling facilities are lacking which hinder the refurbishment and maintenance of some e-waste.

> Generally speaking, there is a storeroom in which e-waste is stored. Since we have been given the mandate to collect e-waste from other institutions, we collect a very limited number of e-waste and sent them to CRTC. However, it is beyond the capacity of CRTC to handle e-waste due to a shortage of sufficient warehouses, the absence of professionals and e-waste facilities (MoCIT, GSD, interviewed in January 2016, verbatim).

The above excerpts showed that there were shortages of e-waste storage and e-waste handling facilities in most of the EIs and GSOs. Therefore, the e-waste was exposed to scratching and breakings.

Table 6.21: Theme II: Storage and facilities to handle e-waste

Topics	Core Responses Obtained Via Interview	Codes
Storage and Facilities to Handle E-waste	• We have enough space but due to lack of attention we store e-waste together with other types of waste • Absence of e-waste categorization and labeling	MoR
	• Not sufficient to handle	AAUFBE
	• Very poor	AAUSF
	• Not sufficient and lacking facilities	MoT
	• Sufficient storage but e-waste put with other materials or wastes	MoScT
	• Not sufficient space, no separate room for e-waste	Entoto
	• No storeroom simply we drop into the basket container	PESC
	• Sufficient storage	MoA
	• Insufficient storerooms, we put with functional equipment	KMU
	• Very limited warehouses, put with functional one	MoFED
	• Sufficient storage	EiABC
	• Sufficient storage and lack facilities	Orbit
	• Not sufficient and their space shortage, we need the support of other institutions to share a huge amount of e-waste in CRTC.	MoCIT
	• Not sufficient	Admas
	• Not sufficient and appropriate storerooms	MoH
	• Sufficient room	CPUC
	• Not enough space and we suffer for a long time	St.MU
	• Very good and the overall setting of the storerooms are good and e-waste are put in a category.	ECSU
	• Enough space	UU

6.8.4. Efforts to minimize e-waste generation

In the course of e-waste management approaches, one of the crucial aspects of e-waste management is the principle of 3R such as reuse, recycle and redesign. On the other hand, the purchase of durable, original and environmentally friendly EE may also contribute to e-waste minimization efforts. Furthermore, other methods include maintaining and refurbishing of broken and old equipment. ITU (2012); ITU (2016b); ITU (2017b), as cited in Baldé *et al*. (2017), there are many efforts underway to limit

the number of obsolete devices and equipment and to reduce the amount of energy needed for EEE and especially ICT devices. These include the development of universal power adapters and chargers. Regarding the e-waste generation minimization techniques, the interview result showed that there were some methods considered among the EIs and GSOs as waste minimization techniques. As indicated in Table 6.22, the GSD personnel stated providing some awareness and urging their employees to properly utilize and handle all government properties. Besides, it was identified that some institutions provide manuals and guidelines on how to utilize and operate with electronic equipment. In addition to this, UPSs and regulators have been provided to control power fluctuations. The power fluctuations were also detected as a common problem in case of the households for the burning fuses and then EE. What is more, in some cases, ICT professionals checked whether the electronic have defects and performs some elementary maintenance works. On this matter, the GSD personnel stated the situation as follows:

> We urge and advise all of our employees to properly use electronic equipment to minimize e-waste creation. Besides, UPSs were provided to control power fluctuations. However, it is not sufficient that several e-waste has been generated due to improper handlings and obsolescence of the equipment and lack of maintenances (MoH, GSD, interviewed in January 2016, verbatim).
>
> E-waste creation is inevitable. However, there are some mechanisms to reduce its creation and accumulation. With regard to our campus, there is "Property File Model", a file on which every academic and administrative staff has to sign and become responsible for all properties including electronic equipment owned by the university. By the help of this model, we have been able to monitor the status of the equipment. Hence, this technique was useful in encouraging our staffs to use the electronic equipment properly. Thus, to some extent, we were able to prolong the equipment's lifespan (AAUFBE, GSD, interviewed in January 2016, verbatim).
>
> What we did all is the hiring of ICT professionals who are given the mandate to identify, collect and repair broken and non-functional electronic equipment. However, still, we are facing challenges with some electronic

equipment to repair. We don't know what to do with it (UU, GSD, interviewed in January 2016, verbatim).

This office has been practicing and implementing "Periodical Maintenance System" in which each electronic equipment is regularly watched, identified and maintained (MoFED, GSD, interviewed in January 2016, verbatim).

Table 6.22: Theme III: Efforts to minimize e-waste generation

Topics	Core Responses Obtained Via Interview	Codes
Efforts to Minimize Electronic Waste Generation	• UPS and server to control power fluctuation	MoR
	• Awareness creation	AAUFBE
	• Checked by professionals before considered as e-waste	AAUScF
	• ICT centres maintain minor defects	MoT
	• Awareness creation	MoScT
	• UPS and Stabilizers, awareness creation	Entoto
	• Regular services and maintenances	PESC
	• UPS provision for employees	MoA
	• No preventive methods	KMU
	• Periodical Maintenance System is applied	MoFED
	• UPS and manual provision	EiABC
	• Regular check-up	Orbit
	• UPS	MoCIT
	• Proper utilization of equipment	Admas
	• Nothing	MoH
	• Sharing the equipment, maintaining them	CPU
	• Cannibalization and upgrade of some parts	St.MARRY
	• Proper handling	ECSU
	• Employing IT professionals to maintenance	UU

6.8.5. Challenges in e-waste management

Studies confirmed that e-waste management is complex by its nature and require special attention from government, manufacturers and private sectors. Regarding this, the GSD personnel were interviewed to point out challenges in e-waste management. As indicated in Table 6.23, the major challenges include governments' lack of concern and attention towards e-waste, the absence of e-waste legislation and recycling centres, budget shortage, limited involvements of private sectors and NGOs, and the penetration and importation of second-hand electronic equipment. Here are some of the excerpts;

> I think one of the challenges in e-waste management is a challenge related to e-waste disposal agencies and offices. For instance, the mandate is given only to ICT minister to collect and dispose e-waste from all government sector offices. However, it is beyond the capacity of the minister office to collect and dispose of. Due to this fact it has been two years, we have started waiting for the office to collect all e-waste from our university (EiABC, GSD, interviewed in January 2016, verbatim).

This indicates that the e-waste management challenges are associated with the limited capacity of e-waste disposal agencies to offer quick and wide collection and disposal services.

> Personally, I have identified three challenges in e-waste management. The first one is the absence of e-waste policy in the country, which mostly limits our actions and reactions towards e-waste management. Secondly, assume that we have e-waste policy, but policy by itself is not a guarantee to ensure proper e-waste management. Thus, shortage of skilled manpower and e-waste recycling plants hampered activities in e-waste. Finally, e-waste management requires huge financial resources, but there is no budg*et al*located for e-waste management (CPUC, GSD, interviewed in January 2016, verbatim).

> E-waste management requires huge costs to recycle. One of the challenges we are facing is impossibilities of some of the equipment to maintain here in Ethiopia. So that we send them to other countries for dismantling and recycling at huge costs. The other challenges are the absence of framework

> on how to manage e-waste (MoCIT, GSD, interviewed in January 2016, verbatim).

According to these excerpts, the major e-waste management challenge includes the absence of e-waste policy, skilled manpower, budget, and recycling centres.

> This sector (e-waste management) invites private sectors, NGOs and CBOs to participate in the collection, transportation, dismantling, recycling and disposal of e-waste. Having said this, the challenge is associated with low involvements of these stakeholders, which limits the successes in e-waste management (St.MU, GSD, interviewed in January 2016, verbatim).

> Attention, attention, attention!! The challenge is related to the absence of attention among higher government officials towards e-waste management even to formulate e-waste legislation. E-waste has not been considered hazardous. This is because of lack of awareness of e-waste and its impacts. Besides, there are no standards to control the import of second-hand equipment and other hazardous materials that bring burden to recycle and dispose of here in Ethiopia (MoT, GSD, interviewed in January 2016, verbatim).

According to this excerpts, the major e-waste management challenge is the absence of emphasis and lack of awareness. Due to this fact, there is no e-waste policy, no standards to control the trans-boundary movements of e-waste and other hazardous materials.

Table 6.23: Theme IV: The challenges in electronic waste management

Topics	Core Responses Obtained Via Interview	Codes
Challenges in Electronic Waste Management	• Requires huge costs to handle e-waste	MoR
	• Absence of supports and lack of experts, budget shortage	AAUFBE
	• Less commitment from government, lack of storage, absence of committee even to collect e-waste, lack of budget, lack proper handling, lack of awareness of the impacts of e-waste	AAUSF
	• Lack of attention among government officials, poor attitudes towards e-waste, lack of storage, capacity to recycle e-waste, purchase of second-hand equipment	MoT
	• Lack of attention among government officials	MoScT
	• Low attention	Entoto
	• Not discussed	PESC
	• Bureaucracy and huge budget	MoA
	• Lack of concerns	KMU
	• The absence of legislation on e-waste, simply a directive which command e-waste to send to MCIT. No budg*et al*location, lack of awareness	MoFED
	• Very limited number of disposal organization, which MCIT we wait 2 years to dispose	EiABC
	• Budget problem	Orbit
	• Difficult to dismantle and recycle in Ethiopia, we send some e-waste to other countries it costs us. No legislation deals with e-waste.	MoCIT
	• Unwilling to mention	Admas
	• Backward system to collect and dispose of e-waste, absence of policy	MoH
	• Absence of regulation, recycling plants, skilled manpower and budget shortage	CPUC
	• Lack of NGOs and private organizations in this sector	St.MU
	• Fail to discuss	ECSU
	• No awareness creation program and promotion to the public	UU

6.8.6. Stakeholders involvement in e-waste management

Literature identified stakeholders in e-waste management such as authorities, producers, waste managers and users (Carisma, 2009). Therefore, without the involvement of these stakeholders, e-waste management will become a fruitless exercise. The stakeholders' actions and reactions considerably affect the management of e-waste. For instance, authorities (government and state agencies) that are formulating and enforcing laws/legislation that deal with e-waste play a very important role in e-waste management. Waste managers also have an essential role through the collection, transportation, recycling and final disposal of e-waste. In this regard, interview results show that the EIs and GSOs have attempted to establish partnerships with government agencies and e-waste vendors. However, it doesn't bring a substantial change in e-waste management. As it was noticed from the interview, the majority of them didn't make any partnership with stakeholders (See Table 6.24).

> In this regard, both INSA and PPDA were communicated by our office some two years back on how to dispose of e-waste. However, nothing has been done and e-waste has been accumulating with us (MoR, GSD, interviewed in January 2016, verbatim).

> We have not been able to make a partnership with any government organizations. However, we have regular communications with e-waste vendors to sell some non-functional, broken and obsolete electronic equipment (Admas, GSD, interviewed in January 2016, verbatim)

Table 6.24: Theme V: Stakeholders involved in e-waste management

Topics	Core Responses Obtained Via Interview	Codes
Stakeholders/organizations Communicating on e-waste issues	• INSA, FDRE PPDS, but not sufficient	MoR
	• MoCIT, CRTC.	AAUFBE
	• E-waste vendors/we sell e-waste	AAUSF
	• FDRE MoCIT	MoT
	• CRTC	MoScT
	• AA city purchasing and procurement agency	Entoto
	• With no one	PESC
	• With nobody	MoA
	• FDRE PPDS	KMU
	• MoCIT, to collect obsolete and damaged e-equipment	MoFED
	• MoCIT, Ministry of Defence	EiABC
	• No stakeholders we are working with	Orbit
	• World Bank and all government Bureaus	MoCIT
	• E-waste business/vendors	Admas
	• Government agencies	MoH
	• Nobody	CPUC
	• No stakeholders	St.MU
	• MoScT	ECSU
	• Daylight Recycling centre around 'summit' BOLE	UU

6.8.7. General recommendations

The GSD personnel recommends what should be done in the future to improve the e-waste management in their institutions and offices. As shown in Table 6.25, the majority of them mentioned awareness creation programs should be widely designed and conducted, the government should encourage NGOs, private sector to involve in this untapped sector. In addition, they have also pointed out that proper utilization of electronic equipment should exist, other organizations and institutions should be given to handling e-waste (decentralization), now the responsibility is vested in MoCIT to collect and dismantle e-waste from all government sector offices including educational institutions. What is more, the MoCIT is responsible for the provision of e-waste storage and disposal facilities, enforcement of e-waste laws and standards on the importation of second-hand electronic equipment. This could be evident from

the ideas forwarded by the GSD personnel of the EIs and GSOs during the interviews as quoted below:

> I thank that we have three aspects of e-waste management to work on. These include capacity building in e-waste policy, human resources and infrastructure, awareness creation program, and decentralization of e-waste management (MoT, GSD, interviewed in January 2016, verbatim).
>
> Until e-waste policy is formulated and enforced it is essential to properly handle all e-waste in the storerooms. Therefore, there is a need to construct sufficient and appropriate warehouses and to provide adequate e-waste disposal facilities (KMU, GSD, interviewed in January 2016, verbatim).
>
> It is essential to outsource e-waste management to other organizations. I strongly recommend involving the private sectors, CBOs, and NGOs in e-waste management. Finally, there should be standards on the purchase of second-hand equipment and reception of electronic equipment from the donating organizations (EiABC, GSD, interviewed in January 2016, verbatim).
>
> I think the government should organize training for employees on e-waste and its impacts and advanced training to ICT technicians to enable them to maintain, refurbish and dismantle e-waste. Above all promotion and awareness creation should be organized on Mass Media and other social networks for the public at large (UU, GSD, interviewed in January 2016, verbatim).

Table 6.25: Theme VI: General recommendations

Topics	Core Responses Obtained Via Interview	Codes
General Recommendation towards Electronic Waste Management	• Attention should be given to minimize health effects of e-waste	MoR
	• Buying original equipment and repairing broken equipment	AAUFBE
	• Proper utilization of electronic equipment.	AAUSF
	• Capacity building, awareness creation, decentralization of e-waste management.	MoT
	• Attention should be paid	MoScT
	• No recommendation	Entoto
	• Awareness creation	PESC
	• The mandate should be given to other organizations and institutions.	MoA
	• Providing sufficient storerooms and e-waste facilities.	KMU
	• Proper inventory management, recovery, and re-use, e-waste regulation, integrated e-waste management,	MoFED
	• Decentralization of e-waste disposal, involving private and CBOs, and enforcing standards on e-equipment importation issues	EiABC
	• We should donate non-functional and old electronic equipment rather than store	Orbit
	• Providing storerooms and developing recycling centres in the country.	MoCIT
	• Awareness creation and training programs	Admas
	• Sufficient storage areas and financial allocation to this sector	MoH
	• Recycling of e-waste should be encouraged	CPUC
	• There should be enough Skilled manpower, infrastructure, and awareness creation program	St.MU
	• Disposing e-waste within a short period of time.	ECSU
	• Provide appropriate training to employees, advanced training to IT technicians, to promote on Mass Media and social networks.	UU

6.9. RESULTS FROM HIGHER GOVERNMENT OFFICIALS (HGOs)

6.9.1. Profile of the sample officials

As far as HGOs are concerned, the researcher has consulted about six higher governmental officials who were working in bodies that are for solid waste management sector. The data were collected through some survey questions, which were concerned about awareness of e-waste management and through the interview, which was widely employed to obtain deep insight on e-waste management of the city in particular and the country in general. As shown in Table 6.26, the interviews were conducted with officials two from AA city government and four from federal government sector offices.

Table 6.26: Sample higher governmental officials

S.N	Organizations/Bureaus	Education	Gender	Office Position
1	Addis Ababa City Solid Waste Re-use, Recycling, and Disposal Office (AASWRRDO)	M.Sc.	M	Director of Cleansing Agency
2	Addis Ababa City Solid Waste Re-use, Recycling, and Disposal Office (AASWRRDO)	M.Sc.	M	Solid Waste, Re-Use, Recycling and Disposal Office Core Process Manager
3	Computer Refurbishing and Training Centre, Ethiopia (CRTC)	M.Sc.	M	Electronic Waste Management Director
4	FDRE, Public Property and Disposal Service (PPDS)	B.Sc.	M	Senior Expert, Public Property Disposal Service
5	FDRE, Public Procurement and Property Administration Agency (PPPAA)	M.Sc.	M	Director, Public Property Administration
6	Ministry of Information and Communication Technology (MoCIT)	B.Sc.	M	ICT Development Sector, Senior Expert

Source: Field Survey, 2016

Concerning their educational background, about two-thirds of the officials held M.Sc. or M.A. degree whereas the remaining one third held B.Sc. or B.A degree. This indicates the HGOs were with a good educational status that might enable them to adequately understand and respond to the issues related to e-waste management.

6.9.2. Awareness about e-waste

The responses obtained regarding the awareness of e-waste management from the higher officials showed that, as presents in Table 6.27, all of the HGOs were aware of what it meant by e-waste and the environmental and health impacts of e-waste.

Table 6.27: Summary of responses to awareness of e-waste management

ITEMS	PERCENTAGE		
	Yes	No	Uncertain
Do you know electronic waste?	100	0	0
Are you conscious/aware of the volume of electronic waste generated in this city?	0	66.7	33.3
Are you conscious/aware of the volume of electronic waste generated in this country?	16	66.7	16.7
Are you aware of any health risk/s associated with electronic wastes?	100	0	0
Does electronic waste pose a serious threat to the environment?	100	0	0
Do you know of any local or international laws pertaining to electronic waste management?	16.7	50	33.3
Is there any policy/legislation on e-waste management at the state/federal level that your institution is aware of?	16.7	83.3	0
Are you aware of local programs, projects or activities pertaining to electronic waste management?	33.3	33.3	33.3
Are you aware of recycling/trading fairs for electronic wastes?	83.3	16.7	0
Are there e-waste recycling sites in Addis Ababa or elsewhere in the country that you know?	0	83.3	16.7
TOTAL PERCENTAGE	46.6 %	40%	13.4%

Source: Field Survey, 2016

Similarly, the majority of the HGOs were aware of recycling fairs for electronic waste. On the other hand, the majority of them (66.7%) were not aware of the volume of electronic waste generated in the city and the country. Besides, about 83.3% of the sample officials were not aware of e-waste legislation, guidelines, and rules in the country. Furthermore, about 83.3% of them replied there is no recycling centre in Addis Ababa or elsewhere in the country. Finally, a considerable number of participants were uncertain about some aspects of e-waste as depicted in the table.

6.9.3. Findings from the interviews

As mentioned earlier in the methodology part of the study, interviews were conducted with HGOs. Accordingly, in-depth interviews were held with officials from AASWRRDO (Cleansing Director and SWRRD Core Process Manager), CRTC (E-waste Management Director), FDRE PPDS (Senior Expert), FDRE PPPAA (General Director) and FDRE MoCIT (Senior Expert). From the data, the study has identified seven major thematic topics. These were roles of the offices in e-waste management, major activities performed by the offices pertaining to e-waste management, purchasing and procurement processes of electronic equipment, challenges in e-waste management, e-waste recycling sites, stakeholders in e-waste management, and future plans and general recommendations forwarded towards e-waste management. It was analysed using qualitative data analysis software named "ATLAS ti. 7" and presented both in the form of a table to make the huge data simple and easier to understand. Besides, we have also presented quotations that were directly taken from the interview results.

6.9.3.1. The office's role in e-waste management

It was understood from the interview result that the role of the selected government sector offices in e-waste management was very good. These offices have significant roles in the proper planning, implementation, monitoring of integrated solid waste management in the city, involving in the collection and disposal of solid wastes,

minimizing the effects of e-waste on the environment and human health. They are also involved in enforcing of rules and regulation governing e-waste management, facilitating the procurement and disposal services for government institutions. However, the majority of the offices did not mention about their roles in e-waste management. This implies the absence of e-waste management in the organizational structure of solid waste management and e-waste is treated like any other type of solid waste (See Table 6.28). Some of the interview results were described as follows:

> "The main role of the Addis Ababa City Administration Solid Waste Reuse, Recycling, and Disposal Office is planning, organizing, implementing and monitoring of solid waste management of the city. Specifically, we have been involved in reusing, recycling and dumping of solid waste of the city. However, e-waste management is not dealt with independently of other types of solid waste management. Therefore, our role towards electronic waste management is poor, hence, it is treated with other solid wastes of the city." (AASWRRDO, HGO, interviewed in December 2016, verbatim).

This excerpt show that the office was involved in the management of the solid waste of the city than e-waste. It did not consider e-waste as an independent issue which should be handled independently. There were poor e-waste treatment and handlings in the city of Addis Ababa.

> "The role of this centre in e-waste management is to minimize or culminate the effects of e-waste on both environment and human health. In the meantime, to create job opportunities, hence e-waste is a resource. E-waste consists not only of hazardous substances but also valuable minerals and has economic value." (CRTC, E-waste Management Director, HGO, interviewed in November 2016, verbatim).

> "The central role of this ministry in electronic waste management is to facilitate the collection of electronic waste and sending them to Computer Refurbishment and Training Centre for disposal. Associated with our limited capacity, we did this only for governmental institutions and sector bureaus. In fact, the request to dispose of electronic waste first comes from the institutions themselves. We didn't cover any cost of transportation of e-waste." (MoCIT, HGO, interviewed in November 2016, verbatim).

These excerpts reveal that the officials were aware of the environmental and human health impacts of e-waste and the economic values of e-waste. Therefore, these offices were highly involved in reducing the improper disposal e-waste through the collection, transportation and proper disposal of e-waste. Besides, e-waste management can be considered as an opportunity for creating a job. However, they mentioned challenges associated with budget and facilities to cover the whole governmental institutions and sectors. On the other hand, the higher governmental official from PPPAA stated about the role of their as follows:

> "In fact, this agency has established to enforce laws/legislation that could enable federal sector bureaus and governmental institutions to properly manage government properties. Fundamentally, Ministry of Finance and Economic Development is responsible to enforce laws/legislations toward e-waste after the proclamation was approved by FDRE House of Peoples Representatives. Even though our agency is accountable to MOFED, through the provision of technical and professional support, it shall play the greatest role in making the legislation inclusive and workable. Beside this, we might prepare guideline/manuals on how to dispose of e-waste based on the approved proclamation. It provides capacity building and technical assistances to the institutions and government bureaus. Our agency, once a year, provides short term training on how to utilize and manage government properties." (PPPAA, HGO, interviewed in December 2016, verbatim).

According to this excerpts, the main role of this office was to enforce laws and legislations towards proper management of government properties. For e-waste management sector, the laws have to be formulated and enforced by the Ministry of Finance and Economic Development. Besides, it is responsible to prepare manuals and guidelines that might facilitate e-waste disposal. It provides capacity building, technical assistances and training provisions for government organizations to ensure proper management of government properties in general. Despite the fact, however, there was no e-waste laws and legislation that this office has knowing.

Table 6.28: The office's role in e-waste management

Topic	Core Responses Obtained Via Interview	
The role of the offices in e-waste management	• Realizing and monitoring proper implementation of integrated solid waste management in the city • Involving in various waste disposal activities in collaboration with micro and macro enterprises to collect, transport and disposal of solid wastes	AACA
	• Planning, organizing, implementing and monitoring of solid waste management of the city • e-waste management is not dealt independently of other types of solid waste management	AASWRRDO
	• Minimizing or culminating the effects of e-waste on both environment and human health. In the meantime, to create job opportunities, hence e-waste is a resource.	CRTC
	• Facilitating the procurements and disposal services of equipment of governmental institutions and sector bureaus • Enforcing rules and regulations concerning the disposal of electronic waste.	PPDS
	• Enforcing laws/legislations that could enable federal sector bureaus and governmental institutions to properly manage government properties.	PPPAA
	• Facilitating the collection of electronic waste and sending them to Computer Refurbishment and Training Centre for disposal. Associated with our limited capacity, we did this only for governmental institutions and sector bureaus.	MoCIT

6.9.3.2. E-waste management activities

As shown in Table 6.29, these offices have been involved in some e-waste management activities. For the sake of clarity, the activities were classified into three parts. Firstly, they were involved in the collection, transportation, and disposal of e-waste, undertaking e-waste study to know the status of e-waste in the city and creating awareness on e-waste. Secondly, they have been providing advanced training for ICT professionals on e-waste maintenance, refurbishment and dismantling, and encouraging educational institutions and government sector offices to identify, collect, transfer, donate and sell e-waste. Finally, they organized discussions on the legislations that might facilitate e-waste disposal.

> "In this centre, there are three wings that are performing activities of e-waste management. Firstly, refurbishment sub-center; the central role of this sub-centre is refurbishing of used and second-hand computers obtained from other countries through donations and purchasing. After refurbishment, those computers will be distributed to public educational institutions, health organizations and Community Based Organizations (CBOs) in all regions in the country on the basis of cost recovery. Secondly, training sub-centre; the major task of this wing is to invite high skilled professionals from other countries to provide training to professionals or ICT technicians who can refurbish and maintain broken and non-functional electronic equipment. Finally, e-waste management sub-centre; established to examine the effects of e-waste and create awareness in the community, identifying the job opportunities related to e-waste." (CRTC, E-waste Management Director, HGO, interviewed in November 2016, verbatim).

According to this excerpts, the centre has an organized working system to handle e-waste. The three wings performing refurbishment, dismantling, awareness creation and training provision on e-waste management but limited to computer and its accessories.

> "The main activities that have been doing regarding e-waste management were not satisfactory. However, currently, it has been taking initiatives to investigate e-waste generation status at the city level by conducting surveys. Secondly, we have been notifying higher educational institutions and government sector offices bureaus to collect, transfer, donate and sell

> e-waste which they generate in accordance with regulations stated in a circular letter. What is more, we are monitoring the procurement of office equipment including e-waste for institutions and sector bureaus to rely on the purchase of original and durable items." (PPDS, HGO, interviewed in October 2016, verbatim).
>
> "With its regulatory role, our office had been discussing legislations that might facilitate disposal of electronic wastes generated from educational institutions and public offices. What is more, the agency has been informing and encouraging institutions to make proper disposal of electronic wastes; like computers and its accessories, laboratory and medical equipment in collaboration with stakeholders. Hence, improper disposal of these wastes might pose a threat both to the environment and human health. We advise the institutions to send back to its source of the country some of the wastes which couldn't be disposed within our country. On the other hand, after maintaining non-functional electronic items, in fact, sector bureaus and institutions has the right to donate, sell and transfer the items to other institutions, surrounding schools or offices. However, if they are beyond repair, the Ministry of Communication and Information Technology has taken the responsibility to collect and dispose of such items." (PPPAA, HGO, interviewed in December 2016, verbatim).

These excerpts reveal that the activities towards e-waste management have very poor. What they have mentioned is their future plan to carry out e-waste studies at the city level. They simply notify the educational institutions and government sector offices to manage e-waste and purchase original and durable electronic equipment. The main challenge was absence of e-waste guidelines, laws and legislations, which enable those institutions and government sectors to properly handle e-waste.

Table 6.29: The office's major activities in e-waste management

	Core Responses Obtained Via Interview	
E-waste management activities implemented by HGOs	• Engaging in solid waste collection with micro and small enterprises • Transporting and dumping solid waste in an open landfill	AACA
	• Involving in separation of e-waste. • Undertaking a study focusing on e-waste with aim of knowing the generation status of e-waste in the households of the city.	AASWRRDO
	• refurbishing of used and second-hand computers obtained from other countries through donations and purchasing • Inviting of high skilled professionals from other countries to provide training to professionals or ICT technicians who can refurbish and maintain broken and non-functional electronic equipment. • Examining the effects of e-waste and create awareness in the community, identifying the job opportunities related to e-waste.	CRTC
	• Taking initiatives to investigate e-waste generation status at city level through conducting surveys. • notifying higher educational institutions and government sector offices bureaus to collect, transfer, donate and sell e-waste • monitoring the procurement of office equipment including e-waste for institutions and sector bureaus to rely on the purchase of original and durable items	PPDS
	• Discussing on legislations that might facilitate disposal of electronic waste. • Informing and encouraging institutions to make proper disposal of electronic waste and to send back to its source of country some of the wastes which couldn't be disposed within our country. • Encouraging donations, selling and transferring of e-waste to other institutions, surrounding schools or offices.	PPPAA
	• Computer Refurbishment and Training Centre for disposal.	MoCIT

6.9.3.3. EE purchasing and procurement

The issue of e-waste management starts earlier at the stage of purchasing and procurement of electronic equipment. In order to ensure the purchase of quality and original equipment, having standards and procurement guidelines are necessary. Associated with the low and stagnant economic status of the majority of developing countries, importation of second-hand electronic equipment is very common. It is estimated that 50 to 80 percent of e-waste collected in developed nations is exported to developing countries due to cheap labour and lenient environmental regulations (StEP, 2009, Lundgren, 2012).

Furthermore, some of the world's e-waste is shipped over great distances to developing countries in the form of free trade where crude and inefficient techniques are often used to extract materials and components (Baldé *et al.,* 2015). What is more, according to Robinson (2009) and Borthakur and Sinha (2013), old yet functional electronic equipment is often shipped to developing countries by well-meaning donors in the West and reuse is ultimately the source of some e-waste in many poor countries that accept donations of equipment considered obsolete in rich countries. What makes the situation worse is that these developing nations lack the health and safety infrastructure to process and dispose of materials safely, and consequently, workers handle toxic metals without proper equipment (Toxics Link, 2004; Joseph, 2007; Namias, 2013).

Regarding this, data obtained through interview shows methods by which the purchase and procurement of electronic equipment are taking place. As indicated in Table 6.30, it was realized that most of the process is takes place through a national bid. Institutions and government sector offices were encouraged to present a purchase requisition form based on original and new equipment. To some extent, there is a system to control and check the equipment vis-à-vis the purchase request when received from general distributors mostly of by purchasing teams. However, it was confirmed that non-functional and broken electronic equipment were frequently

entering the country. Due to the issue of economic status, it seems difficult for educational institutions and government sector offices to make a purchase of original equipment. Therefore, the study realized that the institutions and sector offices have owned second-hand electronic equipment from donating organizations. One of the results obtained via interview was presented as follows:

> "This centre made through national biding to purchase second-hand and used computers based on some standards. This is done associated with the low economic status of our country to make a purchase of original electronic equipment to all regions. In the course of this process, there is a condition to receive non-functional and irreparable computers along with functional once. Some of the foreign companies were also sending additional computers than requested quantity to compensate non-functional and irreparable computers." (CRTC, E-waste Management Director, HGO, interviewed in November 2016, verbatim).

The outcome of the study is also consistent with the findings of previous studies such as Otieno and Omwenga (2015) which pointed ICT and other EEE are relatively expensive in the developing countries comparative to developing countries considering the poverty levels, purchasing power and low income per capita of the citizens of the developing countries. This has led to a high demand for and consumption of second-hand EEE. Some of these equipment are old and have almost reached their End-of Life (EoL) and are usually imported illegally under the pretext of bridging the "digital divide". The products are normally imported without confirmatory testing for functionality and majority of them end up being WEEE because they are unusable or cannot serve the intended purpose

> "The legislation or laws do not allow purchase of electronic equipment directly from manufacturers. However, through national and international bid, wholesalers and importers have the right to involve in the procurement competitions. To make it clear, there are two types of procurements; international and national procurement, as to international procurement, there are pre-shipment inspections and post-shipment inspections to approve whether the required standards have been fulfilled. With regards to donation, the responsibility is vested in both the donor and the requesting institution or organization. In this regard, there is no room to argue with

donating organizations on the quality, standards, and quantities of the equipment, only “I need or not”. It doesn’t mean we are allowing non-functional electronic equipment to receive as a donation.” (PPPAA, HGO, interviewed in December 2016, verbatim).

Table 6.30: Electronic equipment purchasing and procurements condition

	Core Responses Obtained Via Interview	
Purchasing and procurements of electronic equipment	• Leasing committee will organize and monitor bidding process. • Directly sending our request to FDRE PPAA to make a purchase. • Professionals might check up on the originality and functionality of the equipment • Common to find non-functional and second-hand electronic items mixed with functional and original items.	AACA
	• Both procurement and purchase process of equipment including e-waste is taking place through a national bid • Examining the purchasing requisition documents of various governmental institutions and sector bureaus of the city. • Mostly making purchase of original electronic equipment • Common to find second-hand and non-functional electronic items.	AASWRRDO
	• Making procurements through national biding to purchase second-hand and used computers based on some standards. • There were some conditions to receive non-functional and irreparable computers along with functional EE. • Some foreign companies sent us additional computers than we requested to compensate the non-functional and irreparable computers.	CRTC
	• Collecting and organizing purchase requisitions from government institutions and sector bureaus. • Releasing national or international bids based on the nature of the requisition document. • Both financial and technical aspects of the purchase requisition document need to be evaluated. • The document then sent to Ethiopian Standard Agency for an approval. After its approval, an agreement has to be made with wholesalers, importers and general distributors to make a purchase of the requested equipment.	PPDS
	• Enforcing laws/regulations that govern the proper administration of government properties. • The legislation or laws doesn’t allow the purchase of electronic equipment directly from manufacturers. However, through the national and international bid, wholesalers and importers have the right to involve in the procurement competitions. • With regards to donation, the responsibility is vest on both the donator and the requesting institution or organization.	PPPAA

6.9.3.4. E-waste legislation and hindering factors

As it was frequently mentioned, policy/legislation that deals with e-waste is the essential aspects of e-waste management. It is a document which may encompass basic elements that ultimately ensure proper management. Developing countries have lacking legislations that specifically deal with e-waste. This was considered as a challenge in e-waste management for the majority of African countries. According to Ramanchandra (2004), a comprehensive law that provides e-waste regulation and management and proper disposal of hazardous wastes are required. Baldé *et al*., (2017) notes that in countries where there is no national e-waste legislation in place, e-waste is likely treated as other or general waste. The same author states that this is either land-filled or recycled, along with other metal or plastic wastes.

Concerning e-waste policy and legislations, it was realized from the interview result that Ethiopia had no e-waste policy until recently. The issue of e-waste was mentioned in a single article in the "Solid Waste Management Proclamation". The reasons for not having e-waste policy were lack of emphasis on e-waste among higher governmental officials, lack of researches on e-waste management in the country, and less attention given to waste management sector in general (See Table 6.31).

> "Sadly speaking, we have been looking for e-waste legislation for a long time to begin projects and activities of e-waste management. What is more, we have been raising the issue of e-waste management on different discussion forums and workshops. However, we found no legislations that specifically deals with e-waste either at the country level or city level until today. The main reason is lack of knowledge and awareness about e-waste among higher officials and policymakers." (AASWRRDO, HGO, interviewed in November 2016, verbatim).

> "There is no legislation/guidelines that deal specifically with e-waste in this country. In fact, the e-waste management project was established some three years ago with the aim of supporting our centre and to play a facilitating role in the enforcement of legislations or guidelines aiming at e-waste management. The project had frequent discussions and workshops

by inviting stakeholders to discuss the issue. As a result, it reaches consensus to prepare drafts of e-waste legislation after a wide review of other countries practices and inclusion of stakeholders' suggestions. However, due to the less emphasis given to e-waste and lack of awareness on the impacts of e-waste on environment and human health, the legislation has failed to be understood and enforced. Even if it was presented to council of ministers and house of people's representatives because e-waste was more technical many of the members rejected the draft. In fact, it was witnessed that there were disagreements among the members on considering e-waste as a waste." (CRTC, E-waste Management Director, HGO, interviewed in November 2016, verbatim).

"Accordingly, the first procurement proclamation in Ethiopia has declared in 2005 and property administration proclamation in 2009. Thus, we have little and infantile experiences and trends towards e-procurement, e-commerce, e-management, and disposal. In addition to this, it is very difficult to make the paradigm shift from the classical approaches to modern approaches; hence, it requires infrastructural, resource and human development. We don't have any guidelines or legislations that specifically deal with e-waste management except stating about e-waste on one article in the proclamation of solid waste management. There is a provision on this proclamation that MOFED will enforce laws pertaining to e-waste management in the future. Basically, procurement and property management got emphasis and concerns very recently." (PPPAA, HGO, interviewed in December 2016, verbatim).

Recent findings confirm the absence of e-waste policy in the majority of developing countries mainly of Africa. Only Cameroon and Nigeria have enforced national e-waste related legislation, while Ghana, Ethiopia, and Kenya still have legislation pending approval. On the continent, the e-waste challenge has remained on the political agenda during the past couple of years. However, there is generally a lack of e-waste management infrastructure, which is reflected by the absence of e-waste management laws (Baldé *et al.,* 2015). This situation will pave the way for developed countries to export e-waste to developing countries. In this regard, Askari and Ghadimzadeh (2014) stated developed countries began exporting e-waste to

developing countries, where laws to protect workers and the environment are inadequate or are not being enforced.

Table 6.31: E-waste legislation and hindering factors

	Core Responses Obtained Via Interview	
E-waste legislation and hindering Factors	• No e-waste legislation in the country. • Government holds poor attitude towards e-waste management and it doesn't consider e-waste as a waste to be disposed of. • Not only e-waste but there is less concerns about solid waste management sectors in general.	AACA
	• Looking for e-waste legislation for a long time to begin projects and activities towards e-waste management. • Raising the issue of e-waste management on different discussion forums and workshops. However, we found nothing legislations that specifically deals with e-waste. • The main reason is lack of knowledge and awareness about e-waste among higher officials and policy makers.	AASWRRDO
	• No legislation/guidelines that deals specifically with e-waste in this country. • The e-waste management project was established to play a facilitating role in the enforcement of legislations or guidelines towards e-waste management. • However, due to the less emphasis given towards e-waste the legislation has failed to be understood and enforced.	CRTC
	• No legislation/rules and guidelines of e-waste management in Ethiopia. • There is Solid Waste Management Proclamation in which e-waste has treated in a single article. • Lack of concerns or emphasis from higher officials towards e-waste and limited studies on e-waste management of the city or the country in general.	PPDS
	• There is no e-waste legislation in Ethiopia. • The issue of e-waste have mentioned in a single article on solid waste proclamation. • Government doesn't consider e-waste as a problem of the country. This is due to lack of researches and awareness creation programs on the impacts of e-waste on environment and human health if disposed improperly.	MoCIT

Balde *et al*. (2017) asserted that national e-waste policies and legislation play an important role because they set standards and controls to govern the actions of stakeholders who are associated with e-waste in the public and private spheres. Moreover, these policies and legislation shall frame the setting of a workable and fair financial and economic model, which must be sustainable and function properly.

6.9.3.5. Recycling centre and hindering factors

While electronic products may contain reusable and valuable materials, most of the components in E-waste are however hazardous and toxic, hence unsafe to the environment. EEE contains various materials including hazardous, valuable and scarce metals. Common hazardous materials found in e-waste are: heavy metals (such as mercury, lead, cadmium etc.) and chemicals (chlorofluorocarbon). In addition to hazardous materials, e-waste also contains many valuable materials (such as iron, copper, aluminium, and plastics) and precious metals (like gold, silver, platinum and palladium) that can be recycled. In fact, up to 60 elements from the periodic table can be found in complex electronics, and many of them are recoverable, though it is not always economic to do so presently (Widmer *et al.,* 2005; Adediran and Abdulkarim, 2012; Baldé *et al.*, 2015).

Shortage or lack of recycling centres have been mentioned as challenges in e-waste management in developing countries. Studies highlighted that despite its economic and environmental vitality, the e-waste recycling activities in developing countries are largely unregulated and carried out in a very small countries due to scarcity of land, economic and legal reasons (Arora, 2008, Lundgren, 2012, Veit and Moura, 2015). Similarly, as it was realized from the interview, there are no e-waste recycling centre in Addis Ababa or elsewhere in other secondary cities in Ethiopia. However, there is a recently established centre which is called “Computer Refurbishment and Training Centre” (CRTC) around Akaki Kaliti 30km south of Addis Ababa. Besides, there are some recycling centres which are established to recycle cartridges and tonners. The major hindering factors were the governments’ low or insignificant interest in e-waste management, low involvement of the private sector and NGOs in e-waste

management due in part to the absence of facilitating policy, shortage of budg*et al*located for waste management, great concerns for procurement than final disposal, more emphasis on organic wastes than e-waste, and lack of professionals who can not only recycle but also refurbish, dismantle and maintain broken and non-functional equipment (See Table 6.32). Here are some of the results obtained through interviews:

> "There are no recycling sites in Addis Ababa and other secondary cities to recycle e-waste. As I think it is due to three factors; firstly, lack of awareness about e-waste as a resource and its negative impacts on the environments and human health. Secondly, there is discouraging policy and low emphasis on waste management in general. Finally, lack of not only professionals who can perform recycling activities but also professionals who may refurbish and maintain e-waste has been critical factors. Personally, I recommend to widely involve the private and non-governmental organizations in e-waste management sectors before launching recycling plants." (AACA, HGO, interviewed in October 2016, verbatim).

> "When it comes to e-waste recycling sites, the city administration has no e-waste recycling plants or sites. Due to the fact that great emphasis has been given to recycling of organic waste, e-waste has for long been collected and dumped on open grounds largely by informal waste collectors. What is more, there is lack of knowledge about the possibilities of recycling of e-waste." (AASWRR, HGO, interviewed in November 2016, verbatim).

> "As far as my knowledge is concerned, there are no e-waste recycling plants in Addis Ababa or elsewhere in the country. One of the hindering factors is the low attention given by the central government to the e-waste sector. As a paradox, the informal sector has shown initiatives in collecting and disposing e-waste from households. From the government side, more attention has been given to the procurement aspects than the final disposal of e-waste. Besides, economic scarcities like shortage of infrastructure to collect and transport e-waste have been detrimental factors. Thirdly, the budg*et al*located for disposal service is very low at the state level." (FDRE PPDS, HGO, interviewed in October 2016, verbatim).

Table 6.32: Recycling centres and hindering factors

	Core Responses Obtained Via Interview	
E-waste recycling centres and hindering factors	• No recycling sites in Addis Ababa and other secondary cities to recycle e-waste. • Lack of awareness about the economic values and its negative impacts on environments and human health. • Discouraging policy and low emphasis towards waste management in general. • Lack of professionals who cannot only performing recycling activities but professionals who could refurbish and maintain e-waste.	AACA
	• The city administration has no e-waste recycling plants or sites. • Great emphasis was given to recycling of organic waste, e-waste has been remain collected and dumped in the open land through informal waste collectors. • Lack of knowledge about the possibilities of recycling of e-waste.	AASWRR
	• No e-waste recycling sites except CRTC, which offer very limited services. • The private sector has not involved in this sector. Due to lack of knowledge about e-waste HGOs perceive e-waste as it should not be handled by the private sector.	CRTC
	• No recycling plants in Addis Ababa or elsewhere in the country to recycle e-waste. • Less emphasis paid by central government towards e-waste management sector. Attention has been given to the procurement aspects than the final disposal of e-waste. • Informal sectors have shown initiatives in collecting and disposing e-waste from households. • Economical scarcities like shortage of infrastructure to collect and transport e-waste have been detrimental factors. • Budget allocated for disposal service is very low at the state level.	PPDS

6.9.3.6. Challenges in e-waste management

Studies indicate that the fast-rising volume of e-waste has put up formidable challenges in developing countries. E-waste is a global, interregional, and domestic problem (Devin *et al*., 2014). The main problem is that the storage, collection, transfer and disposal of WEEE in developing countries has not been streamlined and managed in an effective manner to ensure re-use; conservation of the environment; and safety of the people involved. Besides, the infrastructure and resources required to manage WEEE are non-existent or ineffective (Otieno and Omwenga, 2015). According to Afroz *et al* (2013) stated in developing countries, the management of e-wastes is causing concern because of the lack of adherence to the norms of proper documentation of electronic devices imported or smuggled into the country, the low awareness in the society about the environmental and health impacts of hazardous substances contained in e-waste, and failure to regulate illegal e-wastes recycling operators.

There are several challenges in e-waste management. From the analysis, it was possible to classify the challenges into three major categories. These are administrative challenges, economic challenges, and social or cultural challenges. To begin with administrative challenges, the study identified challenges related to the administration as the absence of e-waste policy, lack of research-based data on e-waste, the absence of a policy that encourage the private sector, miss procurement problems, low emphasis on e-waste, and absence of independent bureaus for handling e-waste. Secondly, economic challenges encompass, budget shortage, low involvement of private sectors, NGOs and CBOs in e-waste management sector, shortage of skilled manpower, backward technology, and a shortage of storage and e-waste facilities. Finally, the problems related social and cultural challenges include, governments' low interest in the issue of e-waste, the attitude of the community towards e-waste (considering e-waste as asset and inheritances), the workers' attitudes towards government property (See Table 6.33).

> "It includes government's low emphasis on e-waste management, the absence of independent units to handle e-waste, the absence of e-waste management section/team in the organizational structure and absence of legislations, rules and regulations or guidelines on e-waste are some of the administrative challenges. Secondly, economic challenges are a shortage of warehouses, storages, and facilities in the storage to properly store e-waste generated in governmental institutions and sector bureaus. On top of this, it is too costly to transport e-waste from all the corners of the country to the capital city for disposal. Concerning the social and cultural challenges … poor attitude towards e-waste and considering e-waste as an asset that should not be disposed of… lack of e-waste technicians or professionals to repair, dismantle and refurbish e-waste."(PPDS, HGO, interviewed in October 2016, verbatim).

Similarly, the other higher government official described the challenges as follows:

> "It seems more difficult for us to bring attitudinal changes among higher officials, government workers and the communities on proper utilization of government property than to design workable strategies…there is the inefficient utilization of resources we have at hand in all sector bureaus. There are tons of e-waste in the storerooms of educational institutions and sector bureaus. This is due to the fact that our agency has given low attention to e-waste management…the other challenge is the attitude of the people and workers towards government property. In doing so, it has been realized that many functional and workable electronic equipment were disposed and stored as e-waste…shortage of skilled professionals, lack of technology and resources in this country… we didn't work on awareness creation on how to utilize the equipment. Another challenge is associated with miss-procurement. Accordingly, there is newly acquired electronic equipment simply stored due to the absence of manuals and miss-procurement problems. Even due to poor property management, in some institutions, it is found that the volume of e-waste is estimated to be greater than those of the functional equipment, for example, Addis Ababa and Haramaya Universities. …technological advancements, dynamism and complexities. Lastly, we are mostly focusing on import based procurement rather than consuming on the local innovations. This could also be regarded as a challenge." (PPPAA, HGO, interviewed in December 2016, verbatim).

These findings were consistent with the findings of studies made by Widmer *et al.*, 2005; Osibanjo and Nnorom, 2007; Tengku-Hamzah, 2011; Adediran and Abdulkarim, 2012; Chibunna *et al.*, 2012; Lundgren, 2012; Kiddee *et al*., 2013; Jhariya *et al.*, 2014; Mesfin *et al.*, 2014; Baldé *et al.*, 2015; Tyagi *et al*., 2015; Otieno and Omwenga, 2015. These studies, in a nutshell, showed that the lack of appropriate facilities, lack of attention from the government, weak enforcement of law and regulation, importation of e-waste, lack of coordinated approaches, low level of awareness and knowledge as the main challenges of e-waste management in developing countries. In summary, the major problems include the lack of adequate public awareness, lack of government policy and legislation, lack of an effective take-back/collection system and EPR system, the dominance of the recycling sector by an uncontrolled, ill-equipped informal sector that pollutes the environment, lack of adequate recycling facilities, and poor financing of hazardous waste management activities (Balde *et al*., 2017).

On the other hand, several studies have been undertaken in Addis Ababa on solid waste management issues. According to Selamawit (2006), Tolon (2008), Addis Ababa City Government (2011), Daniel (2011), Nigatu *et al.* (2011), and Schleicher *et al.* (2015), the city (Addis Ababa) has faced challenges in solid waste management. This was largely due to the poor infrastructure, bureaucratic competence and limited institutional capacity of the municipalities. Besides, lack of properly designed collection route system and time schedule, lack of proper collection of containers and lack of emptying containers when full. Furthermore challenges including lack of proper truck maintenance, poor condition of the final dumpsite as well as lack of promotion on waste reduction, recycling and composting affected the solid waste management of the city.

Table 6.33: Challenges in electronic waste management

	Core Responses Obtained Via Interview	
Major challenges in electronic waste management	• Lack of research-based data on e-waste generation status, nature of e-waste, values and the effects of e-waste. • Low awareness about e-waste & concerns among governmental officials. • Shortage of budget and lack of awareness among households and governmental bureaus on how to handle e-waste.	AACA
	• Lack of policies, the absence of legislations or regulations to handle e-waste, and less concern towards e-waste management. • Less involvement of private sector and other non-governmental organizations, shortage of budget and infrastructure. • Communities are not cooperative to give e-waste when informal waste collectors have to request during collection phase. • E-waste is considered as an asset and inheritances. • The absence of appropriate e-waste management model.	AASWRR
	• Less emphasis is given towards e-waste and lack of awareness. • Shortage of storage space to properly manage e-waste collected from sector bureaus and institutions. • People consider e-waste as an asset and they plan to sell it than dispose and a shortage of professionals in the area.	CRTC
	• Shortage of skilled professionals, lack of technology and resources • Miss-procurement: electronic equipment simply stored due to absence of manuals and miss-procurement problems. • Poor property management, in some institutions it is found that the volume of e-waste is estimated to be greater than the functional one. • Technological advancements, dynamisms and complexities. • Import based procurement rather than consuming on the local innovations.	PPPAA
	• Lack of researches, absence of information on the current status of e-waste in the country, exclusion of e-waste management unit in organizational structures of government sector offices, absence of policy that encourage or allow private sectors to involve in e-waste management. • Capacity limitation to fully collect, transport, dismantle and dispose e-waste and shortage of storage to properly store e-waste and lack of professionals on e-waste management area.	MoCIT

6.9.3.7. Stakeholders in e-waste management

As said earlier, stakeholder plays pivotal role in e-waste management hence, their actions and reactions considerably affect the management of e-waste. Particularly, authorities (government and state agencies), through formulating and enforcing laws/legislations that deals with e-waste play a great role in e-waste management. Waste managers also have an essential role through the collection, transportation, recycling and final disposal of e-waste.

According to Nigatu *et al.* (2011), Mazhindu *et al.* (2012), Ministry of Urban Development and Construction (2012), Stephanie (2013), Hayal Desta *et al.* (2014), Leulseged, (2014), Tilay and Dijk (2014), in Addis Ababa, there are different actors who are directly involved in a wide range of solid waste management activity including Non-Governmental Organizations (NGOs), MES, academic and research institutions, private companies ,informal and formal waste collectors and dismantlers.

In this regard, interview results show the majority of the higher officials have tried to make collaboration with foreign and domestic organizations and institutions with regard to e-waste management. These are UNIDO, World Bank, Caliph in Korea, Ethiopian E-waste Management Project, StEP, EPA, GEF, MICT and Ministry of Agriculture. They have been involved in conducting discussion forums on e-waste, organizing training, establishing computer de-manufacturing centre, providing solid waste management policy, and sharing of experiences. However, some higher officials argue that the budget obtained from some of these organizations to carry out the studies on e-waste have been abused in many aspects thus little had been done (See Table 6.34).

> "Honestly speaking, Environmental Protection Agency has offered short-term training for our professionals about the impacts of e-waste on the environment and human health in 2012. The training was offered based on the lessons drawn from Sweden e-waste management by professionals who came from Sweden." (AACA, HGO, interviewed in October 2016, verbatim).

“There were stakeholders working with us on e-waste management. For instance, the Ethiopian E-waste Management Project, the Global Environmental Facility, and UNIDO as implementers of the project, were established two years ago to scale up computer Refurbishment and Training Centre and to enforce legislations towards e-waste. However, when it comes to reality they didn’t bring visible changes as expected. Beside, StEP was also involved in the study of e-waste in Ethiopia. The budg*et al*located for the project to achieve the goal had been abused in many aspects.” (CRTC, E-waste Management Director, interviewed in November 2016, verbatim).

Table 6.34: Stakeholders and their roles in e-waste management

	Core Responses Obtained Via Interview	
Stakeholders involvement in e-waste management	• Environmental Protection Agency has offered a short-term training about the impacts of e-waste on the environment and human health in 2012 based on the experiences of Sweden e-waste management.	**AACA**
	• Ethiopian E-waste Management Project, Global Environmental Facility, and UNIDO, StEP has also involved in the study of e-waste in Ethiopia.	**CRTC**
	• Ministry of ICT. Besides, the agency’s regulatory bodies were obtained a short-term training on procurement and property administration aspects in Dubai. Similarly, higher officials had been in Korea and Italy for training. In both of the training, we didn’t observe any concerns about e-waste management and disposals.	**PPDS**
	• In collaboration with World Bank, our office is on a process to undertake studies in this year (2016). • We have been striving to observe and draw lessons from many African countries in general and Korea in particular. For instance, we have been working a lot regarding e-procurement and e-management through conducting research on the field in the last two years. Our benchmark was “caliphs”, which is one of the government institutes in Korea.	**PPPAA**
	• Some NGOs, we were successful to establish the computer refurbishment and training centre in Akaki, Addis Ababa. The other stakeholder is Ministry of Agriculture which provides us solid waste management policy to adopt and implement it. Finally, UNIDO has been worked with us in many aspects.	**MoCIT**

> “In this regard, frankly speaking, electronic property management, electronic waste disposal and electronic property improvement program didn’t launch until this day. To do work on electronic procurement, in collaboration with World Bank, our office is on a process to undertake studies in this year (2016). The overall goal of this study will be to make impact assessment and to identify possibilities and challenges to launch the program within the real situation of our country. We have been striving to observe and draw lessons from many African countries in general and Korea in particular. For instance, we have been working a lot regarding e-procurement and e-management by conducting research on the field in the last two years. Our benchmark was “caliphs”, which is one of the government institutes in Korea.” (FDRE PPPAA, HGO, interviewed in December 2016, verbatim).

6.9.3.8. Future plans and recommendations on e-waste management

This result deals with the future plans and recommendations towards electronic waste management in the city in particular and the country in general. Accordingly, the data revealed that the HGOs plan to carry out studies, researches, trainings and discussion forums on e-waste, to expand the CRTC, to establish independent units that can handle e-waste, to collect e-waste not only from government institutions and offices but also from households, businesses and non-business organizations, and to make requests for amendments on the previously approved SWM legislation to encompass e-waste issue. Besides, the HGOs have forwarded some recommendations that should be taken into consideration in order to improve e-waste management.

These include, formulation and enforcement of e-waste policy, conducting of studies, researches and discussion forums, awareness creation programs, adoption of appropriate model, advanced trainings, adopting and sticking to modern approaches, to have mass media such as radio, television and periodicals in which solid waste management including e-waste could be widely discussed, increasing of professionalization and specialization, appropriate budget allocation, to have

standards on e-procurement and utilization, encouraging the private sector and NGOs to involve in e-waste management (See Table 6.35).

> "We plan nothing specifically towards e-waste management without having e-waste legislation at hand. However, we will make an inventory of e-waste accounting at the city level in the near future. In order to start e-waste management, I recommend the followings;
>
> - In all educational institutions, there should be researches, studies, workshops, training and knowledge dissemination programs about e-waste and solid wastes too.
> - There should be awareness creation programs through media to higher, middle, and lower level managers and to the communities at large.
> - The government should have to formulate and enforce legislation that specifically deals with e-waste within the shortest time." (AACA, HGO, interviewed in October 2016, verbatim).

Similarly, the other higher government official stated as follows

> "We plan to organize awareness creation program on the environmental and human health effects of e-waste. Secondly, we are planning to make strenuous efforts to expand this centre and to establish regional centres that can serve as a centre for electronic waste refurbishment and maintenance. Basically, the legislation should be enforced and policymakers should give emphasis towards e-waste management. Our centres providing services mainly e-waste that comes from AA and its surroundings and to some extent from regions for it is costly to collect and transport e-waste from regions that it makes the service limited to AA. Therefore, there should be a system that permits wide involvement of private companies in this sector. In addition to this, appropriate e-waste management models should be modeled and adapted to facilitate e-waste management. For instance "Extended Producer Responsibility" is a common practice in many developed and developing countries. However, it has not yet been conceptualized in our country. I have a strong belief that the model might be adopted with other models based on the country's context." (CRTC, E-waste Management Director, HGO, interviewed in November 2016, verbatim).

"Our future plan towards e-waste management is to request the government to make necessary amendments to the previously approved solid waste management legislations. Secondly, we plan to organize discussion forum on the ways in which this office shall be widely involved in e-waste management to effectively dispose of e-waste in the country. Consequently, I recommend the following;

- The government should undertake e-waste study in different parts of the country. As a result, the findings will serve as input to formulate and enforce laws towards e-waste management.
- The organizational structure of all sector bureaus and institutions need to be modified in a way that it shall incorporate e-waste management unit/team.
- The government should organize short, medium and long-term training on e-waste management.
- Sufficient budget should be allocated to facilitate e-waste management." (PPDS, HGO, interviewed in October 2016, verbatim).

Table 6.35: Plans and recommendations on e-waste management

	Core Responses Obtained Via Interview	
Future plans & recommendations towards e-waste management	• We plan to prepare e-waste proposal to undertake e-waste study and to collect and recycle e-waste • The government should formulate and enforce e-waste legislations and encourage private companies and non-governmental agencies to widely participate in e-waste management.	AASWRR
	• We plan to organize awareness creation program on e-waste and • To expand this centre and to establish regional centres that can serve as a centre for electronic waste refurbishment and maintenance. • The e-waste legislation should be enforced and policymakers should give emphasis towards e-waste management. • There should be a system that permits wide involvement of private companies in this sector. • In addition to this, appropriate e-waste management models should be modeled and adopted to facilitate e-waste management.	CRTC
	• There should be standard regarding the procurement and utilization of electronic equipment. • Sector bureaus should restructure their working systems, particularly of the property management. • Scholars need to become partakers in e-waste management by undertaking wide studies on e-waste to create awareness among the society. Beside this, media has a great contribution to aware the community about e-waste management. • Thus, we need to have a journal named as “procurement and property Management journal” to conduct and publish researches as it is practiced in other countries. • The system needs to be revised and improved for there are many challenges related to it. Thus, sticking on the modern approaches and adopting a workable strategy are deemed necessary to improve the existing systems. • It was planned to consider about “green procurement”, which enable to procure environmental friendly equipment that will minimize environmental pollution.	PPPAA

	• We plan to expand Computer Refurbishing and Training Centre and to establish independent units who can handle e-waste. • To collect e-waste not only from governmental institutions but also from households, business, and non-business centres. • To undertake researches towards e-waste. • Lastly, the government should formulate and enforce laws, legislations, and guidelines towards e-waste management. • Professionals should be provided with short-term, medium and long-term training. • Appropriate e-waste management model should be adopted or modeled. • There should be a proper collection of e-waste, hence e-waste has valuable parts. Besides, there should be awareness creation program on e-waste through workshops, media, conferences, and knowledge dissemination.	**MoCIT**

6.10. THE FINDINGS FROM OBSERVATIONS OF E-WASTE STORAGE

As indicated in the methodology part of the study, the observation was one of the data collection methods used in this study. The purpose was to examine the existences, appropriateness, and adequacy of e-waste storage and handling facilities. In addition, the study scrutinises types of e-waste stored, and conditions under which e-waste was stored. These were essential in the study to cross-validate data obtained from questionnaires, interviews and document reviews. To this end, about eighteen e-waste storage from PREIs, PUEIs, and GSOs were observed with the help of checklists. What is more, the CRTC (Computer De-manufacturing Centre) was also observed. In the course of the observation, however, it was very challenging to record the overall situation in the storage areas due to the reluctance of some of the EIs and GSOs and absence of sufficient light within the storage. This section presents the data attained through observation. To make the data presentation clear and understandable, the results were organized in the form of tables, verbatim and pictures.

6.10.1. Findings from observations of educational institutions

As shown in Table 6.36, the majority of the EIs don't have independent storerooms that were reserved for e-waste. E-waste, in most cases, were stored together with other types of wastes. In addition, even the storage rooms were not sufficient in terms of size and quality. What is more, it was also realized that e-waste handling facilities like shelves, containers, punnets, and others are lacking. The entire parts of the storerooms were poorly constructed from corrugated iron and steel, which are sensitive to warm temperature and rain. In most cases, the e-wastes They have simply thrown e-waste and other solid wastes in such a way that gadgets of different make, size, and shape are piled up one over the other largely in unsightly manners. There was no sufficient light in the storerooms and windows were almost absent. In the long run, this situation could adversely reduce the quantity of e-waste to the point that they might no longer be useful. Thus, it reduces the potential quantity of electronic items that might be donated, reused, recycled and refurbished. These

results were consistent with the results obtained through questionnaires and interviews.

Therefore, one can understand from these observation report, less emphasis was given to e-waste storage areas and handling facilities. This might be associated with the lack of awareness about the impacts and values of e-waste, budget shortage, and absence of clear direction on how to handle e-waste. The overall summaries of the storerooms of some of the PREIs and PUEIs were described in the table and depicted in pictures respectively.

Table 6.36: Results obtained from observations of the storerooms of EIs

CODES	E-WASTE STORAGE SITUATION IN EDUCATIONAL INSTITUTIONS
PESC	No storeroom reserved for e-waste and other types of wastes. E-waste stored in different containers and baskets inappropriately with functional equipment.
Orbit	A small container within the campus which is used to store e-waste.
Admas	No storeroom constructed to store e-waste. E-waste stored in cartoons. E-waste treated like any other waste, and thereby stored together with other types of wastes.
UU	E-waste stored together with other types of waste.
CPUC	No storerooms. Putting e-waste along corridors and hallways.
St. MU	No organized way of storing e-waste. E-waste scattered on the ground.
EiABC	Organized ways to store e-waste, separate rooms for e-waste, there are shelves and containers to put e-waste according to their categories. However, the storerooms are not sufficient.
AAUMC	The storage is highly disorganized and even difficult to enter. E-waste put with other types of wastes. E-waste simply put here and there. The storerooms are not appropriate. E-waste put one over the other.
AAUSF	The storage is not appropriate and sufficient to properly store e-waste. All kinds of materials including functional electronic equipment have stored. E-waste put one over the other.
ESCU	The storage is appropriate but not sufficient. E-waste stored with all kind of wastes. Facilities are lacking.
Entoto	The storerooms are not sufficient and appropriate for e-waste. E-waste put here and there. E-waste put one over the other. No sufficient light even to take pictures.
KMU	Temporary storeroom, relatively good. E-waste put separately. There are shelves.

As shown in Table 6.36, it was realized that compared to public educational institutions, the majority of the PREIs do not even have storerooms to keep e-waste and other types of wastes. Largely due to their relatively lower rates of e-waste generation, they stored in different forms. Accordingly, e-waste has stored along corridors, hallways, open fields, in containers, punnets and on shelves. Besides, others store mixed with functional electronic equipment. On the other hand, the e-waste storage in the PUEIs was not sufficient and appropriate, and lacking e-waste handling facilities (See Figure 6.20, 6.21 and 6.22).

Figure 6.20. Partial view of e-waste stored in PREIs

Source: Field Survey, 2016

Figure 6.21. Partial view of e-waste in PUEIs

Source: Field Survey, 2016

Figure 6.22. Obsolete tape-records and desktop computers in PUEIs

Source: Field Survey, 2016

6.10.2. Findings from observations of government sector offices

Similar to EIs, the overall conditions and settings of storerooms in most of GSOs were not sufficient, not appropriate and disorganized. E-waste storage facilities such as shelves, containers, boxes, and others were lacking. In some cases, e-waste placed together put with functional electronic equipment (See Figure 6.23 and 6.24). In this regard, summaries of this findings are presented in the following table (See Table 6.37).

Table 6.37: Results obtained from observations of GSOs

Codes	E-WASTE STORAGE SITUATION IN GSOs
MoR	No separate storeroom for e-waste. E-waste accumulated with other types of waste. E-waste facilities such as shelves, containers, and boxes are not fullfilled. No sufficient light even to take pictures.
MoE	The storeroom is highly disorganized and even difficult to enter. E-waste put with other types of wastes. E-waste scattered on the ground.
MoScT	The storeroom is not appropriate and sufficient to properly store e-waste. All kinds of materials including functional equipment have stored.
MoCIT	Not sufficient partly sent to CRTC.
MoA	Appropriate but not sufficient. E-waste stored with all kind of wastes. Facilities are lacking.
MoFED	Temporary storeroom, relatively good. E-waste put separately. There are shelves.

Figure 6.23. Partial view of e-waste stored in GSOs

Source: Field Survey, 2016

Figure 6.24. E-waste stored with other types of waste in GSOs

Source: Field Survey, 2016

6.10.3. Findings of observations from CRTC

The Computer Refurbishment and Training Centre is located in Akaki Kality sub-city in Addis Ababa. It was established in 2012 in collaboration with the World Bank, UNIDO, and MoCIT. There are three wings in the centre that are performing activities of e-waste management. Firstly, it has a refurbishment sub-center which is refurbishing used and second-hand computers. Secondly, it has a training sub-center which invites high skilled professionals from other countries to provide training to professionals or ICT technicians who can refurbish and maintain broken and non-functional electronic equipment. Finally, it has an e-waste management sub-center to examine the effects of e-waste and create awareness in the community, identifying the job opportunities related to e-waste. However, the centre provides refurbishment, maintenance, and dismantling services only for computers and their accessories. Due to a shortage of professionals, budget, storage areas and facilities, it couldn't provide services for e-waste disposed of the EIs and GSOs. The study tries to present the overall situations in the CRTC through pictorial representations.

Figure 6.25. E-waste cables and plastics in CRTC

Source: Field Survey, 2016

The Figure 6.25 shows e-waste cables and plastics located in CRTC compound. Due to shortage of storage space, the e-waste plastics have been stored in the open field as it is observed from the picture. With regard to the cables, they are simply stored since there are no e-waste recycling possibilities in the country, its final destination will be disposing of in open waste dumping sites or incirinating.

Figure 6.26. E-waste storage facilities in CRTC

Source: Field Survey, 2016

Figure 6.26 shows some of the e-waste facilities to store broken, obsolete and non-functional electronic equipment. They are shelves and plastic containers. They are used to properly store e-waste in accordance to their categories. Since e-waste has useful parts/materials, it is highly recommended to exercise proper e-waste handlings. As it can be observed from Figure 6.31, the e-waste refurbishment centre is used to refurbish non-functional and obsolete electronic equipment. This equipment were initially received from donor organizations based on some standards. After they got refurbished they will be sold to institutions and organizations at a decent price. On the other hand, the picture on the right-hand side is e-waste dismantling center (See Figure 6.27), in which professionals are dismantling e-waste and

collecting useful parts from e-waste. Some of the equipment was difficult to dismantle thus, they are sent to foreign countries to dismantle and recycle at a huge cost.

Figure 6.27. E-waste dismantling and refurbishment centre in CRTC

Source: Field Survey, 2016

Figure 6.28. Obsolete and broken e-waste in CRTC

Source: Field Survey, 2016

Figure 6.28 depicts both obsolete and broken e-waste stored in CRTC mainly of computers and their accessories. They are collected largely from government institutions mainly in Addis Ababa. They are going to be dismantled so that their useful parts may be collected. Their quantity or volume is not proportional to the number of professionals in the centre. Currently, the service is conducted only by five professionals.

Figure 6.29. Non-functional power supply in CRTC
Source: Field Survey, 2016

Figure 6.30. E-waste beyond repair in CRTC

Source: Field Survey, 2016

As Figure 6.29 and 6.30 respectively shows there are huge volumes of non-functional power supply stored in the CRTC and the e-waste beyond repair. They have simply been stored because no e-waste management actions have been taken on due to the absence of directions on how and where to dispose such gadgets.

6.11. CONCLUSION

This chapter presents the results of the study obtained from PREIs, PUEIs, and GSOs of Addis Ababa. The study highlighted that the GSOs shares the highest volume of functional electronic equipment followed by PUEIs and PREIs. However, in terms of the e-waste volume, the PUEIs have generated the highest volume of e-waste followed by GSOs and the PREIs. The study also reveals that obsolete electronic waste is the most generated types followed by non-functional and broken e-waste.

Regarding the actions taken towards of e-waste, the study shows, a small number of electronic waste have recycled, donated, incinerated, sold, and dumped. Therefore, the institutions and sector offices rely on e-waste storing as the only management way. The study found that the major causes are breaking and obsolescence, the demand for new design, and incompatibility issues. However, the causes are varying among the three cases. The study identified factors hindering the recycling of electronic waste are the absence of recycling possibilities and lack of awareness about possibilities and values of recycling respectively, costs of recycling and shortage of skilled manpower. With regards to the barriers to the adoption of electronic waste management, the major factors were weak enforcement of environmental consciousness laws, policy barriers (lack of legislation or absence of framework), the absence of an appropriate e-waste management model, e-waste management facility shortage and lack of skilled manpower.

This chapter also presents the results obtained from GSD personnel and HGOs. It provides mainly the results of qualitative data that were achieved through interviews. The major interview topics include the roles of the offices in electronic waste management, major activities performed by the offices pertaining to e-waste

management, purchasing and procurement processes of electronic equipment, challenges in e-waste management, e-waste recycling sites, stakeholders in e-waste management, and future plans and general recommendations forwarded towards e-waste management. Finally, the chapter provided the results obtained through observation, thus, appropriateness and sufficiency of e-waste storerooms, facilities within the storerooms, types of e-waste stored, and conditions under which e-waste is stored

CHAPTER SEVEN

DISCUSSIONS OF THE RESULTS

7.1. INTRODUCTION

The intention of this research was to examine e-waste management and disposal methods in the city of Addis Ababa to recommend appropriate e-waste management models. Therefore, based on this general objective, the following specific objectives were formulated. The specific objectives of the study were to:

1. Explain the status and variations in the awareness of e-waste, e-waste generation level and engagements in e-waste management practices.
2. Examine the e-waste management and disposal methods, and the administrative, economic, social-cultural challenges that influence its practices.
3. Point out the stakeholders' involvements, their future plans, and recommendations on the e-waste management.
4. Identify a workable e-waste management model the practice of which would most likely result in a more effective and sustainable e-waste management system within the realities of today's Addis Ababa.

To achieve these objectives, the qualitative and quantitative data sources were utilized and the data were obtained through questionnaires, interviews, document reviews and observations from the household heads of Bole and NSL sub-cities, GSD personnel of educational institutions and governmental sector offices of Addis Ababa. The results were presented in the preceding chapters. This section presents the discussion of results in light of the previously conducted studies. It has three sections. These are the discussions made on electronic waste management in the HHs, EIs, and GSOs. The further implications of the results were presented under the summaries, conclusions, and implications of the key findings.

7.2. E-WASTE MANAGEMENT IN THE HOUSEHOLDS OF ADDIS ABABA

This sub-section presents discussions of results on five thematic areas of e-waste management in households. Firstly, it discusses the households' awareness about e-waste and e-waste management. Secondly, the results obtained on households' activities and practices in electronic waste management have discussed. Then, it presents the households' engagement level in some electronic waste management practices. Furthermore, it also presents e-waste generation level, types, and characteristics. Finally, discussions have made on the results obtained through independent t-tests, correlations, and ordinal, Poisson and multiple regression models to basically identify factors that affect e-waste management.

7.2.1. AWARENESS OF E-WASTE AND ITS MANAGEMENT

The term e-waste was first introduced in the 1970s and 1980s following the onset of environmental degradation that was caused by the hazardous products that were imported into developing countries (Otieno and Omwenga, 2015). Electronic waste is a new rapidly growing waste and its concept is not widely understood by the people and governments. In developing countries, wider emphasis has been given to other types of wastes such as municipal, domestic, and other industrial wastes than for e-waste management.

Borthakur and Sinha (2013) disclosed that most of the consumers are unaware of the impacts of improper disposal of e-waste and continue to discard their end-of-life appliances with regular household waste. On the other hand (Tengku-Hamzah, 2011) has also asserted that the low level of awareness among the society has considered as one of the challenges in e-waste management. The same author found that "low level of awareness among the society may lead to indiscriminate or improper disposal such as disposing of e-waste together with household's solid waste." Furthermore, NCHEWM (2013) proclaimed that many people do not understand what it is or how it affects them, the world, or the environment.

In view of this, the study examined the awareness level of the HHs of electronic waste and its management in two purposively selected sub-cities of Addis Ababa. To this end, the data were acquired from 100 HHs through questionnaire surveys. Accordingly, the results of the study revealed that the HHs' awareness of electronic waste and its management was low. These includes HHs' awareness about the concepts of e-waste, volume they generate, the environmental and health impacts of e-waste, local or international laws and activities governing e-waste, and safe disposal of e-waste. In general, the mean values are ranging from 1.27 to 2.15, in which nearly 75% (8 items) had a mean score between 1.76 and 2.15. This implies that majority of the respondents were not aware of the concepts and activities in electronic waste.

More explicitly, the respondents' awareness about what it meant by e-waste or about the meaning of e-waste revealed that the majority of the respondents in both sub-cities (60%) were familiar with the term e-waste whilst (23%) and (17%) do "not" know e-waste and "uncertain" about e-waste respectively. It was found that being familiar with the term e-waste was not associated with the educational status of the households, hence, in the χ^2 test result ($p > 0.05$). On the other hand, it was revealed that the majority of the households were "not" conscious of the volume of e-waste they generated while 30% were uncertain about it. As far as the respondents' awareness of the environmental impacts of e-waste is concerned, the majority of the sample respondents were aware of the environmental impacts of e-waste. Besides, the study found a significant difference between the respondents based on their educational qualifications in responding to this question. The χ^2 test result (23.334, and $p = .010$), $p<0.05$, was statistically significant that the educational status of the respondents influences their awareness in understanding the impact of e-waste on the environment. Hence, more educated respondents were more aware of the impacts of e-waste on the environment. Besides, most of the respondents from both of the sub-cities were not aware of the health risks associated with electronic waste.

Concerning awareness about safe disposal of hazardous frictions of electronic waste, most of the respondents were not aware that some hazardous fractions of e-waste

need a special treatment in order to be safely disposed off. Only 29% of the respondents aware of it. The χ^2 test result (6.535, p = .038) showed that there was a significant difference among the respondents from both of the sub-cities. Thus, respondents in NSL sub-city were more aware of the safe disposal of some hazardous frictions of electronic waste than those in Bole sub-city. This indicates more awareness creation program should be facilitated to Bole sub-city households.

The mobile phone is one of the rapidly generating types of e-waste in the world associated with its shortest lifespan. Due to its relative affordability and rapid obsolescence rate, it would add a significant volume of e-waste. Across Africa, a combination of population growth and increased access to mobile phones and other technology will produce a surge in e-waste over the next five years (YSFES, 2014). Moreover, the disposal of cell phone batteries needs special care that if thrown down with other municipal wastes, it might pose a threat to the environment. In light of these, the study found that the majority of the respondents aware that used dry cell batteries need to be disposed of as safely as possible.

Unlike other types of waste, electronic waste management is a complex and challenging task due to its hazardous components. Therefore, it requires the formulation and enforcement of laws, legislations, and guidelines that specifically deal with e-waste to lessen the impacts it might pose to the environment and human health. What is more, awareness creation program should address this component so that customers would abide by those laws and guidelines either to recycle or dispose of the electronic equipment. In this sense, the mean values (2.15 and 2.07) showed that the respondents were not familiar with any local/ international laws governing the electronic waste management and any programs or projects related to electronic waste respectively. This might be associated to the absence of e-waste management policy or legislation in the country. The issue had been discussed widely under the sub-topic of e-waste management challenges.

E-waste is not only containing hazardous chemicals but they contain valuable parts which can be sold to the market (Adediran and Abdulkarim, 2012; Otieno and Omwenga, 2015). Thus, awareness creation in this regard will encourage the households to properly handle and dispose of the e-waste. The result obtained from the survey showed that majority of the respondents were not aware of whether some parts of electronic waste are profitably sold to recyclers. However, the X^2 test result showed that a significant difference between the respondents of Bole and NSL sub-cities (6.708, p = .013). Thus, the respondents from the NSL sub-city were more aware that some electronic parts may be profitably selling to recyclers than those from Bole sub-city.

Similar studies were produced concerning the role of public awareness in electronic waste management. For instance, Theodros (2010) confirmed that in the city of Addis Ababa a lot of awareness raising activities took places through Mass Media such as television, radio, and poster pertaining to the solid waste management; but not to any specific hazardous wastes like the e-waste. Likewise, Gudeta *et al. (*2015) reported that most of the sample households of the city of Addis Ababa had no comprehensive idea about the health risks of electronic waste. This is congruent to the assumptions made by earlier studies that gross lack of awareness about e-waste is a major problem (Akhila *et al.,* 2013).

These findings support the assertion made by Adediran and Abdulkarim (2012), that there is no public awareness on the inherent dangers of handling e-waste in Nigeria. Other authors have also mentioned that household awareness level is an important factor in determining the readiness of the public to deal with different environmental issues (Feras *et al.,* 2012). Similarly, Sivaramanan (2013) has highlighted that the public awareness is essential for the advancement of e-waste management system. According to Askari and Ghadimzadeh (2014), the percentage of knowledge about current management process for e-waste management is low, i.e., most people do not know how to manage the process. Furthermore, the reason for poor e-waste management is due to the poor collection system for EOL products, insufficient information system, and followed by lack of awareness among consumers

(Geethan *et al.,* 2012). In conclusion, therefore, the launching of the awareness creation program should be of the major pillars of e-waste management programs if the government has aimed to bring change in e-waste management.

7.2.2. E-WASTE GENERATION LEVEL, TYPES, AND CHARACTERISTICS

These statistics deemed essential in providing information on the generation status of e-waste which encourages to set e-waste policy in place. Baldé *et al*. (2017) note that without better statistics on e-waste, and closing the main data gaps of current e-waste statistics, it is impossible to measure the effectiveness of existing and new legislation to show any potential improvements in the future. The same author also asserted that it is difficult to provide data that guides business developments without quantitative data on e-waste.

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. Similarly, Benedicta (2012) asserted that 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.

According to Lundgren (2102), e-waste is the fastest growing waste stream and growing at a much higher rate compared to the normal municipal waste. By the end of 2016, 93.5 million tons of e-waste will be generated globally which was 41.5 million tons in 2011 and with a compound annual growth of almost 18%, it is becoming one of the biggest challenges to handle (Tyagi *et al*., 2015). Jhariya *et al*. (2014) disclosed that reuse is ultimately the source of some e-waste in many poor countries that accept donations of equipment considered obsolete in rich countries. Old yet functional electronic equipment is often shipped to developing countries by well-meaning donors in the West (Robinson, 2009).

Though Ethiopia is not one of the electronic destination countries, the volume of EEE import is the second largest commodity for the country (Leulseged, 2014). UNU (2013) noted that the stored volume of e-waste in Ethiopia is still relatively small and generally confined to urban areas, particularly the city of Addis Ababa. The report further disclosed that “there are some hints that e-waste is disposed of in an uncontrolled manner”, though most of it is simply stored in households and offices, as it is considered to be an asset rather than waste electrical and electronic equipment to be discarded.

One of the objectives of this study was to examine e-waste generation level, types and characteristics in the homes of the selected respondents from both sub-cities. Therefore, this section presents the findings and discussions made on the quantities of electronic waste which were obtained through the questionnaires and document reviews. The findings of the study revealed that the total volume of e-waste generated by the respondents of Bole and NSL sub-cities was about 7,943 in number. Specifically, it was recognised that the respondents of Bole sub-city have generated the highest number of e-waste (5,211) which accounts about 65% of the total e-waste generated. However, the respondents from NSL sub-city has generated about 2,732 e-waste in number, which makes 35% of the total e-waste generated. These numbers constitute broken, obsolete and non-functional e-waste and e-waste which were sent for maintenance and refurbishment services. The implication of these results is that the higher in the income group of the community is willing to frequently purchase the electronic gadgets and at the same time creating more e-waste than the middle and lower income section. It implies also that if this small number of the respondents generated large quantities of electronic waste, it could be forecasted that there will be a high volume of e-waste existed in the remaining households of the sub-cities in Addis Ababa. Alavi *et al*. (2015) proclaimed that the higher e-waste production can be attributed to the higher income and welfare, development, and social progress, particularly, in the recent decades.

As far as the types of e-waste were generated, a total of 4,010 non-functional, 2,077 obsolete, and 1,856 broken e-waste were generated. Comparatively, the non-functional electronic waste accounted for 51% of the total e-waste, while obsolete and broken electronic waste shares about 26% and 23% respectively. The highest share of the non-functional e-waste was related to the highest generation level of e-waste types like CDs/VCDs/DVDs, headsets/earphones, and fluorescent lamps. Therefore, it could be said that the non-functionality and rapid obsolescence rate in electronic gadgets cause highest volume of e-waste generation.

These findings chime with the findings of Gudeta *et al.* (2015), that the total number of "obsolete" electronic items in Bole and Akaki Kaliti sub-cities was 5654, pointing to the possibility of a considerable volume of obsolete items in the remaining eight sub-cities of Addis Ababa. Besides, Baldé *et al*. (2017) note that the amount of obsolete equipment is further driven by relatively short replacement cycles. Since technologies change quickly, many users change device, such as their mobile phone, regularly and often before it actually breaks.

The other findings of the study reveal that the most generated types of electronic waste in both sub-cities include batteries of different categories, CDs/VCDs/DVDs, fluorescent lamps/bulbs, headsets/earphones, cell-phones. Besides, it was found a significant number of tape-recorders, MP3/VCD/DVD players, television sets and computers/laptops. This finding is consistent with the findings of UNIDO (2010), reported that more than 300 million dry-cell batteries are consumed in Ethiopia annually. The study revealed that the most generated non-functional e-waste were CD/VCD/DVDs, washing machines, MP3/MP4 player, printers/cartridges, headsets/earphones, flat iron, air conditioner, fluorescent lamps, and microwave/ oven. On the other hand, computers/laptops, cameras, tape-recorders, cell-phones, television sets, radio sets and VCD/DVD players were the most obsolete types of e-waste. Regarding this, Bohum (2004), stated that the lifespan of many electronic goods has been markedly reduced due to modern electronics, smart design, and compatibility.

As far as the findings of the lifetime of electronic equipment are concerned, it was found that out of the total 5,211 electronic equipment (now became e-waste), about 3,203 or 62.5% of them served less than a year as reported by the respondents of Bole sub-city. On the other hand, as reported by the respondents of NSL sub-city, out of 2,732 total e-waste, about 1,299 (47.5%) served less than a year, while 880 (32.2%) served from one up to five years. In both cases, the largest value was for electronic equipment, which served less than a year. The shortest in the service years of implies the electronic equipment with short lifespans such as CDs/VCDs/DVDs, fluorescent lamps, headsets/earphones, and batteries had been generated at a very fast degree and rates. Likewise, the longest in the service years implies the electronic equipment with the longest lifetime such as television sets, cameras, radio sets, and tape-records had been generated at low degrees and rates. In this regard, Alswart (2016) reported that short-lived products place a far greater burden on our environment than appliances with a longer service life. Regarding this, Thiébaud *et al*. (2017) admitted that TVs and monitors have the longest mean total service lifetime. In contrast, laptops and mobile phones and their software are subject to fast innovation cycles, so that new devices are bought due to their additional functionality. The other implication of this result was that the middle income respondents who were mainly from the NSL sub-city served the electronic equipment relatively for longer years than those of Bole sub-city respondents. This result was consistent with the results obtained through questionnaires that the respondents of NSL sub-city strived to reuse the old, broken and non-functional e-waste after repairing them than the of the respondents of Bole sub-city.

When it comes to storage years, the study confirmed that out of 5,211 total e-waste, 2,268 (43.5) stored from 1-5 years and 1,604 (30.7%) stored less than a year as reported by the respondents of Bole sub-city. On the other hand out of 2,732 total e-waste 1,646 (60.2%) stored from 1-5 and 729 (26.6%) stored less than a year as reported by NSL sub-city's respondents. This result implies that the respondents store e-waste for about five years without any e-waste management measures taken to them. It also implies that the low awareness level, lack of proper collection system, the attitudes toward e-waste (considered as an asset), the absence of good disposal

methods, and the lack of e-waste recycling, refurbishing, and maintenance centres contributed to the prolonged storage of e-waste. This finding is opposed to the findings of Alavi *et al*. (2015) found that the average storage period of used e-waste at the households was about 1 year. The authors further argued that the long storage period is attributed to the empty adequate space and lack of a proper collection system, especially in the urban areas.

The study examined the purchase year of households' electronic equipment in the selected sub-cities to see the effects of scale economies, technologies and the tastes and preferences toward electronic gadgets. As a result, out of the 7,943 total electronic waste generated in the respondents' homes of both sub-cities 3,609 (45.4%) between 2005 & 2015, and 2,574 (32.4%) were after 2015. From these results, it could be understood that the purchase of electronic equipment was increasing from time to time and the highest number took place in the year between 2005 and 2015. This increase in the volume of electronic equipment might be associated with the better economic status of the people and provision of electronic gadgets at a relatively affordable price. In this regard, NCHEWM (2013), pointed out that the transformations in the lifestyle of people i.e. increase in the dependency of individuals on the technology or electronics has made this sector the fastest growing and most essential sector globally. This was asserted with the findings of Alavi *et al*. (2015) stated that the higher e-waste production can be attributed to the higher income and welfare, development, and social progress, particularly, in the recent decades.

The study also found that electronic items such as cameras, radio sets, tape-recorders, television sets, and telephones were among mostly purchased equipment before 1993. Whereas equipment such as cell phones, laptops, computers, Mp3/Mp4 players, electric fan, washing machines, air conditioners are the most dominantly purchased items in between 2005 & 2015. This might be related to the influence of the rapidly expanding technologies in those types electronics industry with the changing in the lifestyle of the people.

7.2.3. E-WASTE CAUSES, MANAGEMENT METHODS, AND THE CHALLENGES

The volume of generated e-waste has been increasing in line with the economic development all over the world (Hossain *et al*., 2015). Basically, the electronic equipment selling shops, companies, and factories play a big role in e-waste management through the productions, importations, exportations and marketing with the original and environmentally friendly electronic appliances. Studies proved that the manufacturers are the most trusted sources than retail shops in providing original electronic items and it might be difficult for consumers to directly make a purchase of EE from the manufacturers. For instance, NCHEWM (2013) stated that it is difficult for the government to place responsibility on all producers or importers, including brand holders of original equipment manufacturer to directly sell to the consumer. On the other side, there will be an established network between manufacturers (producers) and wholesalers (importers) to provide electronic items for organizations, institutions, and businesses.

Nevertheless, the purchase of electronic equipment might be influenced by several factors such as people's awareness and knowledge, tests, preferences, income, and supply factors. In this regard, the findings of the study found that the majority of the respondents made the purchase of their electronic appliances from retail shops followed by general distributors. It was revealed that the tendency of the respondents to purchase EE from the second-hand markets and directly from manufacturers was low. The less likely of the respondents rely on the second-hand equipment might be due to the purposive selection of the sample respondents from the relatively affluent sub-cities of Addis Ababa.

One of the major objectives of the study was to point out the major causes of e-waste generation. Accordingly, the results of the study identified that the breakage of electronic appliances, increasing of obsolescence rate, and the demand for new design as the major causes for the e-waste generation. However, the causes were different between the respondents of the two sub-cities. Thus, respondents of Bole sub-city reported that the rapid obsolescence rate, the demand for new design, and

breakage of electronic equipment were the major causes respectively. Whereas, breakage of the electronic equipment, rapid obsolescence rate, and the demand for new design were the major causes of e-waste as reported by NSL respondents. Ahmed (2016) proclaimed that whether from the breakdown, slow-down, or just the availability of a newer model, lead to e-waste creation. Similar to this result, the findings of the study regarding the reasons for households to replace old electronic appliances as reported by the majority of the households were the need for newer technologies (models) or designs. The results of the study disclosed that the majority of the respondents (51%) reported that they replaced old electronic equipment because they wanted newer technologies, additional appliances and features not available on old electronic equipment respectively. From these results, it was concluded that the rapid obsolescence rate of the electronic gadgets might be associated with the level of incomes. The result implies that consumers with the higher income tend to make the electronic equipment obsolete just before the lifetime of the equipment. In this case, the Bole sub-city respondents claimed that they have been frequently replacing old equipment with new electronic gadgets demanding for new models or designs. In this regard, Devin *et al.,* (2014) stated that the consumer demand for additional and new design electronic equipment and the high obsolescence rate lead to the frequent and unnecessary purchase of electronic gadgets. Theodros (2010) also claimed that the increasing obsolescence rates of electronic products added to the huge import of junk electronics from abroad will create a complex scenario for solid waste management in Addis Ababa.

These findings are substantiated by the finding of Rudareanu (2013) which affirmed that the increasing demand for electric and electronic equipment, as well as the decrease of its lifespan due to fast technological innovation, which leads to EEE quickly becoming obsolete, are just some of the reasons WEEE have known the most remarkable growth out of all waste categories. In addition to this, Oomman (2014) claimed that the major elements that influence the purchase of the electronic equipment are a necessity, new features, status symbol, higher incomes, and advertisements. Baldé *et al*. (2017) disclosed that to benefit from the latest

upgrades, higher speeds, and the latest technologies, consumers and businesses regularly change their laptops, PCs, routers, TV sets, and other devices. In many cases, older equipment is replaced even if it is not broken or obsolete but simply regarded as outdated. Balde *et al*. (2017) asserted that in some cases, a single device with single functionality is being replaced by items with multiple functionalities, such as a mobile phone or laptop.

Electronic waste identification or categorization is among the elements of e-waste management practices. It is the conditions under which the consumers are trying to put electronic waste at the end-of-life. This arrangement is quite essential in electronic waste management to identify obsolete, broken, and non-functional electronic equipment in the case when the recycling and reusing campaign have launched. Knowingly, people made electronic equipment at the end-of-life in various conditions. As such some households do it based on the technological level as 'obsolete and modernn', some based on working level of the equipment as 'operational and non-operational' equipment. Regarding this, the findings of the study revealed that the majority of the participants categorize e-waste or put at electronic gadgets at their end-of-life based on the working level (as operational and non-operational) and broken (serviceable and unserviceable). Other also did this based on technological level (as obsolete and modern) and the age (old and new). However, a significant number of the respondents didn't apply any of these e-waste categorization options. The evidence from this result implies that any electronic equipment that is non-operational, unserviceable, and old or obsolete will never continue to function. As a result, it will encourage the consumers to demand and own additional electronic equipment that is technologically faster, efficient and effective.

Concerning the e-waste disposal methods practiced by the respondents, the data obtained through questionnaires revealed that the majority of the respondents store e-waste and considered storing as the only e-waste disposal method followed by reuse. However, the X^2 test result (15.650 and, $p < 0.001$), was used to measure the differences in the disposal methods that existed between the respondents of the two sub-cities showed a significant difference in e-waste disposal methods. Relatively,

the majority of the respondents of Bole residents promoted storing of e-waste as the only e-waste disposal methods whereas the majority of NSL sub-city respondents attempted reusing of old electronic equipment. This implies that the higher income respondents who were mainly from Bole sub-city simply put the non-functional and old electronic equipment to the store while the middle-income respondents who were mainly from NSL sub-city promoted the reuse of old electronic gadgets.

The outcome of this study is substantiated by the findings of previous studies such as Babu *et al*. (2007), Kalana (2010), Feras *et al*.(2012), Borthakur and Sinha (2013) claimed that the majority of the e-waste is stored than it is recycled and reused. These authors further stated that many consumers do not immediately dispose of or recycle unused electronics since they think that the products still have value and due to uncertainty how to manage it. A study has also realized that in Ethiopia people consider old electronic appliances as an asset and a sign of prosperity (UNU, 2013).

Similarly other authors also established that reuse and recycling activities are found to be at low status. Kahhat *et al.* (2008) stated that the substantial growth in electronic devices has not paralleled to growth in collection, reuse and recycling. For instance, as indicated in (Kumar *et al.,* 2013), over 20 million personal computers became obsolete in 1998. Only 13 percent were reused or recycled. In Ethiopia e-waste collection and recycling activities are found at a low level (Manhart *et al.,* 2013). With its large population and role as a political and economic centre, Addis Ababa is also the city with the highest demand for EEE and generates the most e-waste in Ethiopia (Manhart *et al.,* 2013). However, e-waste is currently being handled through prolonged storage in households, offices and government warehouses, irregular dumping (particularly of all kinds of batteries, lamps, and bulky items such as refrigerators) and disposal with household waste (Tadesse & Sue, 2013).

Basically, people might store unused electronic items for various reasons. Among these reasons, some of them may not consider it appropriate to throw it in the garbage or may not know what to do with it while others have not found good disposal methods or recycler to reuse and recycle. What is more, others shall want to donate/sell it. In

view of this, the other findings of the study pointed out reasons for the households to store electronic waste. Accordingly, the results of the study showed that the absence of good disposal methods/recyclers in the city was leading reason to store e-waste. Besides, some of the households consider e-waste as a resource, which can be sold/donated. Furthermore, the respondents claimed that they stored e-waste because they have not upgraded/repaired them. From this, it was concluded that factors such as the absence of e-waste recycling, refurbishment and maintenance centres in the city, and the attitudes of the households toward e-waste contributed for the prolonged storage of e-waste.

This finding is unswerving with the findings of Gudeta *et al.* (2015), found that most of the households of Bole and Akaki Kaliti sub-cities were simply storing the e-waste with the belief that sometimes either they would extract useful spare parts from them or sell them for a good price. This finding is substantiated by the study conducted by Ongondo *et al*. (2011) which claimed e-waste does not only contain hazardous elements but it can regard as a resource of valuable materials such as ferrous and nonferrous metals, engineering plastics, precious metals, platinum group metals, and rare earth elements. Similarly, Thiébaud *et al*. (2017) disclosed that electronic devices contain many important resources, including critical chemical elements such as indium or neodymium. On the other hand, Mesfin *et al*. (2014), confirms the remaining products in storage are beyond repair due to severe damage, lack of expertise, and financial resources. Similarly, studies by Askari and Ghadimzadeh (2014) revealed that there were very few respondents knew how to dispose the e-waste.

The increase in the production of electronic gadgets, consumption rates, non-repairable and the higher obsolesce rate leads to the creation of a considerable volume of electronic waste. Therefore, care should be taken on the old or outdated, broken and non-repairable electronic equipment to ensure proper e-waste management. The peoples' practices and actions on the old, broken and unserviceable EE are indispensable. In addition to this, it has implications to indicate the country's status regarding electronic waste management activities and programs. Therefore, in this regard, the study found that the majority of the respondents stored

the non-repairable, broken and old electronic equipment in their homes. Besides, few number of the households sold some of them. What is more, the respondents also disposed of off a small portion of the e-waste with domestic or regular solid wastes. In this regard, studies revealed that people have improperly disposed (thrown) e-waste with other types of waste. For instance, Molly *et al*.(2003) and Feras *et al.* (2012) found that people store e-waste for certain time or throw away e-waste with other wastes because they don't know how and where to dispose of these e-wastes. Furthermore, Alavi *et al*. (2015) asserted that a portion of e-waste generated enters into the waste stream is disposed of with other wastes. This finding is also chimed with the findings of Askari and Ghadimzadeh (2014) specified that e-waste disposal is performed in a highly disorganized and uncontrolled manner in many parts of the world. The same author added, "*our interaction with several layers of society has indicated that lack of knowledge in handling e-waste and the absence of proper policies and guidelines at the state level are basic reasons of e-waste mismanagement*." This implies that the electronic wastes that are landfilled produce contaminated leaches that eventually pollute the ground water. In addition to this, acids and sludge obtained from melting e-waste items, if disposed on the ground causes acidification of soil. Therefore, the government and other concerned stakeholders need to launch awareness creation program a head of time to ensure the proper disposal and handlings of e-waste.

7.2.4. ENGAGEMENT LEVEL IN E-WASTE MANAGEMENT PRACTICES

Concerning the engagement level of the respondents in e-waste management practices, an attempt was made to present and discuss the obtained results. Accordingly, this section discusses the major results on the explanation of the mean score, percentages, the X^2 test results and the ordinal regression outputs. As far as the mean score is concerned, the mean scores ranged from 1.08 to 2.86, which mean it ranges between 'always' and 'never' for most parts of the items. However, variations occur in some of the items. The X^2 result (13.710), p = .001, hence p<0.05 is, however, statistically significant that the majority of Bole sub-city respondents 'always' buying new electronic equipment even if the older ones are still working than

the respondents of NSL sub-city. The $\mathcal{X}^2$ test result (8.143) and p = .017, which was statistically significant, showed the high-income groups, which were mainly from Bole sub-city had 'always' buying reputable equipment than middle-income groups (NSL sub-city). Similarly the ordinal regression output clearly showed that the increase in monthly incomes (expressed in ETB) was associated with an increase in the odds of the respondents 'buying gadgets with brands that are reputable for their durability and longer life over other brands', with an odds ratio of 1.000 (95% 1.000 to 1.000), Wald X^2 (1)=4.002, p < .045. It also depicts an increase in a monthly income (expressed in ETB) was associated with a decrease in the odds of the respondents 'buying second-hand gadgets and/or re-assembled gadgets', with an odds ratio of 1.000 (95% 1.000 to 1.000), Wald X^2 (1)=7.072, p < .008.

This implies that the majority of the respondents 'always' engaged in buying of new electronic gadgets even if the older one is working and tend to buy gadgets with brands that are reputable for their durability and longer life over other brands. Therefore, it can be understood from these results that the e-waste volume was influenced by the monthly incomes, the preferences, and tastes of the respondents and rapid technologies. In this regard, Veit and Moura (2015) noted that the life cycle of many electronic goods has been substantially shortened due to advancements in electronics, attractive consumer designs, and marketing and compatibility issues. For example, the average life cycle of a new computer has decreased from 4.5 years in 1992 to an estimated 2 years in 2005 and is further decreasing (Veit and Moura, 2015).

On the contrary, the majority of the respondents 'never' recycle electronic gadgets which can still be recycled and never observed proper waste segregation practices. This strengthens the data obtained regarding the e-waste disposal methods that households have practiced. Thus it gives rise to the increase in the volume of e-waste. This implies that e-waste recycling centres should be established in the city to facilitate the recycling process. Hence, the recycled materials can be used in developing new equipment that opens great opportunities for innovation of new

products, valuable materials will be retrieved and it helps in minimizing the environmental effects improper disposal of e-waste.

The study revealed that the majority of the respondents (78%) were 'never' involved in proper waste segregation practices while 17% of the respondents 'sometimes' involved in proper waste segregation practices. This result indicates poor activities and involvements in e-waste segregation practices in the city. The majority of the respondents (70%) were 'never' buy second-hand gadgets or re-assembled electronic items while 27% of them sometimes buy these kinds of electronic gadgets. When we see the differences in between the respondents of Bole and NSL sub-cities, the X^2 test result (12.416, p = .002) which was statistically significant that compared to the respondents of Bole sub-city, the majority of the NSL residents 'sometimes' buy second-hand gadgets. The implication of this results is that the monthly incomes of the respondents were determining a factor for the households to rely on the purchase of an original electronic equipment (for Bole sub-city respondents) and the purchase of second-hand equipment (for NSL sub-city respondents).

These findings are consistent with the findings of Borthakur and Sinha (2013) which proclaimed that the considerable price difference between the new and used EEE makes the consumer go for the purchase of the second-hand EEE in developing countries. Circulate (2017) stated that the customers are looking for durable products and updatable appliances. Sotelo *et al*. (2016) further found that customers are motivated by new models, thus increasing the waste flow, so electronic waste volume increases faster than rest.

7.2.5. INDEPENDENT SAMPLE T-TEST RESULTS

In the courses of examining the electronic waste management in the selected households of Addis Ababa, the study tried to examine if any variations occur in terms of the volume of e-waste based on location, income, gender, educational qualifications and family size. Besides, it investigates whether variations occur in terms of the types of electronic waste generated. Furthermore, the variations in the

purchase of electronic waste based on location were also computed. To this end, the study made independent sample t-tests to measure the differences.

Where independent samples test was used to examine differences, equal variance was assumed as Levene's test for the variables was not significant if p>0.05. Accordingly, there was a significant mean difference in the respondents' total electronic waste generation based on their location or sub-city. Thus, respondents of Bole sub-city had higher mean value than those of NSL sub-city. In addition, the test result revealed p-values <.001, which are less than the significance level of 0.05, showing that there was statistically significant. Therefore, this study found that the high income respondents (Bole residents) had statistically significant higher e-waste volume (104 ± 29.674) compared to the middle income respondents of NSL sub-city (55 ± 11.616), t (98) = 11.002, p <.001. Similar to the findings obtained by this study, Feras *et al.* (2012) confirmed that the income level affects the living standards and consumption pattern of electronic gadgets. The ownership by households of electrical and electronic equipment was seen to cut across all income levels. However, the number and range of multiple electrical and electronic equipment units owned was higher in the high income segment (PAN-ETHIOPIA, 2012)

Next, the study computed independent sample t-test to test whether any significant difference existed in the volume of e-waste among the respondents based on their gender and educational qualifications. So far, the data was tested for female and male household heads. Thus, the independent sample test result (t (98) = -1.454, p = .149) for gender and (t (98) = .096, p = .924) for educational qualifications revealed that the p-value was quite greater than 0.05, which proved as there was no significant difference in the total e-waste volume of the respondents based on their gender characteristics and educational qualifications. Therefore, this indicates gender difference and varying in the educational qualifications had no contribution in the volume of electronic waste.

On the other hand, an independent sample test was employed to look whether there was a significant difference in broken, obsolete, and non-functional e-waste among

Bole and NSL residents. Accordingly, the found that the high-income participants (Bole residents) had statistically significantly higher mean and SD in obsolete e-waste volume (30 ± 16.748), non-functional (52 ± 21.161) and broken e-waste (21±8.079) compared to middle-income groups of NSL residents (11 ± 5.531), (27±8.17) and (15±6.873) respectively. This attributed mainly to the monthly incomes, preferences, and tastes of the people in the purchase and increasing in the consumption rates of EE. This has implications that the rapid economic growth and the scale economies of the countries will play a pivotal role in creating the high-income groups of the society who may consume large amounts of electronic equipment and generate more e-waste.

7.2.6. THE CORRELATION RESULTS

As far as correlation test was concerned, the study tried to examine the correlation between volume of e-waste and the monthly income while controlling for family size and educational qualifications. Regarding to the result obtained from partial correlation, it was found that the respondents generated a mean score of 79.4300 with a standard deviation of 33.51 of electronic waste, while the mean monthly income of participants was 35, 5550 ETB with a standard deviation of 17159 ETB, and finally, the mean family size of participants was 5.2 with a standard deviation of 2. This suggests that the sample of participants was slightly in the middle and high-income groups rather than representing the whole population. The results of the partial correlation showed that there was a high positive partial correlation between the dependent variable, "e-waste volume", and independent variable, "monthly income", while controlling for "family size" ($r(97) = .943$, $n = 100$, $p < .001$), and without controlling for family size ($r(98) = .944$, $n = 100$, $p = .000$) which was statistically significant. This suggests that "family size" had very little influence in controlling for the relationship between "e-waste volume" and "monthly income".

The study attempted to test a hypothesis that sought whether a correlation existed between obsolete e-waste and monthly income. The study found that there was a strong positive correlation between monthly income and obsolete e-waste generation

of the households. The Pearson correlations result showed (.691 nearly .70 and $p<0.01$), which establishes a significant correlation between the two variables. As repeatedly said, it was concluded that people with higher income tend to bring functional electronic equipment at the end-of-life before their actual lifetime. Thus, the majority of the respondents of Bole sub-city had produced a high volume of obsolete e-waste than NSL sub-city. This result was consistent with the data obtained through questionnaires and review of documents that Bole sub-city respondents had generated a high volume of obsolete e-waste than NSL sub-city.

7.2.7. MULTIPLE AND POISSON REGRESSION MODEL OUTPUTS

Studies indicate household income determines the volume electronic equipment. For instance, Oomman (2014), found that the level of disposable income is a major factor in determining the decision to own an electronic gadget. The author has asserted as the income levels increases, the amount of money spent on the purchase of gadgets also increases. The study employed multiple regression models to predict the volume of household's electronic waste based on their gender, monthly incomes, family size and educational qualifications. Accordingly, the simple correlation 'r' result is 0.944, which indicates a high degree of correlation between the predictor (gender, monthly income, family size and educational status) and the dependent variable (e-waste volume). Therefore, it can be explained by 89% which is very large. In addition to these, the ANOVA table result indicates that the regression model predicts the dependent variable significantly well. The p-value is less than 0.05 and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data). Similar to the results obtained from the independent sample t-tests and correlation tests, the coefficient table output doesn't show statistical significance between the predictor variables such as gender ($p=.443$), educational status ($p=.971$) family size ($p=.881$) and the dependent variable 'e-waste volume.' However, the Poisson regression model output indicated significant result in terms of gender characteristics that as one moves from female-headed household to male-headed household, there will be an 11.3% decrease in the volume of e-waste.

This implies that female-headed household generates a high volume of e-waste than male-headed households.

7.3. E-WASTE MANAGEMENT IN THE EDUCATIONAL INSTITUTIONS AND GOVERNMENTAL SECTOR OFFICES OF ADDIS ABABA

This sub-section presents discussions of results on five thematic areas of e-waste management in the educational institutions and governmental sector offices. Similar to the discussions made for e-waste management in the households, this section first discusses the awareness of electronic waste management. Secondly, it presents discussions made on the e-waste generation level, types, and characteristics. Then, it presents and discusses the e-waste causes, management methods and challenges. Thirdly, it presents discussions on the GSD personnel's' engagement level in some electronic waste management practices. Furthermore, discussions were made on the results obtained through interviews with GSD personnel and HGOs.

7.3.1. AWARENESS OF E-WASTE AND ITS MANAGEMENT

Public education and outreach may be the most important component in the management of e-waste. That is because no matter what infrastructure is available and developed, what the laws are, and what the option is, no one will be aware of it without public education (Sinha *et al.,* 2005). The study examined the GSD personnel's awareness of e-waste and the impacts of e-waste. Accordingly, the findings of the study revealed that the GSD personnel were aware of what it meant by e-waste, the volume of e-waste generated, and health risks of from the inappropriate e-waste disposal methods, the threat of e-waste on environment, a special treatment of some hazardous fractions e-waste and safely disposal of dry-cell batteries, the possibilities to sell some parts of electronic waste to recycler. The χ^2 test results show no significant for all items except for some questions. Thus, the majority of GSD personnel from the PREIs were 'uncertain' about the impacts of e-waste on the environment, and the used dry-cell batteries need a special treatment

in order to be safely disposed of. The implications of these results are that though the GSD personnel are aware of e-waste and the impacts, a significant number of the GSD personnel from the PREIs need awareness creation program on some of the impacts of e-waste. The outcome of these results was not consistent with the findings of previous studies, for instance, Oomman (2014), the pointed majority of the people were not aware of the effects of improper disposal, any recycling initiatives, and harmful chemical in e-waste. There is generally low public awareness of the hazardous nature of e-waste management techniques used in developing countries (Samarakoon, 2014). Therefore, there is a need to examine there is need to recognize the awareness level based on various criteria than going for generalizations.

Conversely, the majority of the GSD personnel were not aware of any local or international laws pertaining to electronic waste management. Besides, about 75% of the respondents also reported that they were not aware of any policy/legislation on e-waste management at the federal/state level. Similarly, most of the GSD personnel were not aware of programs, activities, and projects towards e-waste management. Finally, it was found that most of the GSD personnel argued that there are no e-waste recycling centres in Addis Ababa or elsewhere in the country. This implies that there were poor or no e-waste management activities in the city that were aggravated by the absence of e-waste legislations and absence of recycling centres. This is because electronic waste management is quite different from other types of waste management due to its complex nature in its management. It is the rapidly growing waste stream in the world. In addition to this, it is composed of both hazardous and valuable materials, and the recycling and dismantling process requires high and special skills. Thus, designing of specific laws and legislations, guidelines or regulations that deal with e-waste is paramount. This finding is consistent with MICT (2013) point out that although government institutions are the biggest generators of e-waste, most have no idea on how to dispose of e-waste that is lying idle in their stores awaiting disposal.

7.3.2. E-WASTE GENERATION LEVEL, TYPES, AND CHARACTERISTICS

This section presents findings obtained from a review of documents on the overall quantities functional electronic equipment, electronic waste, types of e-waste and the actions taken to e-waste in selected EIs and GSOs. Balde *et al*. (2017) point out that better e-waste data will help to minimize its generation, prevent illegal dumping and emissions, promote recycling, and create jobs in the reuse, refurbishment, and recycling sectors.

Such stakeholders: IT industries, the governmental sector offices, the public and private sector establishments, the educational institutes, the business and corporate houses etc. are chiefly responsible for the production or generation of the e-waste (Borthakur and Sinha, 2013). E- waste mainly comes from several sources. Likewise, Kalana (2010) asserted that the sources are residue materials from the electronic products manufacturing process, discarded electrical generated from a repair shop, obsolete electronic equipment coming from governments, companies, and households, and obsolete electronic products brought in by smuggling.

The study found the GSOs have owned a maximum volume of functional electronic equipment followed by the PUEIs and PREIs. In all selected cases it was found that a total of 123,041 functional electronic equipment provided services. Out of these, 112, 062 were newly purchased equipment, 5,697 were second-hand equipment, and finally, about 5,282 of the total functional electronic equipment were owned by donor organizations. Thus, newly purchased equipment accounted the highest value with 91%, electronic equipment from donor organizations accounted 5%. About 4% of the total functional electronic equipment was purchased from second-hand markets. This implies that the EIs and GSOs were owned second-hand electronic equipment from donor organizations, which increases the creation of e-waste.

The study found that the most dominantly available category of functional electronic equipment was IT and telecommunication equipment which constitutes 73% of the total functional electronic equipment. The types of electronic equipment fell under this category were computers, printers, photocopy machines, scanners, fax machines,

phones (land lines). Next, to this, lighting equipment accounted for about 15%, which include fluorescents and luminaries. Thirdly consumer equipment also shares 10% which includes projectors, cameras, DVD players, radios, televisions, audio-amplifiers, UPSs, and tape-recorders. Lastly, controlling and monitoring equipment such as smoke detectors, heating regulators, and laboratory equipment have been identified in EIs and GSOs. It was realized that IT and telecommunication equipment were highly obtained through donations and from the second-hand market than other categories of electronic equipment. This is true that most of the donating organizations throw IT and telecommunication equipment to the developing countries and the institutions demands this types of electronic equipment than others.

The major findings of the study were associated with the total e-waste generated in EIs and GSOs. Thus, a total of 38,424 (in number) e-waste (broken, obsolete and non-functional e-waste) have been generated. Obsolete electronic waste accounts 41% of the total e-waste while broken and non-functional accounted about 30% and 29% respectively. It was also revealed that the PUEIs have generated the highest volume of e-waste which accounted 43.8% followed by GSOs (31%) and PREIs (25%) of the total e-waste. This implies that despite the truth of being the owners of the high volume of electronic equipment, the GSOs relatively generated a small amount of e-waste than the PUEIs. This might be associated with the miss-management, miss-procurements and inappropriate utilization of the electronic gadgets in the PUEIs. However, the rapid technological advancements, scale economies and changing in preferences which ultimately results in making the electronic equipment obsolete or old could be among the practical reasons for e-waste generation. Besides, due to miss management and related reasons electronic equipment had been broken. Lastly, non-functional electronic equipment will be caused by the power fluctuations, the quality, and durability of the equipment, lack of know-how when using or operating the equipment, absence of manuals/guidelines on the equipment, and related factors.

Again the study identified types of e-waste which were most generated. Thus it was found that the IT and telecommunication equipment which includes computers,

photocopy machines, scanners, fax machines, printers, laptops, phones, and typewriters were the most generated e-waste types followed by lighting equipment such as straight fluorescent, compact fluorescent and luminaries. A one way ANOVA result was tested at a significance level of 0.05 reveals no statistically significant differences in the total e-waste generated, in broken and obsolete e-waste. However, the test was significant at 0.05 in terms of non-functional electronic equipment. In order to see which group is differed, the Tukey post hoc test was conducted. The result shows there is a statistically significant difference in non-functional electronic equipment between PREIs and PUEIs. However, there were no differences between PREIs and GSOs and between PUEIs and GSOs. This is very important to identify the real causes of e-waste generated in the EIs and GSOs either from breakage or obsolescence.

7.3.3. E-WASTE CAUSES, MANAGEMENT METHODS, AND THE CHALLENGES

This section attempts to present and discuss major findings obtained on the status, characteristics, and management practices of electronic waste in the selected EIs and GSOs of Addis Ababa. Environmentally responsible electronics use involves not only proper end-of-life disposition of obsolete equipment but also purchasing new equipment that has been designed with environmental attributes. Looking for electronics that are made with fewer toxic constituents, use recycled content, are energy efficient, are designed for easy upgrading or disassembly, utilize minimal packaging, offer leasing or take-back options and have been recognized by independent certification groups as environmentally preferable (Veit and Moura, 2015).

The purchasing of durable, original and quality of electronic products will also considerably reduce the rate and degree of e-waste creation. On the other hand, Mihai (2016) claimed that the most common reasons for not buying second-hand products were related to concerns about product quality and usability. Concerning this, the study highlighted that the majority (79.2%) of the selected EIs and GSOs purchase new electronic equipment and the remaining percent purchase used and working electronic equipment. Obviously, it was due to the fact that both used and

working electronic equipment were affordable and found at a low price when compared to those of original or new equipment. As a result, a significant number of the institutions and organizations might rely on the purchase of second-hand equipment.

It is evident that some of the electronic equipment will remain non-functional and others might experience technical defects after the purchasing process has completed. According to UNEP (2007), electronic equipment is also considered to be "waste" if it has a defect that materially affects its functionality. e.g. it does not power up; or, physical damage that impairs its functionality or safety e.g. the screen is broken or cracked; or faulty hard disk drive, or RAM or video card; or batteries containing lead, mercury or cadmium or liquid cathodes that are unable to be charged or to hold power; or Insufficient packaging to protect it from damage during transport. Therefore, emphasis should be given to the quality of the electronic product purchased along with the providers of the products.

Therefore, it is highly recommendable that ICT technicians should check up on the status of the equipment before receiving them. Regarding this, the data gathered from the sample EIs and GSOs showed that about 68.8% pre-testing the status of the newly purchased equipment by ICT technicians, while 25% of the respondents reported that there were purchasing teams who can check it. These practices are highly encouraged to minimize the number of non-functional electronic equipment when purchasing or owning from donor organizations. In this regard, studies showed that the developing countries owned the electronic equipment which is typically imported without confirmatory testing for functionality and majority of them end up being waste electrical because they are useless or couldn't serve the intended purpose (Namias, 2013; Otieno and Omwenga, 2015; Veit and Moura, 2015).

Inevitably rapid technological advancements, affordability of electronic equipment and rapid obsolescence rate would enforce both EIs and GSOs to undertake to purchase of electronic equipment frequently. Arguably electronic equipment selling shops, companies, and factories are contributing a significant role in e-waste

management through the production and provision of original and environmentally friendly electronic appliances. Fundamentally, the purchase of electronic equipment and their sources would be affected by the economic status, established linkages, availability, and accessibility of original and ecologically friendly products. There were various sources for the educational institutions and offices to make a purchase of electronic items; these are retail shops, wholesalers, second-hand market and manufacturers. In some cases, there are established networks between manufacturers and wholesalers to provide electronic items for organizations, institutions, and businesses. Besides, the purchase of electronic equipment could also be influenced by people's awareness in identifying reputable and original equipment, tastes and preferences, accessibility of the shops and the like.

Regarding the sources of the purchase of electronic equipment needed for the institution, the majority of the EIs and GSOs (70.8%) purchased most of their electronic appliances from general distributors followed by retail shops which constituted for about 18.8%. There were few EIs and GSOs which purchased the electronic equipment by lease and directly from the manufacturers. The χ^2 test result (20.314, p=.002) showed statistically significant that the majority of the PREIs made the purchase of electronic equipment from retail shops. This implies that the PUEIs and GSOs were requested to the made purchase of electronic equipment from the general distributors based on some criteria. Hence, they were accountable to the government. In addition, there was no organized system that allows the consumers to go for the purchase of electronic equipment directly from the manufacturers.

The total amount of e-waste is produced is exponentially increasing because of multiple factors. Consumer demand and high obsolescence rate lead to the frequent and unnecessary purchase of electronic equipment (Devin *et al*., 2014). According to (Tengku-Hamzah, 2011), with the growth of the electronic industry, the quantities of discarded electronics have also grown. Rising incomes and falling prices have ensured that more people are able to afford the electronic equipment. Furthermore, rapid technologies progress has resulted not only in a multitude of new electronic products but also reduced their lifespan by making products to obsolete faster.

Increase in the end-of-life of electrical and electronic products depends on the economic growth of the country , population growth, market penetration, technology up gradation, and obsolescence rates. Besides that , due to the increase in affordability of new products and technological advancements, it is easy to purchase rather than repair outdated equipment (Kalana, 2010). Based on these concepts, the study examined the causes of e-waste in the EIs and GSOs of Addis Ababa. Accordingly, the rapid obsolescence rate and breakage of electronic equipment were mentioned as the major causes of e-waste in the EIs and GSOs. In addition to this, the other causes such as the demand for new designs and incompatibility issues were also identified as least cause of e-waste. The χ^2 test result (13.066, p=.042) was statistically significant in terms of the causes of electronic waste among the EIs and GSOs. This result is consistent with the results of obtained from the review of relevant document that both obsolete and broken e-waste constitutes the highest share. Therefore, the implication of this is that rapid technological advancements, reduce in the performances of electronic equipment, poor utilizations and handlings in the EIs and GSOs brought the generation of obsolete and broken e-waste.

According to Baldé *et al.* (2015), as cited in Manhart *et al*.(2013), disclosed that in Africa, although there are some evidence that e-waste is disposed of inappropriately, the majority of obsolete EEE is presently stored within government buildings, offices, international organizations, and households or awaiting future solutions. Oteng-Ababio (2012) asserted that most obsolete electronic devices are usually stored for a while for a perceived value (physical or emotional) before disposal. The author further stated that even in both public and private establishments, these items are usually stored until directives are issued for their disposal. As far as e-waste disposal methods are concerned, almost all of the EIs and GSOs store e-waste than going for other disposal methods. This implies that other e-waste disposal methods such as reusing, refurbishing and recycling activities were flimsy. As for disposal options, both reuse and reduce are the most favoured options from the other methods of e-waste treatment (Namias, 2013). In fact, NCHEWM (2013) reported that to store e-waste is not dangerous as far as chemicals stay contained inside the device, hence,

it provides an opportunity to reuse before recycling or to donate. USEPA (2001) further recommended that to the extent possible, electronics waste should be prevented, and older electronics should be reused and recycled. The study was also found the reasons for the EIs and GSOs to store unused electronic equipment were because they wanted to sell/donate them. Besides, some of the GSD personnel mentioned they don't know what to do with them and the absence of good disposal methods or recyclers in the city. Similarly, the document review showed that about 81.7% of the e-waste was simply stored in all of the EIs and GSOs. Thus, a very small e-waste quantities were recycled, donated, incinerated, sold and dumped. This also indicates the less the attention paid for the e-waste management in the country which is aggravated with the absence of e-waste recycling centres and lack of e-waste refurbishing and maintaining shops in the city.

It is in line with the waste hierarchy (reduce, reuse, recycle) and also environmentally preferable that functional EEE items are not discarded as waste, but rather given an opportunity for reuse either directly by the owner, who may choose to donate or sell the item, or by a specialist organization that may donate or sell the item following a functional test, data wipe, evaluation process or repair (StEP, 2014). According to Nandkumar (2011), an important method of waste management is the prevention of waste material being created, also known as waste reduction. Methods of avoidance include reuse of second-hand products, repairing broken items instead of buying new, designing products to be refillable or reusable. In this regard, the study found that the major actions taken on old, broken and irreparable electronic equipment. Thus, the majority of the EIs and GSOs store these kinds of electronic waste while a very small number attempted to sell to scrap dealers or e-waste business and donating to other institutions. It also was confirmed that waste collectors didn't go and collect e-waste and even those who came to their institution never collect e-waste. This indicates that there is lack of clear directions which require the waste collectors to collect electronic waste generated from EIs and GSOs.

It was also evident that majority of the EIs and GSOs got it repaired the electronic equipment sent for repairing by certified professionals, however, done on a case by

case modality. This might imply a limited number of e-waste maintenance and refurbishment shops in the city, as well as high volume of e-waste generation from EIs and GSOs, sent to these centres for repair. The study found that the storerooms and facilities within the storerooms for storing the electronic waste were poorly constructed and facilities such as containers, shelves and other were lacking in EIs and GSOs. Due to this fact, e-waste stored in combination with other types of waste in the same room. Similarly, this showed the attention paid to e-waste management was very low.

According to Veit and Moura (2015), the value of recycling from the element could be much higher if appropriate technology is used. Therefore recycling is the best possible option for the management of e-waste (Arora, 2008). Recycling electronics avoids pollution and the need to extract valuable and limited virgin resources. It also reduces the energy used in new product manufacturing. In addition, public and private organizations have emerged that accept computers and other electronics for recycling (Namias, 2013). As discussed earlier, most of the selected EIs and GSOs never recycled e-waste. It was mentioned that the absence of recycling possibilities and lack of awareness about the possibilities and values of recycling e-waste were some of the hindering factors. Besides, some GSD personnel reported the costs of recycling and shortage of skilled manpower as hindering factor for e-waste recycling. In this regard, for instance, India generated about 4, 00,000 tons of e-waste annually of which only 19,000 tons is getting recycled according to the recent data by hardware manufacture association (Jhariya *et al*., 2014). The e-waste recycling sector in developing countries is largely unregulated and the process of recovering valuable materials takes place in small workshops using simple recycling methods (Lundgren, 2012). Except for South Africa, where an increase in material recovery activities has been reported, data on the recycling of WEEE in Africa is scarce (Veit and Moura, 2015).

Several challenges influence the management of electronic waste generated from households, government sector offices, educational institutions, industries and business centres. These include; the absence of policies or legislations that

specifically deal with electronic waste management, the absence of organized structure, unlawful exporting of e-waste to developing countries and the low public familiarity with e-waste (Osibanjo and Nnorom, 2007; Tengku-Hamzah, 2011; Chibunna *et al*., 2012; Lundgren, 2012; Kiddee *et al*., 2013; Mesfin *et al*., 2014; Baldé *et al*., 2015). In this regard, the study revealed that the challenges of electronic waste management were weak enforcement of environmental consciousness laws, lack of e-waste legislations or absence of frameworks, the absence of appropriate e-waste management models, e-waste management facility shortage, and lack of skilled manpower.

This finding to some extent is chimed with the findings of Otieno and Omwenga (2015) that asserted that the greatest challenges facing for instance Kenya in the management of WEEE include: low citizen awareness, lack of proper policy and legislative framework including public procurement and disposal laws, inadequate infrastructure for WEEE management; high cost of brand new EEE, absence of frameworks for End -of-Life (EoL) product take-back and implementation of Extended Producer Responsibility (EPR). The implication of this finding, therefore, is due to such practical factors e-waste management in the city in particular and the country, in general, is lagging behind. For sustainable management of e-waste, a country has to develop a flexible and adaptive system that can handle the variability in quantity and quality of e-waste flow (Sinha *et al.,* 2005). What is more, the findings on the city's e-waste management challenges were discussed under another sub-topic. Hence, the data was mainly obtained from the interviews conducted with GSD personnel and HGOs.

Concerning the activities done, the involvements of EIs and GSOs in e-waste management activities was very low. Even e-waste inventory and awareness creation programs on e-waste did at small scale. Partnership creation deemed important with key actors in e-waste management. The key actors include the producers (manufacturer, distributors, and importers) authorities (government, state agencies and local offices), waste managers (collectors /formal and informal collectors/, dismantlers and recycles) and users (organizations, consumers and citizens).

Similarly, Were *et al*. (2014) asserted that an organized a collaborative forum with stakeholders that included service providers, researchers, distributors, regulators, policy makers, manufacturers, public health, environmental advocators, consumer information network, formal and informal recyclers needed to ensure proper e-waste management. In this regard, the study revealed that the majority of the EIs and GSOs didn't establish a partnership with any of the stakeholders to manage e-waste and some did communicate with government bodies/agencies on how to manage e-waste.

7.3.4. ENGAGEMENT LEVEL IN E-WASTE MANAGEMENT PRACTICES

The findings of the study regarding the activities of EIs and GSOs related to inventory of e-waste, establishing departments handling e-waste, adopting e-waste policy, e-waste recycling, storage of e-waste, and awareness creation programs. Accordingly, the study highlighted that e-waste inventories were practiced among EIs and GSOs. These include e-waste identification and characterization, labeling and recordings. Despite the fact, it was hardly possible to obtain data on temporal dimension of electronic waste, which hinders the presentation on the e-waste generation level in the last five years. In addition, what the researcher noticed during document review was almost all of the selected EIs and GSOs had no organized e-waste data.

Electronic waste management, due to its nature, should be handled by special bodies who are knowledgeable and professionals with basics of e-waste categorization, dismantling, refurbishing, and recycling. In this regard, it was found that there were no independent units, which were responsible to handle e-waste in the majority of the selected EIs and GSOs. What is more, the GSD personnel considered and treated e-waste like other types of waste. This implies the awareness creation programs should be facilitated by the GSD personnel on how to handle e-waste.

The study also revealed that the majority of the GSD personnel reported that they had no policy or legislation governing e-waste management. Besides, there were no appropriate and sufficient storage areas to handle the discarded electronic waste. This indicates fewer concerns paid to e-waste management and the lack of proper

handling of discarded appliances. Regarding types of electronic waste that EIs and GSOs consider hazardous, the result shows there were types of electronic waste, which were considered hazardous by GSD personnel. In this aspect, the chi-square test result to see whether there was a significant difference between EIs and GSOs was statistically significant at .045. The study found that there was electronic equipment which was non-functional due to the absence of manuals, their sizes, their designs and lack of knowhow to operate the equipment in about 47% of the selected EIs and GSOs. This indicates that electronic equipment needs special care and knowledge during the purchase, consumption, and disposal. Finally, the study highlighted that about half (50%) of the selected EIs and GSOs were currently addressing the growing need for knowledge and skills relating to resource consumption or electronic waste. This practice should be expanded to the existent that it covers the population of the city.

Studies indicated that Africa is the latest destination for e-waste, referred to as the 'digital dump' by the Basel Convention Network (BAN), since many Asian countries are now coming up with legislation that bans uncontrolled importation of certain categories of used EEE (Adediran and Abdulkarim, 2012). Almost half the e-wastes of US and Australia are dumped as landfills while the rest are exported to Asia and Africa (Sivaramanan, 2013). It is estimated that 75% to 80% is shipped to countries in Asia and Africa for "recycling" and disposal (Devin *et al*., 2014). Many African countries receive second-hand equipment. Veit and Moura (2015) avowed that most electronic equipment exports to Africa are not pre-tested for functionality. The same author further note that it is not possible to assess whether these exports are legally defined as hazardous waste under the Basel Convention.

In this regard, the study discovered that the majority of the selected EIs and GSOs received electronic equipment from donating organizations and other institutions abroad. This has an implication on the volume and speed of e-waste generation. Townsend (2011) asserted that '*debate is still underway regarding the role of international transfer of old electronic equipment to developing countries. Certainly,*

the donation of working computers to households and students who otherwise would not have such equipment is of benefit, but the EOL implications must be considered'.

In addition to the activities, this section also presents the results and findings obtained on the engagement level of the selected EIs and GSOs in some of the electronic waste management related activities. Thus, it was found that the GSDs' engagement level in some electronic management activities ranged from 'always' to 'never'. However, there were variations in the mean score among the three cases were 'sometimes' engaged in all of the activities listed in the table, hence the mean value for the whole activities is 2.11. Besides, the χ^2 test results were significant at (p=.001, .007, .040), which indicates significant differences among EIs and GSOs in responding to questions such as: "I observed proper waste segregation practices", "the institution buy electronic equipment with brands that are reputable for their durability and longer life over other brands" and "the institution trades or sells used electronic equipment" respectively. These results were clearly indicated in the ordinal regression outputs.

Thus, the ordinal regression result shows that the odds of PREIs and PUEIs in 'observing proper waste segregation practices' was .089 (95% CI, .018 to .448) and .035 (95% CI, 006 to .195) times that of GSOs, a statistically significant effect, Wald $X^2(1) = 8.608$, $p = .003$ and Wald $X^2(1) = 14.571$, $p < .001$ respectively. Then, the odds of PREIs in 'buying second-hand gadgets and/or reassembled' equipment was .067 (95% CI, .011 to .407) times that of PUEIs and GSOs, a statistically significant effect, Wald $X^2(1) = 8.641$, $p = .003$. Thirdly, the odds of PREIs in 'trading or selling used electronic equipment' was .102 (95% CI, .023 to .445) times that of PUEIs and GSOs, a statistically significant effect, Wald $X^2(1) = 9.236$, $p = .002$. Finally, the odds of PREIs in 'donating some old electronic equipment to other institutions' was 4.594 (95% CI, 1.140 to 18.518) times that of PUEIs and GSOs, a statistically significant effect, Wald $X^2(1) = 4.596$, $p = .032$.

7.3.5. DISCUSSION OF THE INTERVIEW RESULTS

The study attempted to obtain a qualitative data through an interview and observation to complement the quantitative data. Accordingly, it involves twenty-four GSD personnel of EIs and GSOs and eight HGOs. The central questions forwarded to GSD personnel include; electronic waste management activities, challenges in e-waste management, storage areas and facilities of e-waste management, efforts to minimize e-waste, stakeholders in e-waste management and general recommendations forwarded towards e-waste management.

Pertaining to GSD personnel, the findings from the study confirmed that majority of the GSD personnel did not widely involve in e-waste management activities including the offering of e-waste management related training, awareness creation programs, data improvements, projects, and partnerships. Besides, the overall e-waste storage and facilities within the storage in most of the selected educational institutions and government sector offices were very poor as suffering from the absence of sufficient and appropriate storage area to handle e-waste. The study also showed the GSD personnel attempted some elementary efforts to minimize e-waste generation through the provision of manuals and UPSs/regulators, performing simple maintenances. In addition to this, reducing the amounts of electronic equipment required for the organization using, for instance, centralized printer, job sharing or multi-function appliances are considered some times as a basic strategies to reduce electronic waste before their creation.

With regards to the e-waste management challenges, the GSD personnel told that governments' lack of concern and attention towards e-waste, the absence of e-waste legislations, the absence of recycling centres, budget shortage, poor involvements of private sectors and NGOs, and importation of second-hand electronic equipment were some of the challenges. What is more, very recently, some of the selected educational institutions and government sector offices tried to create a partnership with government agencies and e-waste vendors. However, the expected results were not satisfactory. Eventually, the GSD personnel forwarded recommendations that a

wide range of activities should be placed on awareness creation programs, policy formulation, stakeholders' involvement, proper utilization of resources, decentralization, e-waste storage and facilities, and importation standards to ensure proper e-waste management in the city. The study also conducts an interview with HGOs having seven major thematic topics. These were roles of the offices in electronic waste management, major activities, purchasing and procurement processes of electronic equipment, challenges in e-waste management, e-waste recycling sites, stakeholders' involvement in e-waste management, and future plans and general recommendations forwarded towards e-waste management.

The findings of the study revealed that the selected offices were playing a pivotal role in the planning, implementation, monitoring of integrated solid waste management in the city (AACA). In addition, they involved in the collection and disposal of solid wastes, striving in minimizing the effects of e-waste on the environment and human health (AASWRR). Besides, they have been given a mandate to enforce rules and regulation towards e-waste management, facilitating the procurement and disposal services for government institutions (PPDS & PPPAA). Despite the facts, however, the majority of the offices were not involved in the e-waste management activities as stipulated in their roles. The study concluded that the vested roles and performances were not balancing. It has been witnessed in several ways including the absence of the organizational structure of e-waste management, treating of e-waste with other wastes, the absence of e-waste management directives, and exacerbation of e-waste problems.

From the results, the offices had been striving to involve in some e-waste management activities. Thus, they made several efforts towards e-waste collections, transportations, and disposal of e-waste, undertaking a study on e-waste, creating awareness on e-waste (AACA, PPDS & AASWRR). In addition, they offered advanced training for ICT professionals on e-waste maintenance, refurbishment, and dismantling, encouraging educational institutions and government sector offices in order to identify, collect, transfer, donate and sell e-waste (CRTC & PPDS). Besides, they encouraged the donations, selling, and transferring of e-waste to other

institutions, surrounding schools or/and offices which require e-waste. What is more, they organize the discussion forums on the e-waste legislations that might facilitate e-waste disposal (PPPAA).

In the purchasing and procurement process, every institution and government sector offices were supposed to prepare purchase requisition form based on original or new equipment. In addition to this, a system to control and check the equipment vis-à-vis the purchase request has designed. Despite the fact, however, it was confirmed that non-functional and broken electronic equipment were often entering the city mixed with the original equipment. Due to the issue of economic status, it was realized that the educational institutions and governmental sector offices should rely on the purchase of only original equipment. Therefore, the study confirmed that the institutions and sector offices sometimes owned second-hand electronic equipment from donor organizations.

Concerning e-waste policy and legislations, the result showed that Ethiopia has no e-waste policy until recently except the existence of the issue of e-waste in a single article in the proclamation named "Solid Waste Management Proclamation." The very practical reasons were governments' lack of emphasis towards e-waste and solid waste management and lack of studies on e-waste management. Similarly, as it was realized from the interviews, there were no e-waste recycling centres in Addis Ababa or elsewhere in other secondary cities in Ethiopia except the CRTC, which was recently established to refurbish, dismantle and maintain e-waste mainly of computers and their accessories. Besides, there was some recycling centres established in the city to recycle cartridges and tonners. The major hindering factors for the absence of recycling centre again include governments' lack of emphasis, fewer involvements of the private sectors and NGOs, the absence of facilitating policy, shortage of budg*et al*located. In addition, great concerns were owed to procurement than final disposal and to the organic wastes than e-waste, and lack of professionals who can not only recycle e-waste but who can refurbish, dismantle and maintain broken and non-functional equipment.

The other findings of the study disclosed that the administrative, economic, and social or cultural challenges that predominantly influenced e-waste management in the city and the country in general. The administrative challenges related mostly to the absence of e-waste policy, lack of research-based data on e-waste, absence of a policy that encourage the involvement of the private sector, miss procurement problems, the low emphasis for e-waste management, and absence of independent bureaus which handle e-waste. On the other hand, the economic challenges encompass budget shortage, low involvements of private sectors, NGOs and CBOs in e-waste management sector, shortage of skilled manpower and backward technology, shortage of storage areas and e-waste handling facilities. Moreover, the study identified the socio-cultural challenges that include governments' poor attitude towards e-waste, the attitude of the community towards e-waste (considering e-waste as asset and inheritances), attitudes towards the governmental properties. Regarding this, MICT (2013) asserted that the socio-economic and cultural attachments are a hindrance to sustainable management of e-waste. The study further reveals that most users of electronic equipment have sentimental attachments and as such many of these items are stored in homes and offices.

Studies indicate that the collaboration among stakeholders is an effective tool in the management of e-waste and related health effects (Were *et al*., 2014). Further Sotelo *et al*. (2016) notes that e-waste management processes such as collecting, reconditioning, repair, reuse, storage, and disposal should involve all stakeholders from the value chain, including those involved are producers, traders, consumers, carriers, collectors, repairers, and recyclers. Studies identified key actors in e-waste management such as producers (manufacturer, distributors, and importers) authorities (government, state agencies and local offices), waste managers (collectors /formal and informal collectors/, dismantlers and recycles) and users (organizations, consumers, and citizens) are greatly required for effective management of e-waste (Carisma, 2009). Each of these stakeholders has their particular role to play. For instance, among the responsibilities of producers, adopting waste minimization technique through producing those electrical equipment with a long lifespan in order to reduce the number of non-working equipment in development

sectors of the country is one of them. Moreover, they are responsible to collect e-waste generated from industrial, business, trade and educational institution by providing contact details such as address, telephone number /helpline number and e-mail of distributors and authorized collection centres to users so as to facilitate the return of used electrical and electronic equipment.

By providing an adequate system of laws, controls and administrative for hazardous waste management, control risks from manufacturing, processing, distribution, consumption, and disposal of e-waste and encouraging and supporting NGOs including formal and informal waste collectors to involve in solving the nations waste problems, the government can play its own part. In this regard, the study highlighted that the HGOs tried to establish a partnership with foreign and domestic organizations and institutions on e-waste management at different period of time. The organizations were the UNIDO, the World Bank, Caliph in Korea, the Ethiopian e-waste Management Project, the StEP, the EPA, the GEF, the MICT and the Ministry of Agriculture. These organizations had been involved in conducting discussion forums on e-waste, organizing training, establishing computer de-manufacturing centre (CRTC), providing solid waste management policy, and sharing of experiences. However, some higher government officials claimed that the budget obtained from some of these organizations in order to carry out e-waste studies had been abused in many aspects.

Lastly, the HGOs reported that there will be plans to carry out studies, researches, training and discussion forums on e-waste management. Besides, the government plans to expand the CRTC, establish independent units who can handle e-waste, collecting e-waste not only from government institutions and offices but also from the households, businesses, and non-business organizations. Moreover, efforts will be made to amend the previously approved SWM legislation in such a way that it should encompass the e-waste management. The recommendations include formulation and enforcement of e-waste policy, conducting of studies, researches and discussion forums, awareness creation programs, adoption of the workable model, advanced training, adopting and sticking to modern approaches. Other higher officials claim that

they working to have mass Medias such as radio, television, and periodicals in which solid waste management including e-waste can be widely discussed. They are working increasing of professionalization and specialization, appropriate budg*et al*location, to have standards on e-procurement and utilization. Moreover, encouraging private sector and NGOs to involve in e-waste management.

7.3.6. DISCUSSION OF THE OBSERVATIONS RESULTS

E-waste management is characterized by lack of e-waste handling facilities and infrastructures, which is reflected by the weak e-waste management laws (Baldé *et al*., 2015). The storerooms for storing the electronic waste should be properly constructed and facilities should be fulfilled to ensure proper management of electronic waste until any management actions are taken. E-waste is comprised of both valuable and harmful materials care should be given to reduce resource depletion and its effects on human health. Appropriate warehouse to store e-waste should be placed, the right containers should be used for storing different electronic waste items separately and there should be no mixing of different kinds of e-waste as well as other types of wastes. It has several implications that for instance, all batteries should be handled and stored having regard to the potential fire risk associated with them. Appropriate sites must be provided for disassembled spare parts. Some spare parts will contain oil and /or other fluids. Such parts must be appropriately segregated and stored in containers that are secured such that oil and other fluids cannot escape from them.

In this regard, the study revealed the EIs and GSOs do not have independently reserved e-waste storage areas. Thus, in most cases, e-waste had stored together with other types of wastes given the insufficient and unequipped storage. The study confirmed that facilities like shelves, containers, boxes and the like were lacking. Due to these prevailing factors, therefore, several wastes spilled one over the other including e-waste. Others used the corridors, open fields, and containers to store e-waste. The study found that the CRTC had relatively better e-waste storage and e-waste handling facilities than the EIs and GSOs. Therefore, the study concluded that

emphasis were not given to the management of e-waste in the store rooms which were triggered by the lack of awareness on the adverse impacts and the economic benefits of e-waste, the absence of recycling centres, budget shortage and absence of clear directions on how to dispose e-waste.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1. INTRODUCTION

As a result of the outstanding growth of WEEE globally and the complexity of EEE, concerns, and challenges in WEEE management have become a top priority for international institutions (Rudáreanu, 2013). Since Ethiopia has adopted a pathway to progress exploring Information and Communication Technology (ICT) possibilities, e-waste or the waste generated out of electronic and electric gadgets have emerged as a major constituent among the solid wastes. The steady but noticeable growth of e-waste demands early planned strategies for dealing with it.

As mentioned earlier, several studies have been conducted on solid and liquid waste management in Addis Ababa and other secondary cities in Ethiopia. However, most of these studies were emphasized on municipal solid waste management and other types of waste than e-waste. The study of e-waste management was firstly conducted by the researcher in 2012, which selects only one public educational institution in Addis Ababa. Since then very few studies began to conduct a study of e-waste management in the city. However, these studies were very limited in terms of scopes, methodology, objectives, and findings. Therefore, this study fills the research gaps noticeable in the prominent previous works.

The objective of this study was to probe the overall waste electrical and electronic equipment management in Addis Ababa, Ethiopia. Specifically, it surveyed the awareness of e-waste, generation level, and engagement in e-waste management practices. Again, it also explained the causes, disposal methods, challenges and factors affecting e-waste management. Then, it examined the stakeholders' involvement, their plans, and recommendations towards e-waste management. Finally, it proposes the prominent e-waste management models/theories to ensure

proper e-waste management in the city. In light of this, the study attempted to investigate the status of e-waste management and explain variations in the e-waste generation, management and disposal among the households, educational institutions and governmental sector offices. The study also intended to point out the challenges in e-waste management and the involvements of the stakeholders in e-waste management. Furthermore, an attempt was made to identify e-waste management models that would most likely result in better e-waste management within the realities of today's Addis Ababa.

To this end, the study employs descriptive and explanatory research designs. Data were collected through multiple data collection tools such as questionnaires, interviews, review of documents and observations. The study selects 100 households from the two affluent sub-cities (Bole and NSL) of Addis Ababa, 72 GSD personnel from EIs and GSOs and 6 from HGOs. Quantitative data were analysed through the application of IBM SPSS 21 software and by computing statistical tools such as frequencies, percentages, chi-square, independent t-tests, partial and product-moment correlations, one way ANOVA, ordinal, Poisson and Multiple regression. Conversely, the qualitative data were analysed using ATLAS ti 7 software. Furthermore, the findings were presented and discussed in line with previous studies. Therefore, this chapter presents a summary of key findings and conclusions, recommendations for policy and identification of areas for future research. The key findings were presented in accordance with the basic Research Questions (RQs).

8.2. SUMMARY OF THE KEY FINDINGS AND CONCLUSIONS

8.2.1. AWARENESS OF E-WASTE AND ITS MANAGEMENT (RQ1)

This section summarizes and concludes key findings obtained regarding the households', educational institutions' and government sector offices' awareness about e-waste and its management. The study attempted to survey the awareness level on the concepts of e-waste, the volume of e-waste generates, the environmental and health impacts of e-waste, local or international laws and activities towards e-waste, safe disposal methods, recycling centres and recycling possibilities of e-waste.

The findings discovered that households' level of awareness about e-waste and its management was much lower than the EIs, GSOs, and HGOs. In general, the mean values were ranged from 1.27 to 2.15, in which nearly 75% (8 items) had a mean score between1.76 to 2.15. This implies that majority of the households were not aware of e-waste and related aspects. For instance, the households claimed not be aware of e-waste policy/legislations, projects, activities and e-waste recycling centres in Addis Ababa. Supporting this finding, similarly the interview result inveterate that Ethiopia has no e-waste policy until recently except a single statement about e-waste in a proclamation named "Solid Waste Management Proclamation." Besides, there were no e-waste recycling centre in Addis Ababa or elsewhere in other secondary cities in Ethiopia except the CRTC. It is a recently established centre to refurbish, dismantle and maintain e-waste mainly on the computers. Besides, it was found that some recycling centres were established to recycle printers' cartridges and tonners in the city.

The study also attempted to see if variations occur in awareness level of households based on educational status. With regards to households, the study found educational status have influenced the awareness of the impacts of e-waste posed on the environment. This implies that the households with higher education status were likely to aware of the environmental impacts of e-waste. However, the

educational qualifications did not affect the remaining awareness related questions presented in this study. On the other hand, the chi-square test result showed there was statistically significant difference in terms of the awareness of the respondents about the impacts of e-waste on the environment and safe disposal of dry-cell batteries among the PREIs, PUEIs, and GSOs. Accordingly, it was found that the majority of the GSD personnel in the PREIs were uncertain about the impacts of e-waste on the environment and safe disposal of dry-cell batteries than the PUIEs and GSOs. From these findings, in general, it was concluded that the GSD personnel and HGOs were more aware of the e-waste and issues in its management than the households of Bole and NSL sub-cities. This might be associated with several factors including the educational qualifications, exposition to various waste management related information, the working environments, and the office responsibilities. The improper disposal of e-waste poses a long term threat to public health and the environment because it is the largest source of heavy metals and organic pollutants in the solid waste stream. In addition, e-waste needs to be handled properly in order to conserve resources because they contain valuable recyclable materials. The valuable spare parts of more selective types of electronic equipment will generate revenue for the organization.

Therefore, the implications of these findings are the awareness creation program need to be facilitated by the households than GSD personnel and higher government officials. Besides, proper measures should be taken during the purchase and utilization of electronic equipment as well as during the storing, transportation, and disposal of the e-waste. It is evident that due to the lack or absence of management system to handle e-waste, the majority of the consumers might lack awareness about what to do with the non-functional, obsolete and irreparable electronic waste generated. As a result, there will be either prolonged storage or disposal of electronic waste with other types of domestic or municipal waste. At the end of the day, the improper disposal practice of e-waste would considerably affect both the environment and human health. Thus, awareness creation programs and activities are among the pillars of electronic waste management. The communities, workers in educational

institutions, businesses, industries, health organizations, and government sector offices, banks, as well as the households in general should be aware of electronic waste and its management. Fundamental achievement of proper waste management, consequently, is the information consultation and participation of government authorities and responsible stakeholders to create public awareness through designing communication tools for awareness enhancing and implement training needs on the issue of environmentally sound management of electronic wastes.

8.2.2. E-WASTE GENERATION LEVEL, TYPES, AND CHARACTERISTICS (RQ1)

This section briefly presents the key summaries and conclusions of the study related to the e-waste generation levels, types and the characteristics in the HHS, EIs, and GSOs of Addis Ababa. First, it summarizes and concludes the findings obtained from the HHs and then EIs and GSOs. The findings of the study explored the total volume of e-waste generated by the respondents of Bole and NSL sub-cities was about 7943 (in number). It was concluded that respondents of Bole sub-city have generated the highest e-waste volume than the NSL sub-city respondents. This infers that there were positive relationships between household's monthly incomes and the volume of e-waste generated. More specifically, the study found that a total of non-functional (4010=51%), obsolete (2077=26%), and broken (1856=23%) e-waste were generated. This also indicates non-functionality was considered as the major cause for e-waste generation in the households of the sub-cities followed by the rapid obsolescence rate and breakage. However, the maximum number of non-functional e-waste is associated with the inclusion of the most generated types of e-waste.

The findings of the study also revealed that the most generated types of electronic waste in both sub-cities include batteries of various categories, CDs/VCDs/DVDs, fluorescent lamps/bulbs, headsets/earphones, cell phones. Besides, it was found a substantial number of tape-recorders, MP3/VCD/DVD players, television sets and computers/laptops. More specifically, the most generated non-functional types e-waste are CD/VCD/DVDs, washing machines, MP3/MP4 player, printers/cartridges,

headsets/earphones, flat iron, air conditioner, fluorescent lamps, and microwave/ oven. On the other hand, computers/laptops, cameras, tape-recorders, cell phones, television sets, radio sets and VCD/DVD players were the most obsolete types of e-waste. These analysis found to be very relevant in the understanding of why these non-functional and obsolete types of e-waste have generated. Accordingly, the power fluctuations, technical defects of the equipment, absence manuals, short lifespan and miss-uses could be considered as the possible reasons for electronic equipment to become non-functional and then e-waste. On the other hand, rapid obsolescence rate in EE was associated with speedy technological developments in the designs, functions, sizes, and operating speed of the equipment which might inspire the households to discard old electronic appliances.

The study also explored the service and storage years of electronic equipment in the households of Bole and NSL sub-cities. Accordingly, it was found that in Bole sub-city nearly 63% of the electronic equipment served for <1 year and 25% have served from 1-5 years. On the other hand, in NSL sub-city, about 47.5% served less than a year and 32.2% served from 1-5 years. From this analysis it was found that in both sub-cities the highest share of electronic equipment served less than a year. This infers that the service years of the electronic equipment vary based on various factors such as the equipment's lifespan and capacity, proper utilization and handlings, rapid technological developments, consumers' tastes and preferences and the like. Hence, the study has identified electronic items that have relatively longer and shorter lifespan. For instance, electronic equipment like cameras, tape-recorders, radios, televisions, refrigerators, and telephones had a relatively long lifespan. Whereas CDs, VCDs, DVDs, batteries, headsets/earphones, fluorescent bulbs were some of the electronic equipment with a shorter lifespan.

With regards to the storage years, in Bole sub-city, 43.5 stored from 1-5 years and 30.7% stored less than a year. As far as NSL sub-city is concerned, 60.2% stored for 1-5 years and 26.6% stored less than a year. From this analysis it was realized that majority of the e-waste stored between 1-5 years followed by < 1 year. Thus, it implies that due to the absence of good disposal methods and recyclers, shortage of e-waste

maintenance, refurbishing and recycling centres, and the households' attitude toward the disposal of e-waste resulted in a prolonged storage of e-waste.

Concerning the purchase years of households' electronic equipment, the study found that out of 7943 the total electronic waste generated in the selected households of both sub-cities, about 45.4% were purchased between 2005 & 2015, and 32.4% after 2015. The study also found that electronic items such as cameras, radios, tape-recorders, televisions, and telephones were among mostly purchased equipment before 1993. Whereas equipment such as cell phones, laptops, computers, Mp3/Mp4 players, electric fan, washing machines, air conditioners are the most dominantly purchased items in between 2005 & 2015. From this analysis it was concluded that the households purchase electronic equipment not only in an increasing quantity but also at substantial varieties mainly from 2005 onwards. Thus, it implies that technological progress, peoples' needs, tastes and preferences, affordability rate, scale economies, and changes in the lifestyle have considerably influenced.

The study further explored the relationships between dependent variable i.e. e-waste volume and the independent variables such as gender, monthly income, educational status and family size of the households. As a result, it was confirmed from the independent t-test, the high-income groups (Bole) had statistically significantly higher e-waste volume compared to middle-income groups of NSL residents. The t-test result also indicates family size, gender, and education level had not affected the generation of e-waste. Likewise, the correlational studies proved that there was a high positive partial correlation between the dependent variable, "e-waste volume", and independent variable, "monthly income", while controlling for "family size." This suggests that "family size" had very little influence in controlling for the relationship between "e-waste volume" and "monthly income". Hence, the role of gender, educational status, and family size were insignificant. The implication is that as the households' monthly income increases there is a corresponding increase in e-waste volume and vice versa. The regression model output was significant at p-value of 0.05 and R^2 of .089 showed that how much of the total variation in e-waste volume, can be explained by monthly income. Similar to the results obtained from the

independent sample t-tests and correlation tests, the coefficient table output doesn't show statistical significance between the predictor variables such as gender (p=.443), educational status (p=.971) family size (p=.881) and the dependent variable 'e-waste volume.' However, the Poisson regression model output indicated significant result in terms of gender characteristics that as one moves from female-headed household to male-headed household, there will be an 11.3% decrease in the volume of e-waste. This implies that female-headed household generates a high volume of e-waste than male-headed households.

Concerning to EIs and GSOs, the study found that a total of 123,041 functional electronic equipment were currently available in these institutions and offices. In comparison with PUEIs and PREIs, the GSOs have owned a maximum volume of functional electronic equipment. The study shows the newly purchased equipment accounts 91%, electronic equipment from donating organization accounts 5%, and about 4% of the total functional electronic equipment was purchased from second-hand markets. This implies that even though the EIs and GSOs have purchased electronic equipment on the basis of new equipment, some were owned second-hand electronic equipment from donor organizations, which ultimately increases the creation of e-waste.

The major findings of the study were allied to the total e-waste generated in EIs and GSOs. Thus, a total of 38,424 (in number) e-waste (broken, obsolete and non-functional e-waste) have been generated. Obsolete electronic waste accounts 41% of the total e-waste while broken and non-functional accounted about 30% and 29% respectively. It was also revealed that the PUEIs have generated the highest volume of e-waste which accounted 43.8% followed by GSOs (31%) and PREIs (25%) of the total e-waste. This implies that despite the truth of being the owners of the high volume of electronic equipment, the GSOs relatively generated a small amount of e-waste than the PUEIs. This might be associated with the miss-management, miss-procurements and inappropriate utilization of the electronic gadgets in the PUEIs. However, the rapid technological advancements, scale economies and changing in preferences which ultimately results in making the electronic equipment obsolete or

old could be among the practical reasons for e-waste generation. Besides, due to miss management and related reasons electronic equipment had been broken. Lastly, non-functional electronic equipment will be caused by the power fluctuations, the quality, and durability of the equipment, lack of know-how when using or operating the equipment, absence of manuals/guidelines on the equipment, and related factors.

The study revealed that IT and telecommunication equipment which includes computers, photocopy machines, scanners, fax machines, printers, laptops, phones, and typewriters were the most generated e-waste types followed by lighting equipment such as straight fluorescent, compact fluorescent and luminaries.

8.2.3. E-WASTE CAUSES, MANAGEMENT METHODS AND PRACTICES (RQ2)

In this section, key summaries of the study on sources of electronic equipment, methods of purchasing, methods of e-waste identification, causes of e-waste, management and disposal methods, measures taken to e-waste, e-waste storage and facilities have summarized and concluded.

Concerning the EE purchasing sources and pre-testing practices, the study confirmed that majority of the PREIs were making a purchase of electronic equipment from retail shops while the PUEIs and GSOs made from general distributors. During the purchase, the majority of the EIs and GSOs claimed to pre-test the status of the newly purchased electronic equipment by the help of ICT technicians, while others use purchasing teams and distributors. It implies that this practice and commitment is promising as it plays a vital role in minimizing the number of broken, non-functional and technically defected electronic equipment while purchasing. Ultimately this practice is highly encouraged to minimize the number of non-functional or defected electronic equipment when purchasing or owning from donor organizations.

The study highlighted that the major causes for e-waste generation in HHs, EIs, and GSOs were rapid obsolescence rate, breakage of electronic appliances, and the demand for innovative designs. This implies that the major reasons for replacing of old electronic appliances were the need for newer technology or design, wanting additional appliances and demanding features not available on old equipment. Thus,

these foreseeable practices and actions will considerably increase e-waste generation rate. In a nutshell, e-waste could be caused by when the older electronic gadgets are replaced by the most recent equipment due to the selection criteria of consumers based on the quality features that exist in the newly produced equipment. The rapid development of new technologies provides electronic equipment very rich in features that are not available in older one and reduces the lifespan of the products increasingly. The problem would be worsened by the lack of assembly (maintenance) of broken and non-functional electronic equipment with the rapid obsolesce rate and increasing consumption of electric products.

The study attempted to identify e-waste disposal methods practiced among HHs, EIs, and GSOs. Accordingly, it was found that storing was the major e-waste disposal methods followed by reusing. Variations were seen in the e-waste disposal methods. Relatively, the majority of the respondents of Bole residents promoted storing of e-waste as the only e-waste disposal methods whereas the majority of NSL sub-city respondents attempted reusing of old electronic equipment. This implies that the higher income respondents who were mainly from Bole sub-city simply put the non-functional and old electronic equipment to the store while the middle-income respondents who were mainly from NSL sub-city promoted the reuse of old electronic gadgets. Hence, the higher income households had the high disposable income to purchase new EE. The principal reason for the HHs to store e-waste was the absence of good disposal methods/recyclers. Whereas, the EIs and GSOs store e-waste because they wanted to sell/donate it. Moreover, a significant number of the HHs throw/dispose of some of the e-waste with other domestic solid wastes. This implies that the absence of e-waste recycling centres, shortage of e-waste maintenance and refurbishing shops, and absence of e-waste management facilitating policy likely resulted in the lengthy storage of e-waste in the HHs, EIs, and GSOs. The advantage of reuse of electronic equipment markedly reduces the volume of electronic waste generation and money. To recycle the equipment may also vital because the recycled materials can be used in developing new equipment that opens great opportunities

for innovation of new products, valuable materials would be retrieved and it helps the environment by avoiding pollution.

The study further illustrated that the e-waste storage and facilities within the storage were not sufficient, not appropriate, poorly constructed and lacks facilities. Thus, in the same room, e-waste was stored mixed with other types of waste. The interview and observation results also confirmed the EIs and GSOs had no independently reserved e-waste storage. Thus, in most cases, e-waste has stored together with other types of wastes given the insufficient and unequipped storage. The study confirmed facilities like shelves, containers, boxes, and others are lacking. Due to these prevailing factors, therefore, several wastes spilled one over the other including of e-waste, while others used corridors, open fields, and containers to store. This implies that there was lack of attention paid to the improvement of e-waste storage areas and e-waste handling facilities. As a result, most of the equipment which was found in the storage area can easily be broken, scratched and out of use. Hence, e-waste contains useful elements and it can be recycled, reused, transferred, donated and sold.

8.2.4. ENGAGEMENT LEVEL IN E-WASTE MANAGEMENT PRACTICES (RQ1)

This section presents key summaries of the study related to the major e-waste activities and engagement levels of HHs, EIs, and GSOs of Addis Ababa in e-waste management. The study highlighted the majority of EIs and GSOs attempted a modern approach in e-waste inventory, which involve e-waste identifications, characterizations, and recordings. As a result, it was impossible to obtain a well-documented and organized data on the quantities and types of e-waste generation. This implies that the poor e-waste data organization will substantially make the volume of e-waste unknown. Consequently, this might hinder the early designing of appropriate e-waste management strategies. The study found that there were no independent units/departments, which were accountable to e-waste management in EIs and GSOs. The GSD personnel considers and handle the e-waste like other types of wastes due to lack of awareness on the technical aspects of e-waste, the

absence of e-waste management policy, shortage of a suitable and sufficient e-waste storage. Some of the EE stored were not providing services because of the absence of manuals, their sizes (cumbersomeness), designs and lack of know-how to operate the equipment. This implies that the concerned officials need either to establish an independent unit or to organize training packages for the GSD personnel to ensure the proper handlings of e-waste. Further, the procurement process must be thoroughly inspected to lessen unnecessary acquisition of EE, which ultimately saves huge money.

The study reveals the engagement levels of HHs, EIs, and GSOs in some e-waste management activities. Accordingly, it was confirmed that households were 'always' engaging in buying new electronic gadgets even if the older one is working and buying gadgets with brands that are reputable for their durability and longer life over other brands than EIs and GSOs. This implies that rapid technological progress and households' tests and preferences have inspired the households to have new EE models. Eventually, this practice will noticeably contribute in the growing of e-waste generation level. It was also comprehended that a considerable number of HHs, EIs, and GSOs have to buy second-hand electronic gadgets. This denotes that the expansion of the second-hand market in the developing country escorted with the less affordability of old EE inspire people to purchase second-hand EE. Finally, it was found that majority of the PREIs have been engaged in trading/selling of electronic wastes than PUEIs and GSOs.

The findings from the study confirmed the majority of the GSD personnel did not widely involve in e-waste management activities including the offering of e-waste management related training, awareness creation programs, data improvements, projects, and partnerships. The study also shows the GSD personnel attempted some elementary efforts to minimize e-waste generation through the provision of manuals and UPSs/regulators, performing simple maintenances. These denote several e-waste management activities are in front of the EIs and GSOs.

The findings of the study revealed some of the higher governmental offices play a vital role in the planning, implementation, and monitoring of integrated solid waste

management in the city (for instance AACA). In addition, others involved in the collection and disposal of solid wastes, strive to minimize the effects of e-waste on the environment and human health (AASWRR). Besides, given a mandate to enforce rules and regulation towards e-waste management, facilitating the procurement and disposal services for government institutions (PPDS & PPPAA). Despite these facts, however, the majority of the offices not extensively involved in e-waste management activities as stipulated in their roles. The study concluded that the vested roles and performances were not balancing. It has witnessed in several ways including the absence of an organizational structure of e-waste management, treating of e-waste with other wastes, and absence of e-waste management directives.

From the results, it can also be understood that the offices made several efforts towards e-waste collections, transportations, and disposal of e-waste, undertaking a study on e-waste, creating awareness on e-waste (AACA, PPDS & AASWRR). In addition, some of them offer an advanced training for ICT professionals on e-waste maintenance, refurbishment, and dismantling, encouraging EIs and GSOs to identify, collect, transfer, donate and sell e-waste (CRTC & PPDS). Besides, they encourage the donations, selling, and transferring of e-waste to other institutions, surrounding schools or/and offices. What is more, they were organizing discussion forums on the e-waste legislations that might facilitate e-waste disposal (PPPAA). From these results, it was concluded that even though the offices have struggled to at least manage the e-waste generated from the HHs, EIs, and GSOs, it was far from reality and workability. Hence, a huge volume of e-waste has stored for a long time without any e-waste management measures.

8.2.5. MAJOR CHALLENGES IN ELECTRONIC WASTE MANAGEMENT (RQ3)

As discussed earlier, the study reveals most of the EIs and GSOs never recycle e-waste. In fact, the CRTC was launched to offer a very limited provision only for computer refurbishment and dismantling. Even this centre was not offering services for all governmental institutions accompanied by lack of capacity. Nevertheless, it was concluded that the major hindering factors were the absence of recycling centres, lack of awareness about the possibilities and values of recycling, costs of recycling

and shortage of skilled manpower. Likewise, the study reveals barriers to the adoption of proper electronic waste management in EIs and GSOs. It was concluded the barriers include weak enforcement of environmental consciousness laws, lack of e-waste legislation or absence of a framework, the absence of an appropriate e-waste management model, shortage of e-waste handling facilities, and lack of skilled manpower. The country has no e-waste policy/legislation, which facilitates proper e-waste management in the HHs, EIs, and GSOs. This was due to governments' lack of emphasis, poor e-waste studies, unknown e-waste data, and

The study unveiled the administrative, economic, and social or cultural challenges were predominantly influenced e-waste management in the city and the country in general. The administrative challenges related mostly to the absence of e-waste policy, lack of research-based data on e-waste, absence of a policy that encourage the private sector, miss procurement problems, the low emphasis for e-waste, and absence of independent bureau which handle e-waste. On the other hand, economic challenges encompass budget shortage, low involvements of private sectors, NGOs and CBOs in e-waste management sector, shortage of skilled manpower and backward technology, shortage of storage and e-waste handling facilities. Moreover, the study identified the challenges related social and cultural challenges include governments' poor attitude towards e-waste, the attitude of the community towards e-waste (considering e-waste as an asset and inheritances), attitudes of the employee towards government property.

8.2.6. STAKEHOLDER'S INVOLVEMENT IN E-WASTE MANAGEMENT (RQ4)

This section presents key summaries associated with the stakeholders involved in e-waste management of EIs and GSOs. Most of the EIs and GSOs were striving to make a partnership with government agencies and e-waste vendors to solve e-waste problem. However, it has not brought significant effects. Besides, a considerable number of them didn't make any partnership with any of the stakeholders. The government has attempted to establish partnerships with foreign and domestic organizations on e-waste management. These include the UNIDO, the World Bank,

Caliph in Korea, the Ethiopian E-waste Management Project, the StEP, the EPA, GEF, the MoCIT and the MoA. These organizations typically involved in organizing discussion forums and training on e-waste, launching computer de-manufacturing centre (CRTC), providing solid waste management policy, and sharing of experiences. However, the GSD personnel claimed that the budget obtained from some of these organizations have abused and did not invest for the intended purposes. Despite the fact, it was concluded that the involvements of such organizations would bring positive impacts in e-waste management of the city. The implication is that due to the complexity of e-waste items, there should be collaborative activities with stakeholders through information dissemination, providing training or courses, designing curriculum, and making or enforcing rules or legislation that specifically deal with e-waste management.

8.2.7. STAKEHOLDERS' FUTURE PLANS AND RECOMMENDATIONS (RQ4)

Eventually, both GSD personnel and HGOs forwarded their plans and recommendations that a wide range of activities should be placed on awareness creation programs, policy formulation, stakeholders' involvement, proper utilization of resources, decentralization, e-waste storage and facilities, and importation standards to ensure proper e-waste management in the city.

The HGOs reported that there would be plans to carry out studies, researches, training and discussion forums on e-waste. Besides, the government plans to expand the CRTC, establish independent unit who can handle e-waste, collect e-waste not only from government institutions and offices but also from the households, business, and non-business organizations. Moreover, efforts will be made to amend the previously approved SWM legislation in such a way that it should encompass the e-waste issues. The recommendations include formulation and enforcement of e-waste policy, conducting of studies, researches and discussion forums, awareness creation programs, adoption of the workable model, advanced training, adopting and sticking to modern approaches. Working to have mass Medias such as radio, television, and magazines in which solid waste management including e-waste can be widely

discussed, increasing of professionalization and specialization, appropriate budg*et al*location, to have standards on e-procurement and utilization, encouraging private sector and NGOs to involve in e-waste management. This implies that it requires several discussion forums held at various levels, wide stakeholders' involvement, the allocation of finance and manpower, and reviewing of other country's experiences.

8.2.8. PROPOSED E-WASTE MANAGEMENT MODEL/THEORY (RQ5)

One of the very contributions of this study was to propose appropriate e-waste management models/theories, which could be applicable to the realities and contexts of the country and the city. Basically, discussions were made with some of the higher government officials on this particular issue. Furthermore, after a wide survey of literature and examining the feasibility potentials of the models and theories, therefore, the study proposes Extended Producer Responsibility (EPR) as an appropriate e-waste management model and Actor-Network Theory (ANT) as a suitable theory. The EPR model has been extensively adopted and implemented in both developed and developing countries today. In this regard, Balde *et al*. (2017) noted that most African countries are currently developing various models of EPR schemes as part of their solution to the e-waste problem. Likewise, recently the EPR approach has practiced in all EU countries, and in majority of the states in the US that have enacted e-waste legislation (Namias, 2013).

As mentioned in the review literature section, the purpose of EPR is to promote social responsibility by encouraging manufacturers to take into account end-of-life management during the product design phase. Similarly, Rudanearu (2013) asserted that EPR have significantly improve e-waste management by (a) promoting sustainable development by manufacturing products that are compliant with environmental requirements, (b) preventing and reducing waste quantities, (c) reaching a higher degree of refurbishing and reuse of equipment and recycled materials in production, (d) reducing the use of natural resources in manufacturing and (d) integrating environmental costs in the product price. Ahmed (2016) also disclosed that manufacturers have a role to play in assisting the creation of e-waste

recycling centers in developing countries rather than using them as dumping sites. Furthermore, Sotelo *et al*. (2016) note that the absence of EPR is one of the major challenges in e-waste management.

To adopt and implement this model, however, it requires some pre-conditions to be fulfilled. In a nutshell, it necessitates the formulation of e-waste policy and legislation, the construction of recycling plants, stakeholders' involvement, and the material and financial flow of e-waste. Regarding the barriers in the adoption of this model, studies indicate that in developing countries, EPR is being explored theoretically especially in making it operational due to the deficiencies in the regulation, slow implementation and construction of recycling facilities, and defective collection system. Besides, the low involvement of role of informal recycling, and the reluctance of citizens to pay recycling fee made the management more complicated and difficult (Liu *et al*., 2006; Manomaivibool, 2009). Despite the challenges, however, the authors argued EPR is the most appropriate model for all countries in order to minimize generation of e-waste given that the responsibility for e-waste generated post Basel Convention is passed back to the producers (Kiddee *et al*., 2013). Likewise, Pariatamby & Victor (2013), highlighted that the economic, environmental and social situation in most of the developing countries is different compared to the developed countries, hence, the need for adapting, implementing, and scaling up appropriate technologies that are more suited to the local conditions.

Similarly, the Actor-Network Theory (ANT) has also proposed as the best theory that can be adopted and implemented in e-waste management of the city. This theory seeks out various actors/stakeholders come together to become partakers in the most pressing issues of e-waste management. Thus, the degree to which actors are networked shall determine the success and failure of e-waste management. The actors of e-waste management that include the consumers, governments, manufacturers, distributors, informal waste collectors, dismantlers, and recyclers required to work reciprocally to the reduction of e-waste (Carisma, 2009). This is due to the fact that managing e-waste is a multifaceted task and requires these actors to act interdependently. Consequently, their actions, intentions, subjectivities, interests

and perceptions toward the purchase, consumption, generation, and disposal of EE has become very critical to design appropriate strategies in e-waste management. In this regard, NCHEWM (2013) recommended that e-waste management require all actors such as consumers, suppliers, and the manufacturers to play their own role and responsibilities. The same study elucidated that " (a) consumers can affect the environmental impacts of products in a number of ways: via purchase choices (choosing environmentally friendly products), via maintenance and the environmentally conscious operation of products, and via careful disposal (e.g., separated disposal of appliances for recycling), (b), suppliers may have a significant influence by providing manufacturers with environmentally friendly materials and components, and finally, (c) the manufacturers can reduce the life-cycle environmental impacts of their products through their influence on product design, material choices, manufacturing processes, product delivery, and product system support."

Therefore, based on these arguments and the interview held with higher governmental organizations, both EPR and ANT were proposed as an appropriate e-waste management model. By and large, the HGOs claimed that there are a strong enthusiasm and commitment from the government side to work on e-waste management. The implication of this is that the application of this model will be feasible and also promising. Further, it indicates the readiness of the government to confront with the most pressing e-waste management issues in the city and the country.

8.3. THE RECOMMENDATIONS

Several recommendations can be drawn out from the findings of the study. These recommendations focused on e-waste management in Addis Ababa in particular and e-waste management in the country in general. Besides, these recommendations are addressed to policy makers, academic institutions, environmental organizations, NGOs and CBOs, industries and other actors that are at the forefront of e-waste management. Generally, the following recommendations are forwarded to bring effective and efficient electronic waste management in the city of Addis Ababa.

8.3.1. RECOMMENDATIONS FOR POLICY AND PRACTICE

I. THE E-WASTE DATA IMPROVEMENT

One of the essential elements in e-waste management is to have clear data on e-waste. Therefore, establishing groups that are responsible to undertake e-waste accounting and inventory deemed necessary. The e-waste in the HHs, EIs, and GSOs need characterization based on their label as obsolete, non-functional and non-repairable items. As a result, it will support activities like repair, maintenance, sub-assemblies, refurbishment and dismantling of the discarded items to facilitate the process of reusing and recycling of e-waste in or out of the country. Secondly, another area of improvement in aid of policy-making is in terms of capturing actual data on generation, collection, storage of e-waste. Some secondary data from the record offices provide estimates scenarios on the extent of e-waste generation but they are just part and parcel of the bigger picture. The improvement in data collection should be able to capture and take into account illegal movement and importation of e-waste. Another way to improve the e-waste data is to look at the types of electronic waste items that are discarded due to the obsolescence, damaging and unserviceable issues. In addition, the amount of electronic equipment purchased and imported second-hand EE in each year need to be documented. Consequently, the availability of realistic information about the e-waste would serve as a foundation for effective decision-making to take actions proper to the characteristics of each e-waste category.

II. THE E-WASTE STORAGE AND DISPOSAL FACILITIES

The study reveals the storerooms for e-waste and the facilities within the storerooms were not appropriate and sufficient to handle e-waste. As a result, e-waste has been spilled one over the other that increases scratching or breakings of the items. Therefore, appropriate and sufficient e-waste storage areas should be in place. Besides, appropriate e-waste facilities such as containers, shelves, boxes, and the like should also be fulfilled to facilitate the effective treatment of e-waste. Subsequently, it will reduce the scratching of e-waste items and minimize the threat of e-waste items pose to human health and the environments.

III. THE E-WASTE RECYCLING CENTRES

The e-waste refurbishment, dismantling and recycling centres need to be established to take corrective measures towards the huge volume of e-waste stored in the households, educational institutions and governmental sector offices of the city. Likewise, expanding CRTC will significantly contribute to e-waste management. Circulate (2017) stated that the end-of-pipe approach, recycling end-of-usage products, cannot be the only solution. The industry needs to review the way electrical and electronic products are designed, manufactured, used, and collected to keep them out of the waste stream.

V. WORKING ON E-WASTE MANAGEMENT CHALLENGES

The government, GSD personnel, and other stakeholders should involve in e-waste management activities such as e-waste accounting, inventory, organizing of training and launching of awareness creation programs, conducting projects and researches, and reshuffling the organizational structures to ensure proper e-waste management. Several challenges in e-waste management identified were the administrative, economic and social challenges. Therefore, the government, policymakers, and stakeholders should pay attention towards e-waste management of the country and waste management sector in general. This can be done through improving environmental awareness among the managers and improving the enforcement of

environmental laws. Besides, sufficient budget and infrastructures should be allocated to facilitate proper e-waste management in the city. At the same time, through the improvement in the enforcement of environmental laws, it would create positive impression and perception of the seriousness of government and stakeholders in dealing with the e-waste issue.

VI. WORKING ON THE E-WASTE MANAGEMENT POLICY OR LEGISLATION

Government and policy-makers should take leadership roles in developing and adopting an e-waste management framework including enforcement of legislation that specifically deals with e-waste. E-waste is a fast-growing waste stream, yet the existing environmental and waste management policies failed to incorporate e-waste as an area of concern. Therefore, early plan and strategies need to be designed. Developing an e-waste policy framework is not only timely but also attuned to the pressing need to address the continued accumulation and generation of e-waste. The framework should specify the role of different stakeholders. Besides, compulsory requirements might be provided for the specific activities that are likely to cause a direct or indirect impact on environment or health through e-waste disposal. There should be standards when importing electronic items including of testing for functionality. Among the identified e-waste management model, respectively EPR and ANT have found to be the best model and theory that might be adopted within the realities of today's Addis Ababa. The implementation of the proposed e-waste Extended Producer Responsibility (EPR) model to address the problems may be successful provided that; (a) all role players responsible for e-waste production and disposal within all the identified tiers 'buy into' the model to start addressing the challenges and the wrong to date; and (b) actors and stakeholders mutually decide to collectively address the overall production, storage and disposal of e-waste. As the capital of Ethiopia, Addis Ababa could herewith act as a role model not only for other cities and bigger towns in Ethiopia, but also for other African countries to learn from the Addis Ababa experience.

VII. INFORMATION DISSEMINATION AND AWARENESS CREATION

Systematic training including seminars will be useful for the GSD personnel, regional and local authorities and other actors involved to disseminate information especially on the relevance of managing e-waste in a sound manner, technical solutions (maintenances and assembly) and financing mechanisms for the fulfillment of e-waste management and recycling facilities. There should be promotion and awareness creation programs towards e-waste and its management through Mass-medias such as televisions, magazines, newspapers, journals, radios, and pamphlets.

8.3.2. RECOMMENDATIONS FOR FURTHER RESEARCH

The first recommendation is to continue conducting research along similar lines to note and mark out the evolution of e-waste management, and the implications of ineffective management. This would be valuable as a learning process not only for Addis Ababa but also the e-waste issue in the country so that mistakes will not be repeated and useful lessons can be drawn to increase the effectiveness of the management process. In general, it is recommended to develop short and long-term approaches in the future to practice effective e-waste management in the university.

Drawing on the findings of the study, the following are suggested for further research:

- Future studies that encompass all income groups of the households in all sub-cities, other educational institutions (elementary and high-schools) rather than colleges and universities, governmental sector offices of different level are suggested to increase the reliability the study and thereby to make more accurate generalizations on the electronic waste management and disposal methods in Addis Ababa.
- On the other hand, further studies should also explore the e-waste management conditions in other areas such as business organizations,

industries, companies, and other governmental and non-governmental organizations in the city.

- Research on e-waste management in the Ethiopian Higher Educational Institutions has identified as the best area to work on in the future.
- Further studies should explore e-waste management and disposal methods in other cities and towns of the country and thereby it helps to know the e-waste data.
- Further studies, which encompass the dependent and independent variables affecting e-waste management should be carried out and thereby to identify the driving forces of e-waste management in the city.
- To end with, this method of study can be adopted in studying other types of waste, such as medical, chemical and industrial wastes.

8.3.3. LIMITATIONS OF THE STUDY

The study attempted to investigate e-waste management in Addis Ababa in the case of households, educational institutions, and governmental sector offices. It employs both descriptive and explanatory type of research to answer the basic research questions raised. While the study has produced an original, detail and pertinent data to the existing body of knowledge and the discipline, there were some limitations on some aspects of the study.

First, due to the no-noes and impracticalities, the study was restricted to the households from two affluent sub-cities (Bole and NSL), EIs (colleges and universities) and GSOs (ministerial level offices) in Addis Ababa. Thus, it failed to uncover the e-waste management in other sub-cities, institutions, organizations, and industries at large. Secondly, the e-waste management varies from region to region, and from country to country based on the prevailing differences in the economy, social, cultural and technological contexts. Thus, it would be difficult to make an accurate generalization of the findings in developed countries of the world.

Thirdly, the limitations were associated with the willingness of the sample respondents in providing accurate data and the availability of secondary data sources. More

explicitly, due to lack of computerized data, it was tiresome to generate the precise data on e-waste volume. Likewise, some of the educational institutions and governmental sector offices were hesitant to open their door to observe the e-waste storage areas, thus, it made difficult to present a more comprehensive data on the observation part of the study. Besides, few household heads were not cooperative to count on the e-waste generated from their home.

Despite these limiting factors, the findings, recommendations, and policy implications of the study are useful for policymakers, academics and other scientific communities to tackle the problems and conduct further studies.

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LIST OF APPENDICES

APPENDIX I: ETHICAL CLEARANCES

UNISA university of south africa

CAES RESEARCH ETHICS REVIEW COMMITTEE

Date: 03/03/2016

Ref #: **2016/CAES/029**
Name of applicant: **Mr AW Kitila**
Student #: **57662746**

Dear Mr Kitila,

Decision: Ethics Approval

Proposal: Electronic waste management and disposal methods in Addis Ababa, Ethiopia: Challenges and prospects

Supervisor: Dr S Mulugeta

Qualification: Postgraduate degree

Thank you for the application for research ethics clearance by the CAES Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the project, **subject to submission of the questionnaire.**

Please note points 4 and 5 below for further action.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the CAES Research Ethics Review Committee on 02 March 2016.

The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the CAES Research Ethics Review Committee. An amended application could be requested if there are substantial changes from the existing proposal, especially if those changes affect any of the study-related risks for the research participants.*
3) *The researcher will ensure that the research project adheres to any applicable*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
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national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.

4) *The questionnaire and interview guide is outstanding and must be submitted before data gathering may commence.*
5) *The researcher is reminded that each individual participant must sign a consent form as well – it is not only to be used to get permission for the research from organisations.*

Note:

The reference number [top right corner of this communiqué] should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the CAES RERC.

Kind regards,

Signature
CAES RERC Chair: Prof EL Kempen

Signature
CAES Executive Dean: Prof MJ Linington

NB NOTES FOR ACTION

APPENDIX II: SUPPORTIVE LETTERS

UNISA university of south africa

From: Dr Ashley Gunter
Acting Chair: Department of Geography
University of South Africa
P O Box 392
UNISA
0002

9 February 2016

To: Mr. A W Kitila
Student number: 57662746

Supervisor: DR. SOLOMON MULUGETA

Dear student

ACCEPTANCE OF YOUR PROPOSAL FOR DPGGR00

Thank you for your recent submissions of your final proposal and draft ethics application. Attached please find copies of the evaluation of your proposal and ethics application for your information and attention.

Proposal:
Your proposal for the module DPGGR00 has been accepted by the Department of Geography after a process of evaluation. There are two evaluations of your proposal, and I hereby request that you discuss the comments of the evaluators with your supervisor and where possible consider the comments before you commence with the research. Please note you do not have to submit a revised proposal with any corrections, the comments are meant to enrich your work further.

Ethics Application:
Your draft ethics application has been evaluated by our internal panel. Your ethics application must still be submitted to the College Ethics Committee for final approval. Please look at the comments of the evaluators on your ethics application and implement these comments. Please note you may only register for 2016 once you have an ethics approval from the college.
(please follow the link to see how to make an ethics application - http://www.unisa.ac.za/Default.asp?Cmd=ViewContent&ContentID=27669)

Regards

Ashley Gunter
BSc BSc (hon) PDM MA D.Phil
Acting Chair: Department of Geography
UNISA

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የከንቲባ ጽ/ቤት
CITY GOVERNMENT OF ADDIS ABABA
Office of the Mayor

ቀን 07/12/2015
Date

ቁጥር A.A/mo/17/1.1/16
No.

City Government of Addis Ababa

- Technical & Vocational Education And Training Agency
- Arada Sub city
- Bole Sub City
- Yeka Sub City
- Addis Ketema Sub City
- Nifase Silk Lafeto Sub City
- Lideta Sub City
- Gulelie Sub City
- Kolfe Kernio Sub City
- Kirqose Sub City
- Akaki Kality Sub City

Subject:-: Requesting for Cooperation

As per the letter sent from College of Social Sciences and Humanities of Haramaya University, **Mr. Abenezer Wakuma,**who is **aPhD candidate at the University of South Africa,** isLecturer in the School of Geography and Environmental Studies, College of Social Sciences and Humanities, Haramaya University.

He is currently undertaking a **PhD dissertation** entitled"ELECTRONIC WASTE MANAGEMENT AND DISPOSAL METHODS IN ADDIS ABABA, ETHIOPIA".In the course of the research and data collection process, he will going to consult selected governmental offices, educational institutions and households in Addis Ababa.

The City Government of Addis Ababa Mayors office therefore, is pleased to issue permission grant by this letter to collect data relevant to meet the research objectives in the City's Jurisdiction.

Regards,

Wondemagegne Teseme H/Giorgis
Deputy Head, Office of
The Mayor and Cabinet Affairs

CC:-

- Abenezer Wakuma
  Addis Ababa

☎ 55 01 11 ቴሌ ፋክስ 0111 55 36 88 0111 11 06 29 ✉ 356,2445

APPENDIX III: TURNITIN REPORT

feedback studio | Abenezer Wakuma Kitila | PHD THESIS FINAL

WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT (E-WASTE) MANAGEMENT AND DISPOSAL METHODS IN THE CITY OF ADDIS ABABA, ETHIOPIA

By

ABENEZER WAKUMA KITILA

Thesis submitted in accordance with the requirements for the degree of

DOCTOR OF PHILOSOPHY

In the subject

GEOGRAPHY

At the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR

DR. SOLOMON MULUGETA WOLDEMIKAEL

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APPENDIX IV: QUESTIONNAIRES FOR HOUSEHOLDS

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

Questionnaire Survey to be filled by Household Head

Dear respondent,

I am a PhD candidate at the University of South Africa, presently conducting research as a fulfilment for the requirements for the degree of Doctor of Philosophy. The research entitled "Electronic Waste Management in Addis Ababa, Ethiopia: Challenges and Prospects.

This questionnaire has been designed to gather the primary data that is required to achieve the main objective of the above mentioned dissertation research. It consists of various items accentuated around the declared purpose of the study. As such, it seeks logical and fair responses to the questions that have been designed to assess the status and characteristics of e-waste generation and disposal as well as the actors/stakeholders involved in its management in Addis Ababa. In view of this fact, you are kindly requested to participate in the study by filling the questionnaire.

The findings of this study are expected to considerably raise public awareness about the critical issues that surround the generation and disposal of e-waste in Addis Ababa and the rest of the urban centres in Ethiopia. What is more, the outputs of this study are also expected to contribute significantly towards the development of a workable strategy for creating an integrated e-waste management system in Addis Ababa in particular and in the rest of the country in general based on a newly proposed e-waste management model. In light of these facts, the ultimate aim of this study is to markedly reduce the environmental, and health hazards that are caused by improper disposal of e-waste. It will further provide valuable information for national government about the challenges of managing e-waste as well as about the adverse human and environmental impacts of e-waste so that it can formulate and

enforce the requisite rules and legislations that deal specifically with the management of electronic waste.

Your valuable response is deemed very important in coming up with policy recommendations on how the problem of e-waste could be dealt with. Rest assured that your answers would be treated with the strictest confidentiality.

DIRECTION

Read each question carefully and choose the best answer/s from the given alternatives and mark like this "✓" in the provided box/es. For the items that require detailed explanations, you may write your comments or suggestions in the space provided. There are some possibilities to where you might chose more than one answer from the alternatives provided

I. BACKGROUND INFORMATION

1. Sex: Male ☐ Female ☐
2. Sub City: ☐
3. Wereda: ☐
4. Kebele: ☐ Monthly Income: ☐ ETB
5. Family Size: ☐
6. Education Status:

Certificate ☐ Diploma ☐ Degree ☐ M.Sc/M.A ☐ PhD ☐

IfAnyOther……

II. AWARENESSES OF ELECTRONIC WASTE AND ITS MANAGEMENT

■Please selext only ONE BOX in each row

ITEMS	Response Options		
	Yes	No	Uncertain
Do you know electronic waste?	☐	☐	☐
Do you have any electronic waste at your home?	☐	☐	☐
Are you conscious / aware of the volume of electronic waste that you generate?	☐	☐	☐
Are you aware of any health risk/s associated with electronic wastes	☐	☐	☐
Does electronic waste pose a serious threat to the environment?	☐	☐	☐

Are you aware that some hazardous fractions in e-waste need a special treatment in order to be safely disposed of?	☐	☐	☐
Do you aware that used dry cell batteries (of different categories) need to be disposed of as safely as possible?	☐	☐	☐
Do you know of any local or international laws pertaining to electronic waste management?	☐	☐	☐
Are you aware of local programs, projects or activities pertaining to electronic waste management?	☐	☐	☐
Are you aware of recycling/trading fairs for electronic wastes?	☐	☐	☐
Are you aware that some electronic parts may be profitably selling to recyclers?	☐	☐	☐

III. E-WASTE SOURCES, CAUSES, DISPOSAL METHODS,AND ITS MANAGEMENT

1. Where do you purchase most of the electronic appliances needed for your home? Put from most to least rank as 1st, 2nd, 3rd... etc.

   A. Retail Shops ☐
   B. Lease ☐
   C. Second-hand market ☐
   C. General distributors ☐
   D. Manufacturers(direct) ☐
   E. If any other

   _____

2. What do you think are the major causes of e-waste generation in your home? Put from major causes to least Cause as 1st, 2nd, 3rd, 4th cause.

   A. Obsolescence (outdated) ☐
   B. The demand for new design ☐
   C. Incompatibility Issues ☐
   D. Broken ☐
   C. If any other

   _____

3. In what condition does your home make the electronic products at the end-of-life? Alternatively, how do you identify/categorize E-waste?

   A. Working i.e. operational/non-operational ☐
   B. Age i.e. old/new ☐

C. Broken i.e. serviceable/unserviceable ☐
D. Technological level i.e. obsolete/modern ☐
E. Not Applied ☐

4. Why does your home replace old electronic equipment?

A. Too slow ☐
B. Wanting newer technology/design ☐
C. Wanting features not available on old electronic equipment ☐
D. Wanting additional equipment ☐
E. Incompatible with the existing electronic equipment ☐

5. What electronic waste management strategy does your home promoting?

A. Redesign ☐ C. Reuse ☐
B. Recycle ☐ D. Dispose/store ☐

6. What are the major reasons for storing unused electronic equipment in your home?

A. We don't consider it appropriate to throw it in garbage ☐
B. We don't know what to do with it ☐
C. We want to donate it/sell it ☐
D. We have not upgraded/repaired it ☐
E. We have not found good disposal methods or recycler ☐

F. If any other_____

7. Specifically, what do you normally do to old/outdated electronic equipment?

A. Store ☐
B. Sell to scrap dealer/E-waste business ☐
C. Throw them to other institutions and organizations ☐
D. Give them back to the company for servicing ☐
E. Other_____

8. Specifically, what do you normally do to unserviceable/irreparable electronic equipment?

A. Store ☐
B. Sell to scrap dealer/E-waste business ☐

C. Throw them to other institutions and organizations ☐
D. Give them back to the company for servicing ☐
E. Other_____

9. Specifically, what do you normally do to broken electronic equipment?

A. Store ☐
B. Sell to scrap dealer/E-waste business ☐
C. Throw them to other institutions and organizations ☐
D. Give them back to the company for servicing ☐
E. Other_____

10. How do you handle batteries?

11. What is your levels of awareness as regards the hazards associated with keeping or wrongly disposing used dry cell batteries?

12. Explain whether or not you sort solid waste before handling them to the collectors (How do you treat/handle e-waste at your home?

13. Explain whether or not you sell e-waste to the door to door vendors such as the "Quorales"?

14. State whether or not there is a means for safely disposing used major electronic equipment such as non-functional and non-repairable old TV sets, refrigerators, radios, tape recorders or even old desktop computers and land line telephone apparatus and etc?

15. What do you do with those electronic equipment/technological devices after they have been damaged or beyond repair?

……
……
……
……
……

IV. ENGAGEMENT LEVEL IN IN E-WASTE MANAGEMENT PRACTICES

■Please Selext Only ONE BOX in Each Row

ITEMS	How often do you engage in the following practices and activities?		
	Always	Sometimes	Never
How often do you keep inventories of the equipment you discard / store?	☐	☐	☐
I recycle electronic products/gadgets which can still be recycled.	☐	☐	☐
I buy new electronic gadgets even if the older ones are still working.	☐	☐	☐
I buy gadgets with brands that are reputable for their durability and longer life over other brands.	☐	☐	☐
I observe proper waste segregation practices.	☐	☐	☐
I buy second-hand gadgets and/or “re-assembled” gadgets.	☐	☐	☐
I trade or sell used electronic gadgets	☐	☐	☐

APPENDIX V: QUESTIONNAIRES FOR GSD

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

Questionnaire Survey _to be filled by General Service Department Officials

Dear respondent,

I am a PhD candidate at the University of South Africa, presently conducting research as a fulfilment for the requirements for the degree of Doctor of Philosophy. The research entitled "Electronic Waste Management in Addis Ababa, Ethiopia: Challenges and Prospects.

This questionnaire has been designed to gather the primary data that is required to achieve the main objective of the above mentioned dissertation research. It consists of various items accentuated around the declared purpose of the study. As such, it seeks logical and fair responses to the questions that have been designed to assess the status and characteristics of e-waste generation and disposal as well as the actors/stakeholders involved in its management in Addis Ababa. In view of this fact, you are kindly requested to participate in the study by filling the questionnaire.

The findings of this study are expected to considerably raise public awareness about the critical issues that surround the generation and disposal of e-waste in Addis Ababa and the rest of the urban centers in Ethiopia. What is more, the outputs of this study are also expected to contribute significantly towards the development of a workable strategy for creating an integrated e-waste management system in Addis Ababa in particular and in the rest of the country in general based on a newly proposed e-waste management model. In light of these facts, the ultimate aim of this study is to markedly reduce the environmental, and health hazards that are caused by improper disposal of e-waste. It will further provide valuable information for national government about the challenges of managing e-waste as well as about the adverse human and environmental impacts of e-waste so that it can formulate and

enforce the requisite rules and legislations that deal specifically with the management of electronic waste.

Your valuable response is deemed very important in coming up with policy recommendations on how the problem of e-waste could be dealt with. Rest assured that your answers would be treated with the strictest confidentiality.

DIRECTION
Read each question carefully and choose the best answer/s from the given alternatives and mark like this "✓" in the provided box/es. For the items that require detailed explanations, you may write your comments or suggestions in the space provided. There are some possibilities to where you might chose more than one answer from the alternatives provided.

I. BACKGROUND INFORMATION

Sex: Male ☐ Female ☐ Institution's Name: ☐
Education Status:
Certificate ☐ Diploma ☐ Degree ☐ M.Sc/M.A ☐ PhD ☐ Other ☐
Position ☐

II. AWARENESS OF ELECTRONIC WASTE AND ITS MANAGEMENT

■Please Selext Only ONE BOX in Each Row

ITEMS	YES	NO	UNCERTAIN
Do you know electronic waste?	☐	☐	☐
Are you conscious/aware of the volume of electronic waste that you generate?	☐	☐	☐
Are you aware of any health risk/s associated with electronic wastes	☐	☐	☐
Does electronic waste pose a serious threat to the environment?	☐	☐	☐
Do you aware that used dry cell batteries need to be disposed of as safely as possible?	☐	☐	☐

Do you know of any local or international laws pertaining to electronic waste management?	☐	☐	☐
Is there any policy/legislation on e-waste management at the state/federal level that your institution is aware of?	☐	☐	☐
Are you aware of local programs, projects or activities pertaining to electronic waste management?	☐	☐	☐
Are you aware of recycling/trading fairs for electronic wastes?	☐	☐	☐
Are there e-waste recycling sites in Addis Ababa or elsewhere in the country that you know?	☐	☐	☐
Are you aware that some electronic parts may be profitably selling to recyclers?	☐	☐	☐
Are you aware that some hazardous fractions in e-waste need a special treatment in order to be safely disposed of?	☐	☐	☐

III. GENERAL ACTIVITIES IN E-WASTE MANAGEMENT

■Please Selext Only ONE BOX in Each Row

ITEMS	YES	NO	UNCERTAIN
Do you keep inventories of the equipment you discard / store?	☐	☐	☐
Is there any unit that is specifically responsible in e-waste management in your institution/office?	☐	☐	☐
Does your institution have a policy for the management of electronic waste management?	☐	☐	☐
Does your office/institution have appropriate and sufficient storage to handle e-waste and discarded electronic items?	☐	☐	☐
Are there types of electronic waste that you consider hazardous?	☐	☐	☐
Is there any electronic equipment that is not giving service because of its design/size/features?	☐	☐	☐
Has your office/ institution ever recycled electronic waste?	☐	☐	☐

Is your institution currently addressing the growing need for knowledge and skills relating to resource consumption or electronic waste?			
Did you ever receive electronic items from donating organizations or other institutions?			

18. In what condition do you usually purchase electronic products for your institution/office?

A. Used
B. New
C. Broken
D. Working

1. How do you check whether the items are new, broken or old?

A. ICT Professionals
B. Distributers/Wholesalers
C. Purchasing Teams
D. Not Applied

2. Where do you purchase most of the electronic equipment needed for your institution? Put from most to least rank as 1st, 2nd, 3rd... etc.

D. Retail Shops
E. Lease
F. Second-hand market
F. If any other
C. General distributors
D. Manufacturers(direct)

_____

3. What do you think are the major causes of e-waste generation in this institution? Put from major causes to least Cause as 1st, 2nd, 3rd, 4th cause.

A. Obsolescence (outdated)
B. The demand for new design
C. Incompatibility Issues
D. Broken

E. If any other_____

4. In what condition does your institution make the electronic products at the end-of-life? Alternatively, how does your institution identify/categorize E-waste?

A. Working i.e. operational/non-operational
B. Age i.e. old/new
C. Broken i.e. serviceable/unserviceable
D. Technological level i.e. obsolete/modern

5. Why does your institution replace old electronic equipment?

A. Too slow
B. Wanting newer technology/design
C. Wanting features not available on old electronic equipment
D. Wanting additional equipment
E. Incompatible with the existing electronic equipment

6. What electronic waste management strategy does your office/institution promoting?

A. Redesign
B. Recycle
C. Reuse
D. Dispose/store

7. What are the major reasons for storing owned and unused electronic equipment in your institutions?

A. We don't consider it appropriate to throw it in garbage
B. We don't know what to do with it
C. We want to donate it/sell it
D. We have not upgraded/repaired it
E. We have not found good disposal methods or recycler

F. If any other_____

8. Which type of E-waste is dominantly generated/stored in your institution? Put from the highest to the lowest (1,2,3,4,) 1 indicate the lowest and 4 the highest rank (refer to document review for detailed information).

A. IT and Telecommunication equipment
B. Consumer equipment
C. Lighting equipment
D. Electrical and electronics tools
E. Monitoring and controlling instrument

9. Specifically, what do you normally do to old/outdated electronic equipment?

A. Store
B. Sell to scrap dealer/E-waste business
C. Throw them to other institutions and organizations

D. Give them back to the company for servicing ☐
E. Other_____

10. Specifically, what do you normally do to unserviceable/irreparable electronic equipment?

A. Store ☐
B. Sell to scrap dealer/E-waste business ☐
C. Throw them to other institutions and organizations ☐
D. Give them back to the company for servicing ☐
E. Other_____

11. Specifically, what do you normally do to broken electronic equipment?

A. Store ☐
B. Sell to scrap dealer/E-waste business ☐
C. Throw them to other institutions and organizations ☐
D. Give them back to the company for servicing ☐
E. Other_____

12. Are there any electronic products in your organization that are not currently functioning due to the absence manuals or the lack of know-how as regards of their operation?

A. Yes ☐ B. No ☐

Enhance your replies with ideas and comments

13. Do waste collectors come and pick up waste at your institution? Do they collect e-waste too?

A. Yes, every thing ☐
B. Yes, but not e-waste ☐
C. No ☐

14. Did you get it repaired some of the electronic wastes you sent them for repairing?

A. Yes ☐ B. No ☐

15. Who does the repairs or maintenance services?

A. Certified professional ☐
B. By your own ☐
C. Untrained personnel ☐

16. Based on your responses for question no. 31, how often do you get this done?

A. At regular intervals ☐
B. On case by case basis ☐
C. Other_____

17. What do you do with those gadgets/technological devices after they have been damaged beyond repair?

18. In what condition are the electronic wastes in your institution accumulated or stored?

A. Mixed with the functioning electronic equipment ☐
B. Separately ☐
C. With other types of waste than electronic waste ☐
D. The same room as the functioning electronic items but separately. ☐

19. What are the factors hindering recycling of electronic waste generated from your institution? Put from most significant to least rank. Write in the box as 1st, 2nd, 3rd, 4th … etc.

A. Costs ☐
B. Lack of skilled man power ☐
C. Absence of recycling possibilities ☐
D. Lack of infrastructure ☐
E. Lack of legislations/E-waste recycling policy ☐
F. Lack of awareness about the possibilities and values of recycling ☐

20. What are the barriers to the adoption of electronic waste management in your office/institution? Put from most significant to least rank. Write in the box as 1st, 2nd, 3rd, 4th … etc.

A. Policy barriers(absence of frame work/legislation) ☐
B. E-waste facility shortage ☐

C. Lack of skilled man power
D. Weak enforcement of environmental consciousness laws
E. Absence of appropriate e-waste management model
F. If any other_____

21. What activities does your office/institution currently working regarding E-waste?

A. E-waste inventory
B. Training and awareness creation
C. Conducting projects
D. Organizational structure
E. If any other_____

22. Does your office/institution make communication/discussion with any government agency/body regarding e-waste management?

A. Yes B. No

23. With which governmental agency/structure has your office/institution been communicating regarding e-waste management?

■Please Selext Only ONE BOX in Each Row

ITEMS	How often does the institution/office engage in the following practices and activities?		
	Always	Sometimes	Never
It recycles electronic products/gadgets which can still be recycled.			
It buys new electronic gadgets even if the older ones are still working.			
It buys electronic equipment with brands that are reputable for their durability and longer life over other brands.			
I observe proper waste segregation practices.			
It buys second-hand gadgets and/or “re-assembled” equipment.			
It traded or sells used electronic equipment.			
It donates some old electronic equipment to other institutions			

APPENDIX VI: QUESTIONNIARES FOR HIGHER OFFICIALS

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

Questionnaire and Interview Guide to be filled by Higher Officials

Dear respondent,

I am a PhD candidate at the University of South Africa, presently conducting research as a fulfilment for the requirements for the degree of Doctor of Philosophy. The research entitled "Electronic Waste Management in Addis Ababa, Ethiopia: Challenges and Prospects.

This questionnaire and interview guide have been designed to gather the primary data that is required to achieve objectives of the dissertation title. In view of this fact, you are kindly requested to participate in the study by filling the questionnaire and interview guide.

The findings of this study are expected to considerably raise public awareness about the critical issues that surround the generation and disposal of e-waste in Addis Ababa and the rest of the urban centers in Ethiopia. What is more, the outputs of this study are also expected to contribute significantly towards the development of a workable strategy for creating an integrated e-waste management system in Addis Ababa in particular and in the rest of the country in general based on a newly proposed e-waste management model. In light of these facts, the ultimate aim of this study is to markedly reduce the environmental, and health hazards that are caused by improper disposal of e-waste. It will further provide valuable information for national government about the challenges of managing e-waste as well as about the adverse human and environmental impacts of e-waste so that it can formulate and enforce the requisite rules and legislations that deal specifically with the management of electronic waste.

Your valuable response is deemed very important in coming up with policy recommendations on how the problem of e-waste could be dealt with. Rest assured that your answers would be treated with the strictest confidentiality.

I. BACKGROUND INFORMATION

Sex of the respondent: Male ☐ Female ☐
Educational Qualification:
Certificate ☐ Diploma ☐ Degree ☐ M.Sc/M.A ☐ PhD ☐ Other ☐

Organization's Name: ☐
Position ☐

II. AWARENESS OF ELECTRONIC WASTE

■Please Selext Only ONE BOX in Each Row

ITEMS	YES	NO	UNCERTAIN
Do you know electronic waste?	☐	☐	☐
Are you conscious/aware of the volume of electronic waste generated in this city?	☐	☐	☐
Are you conscious/aware of the volume of electronic waste generated in this country?	☐	☐	☐
Are you aware of any health risk/s associated with electronic wastes?	☐	☐	☐
Does electronic waste pose a serious threat to the environment?	☐	☐	☐
Do you know of any local or international laws pertaining to electronic waste management?	☐	☐	☐
Is there any policy/legislation on e-waste management at the state/federal level that your institution is aware of?	☐	☐	☐
Are you aware of local programs, projects or activities pertaining to electronic waste management?	☐	☐	☐

Are you aware of recycling/trading fairs for electronic wastes?	☐	☐	☐
Are there e-waste recycling sites in Addis Ababa or elsewhere in the country that you know?	☐	☐	☐

III. ELECTRONIC WASTE MANAGEMENT RELATED INTERVIEW GUIDES

Please read each question guides and write your suggestions on the space provided.

1. What is the role of this agency/institution/office in electronic waste management?
2. What activities your agency/office has performing in relation to electronic waste management?
3. When and how did you make purchase of electronic equipment needed for offices and institutions? Have you ever received electronic equipment from donating organizations and second-hand markets? Is there mechanisms to check the functionality status of the equipment?
4. Is there any policy/legislation that specifically deals with e-waste management at city or country level? If yes, indicate the sources. If no, explain the hindering factors.
5. Are there electronic equipment recycling plants/sites you know so far in Addis Ababa or in Ethiopia? If yes, describe their status? If no, please briefly explain factors hindering.
6. What e-waste management actions are taken to non-functional and obsolete electronic waste collected from institutions and government sector offices?
7. What do you think are the main challenges related to electronic waste management?

    a. Administrative/political challenges
    b. Economic challenges
    c. Social challenges
    d. Cultural challenges
    e. If any other challenges:
8. Are there stakeholders working in collaboration with your institution to manage e-waste? Who are they? What e-waste management activities are they working with your institution/agency?
9. What is your future plan towards electronic waste management? What do you recommend to improve the existing e-waste management in this country?

APPENDIX VII: INTERVIEW GUIDES FOR GSD

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

Interview Guide to be filled by General Service Department Officials

Dear respondent,

I am a PhD candidate at the University of South Africa, presently conducting research as a fulfilment for the requirements for the degree of Doctor of Philosophy. The research entitled "Electronic Waste Management in Addis Ababa, Ethiopia: Challenges and Prospects.

This INTERVIEW has been designed to gather the primary data that is required to strengthen the data collected through questionnaire. In view of this fact, you are kindly requested to participate in the study by filling the interview.

The findings of this study are expected to considerably raise public awareness about the critical issues that surround the generation and disposal of e-waste in Addis Ababa and the rest of the urban centres in Ethiopia. What is more, the outputs of this study are also expected to contribute significantly towards the development of a workable strategy for creating an integrated e-waste management system in Addis Ababa in particular and in the rest of the country in general based on a newly proposed e-waste management model. In light of these facts, the ultimate aim of this study is to markedly reduce the environmental, and health hazards that are caused by improper disposal of e-waste. It will further provide valuable information for national government about the challenges of managing e-waste as well as about the adverse human and environmental impacts of e-waste so that it can formulate and enforce the requisite rules and legislations that deal specifically with the management of electronic waste.

Your valuable response is deemed very important in coming up with policy recommendations on how the problem of e-waste could be dealt with. Rest assured that your answers would be treated with the strictest confidentiality.

Date: ……Interviewer: ……

Position…… Interviewee: ……

Education status: …… Duration of interview: ……

Telephone: …… Place: ……

Institute's name: …… Time of interview: ……

24. When and how did you purchase electronic equipment needed for your office/institution?
25. Did you undertake any e-waste accounting? Why, how and when? If no, why? Has your office/institution ever been providing any training on electronic waste management and related issues to the General Service Departments namely purchasers, directors and storekeepers? If yes describe the contents. If no, why?
26. Does your office/institution have appropriate and sufficient storage to handle e-waste and discarded electronic items generated? If no, what factors are hindering?
27. Can you explain the overall setting and conditions of e-waste storage of your office/institution?
28. What do you think are the main challenges related to electronic waste management?
    A. Administrative/political challenges
    B. Economic challenges
    C. Social challenges
    D. Cultural challenges
29. Can the amount of electronic equipment currently required be reduced (job sharing, multi-function appliances, use of centralized printer)? If yes how? If no why?

30. Are there stakeholders working in collaboration with your institution/office to manage e-waste? Who are they? What e-waste management activities are they working with your institution/office?
31. Why did you rarely donate and/or sell broken, irreparable and obsolete electronic waste in your office/institution?
32. Were there any efforts that your institution/office made to minimize waste before their creation? If yes, explain how and, if your answer is no, what were the main obstacles to do it?
33. What do you recommend to improve the existing e-waste management in this institution/office in particular and in the city in general

APPENDIX VIII: RESULTS FROM DOCUMENT REVIEWS

Table 8.1: Service and storage years of electronic equipment

S.N	Electronic Items	Bole								NSL							
		Service Year				Storage Year				Service Year				Storage Year			
		>10	5-10	1-5	<1	>10	5-10	1-5	<1	>10	5-10	1-5	<1	>10	5-10	1-5	<1
1	Computer/Laptop	8	35	89	8	6	23	88	23	3	25	13	4	2	13	25	5
2	Camera	25	89	84	14	22	117	52	21	32	27	25	5	14	27	44	4
3	Tape Recorder	33	52	42	9	17	31	68	20	27	32	39	7	17	23	59	6
4	Cell phone	6	28	113	33	13	36	111	20	6	37	60	43	7	36	67	36
5	Television	23	43	32	4	24	46	22	10	16	34	13	7	10	9	40	11
6	Mp3/Mp4 Player	3	16	51	3	0	14	56	3	0	5	11	6	0	4	12	6
7	Radio/Hi-Fi Set	33	38	57	13	13	38	77	13	24	13	21	2	15	16	26	3
8	CDs/VCDs/DVDs	0	0	278	1256	100	244	536	654	18	23	75	256	3	22	213	134
9	Printer + Cartridges	1	15	24	2	2	15	24	1	1	9	3	1	1	3	9	1
10	VCD/DVD/CD Player	3	36	74	43	9	36	74	37	18	25	56	4	9	25	58	11
11	Headset/Earphones	0	0	8	472	14	59	182	225	0	0	137	288	0	2	266	157
12	Batteries	0	0	70	746	89	123	426	178	0	8	264	236	0	8	370	130
13	Telephone	19	45	31	18	23	36	32	22	7	26	15	2	7	9	26	8
14	Microwave/Oven	8	27	17	4	4	30	14	8	4	29	10	10	4	11	27	11
15	Refrigerator	12	32	11	7	3	35	11	13	13	21	25	21	12	9	47	12
16	Flat Iron	3	25	21	9	4	21	21	12	0	16	6	3	0	5	17	3
17	Washing Machine	4	35	20	2	3	20	36	2	4	17	25	7	4	13	29	7
18	Air-Conditioner	0	8	33	10	2	20	27	2	2	12	24	11	0	6	32	11
19	Electric Fan	0	6	47	18	2	6	44	19	1	16	33	8	0	8	44	6
20	Fluorescent Lamps/Bulbs	0	0	195	532	13	26	367	321	0	2	25	378	0	3	235	167
Total		181	530	1297	3203	363	976	2268	1604	176	377	880	1299	105	252	1646	729

Table 8.2: Functional electronic equipment in the EIs and GSOs

		PREI	PUEI	GSO	PREI	PUEI	GSO	PREI	PUEI	GSO
1	Fax machine	36	57	160	0	6	11		1	4
2	Phones(Land lines)	229	329	1310	0	16	0	0	0	15
3	Laptops	692	1425	3339	20	20	225	0	62	102
4	System unit	2681	5532	6781	350	329	245	991	328	93
5	Monitor	2621	4089	6781	400	228	245	998	250	93
6	Keyboard	2671	3903	6781	400	203	245	962	250	93
7	Mouse	2691	4243	6781	400	253	245	952	250	93
8	Pocket and desk	191	470	705	22	10	0	0	0	1
9	LCD monitors	1264	2861	1724	0	20	0	0	0	0
10	Type writer	136	570	68	0	110	0	1	0	2
11	Printers	171	1309	2695	48	176	222	0	0	32
12	Scanners	91	224	383	0	43	13	0	0	4
13	Copying equipment	131	2464	322	0	221	0	1	0	2
14	DVD player	58	178	78	0	17	3	0	0	1
15	Cameras	135	234	431	0	10	36	0	0	0
16	Projectors	97	1371	367	0	104	17	0	0	8
17	Radios	36	624	134	0	58	9	0	8	1
18	Tape recorders	60	122	141	0	0	7	0	0	1
19	Audio amplifiers	52	101	201	0	0	0	0	0	0
20	UPS	627	2686	3944	0	15	124	0	0	94
21	TV	60	357	219	0	1	6	0	0	4
22	Luminaries	262	414	791	0	0	0	0	0	0
23	Straight Fluorescent	3098	3551	6369	0	0	0	0	0	0
24	Compact fluorescent	649	551	2843	0	0	0	0	0	0
25	Smoke detector	10	36	9	0	14	0	0	0	0
26	Heating regulator	33	67	42	0	7	0	0	0	0
27	Laboratory equipment	322	1239	552	0	26	102	0	0	0
Total		19104	39007	53951	1640	1887	1755	3905	1149	643
		112062			5282			5697		

Table 8.3: Purchasing years and quantities of electronic equipment

S.N	Electronic Items	Bole					NSL				
		Before 1993	1994-2004	2005-2015	After 2015	Total	Before 1993	1994-2004	2005-2015	After 2015	Total
1	Computer/Laptop	0	26	86	28	140	0	6	29	10	45
2	Camera	32	73	85	22	212	17	25	43	4	89
3	Tape Recorder	31	23	57	25	136	35	30	31	9	105
4	Cell phone	0	26	98	56	180	0	13	80	53	146
5	Television	12	22	56	12	102	9	12	38	11	70
6	Mp3/Mp4 Player	0	7	45	21	73	0	4	12	6	22
7	Radio/Hi-Fi Set	35	43	56	7	141	22	20	15	3	60
8	CDs/VCDs/DVDs	0	276	712	546	1534	0	93	178	101	372
9	Printer + Cartridges	0	7	29	6	42	0	2	10	2	14
10	VCD/DVD/CD Player	5	39	71	41	156	3	26	48	26	103
11	Headset/Earphones	0	12	197	271	480	0	87	165	173	425
12	Batteries	16	220	276	304	816	3	75	315	115	508
13	Telephone	18	13	36	46	113	16	12	12	10	50
14	Microwave/Oven	2	30	12	12	56	0	15	26	12	53
15	Refrigerator	3	21	23	15	62	0	13	33	34	80
16	Flat Iron	0	16	27	15	58	0	6	14	5	25
17	Washing Machine	3	20	34	4	61	1	13	18	21	53
18	Air-Conditioner	0	16	32	3	51	0	6	31	12	49
19	Electric Fan	0	8	40	23	71	0	11	26	21	58
20	Fluorescent Lamps/Bulbs	0	128	289	310	727	0	2	224	179	405
Total		157	1026	2261	1767	5211	106	471	1348	807	2732

Table 8.4: E-waste types in EIs and GSOs

S.N	Electronic Items	Broken			Obsolete			Non-functional		
		PREI	PUEI	GSO	PREI	PUEI	GSO	PREI	PUEI	GSO
1	Fax machine	6	21	23	250	27	35	2	25	22
2	Phones(Land lines)	71	66	125	179	58	135	12	51	114
3	Laptops	56	133	83	611	143	300	14	155	59
4	System unit	450	583	357	518	615	608	100	747	202
5	Monitor	429	420	255	470	519	599	139	579	258
6	Keyboard	430	472	212	498	489	688	135	622	307
7	Mouse	415	362	288	508	234	619	145	458	238
8	Pocket and desk	65	17	23	56	21	85	12	67	38
9	LCD monitors	78	228	115	265	220	193	1	293	59
10	Type writer	90	273	17	22	329	53	13	304	16
11	Printers	22	208	119	361	216	327	21	209	189
12	Scanners	14	73	68	220	104	62	2	101	50
13	Copying equipment	33	177	20	214	244	59	5	194	23
14	DVD player	7	36	13	34	76	8	0	66	13
15	Cameras	4	47	20	58	136	115	2	85	30
16	Projectors	6	114	22	56	195	46	9	176	16
17	Radios	4	146	13	33	206	32	4	128	18
18	Tape recorders	7	52	3	17	79	20	4	62	34
19	Audio amplifiers	3	112	9	27	116	34	3	121	4
20	UPS	22	233	255	164	126	463	36	367	367
21	TV	13	12	23	5	17	47	3	51	31
22	Luminaries		334	155	21	176	18	31	457	52
23	Straight Fluorescent	773	634	510	268	248	382	254	631	765
24	Compact fluorescent	110	317	126	114	157	532	31	491	136
25	Smoke detector	0	9	3	2	9	2	0	16	10
26	Heating regulator	89	35	3	5	27	9	0	60	32
27	Laboratory equipment	25	57	107	457	66	154	0	293	283
Total		**3222**	**5171**	**2967**	**5433**	**4853**	**5625**	**978**	**6809**	**3366**
		11360			**15911**			**11153**		

Table 8.5: E-waste Generation Level in EIs and GSOs

S.N	Electronic Items	E-waste Generation			Total
		PREIs	PUEIs	GSOs	
1	Fax machine	258	73	80	411
2	Phones(Land lines)	262	175	374	811
3	Laptops	681	431	442	1554
4	System unit	1068	2077	1167	4312
5	Monitor	1038	1518	1112	3668
6	Keyboard	1063	1583	1207	3853
7	Mouse	1068	1054	1145	3267
8	Pocket and desk	133	105	146	384
9	LCD monitors	344	741	370	1455
10	Type writer	125	774	127	1026
11	Printers	404	633	599	1636
12	Scanners	236	278	172	686
13	Copying equipment	252	615	102	969
14	DVD player	41	178	43	262
15	Cameras	64	268	167	499
16	Projectors	71	485	82	638
17	Radios	41	480	56	577
18	Tape recorders	28	193	80	301
19	Audio amplifiers	33	349	93	475
20	UPS	222	726	1028	1976
21	TV	21	80	87	188
22	Luminaries	52	967	225	1244
23	Straight Fluorescent	1295	1513	1657	4465
24	Compact fluorescent	255	965	794	2014
25	Smoke detector	2	34	15	51
26	Heating regulator	94	122	44	260
27	Laboratory equipment	482	416	544	1442
Total		**9633**	**16833**	**11958**	**38424**