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Electronic Waste Management Practices and Development of Electronic Waste Management Guidelines in Addis Ababa

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***Abstract*—** *Growth related EEE generation has also become the major issues of waste management agency. All these waste streams are being collected, transported and disposed with the other municipal waste streams. A sustainably safe management system needs to be installed for the hazardous electronic waste. Therefore, this study is conducted to assess hazardous electronic waste management practice and design standard hazardous waste management guidelines. WEEE generation hotspot points were randomly sampled for data generation and collected data were analyzed to determine generation rates per EEE waste. The data collection for determining hazardous electronic waste generation rate has been conducted for seven consecutive days. The generation rate of 32,597,222.48 kg/year of WEEE was generated in Addis Ababa. Regarding hazardous waste management practices in the EEE hotspot areas, the survey shown that most of the hazardous wastes were not properly segregated and managed across all the three streams. The study showed that the hazardous and non-hazardous wastes are mixed together and disposed into the environment carelessly. This brief assessment showed that no legally registered facilities have been established for the disposal of hazardous electronic wastes. The assessment also revealed that most WEEE facilities that were regularly inspected did not meet the standard limit requirements set by the regulatory bodies. It also showed that there is no institutional system working on hazardous waste management system separately.*

***Keywords*—** *Electronic, generation, hazardous, non-hazardous, waste management.*

I. INTRODUCTION

Addis Ababa, whose population grew from about 2.1 million in the year 1994 to 2.7 million in 2007, is one of the fastest growing cities in Africa. Its current population is estimated to be exceeding 3 million and, apart from its sheer population size, the city is playing significant economic, social and cultural roles both at the national and international levels. Accordingly, the City has significant contribution to the national GDP owing to the concentration of various urban-based service orientated and manufacturing activities. The city, which is the Federal Capital, accounts for almost a quarter of the national urban population that is a mosaic of Ethiopia's multi ethnic and multicultural identities. On the other hand, being the home of the African Union, the Economic Commission for Africa, several specialized UN agencies and other international organizations and more than one hundred diplomatic missions, it is among the few most culturally and ethnically diverse cities in the world.

The city's rapid population and economic growth, coupled with discernible changes in lifestyles and consumption patterns of its residents and visitors that are associated with globalization and improved information and communication technology, contribute to dynamic changes in both the quantity and composition of solid waste to be generated in the city. In particular, the rapid growth of industry, trade and services including the recent proliferation of ICT and expansion of mobile phones has accelerated the generation of Electronic Waste (EW). Yet, the city did not have a comprehensive, integrated and sustainable solid waste management plan to effectively respond to the complexities associated with such dynamics.

Despite the fact that the city has one of the most progressive solid waste management policies and rich experience in adopting decentralized solid waste management systems that gave impetus for the participation of the private sector, it only focused on the collection, transportation and disposal of mixed municipal and hazardous solid waste. Its aim is heavily relied on mitigating the adverse effect of municipal solid waste on public health and improving the city's image as a clean city. The city Administration was in the process of adopting a paradigm shift in the city's solid waste management system as illustrated by the political commitment to institutionalize efficient, effective and customer focused services through business process re-engineering (BPR) and the adoption of a balanced score card (BSC).

The city has established two solid waste management organizations i.e. Addis Ababa City Cleansing Management Agency for collection and transportation services and Addis Ababa City Solid Waste Recycling and Disposal Project office to recycling and disposal activities. The city administration has built four transfer stations and one sanitary landfill so as to promote integrated solid waste management system. But the consideration of hazardous waste management system separated from the municipal/general waste management was a missing part as a crucial element to realize the safety of waste management workers, health of society and environment. There was no adequate information about hazardous solid waste characterization and generation to design proper way of management system. There was a lack of locally adapted standards and guidelines.

Hence, a study has been conducted to assess the characterization, generation and prevailing management

practice of hazardous waste in Addis Ababa. The study has conducted on WEEE streams. Selected hazardous waste generators from potentially identified institutions/organizations of the three steams have been assessed for data collection. A waste generation and characterization including assessments of current management practice has been done for the d WEEE were also assessed basing upon its generation, characterization and management practices. The profile data will be utilized for the development of hazardous waste management guideline. WEEE is generated from individual households to business centres dealing with EEE and scattered across the city. EEE assembling and dismantling locations are considered as hotspot points for generation of WEEE.

There are little hard facts available on the handling, collection, transport and disposal of different categories of hazardous and special wastes, there is no facility in the whole country for appropriate treatment and disposal of hazardous solid waste. As a normal practice; uncontrolled type landfill is being used to dispose variety of toxic and hazardous wastes without considering pre-treatment measures. The collection, transportation and disposal practices of solid waste are without the precaution of hazardous waste. The toxic and hazardous waste is being collected and transported in mixed ways and disposed together with the municipal waste. In general; there was no effective institutional system and specific regulations dealing specifically on hazardous electronic and special wastes. There is no competent, well-staffed regulatory department that deals with such wastes, no studies, inventories and records made on the hazardous waste generators, no specialized facilities and institutions, no list made on the priority hazardous pollutants /red list/, no segregation of hazardous waste at source in a separate bin. Producers were not fully responsible to dispose this waste separately and also there was no facility prepared for such wastes. The problem would be complicated if special hazardous waste management system guidelines, directives and procedures was not prepared.

II. METHODOLOGY

2.1 Description of Study Area

Addis Ababa is a capital city of Ethiopia with great geographical diversity endowed with rich natural and human resource base, and yet it is one of the cities in the world with the seat of many higher international communities and diplomat like UNDP, UNHCR, UNICEF and USAID etc and the head quarter of AU, ECA.

The city has an area of 540 square kilometers, of which 18 square kilometers is rural. It lies between 2,000 and 3,000 meters above sea level. Despite its proximity to the equator, Addis Ababa enjoys a mild, Afro-Alpine temperate and warm temperate climate. The lowest and the highest annual average temperature are about 10^0C and 25^0C. Annual rainfall is around 1200 mm.

The population of Addis Ababa grew from about 2.1 million in the year 1994 to 2.7 million in 2007 and the annual growth rate of 2.1%, is one of the fastest growing cities in Africa. Its current population is estimated to exceeding 3 million. Due to certain reasons like other developing countries, the city has experienced highly accelerated population growth. The rapid population increase of the city has been mainly attributable to natural urban population increase and internal migration. According to the country's 1994 population and housing census, out of the total population of the city, 46.7% were migrants from rural and other urban areas in Ethiopia (CSA, 1999:161). Currently, CSA notifies that birth rate of Addis Ababa city administration is 2.1% with average family size 4.1 persons. At the start 2011; the city has a population of 2,979,206 and if no exaggerated rural urban migration faces, at 2020, it will expected to have a total population of 3,599,003. The projection of population is described in table I below.

TABLE I. Population projection of Addis Ababa City.

Year	Number of household	Total population
2010	711535	2917295
2015	790309	3240270
2016	807081	3309036
2017	824209	3379260
2018	841701	3450975
2019	859563	3524212
2020	877847	3599003

The projection is calculated from initial population of 2010 CSA data with rate equal to 2.1% and statistical projection formula [$P_n=P_oe^{(R/100)\,xt}$], where R is rate of population growth, t is time in years, p_o is initial population, p_n is final population and e is common logarithm.

However, there is no formal economic classification of urban duelers in Addis; we stratified the city into three city socioeconomic classes according to their housing structure. The poorest people lives where in the slummy area of the city like Cherkos, lideta/kereyu areas, Addis Ketema/Atobis Tera and other slum part of the city are categorized under the lower socio-economic classes. The second stratum is those people living in condominium houses which are considered to be middle level income population. The third class of the city dwellers is highest economic class; for which the income of the people is comparatively highest and those living in the well-constructed and furnished villa and multistory buildings in majority at Bole areas.

2.2 Approaches

Both desk review and field based study approaches were used to achieve the goal of this assignment. Reviews of all the existing relevant documents such as previous hazardous waste management reports of different countries as a bench mark, socioeconomic features of the study population and etc, identification of gap, and organization of database and preparation of inception reports have also been carried out.

All available materials, and other pertinent data sources of previous studies concerning the site were reviewed and consulted and Preliminary hazardous waste study road map were prepared for the subsequent ground field study using the existing methodologies. Then assessment of the social, economic and environmental impact as well as generation and characteristics of a hazardous waste, such as type and quantity were undertaken through physical observation and technical

evaluation, and this was further assessed through desk studies using appropriate and up-to-date hazardous waste study and characterization methodology.

2.3 Types and Sources of Data Collection

a. Type of data

Both primary and secondary data were collected. Primary data were generated from 30 households were surveyed to see the trends of WEEE at different socio economic level. Secondary data were collected from reports, journals, research papers and other related international and local literatures that are available in the websites.

b. Relevant stakeholders as a data sources

Various stakeholders have been selected for data sources for WEEE waste streams. As could be seen in table II, the stakeholders selected for data sources were from government and non-government sectors.

TABLE II. List of stakeholders.

WEEE
AACMA and offices
AAEPA
AASWRDPO
SMEs
MoICT
Custom authority
General importers like Glorious, Garad, Philips etc.

2.4 Sampling Techniques

Both multi-layer purposive and systematic random sampling techniques were used to select sample EW institutions for data collection. In the other side; electronic waste profile was developed by taking primary and secondary data from relevant organizations and households. A Primary data was gathered from a randomly selected dismantling and assembling centres in the city also from sample households. Firstly, the households were stratified based on socio economic level according to their housing structure (convenience method). Bole surrounding with high multi-storey building and villas residential areas was selected as high class households. City residents of condominium houses were also been categorised under middle economic class. Households that are living at the slummy villages of Cherkos village lied under the lower economic class. Then, about 10 sample households of each class were taken from high, middle and lower class of the category. Unlimited numbers of informal dismantling centres are present in Addis Ababa however the legal and formal dismantling center in Akaki were contacted. Cross checking activity for the type of WEEE was done by observing few selected informal dismantling centres.

2.5 Data Collection

Well organized hierarchal and networked level of data collection procedures was adopted to keep the quality of data collected. One group that contained four experts was assigned for WEEE data collection. For Waste from Electrical and Electronic Equipment waste, comparative study and analysis were considered using some comparable primary data and secondary data. As discussed in the above; WEEE was analysed in accordance with the socioeconomic class of the households.

2.6 Hazardous Waste Generation and Characterization

Different approaches have been employed to characterize the three hazardous waste streams. Hazardous waste of WEEE was quantified from primary and secondary data. In this study, further characterization and composition study of WEEE was not done at all. Instead of the characterization, an international standard that tells about the percentage of hazardous waste in the EEE was taken. Then, the whole hazardous waste generated from EEE of Addis Ababa was estimated.

2.7 Analysis and Synthesis

Following the field work, data compilation; clearing, analysis, prediction and report writing were done. Collected data was summarized in R_Studio statistical analysis software. The result was summarized in tables and graphs using R. Projection was drawn using graphs and charts. Stella dynamic simulation modeling tool was employed to predict the hazardous waste generation rate in the future.

III. Results and Discussion

3.1 Waste Electronic and Electrical Equipment

3.1.1 General overview of WEEE in Addis Ababa

A variety of electronic and electrical equipment's (EEE) were identified through its channel of importation to consumers via different means, and analysis based on 10 year data from Ethiopia custom authority showed that a total of 123039 tons gross and 119699 tons net EEE are imported from different industrialized countries per year.

Despite the increment of E-waste generation in cities of developing countries, still it managed together with municipal solid waste and mainly by the informal sectors where the case of Ethiopia also shares the same challenge. In the case of Ethiopia there are ongoing efforts by governments together with international development organization like UNDO to develop legislations, regulation for electronic waste management's at national level, in line with that a pilot project to improve Akaki DMA facility considering as initial pilot E-waste treatment centre.

Currently collection of E-wastes in Ethiopia, especially in Addis Ababa is done mainly by informal sectors together with valuable recyclable materials. Most of repairing and refurbishment shops purchasing used electronic materials through auction, they maintains and resell to the user or dismantle the components for replacement of similar electronic devices and sales the scraps of metals components to the middle men. The rest of the components that does not have function for replacement or not recycled are dump together with municipal waste into the rivers or transported to the dam site where notoriously it can cause nuisance to the environment. According to the study by IGNIS (Mapping of formal and informal sector in Addis Ababa solid waste management, 2011) Hundreds of scavengers and around 3200 informal waste pickers " Korales" purchase valuable solid waste included electronic waste and deliver to Middle men

(around 800) and hundreds of recyclers settled in Merkatos " MenalishTera".

Though there is a gradual increase of EEE throughout the year 2014 is the time where the amount of imported EEE shot alarmingly probably which may be increment access to EEE use in line with availability of hard currency in to import the EEE in balk.

Similar to the average EEE imported within the 10 (2006-2015) there is a uniform fashion in increment of the EEE importation through the ERCA except the anomaly in the year 2014. Investigation of the respondents from importer and distributors/retailers in Addis Ababa showed that all of them engaged in importing, distributing and retailing.

Some of the major E-Waste generators identified in the assessment include importers, producers/Manufacturers, retailers (businesses/ government/ others), consumers (individual Households, businesses, government and others), traders, retailers, scrap dealers and recyclers. According to the custom's Authority record new and second hand electrical equipment are imported to Addis Ababa city through different directions. These electrical materials are distributed to different regions of the country. It is estimated that about 30% of the equipment are remain to the city (Ethiopian Custom Authority, 2016). These EEE will join the waste stream after their average life span shown in table III below. The quantity of electronic and electrical equipment imported in to this country is explained in the following section.

3.1.1.1 Telephone apparatus

About 593,980 kg of the telephone apparatus that consisting of mobile phone, wireless or cellular phone apparatus electronics have been imported into Ethiopia in the last 10 years from 2006 to 2015. The amount of these electronics and electrical materials was increased from 62,628.57 kg in 2006 to 160,778.02 kg in the year of 2014. However there was a fluctuation of amount of these EEE imported into the country. As shown in table III, the import trends of telecom apparatus in 2013 was significantly declined due to different reasons like technology shift from heavy weight apparatus to slim and light telecom technology and also telecom strategy shift from wireless and cellular phone to mobile network system.

TABLE III. Total telephone apparatus imported into Ethiopia (2006-2015).

Year	Gross Wt. (Kg)	Net Wt. (Kg)	Net Wt. EEE in Addis Ababa	Net weight per day (kg/day)
2006	62,628.57	54,573.52	16372.06	44.85495
2007	3,948.66	3,946.96	1184.088	3.244077
2008	14,518.42	13,897.53	4169.259	11.42263
2009	9,019.52	8,645.52	2593.656	7.105907
2010	13,447.77	11,583.37	3475.011	9.520578
2011	39,925.49	39,911.09	11973.33	32.80364
2012	139,731.60	139,116.31	41734.89	114.3422
2013	62,264.67	61,808.29	18542.49	50.80133
2014	160,778.02	143,516.09	43054.83	117.9584
2015	87,717	87,172	26151.61	71.64824
Total	593,980	564,171	169,251	464

Source: Ethiopian Custom Authority, 2016.

3.1.1.2 Computer

As shown in figure 1, the total amount of computers and computer aided electronics and electrical materials were exponentially increased from 230086.47 kg in 2006 to 3548103.89 kg in 20014 however it was decreased to 2354112.95 kg by 2015. The decrease in weight of the computer was due to the purchase shift from old desktop type to LCD desktop computers. Even if the weight of computers imported might showed a decreasing trends its demand and import activity remain increased. Therefore, higher amount of WEEE will be expected in the future.

Other computer apparatus supporting materials like tools that capable of connecting to an automatic data processing machine or to a network, software CDS, speakers, mouths, by parts of computers for assembling and relevant connecting cables were imported. About 12,928,415 in number and 100,047,559 Kg in weight of these EEE have been imported into the country by the last 10 years. The trends of importing these tools were increasing through the 10 years. These would have been challenges for WEEE management. This would be more serious in the coming years when the society would be dominated by such kind of technology where most of the country place and society get accessible for computers.

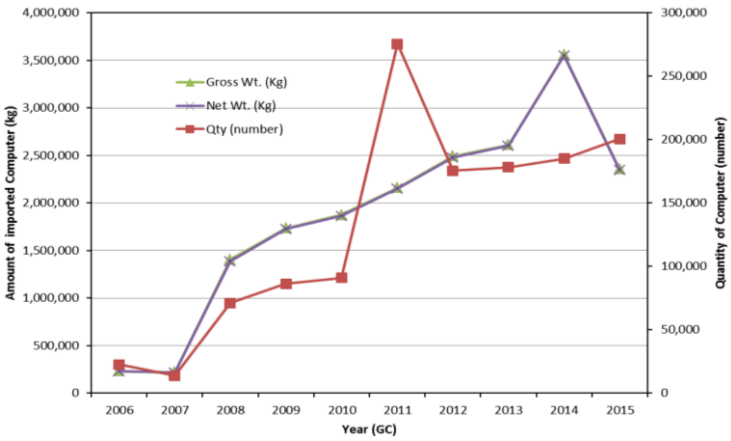

Fig. 1.1 Amount of imported computer into Ethiopia (2006-2015).
Source: Ethiopian Custom Authority, 2016.

3.1.1.3 Television

The number of TV imported into Ethiopia from different developed countries was increased significantly from 328292 in 2006 to a number 1633181 by 2015. Likewise to the computers technology as shown above, the weight of TV imported to the country was decreased in the recent past years. This was attributed to the shift to the light weight LCD TV technology of the global markets. As it demonstrated in figure 2, the net weight of TV retained in Addis Ababa is not less than 1033212 kg. Additionally, 92188 Kg of TV receivers and TV spare parts was imported for two years in 2006 and 2007 GC.

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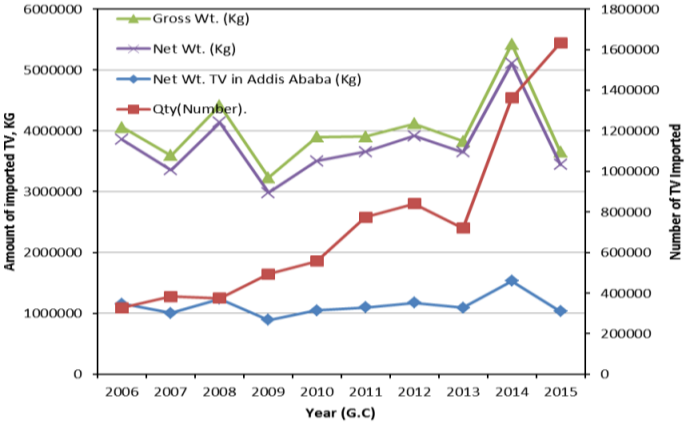

Fig. 2. Amount of TV imported into Ethiopia (2006-2015).
Source: Ethiopian Custom Authority, 2016.

3.1.1.4 Printers, photocopiers and its tonners

It was found that higher amount of printers, photocopiers and its tonners were imported to the country in the last 10 years. Due to global technology improvement the weight of printer and photocopiers was getting smaller from time to time. However, the consumption of tonners were increased with the usage of print and copy materials. As shown in Figure 3, the highest import of these EEE was attributed in 2014. It was also noticed that reduction of weight of printers and photocopy with time was due to the generation of all-purpose photocopy machines. As long as there is a demand of paper work, higher amount of WEEE will be produced in the future.

About 188,650 Kg of related EEE that consists of Spare parts for photo copiers/copier accessories, automatic document feeder, photo copy accessory consumable for b/w analogue co-parts of photocopy machine, developer, digital copier peripheral, drum unit consumable for b/w analogue co photoreceptor, copier stand and canon pedestalir 2016/20 high were imported in the last 8 years since 2008 GC.

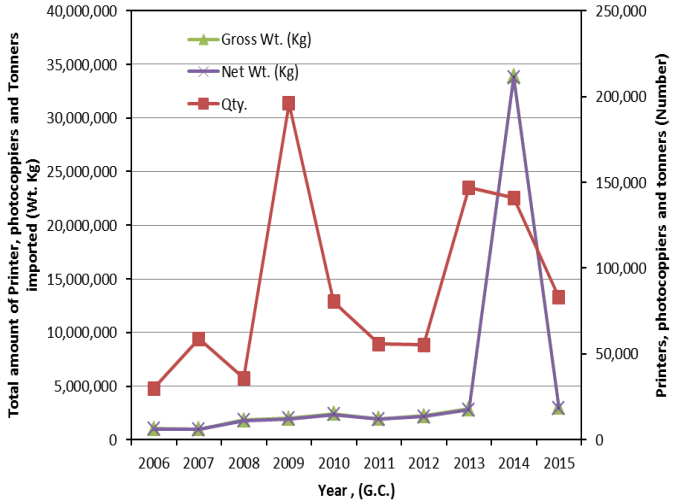

Fig. 3. Amount of printers, photocopiers and tonners imported (2006-2015).
Source: Ethiopian Custom Authority, 2016.

More than 91% of the respondents interviewed were not willing to throw the e-waste for free and to pay money for the collection and disposal of e-waste. Most interviewee disclosed their opinion that they think there will be a time when the obsolete and damaged EEE will be needed and they prefer to keep with themselves. All of them indicated that they are unaware of the potential impact of WEEE on public health and the environment. Some believe that since they import new products, and do not open and dismantle, thus there is less chance of exposing for the hazardous substances.

3.2.2 Second hand importers and distributors

It was very difficult to distinguish between second hand importer and new EEE importers. There was no registration system to differentiate new and second hand products of imported EEE in custom authority.

3.2.2.1 Households

The rapid assessment was also made to check for household consumers for some purposefully surveyed household with category of their income status as high income (Bole area), middle income (Condominium area) and Low income (Cherkos area). Surprisingly there is almost the same EEE usage in all surveyed households.

Based on the survey, 94% keep every unbroken WEEE separately from the solid waste, hoping that it would have benefit/value in the future. It also noted that most of the respondents reported that they had taken back and stored the EEE which were submitted for maintenance and could not be repaired any more by the repair shops.

93% of the households in all income groups indicated that they are not aware of the impact of WEEE on health and environment. More than 96 % of the households in the low and middle incomes were not willing to dispose all their WEEE and only 10% of the high-income households showed their willingness to give the e-waste for free.

The secondary data taken from CSA (2007) indicated that about 97.5% of the city residents used electricity either privately or in share with others. As shown in table IV, all these housing units use around 9,164 lumps for lighting purpose. According to the information obtained from key informant interview Ethiopian electric power corporation distributing power saving lumps and collecting more than 8000 used lumps, approximately from 2000-3000 discarded transformers are given to Metal Engineering for recycling purpose. These data illustrates that EEPCO is one of the major source of electrical waste.

Analysis of the same data showed that around 86% of the housing units have radio and 24% of housing units have no radio, 41% of housing units have telephone and 59% have no telephone and 56% of housing units have TV and 44% have no television. This indicated that the WEEE/E-Waste generated from radio is high as compared to TV and telephone. WEEE generated from TV is significant as compared with telephone (The detail data are shown in Table V).

TABLE IV. Housing units and the lighting condition in Addis Ababa.

Sub city	All housing units	Electricity/Meter private	Electricity/Meter shared	No of lumps
Addis Ababa City	628,986	290,257	323,102	9,164
Akaki Kaliti	45,749	16,830	27,097	1,351
Nifas Silk Lafto	75,079	29,529	42,703	1,437
Kolfe Keranio	93,333	42,044	49,598	719
Gulele	57,837	24,194	33,158	141
Lideta	44,351	25,253	18,709	85
Kirkos	52,581	28,273	24,035	79
Arada	47,364	27,761	19,199	36
Addis Ketema	49,042	26,347	22,197	119
Yeka	87,346	35,932	48,150	2,162
Bole	76,297	34,093	38,254	3,034

Source: CSA, 2007

TABLE V. Housing units of sub cities by availability of radio, telephone and television.

Sub city	All housing units	Radio		Telephone		Television	
		Has radio	Has no radio	Has telephone	Has no telephone	Has TV	Has no TV
A.A City Administration	628,986	542,493	86,493	256,550	372,436	349,990	278,996
Akaki Kality	45,750	38,058	7,692	15,691	30,059	19,214	26,536
NefasSilk Lafto	75,079	64,752	10,327	28,263	46,816	42,221	32,858
Kolfe Keraniyo	93,334	81,028	12,306	36,525	56,809	48,922	44,412
Gulele	57,839	49661	8,178	23,315	34,524	31,320	26,519
Lideta	44,351	38,835	5,516	19,939	24,412	27,644	16,707
Kirkos	52,582	45,981	6,601	25,041	27,541	34,084	18,498
Arada	47,365	41,823	5,542	24,113	23,252	29,946	17,419
Addis Ketema	49,042	42,020	7,022	20,017	29,025	27,445	21,597
Yeka	87,346	74,636	12,710	32,992	54,354	45,093	42,253
Bole	76,298	65,699	10,599	30,653	45,645	44,102	32,196

Source: CSA, 2007

3.2.2.2 Institutions

About 10 institutions from different sector visited and most of them are reluctant to give information some because of lack of data and some because of different reason they are not interested to mention.

Of the 10 respondents, all of them do not have proper inventory for working and defected items, however, they had registration for newly purchased and incoming items. Similarly all of them reported that they do not have any internal WEEE management policy, and put WEEE together with municipal solid waste when they think is no more important. 94% of the storekeepers do not have awareness on impacts of hazardous substance in the EEE, and they did not receive any form of training on e-waste whereas 99% of the institutions lack proper storage facility.

As could be seen in table VI, a large number of computer, printer, mobile phone, TV, refrigerator, LCD, photocopy, UPS and scanners are present in the government and non-government offices. Most of the EEE have been bought before 9 or 10 years. Most employees changes and preferred the new computer, printer and relevant EEE in the office. So that most of the old EEE are stored in the stack. According to the key informant interview made with the store keeper of most institutions the EEE remained stored in the stack until the government procurement agency sold by bidding. The survey found that some private and government organization put the obsolete and unused EEE in their stack without taking disposal actions.

TABLE VI. EEE availability in the government and non-government offices of Addis Ababa.

Source: Own Survey, 2016

Description	Micro link info	AAU Electrical and Electronics Dep't		St. M Univ	MoS T		MoT		AA Healthbureau
	Total no of EEE	Total no of EEE	Total not in use	Total no of EEE	Total no of EEE	Total not in use	Total no of EEE	Total not in use	Total no of EEE
Total no of Employee	85			567	170		520		185
Desktop	165	705	18	1038	227	7	377	183	65
Laptop		265		11	2	1	102	22	22
Printer	15	85	2	92	87		132	71	20
Mobile phone					2	12			
TV	2	5	1	5	9		16		13
Refrigerator	2				4		4		04
Display(CRT)	115								
Display (LCD)	50	704	12		227		377	215	65
Photocopy		8			12	3	4		6
UPS		15	1		130	52	11	7	1
Scanner		20			17				

3.2.2.3 Repairing shops

Interviews and survey results show that most of mobile repairing shops found around Piazza, Merkato, some Bole area and Megenagna. Most of them were carrying out both activities, maintain and selling the EEE.

All the repairing shops responded that 96% of their customers are individuals and house households. 97% of WEEE is from the mobile maintenance centres were collected by waste pickers and sold in *Menalish tera*, the rest of the waste disposed-of together with the municipal solid waste. The maintenance shop visited disclosed that on average the shops generate 10 to 15 Kg of WEEE per 6 month and 4 to 5 Kg for mobile repairing shops.

3.2.3 Extrapolation of EEE import trends

Importing of mobile shows sharp increments from 2006 to 2015, sharp increment in 2014 and after 2014. It shows continues increment with constant rate. In Addis Ababa, the amount of mobile used was increased sharply from about 10 million to 39 million within the five year periods. However, the fixed line subscription is decreasing and getting constant. As shown in figure 4 the mobile phone apparatus will be increased with a constant rate.

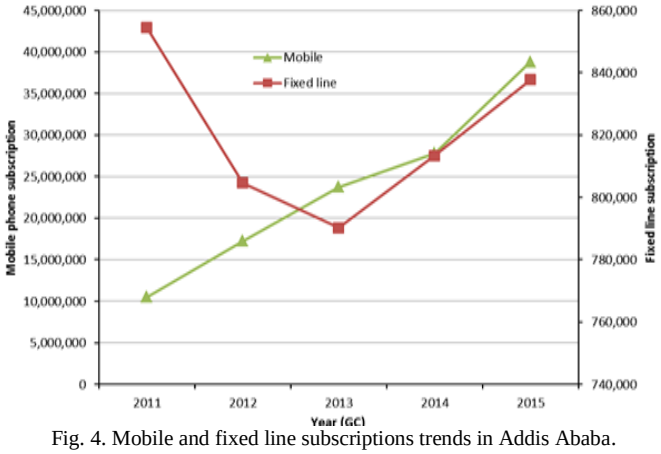

Fig. 4. Mobile and fixed line subscriptions trends in Addis Ababa.

Since the average life span of electrical and electronic equipment is 8 years, and assuming that most of the electrical and electronic equipment available in the city is second hand, their life time is estimated to be from 3 to 5 years, from this assumption about 542,493 unit (2,712,465 kg) radios, 18,541,404.87 Kg Computer (4,858,492.00 kg computer e-waste), 593,980 kg Telephone (1,43,099.6 kg Telephone e-waste) and 37,590,190.8 Kg of TV (10,243,845.00 kg of TV e-waste), 51,692,385.78 kg of printer, copier and its tonners (14,639,320.88 Kg of Tonner, printer and copier e-waste) are generated in the city of Addis Ababa in 2016. So that a total amount of 32,597,222.48 kg/year (89307.46 Kg/day) of WEEE are generated in Addis Ababa city. The future prediction of WEEE in the next five year is depended on the media and condition of import export, public awareness to use technology and also governance system of the country. So that it is sensitive and unable to predict the EEE import/export or local production trends. However, the production of WEEE is very large if it continued by this pace.

3.2.4 Current management practice of E-Waste

WEEE/E-waste is a complex mixture of hazardous and non-hazardous waste, which consists of items of economic value. Therefore, it requires specialized segregation, collection, transportation, treatment and disposal. Current practices of WEEE/ E-waste management provides an understanding of policy/ laws/ regulations and institutional framework related to WEEE/ E-waste management.

3.2.4.1 Policy and Regulatory framework.

Review of the international articles, regulations, strategies, policies, and enforcement practices are done. Policy and legal framework at the local and central government level concerning the management of E-Waste was assessed. Limitations and deficiencies in the regulatory framework implementation were also assessed. Standard institutional guidelines and other directives were assessed with regard to the issues of electrical and electronic waste.

Some of the policies, proclamations and regulations that support the management of E-Wastes are Basel convention of hazards waste management**;** The Motor and Engineering Company of Ethiopia (MOENCO) Environmental, Health & Safety Policy; EFDRE environmental policy, article 3:7; Addis Ababa city administration solid waste management policy, A.A 1995E.C sub articl4.1.7; Environmental Pollution Control Proclamation, Proclamation No. 300/2002; Article4 management of hazardous waste, chemical and radioactive substances. From sub article 1-5; Proc. No. 299-2002 Environmental Impact Assessment of Ethiopia; EFDRE solid waste management proclamation .Proclamation No 513/2007; Regulation no.13/2004 Waste Management Collection and Disposal Regulations of the Addis Ababa city Government and Ethiopian Standards agency and conformity assessment agency: standards on cables and wires, lumps and related items and batteries.

In the European countries the "Extended Producer Responsibility" or "Product Take Back" forms is the basis of policy framework. The EU_WEEE directives provide a regulatory basis for Collection, recovery and reuse/ recycling targets in the European countries. The development of legislation and compliance structure as per EU directives is an on-going process in all EU Countries. The member states have to guarantee minimum collection, recovery and Reuse/ recycling targets as specified in the directive. The fundamental principle of WEEE directive is "Extended Producer Responsibility", where producers are responsible for WEEE/ E-waste take back. Those European countries, which are not part of EU either follow EU directive or more stringent standards based on WEEE/ E-waste management.

Majority of countries have regulations similar to WEEE directives. Countries like Japan have regulations focused on "Reuse, Recycling and Recovery". Other countries like Canada and Australia are developing their systems based on the similar principles of "Extended Producer Responsibility". It may be noted that majority of developing countries are at second stage of development of WEEE/ E-waste management

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framework. The status of WEEE/E-waste in majority of African and Latin American countries is not available (UNEP, 2007).

The countries in Asia and the Pacific, which are Parties to the Basel Convention, have Identified WEEE/E-waste as a priority. These countries emphasized the need to obtain the latest and relevant information on environmentally sound management of WEEE/E-waste, inclusive of information regarding know-how on cleaner technologies or processes used in the repair, refurbishment, recycling or recovery of used or end-of-life electrical and electronic equipment. In view of these identified needs, this partnership was launched in November 2005.The goal of this partnership is to enhance the capacity of Parties to manage electrical and electronic wastes in an environmentally sound way through the building up of public private partnerships, and by preventing illegal traffic of hazardous WEEE/E-waste.

The city administration of Addis Ababa has waste management policy, rules and directives to implement the proper management of municipal wastes. Most of these policies, rules and directives doesn't consider the management of hazardous waste, chemical and radioactive substances (proclamation No.300/2002 ,Environmental pollution control proclamation, article 4 sub article 1-5, Regulation No 13/2004 Waste management collection and disposal regulations of the Addis Ababa City Government, article 13 sub article 1-4), Very recently the Ethiopian Standards agency started to regulate the standards and quality of some imported electrical materials (such as cables and wires, lumps and related items and batteries). However, the specific management of WEEE was not considered in the standards.

3.2.4.2 Institutional arrangement

In Glorious, Garad and other electronics importing and distributing companies the electrical waste management practice are conducted by few technical personnel's until the final disposal is done. While, the waste is disposed to containers and in some place of the compound by janitors and finally transported to land fill by private companies. Observations at Minalesh Tera indicated that there is no organized team that takes the responsibility in the management of WEEE. Therefore; the assessment indicated that there is no organized administration on WEEE management, there is no training provided for the janitors of organization that generates WEEE.

Plate 1. E-Waste observed at the site of the compound (Winget TVETs).

3.2.4.3 Financing Mechanism of WEEE/E-waste Management

The sustainability of WEEE/E-waste management is dependent on financial viability of WEEE/E-waste collection, transportation, treatment and disposal. The financial viability is in turn dependent on regulatory system in place as it will define the standards and Institutional mechanism for WEEE/E-waste management. Financing mechanism of WEEE/E-waste management system in developed countries has evolved after gaining experience over the years of operation. The financing mechanism covers each aspect of WEEE/ E-waste management like collection, transportation and treatment costs of WEEE/ E-waste

Financing of WEEE/E-waste management in developing countries can be established by studying the existing WEEE/E-waste collection, transportation and recycling systems and comparing it with an established WEEE/E-waste collection, transportation and recycling systems in a developed country (UNEP,2007).

The financing mechanism of WEEE in the city of Addis Ababa did not cover most of the WEEE management systems. Based on the observation and key informant interview with the major WEEE generators the collectors were not paid for WEEE collection and transportation, they simply collect using the communal container for collection of Waste Electrical and Electronic Equipment (WEEE)/E-Waste and the transportation is made by government or private truck. The generators made payment for the city administration through water bill system. Unlike others, Winget TVET College collected the E-waste at the compound and used the incineration treatment method.

3.2.4.4 Technology and infrastructure

WEEE/E-waste management requires technical intervention at each step i.e. collection and transportation, treatment, and disposal. Collection and transportation system has been described in terms of collection channels and infrastructure required to support for it. Treatment systems have been described in terms of treatment technologies at three levels.

WEEE is not being segregated at the source according to its type. Most of them did not be stored in their own waste category; rather the WEEE generated is stored in the communal garbage collection containers for disposal in mixture with other municipal wastes. The stored WEEE collected, transported and disposed at the landfill. There are no separate storage, collection and transportation facility for WEEE. The major options for disposal of WEEE/E-waste in the absence of any treatment option are land filling and incineration.

WEEE will be treated by following product testing; accordingly reusable and non-reusable WEEE/E-waste are sorted separately. Non-reusable WEEE/E-waste is disassembled and non-reusable WEEE/E-waste fractions are treated either by incinerator or physicochemical methods before disposal. As shown in Plate 6, WEEE generated in Addis Ababa is treated using incinerators. But the size of WEEE is reduced before incinerating take place.

Plate 2. Treatment practice of WEEE using incinerator (TVET collages, Branded dismantling centers).

3.2.4.5 Akaki De-Manufacturing facility (WEEE recycling)

The facility is 30km away from Addis Ababa located in Akaki Kality sub city. It was established by Ethiopian government in collaboration with the World Bank (provides financial aid), and a closer technical support provided by the International Business Leaders Forum (IBLF)-digital partnership. The facility is under the Ministry of Communication and Information Technology (MCIT), having a vision of filling technological gaps in rural and urban institutions especially for schools, through importation and refurbishment of used computers from abroad and inside the country. At the beginning, the facility received 10,000 computers as aids (which was facilitated by the IBLF) from North America and Europe. Of which 7,068 were refurbished and provided to rural governmental schools, health facilities and community based organizations. But after the phase out of the project the flow stops and to ensure sustainable flow of inputs, the company designed a strategy to buy computers from international markets through auctions and collect from local governmental organizations. The facility managed to purchase 1000 computers from Sweden ICT Company and collected PCs for free from governmental organizations and international NGOs (WFP, FAO).In addition to refurbishments the facility has been providing hard ware and software training for different trainees from governmental institutions and vocational apparent school students. So that it can be taken as WEEE reuse and recycling through parts dismantling and assembling practices.

IV. CONCLUSION

The management of hazardous waste in Addis Ababa requires increased attention to avoid the substantial adverse effect on human health and environment. There is no separate hazardous waste management system that was installed in the city. However, various category of hazardous waste are being collected, transported and disposed with other non-hazardous municipal solid waste under the action of municipality cleansing management agency. Higher amount of hazardous waste are generated from various institutions. A total amount of 89307.5 kg/day of WEEE is generated from the administrative boundary of Addis Ababa.

There is adequate segregation employed in the hazardous waste generating institutions to separate the hazardous waste from the non-hazardous part. As there is no practice of waste segregation in the industrial establishment and WEEE generators. They use mixed collection systems. Incinerators are the common hazardous waste treatment technology employed in most EEE dismantling and assembling companies.

The review of Addis Ababa city hazardous waste management system depicted that the practices in most generators were found poor. This indicates that little effort has been made to adequately manage hazardous waste in the city. In most of the health care facilities, industries and WEEE hotspot areas assessed in this study a waste was collected and transported in unsafe containers without the protocol of set by the WHO, ILO and UNEP/SBC.

Several challenges have been observed. Lack of physical resources, equipment, lack of clear responsibility for hazardous waste management, poor operating procedures for disposal of waste, lack of administrative priority and Shortage of training and subject awareness in the supporting and technical stuffs were few of the problems that needs attention from the government, public and other concerned organization. Lack of stakeholder partnership and integrated working modality was also one bottle neck to improve hazardous waste management. Lack of legal instrument in the hazardous waste management was also observed as one of the sectorial threat that should be revisited in the next time. Lack of well-organized private sector involvement was also a limitation for implementing better hazardous waste management system.

V. RECOMMENDATIONS

Even if there is good start of waste source segregation in the system should be strengthened need to be installed to the WEEE and industrial waste management system. Intensive work need to be done to improve public and private awareness and participation in specific to EEE hazardous waste management.

A separate hazardous waste collection, transportation and treatment system need be installed to the city administration of Addis Ababa to ensure the safety of environment and human health. Separate waste collection containers should be prepared and appropriate warning and descriptive label should be posted on it. Also isolated collection and transportation modality with a specifically assigned collection trucks need be established.

Establishing a sustainable financing mechanism for hazardous waste management should be installed and the service giving private waste collection organization earn comparative payment for the service. A competing agency (Cleansing Management Agency or EPA) should emplace standards for the collection, transportation and treatment of hazardous waste generated from WEEE hotspots. Hazardous waste management should be institutionalized inside the waste management system of Addis Ababa City either in the cleansing management agency or recycling and disposal project office. Therefore, a separate hazardous waste management core process or department should be established. This process will regulate the private waste collection companies who are working on it, administer

treatment centres and hazardous waste generators. Also, the department or core process checks compliancy of the management system against the set of standards on locally prepared guidelines or WHO/UNEP/SBC standards. Adequate trained human labour and budget should be allocated.

Establishing a standardized hazardous waste treatment plant was too expensive that cannot be addressed by single organization. Instead, the government should establish a centralized hazardous waste treatment centres in four corners of the city administration. The treatment centres should be designed and established in account of biomedical hazardous waste from WEEE generated from different hotspot areas. The newly constructed sanitary landfill need to incorporate a hazardous waste disposal cell for residual hazardous waste brought from treatment centres and practice accordingly. Adequate training should be given for landfill practitioners to ensure their OSH.Recycling of EEE dismantling centres should be started.

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