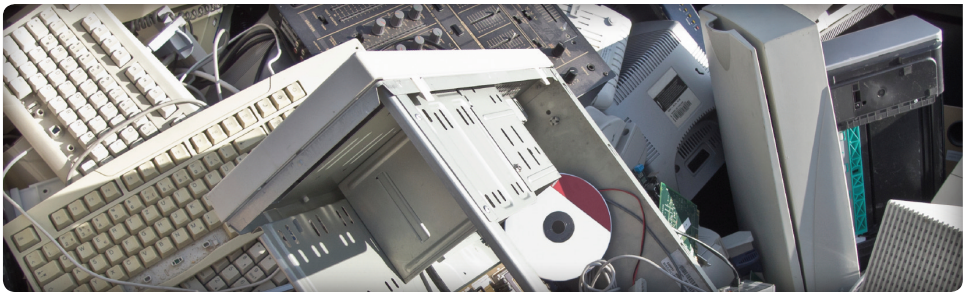

GUIDE FOR CONDUCTING AN E-WASTE INVENTORY IN AFRICA

Pesticide Action Nexus Association-Ethiopia

2013

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Pesticide Action Nexus Association (PAN-Ethiopia) works on environment and development issues to contribute to the eradication of poverty in Ethiopia and beyond through raising awareness among the public in order to prevent the negative public health and environmental impacts of pesticides and other hazardous substances. Its main purpose is to support policies and strategies that enhance and promote the implementation of a safe and sustainable environment for all people and other living things, keeping them protected from harm posed by hazardous substances by building close collaboration among government and non-governmental organizations, civil society interest groups, urban and rural communities, nationally and internationally. PAN Ethiopia coordinates the IPEN E-Products Working Group.

IPEN is a leading global organization working to establish and implement safe chemicals policies and practices that protect human health and the environment around the world. IPEN's mission is a toxics-free future for all.

IPEN brings together leading public interest groups working on environmental and public health issues in developing countries and countries in transition. It helps build the capacity of its member organizations to implement on-the-ground activities, learn from each other's work, and work at the international level to set priorities and achieve new policies.

IPEN's global network is comprised of more than 700 public-interest non-governmental organizations in 116 countries. Working in the international policy arena and in developing countries, with international offices in the US and in Sweden, IPEN is coordinated via eight IPEN Regional Offices in Africa, Asia & the Pacific, Central/Eastern Europe, Latin America & the Caribbean, and the Middle East.

For more information about IPEN see: **www.ipen.org**

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LIST OF ACRONYMS

CD	Compact Disk
CPU	Central Processing Unit
CRTC	Computer Refurbishing and Training Center
CRTs	Cathode Ray Tubes
CSA	Central Statistics Authority
DMF	De-Manufacturing Facility
DNA	Designated National Authority
DVD	Digital Video Disk
E-waste	Electronic waste
EPA	Environmental Protection Authority
EPR	Extended Producers Responsibility
GOs	Governmental Organizations
HHs	Households
IBLF	International Business Leaders Forum
ICCM	International Convention for Chemicals Management
ICT	Information Communication Technology
ICT4D	Information and Communication Technology for Development
IPEN	International POPs Elimination Network
ISIP	International SAICM Implementation Plan
GOs	Government Organizations
kg	kilogram
LCD	Liquid Crystal Display
MCIT	Ministry of Communication and Information Technology
MoFED	Ministry of Finance and Economic Development
NGO	Non Governmental Organization
OLPC	One Laptop Per Child
PAN	Pesticide Action Nexus
PBB	polybrominated biphenyls
PBDE	Polybrominated diphenyl ether
PCB	Polychlorinated biphenyls
PCs	personal computers
POPs	Persistent Organic Pollutants
SAICM	Strategic Approach for International Chemicals Management
SPSS	Statistical Package for Social Science
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
UPS	Uninterrupted Power Supply
WEEE	waste from electrical and electronic equipment

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

In 2009, governments in the second International Conference on Chemicals Management (ICCM2) from across the planet held in Switzerland, Geneva agreed that the issue of ***"Hazardous substances within the life-cycle of electrical and electronic products"*** was an "emerging issue" which needed international attention. Waste from Electrical and Electronic Equipment (WEEE), in short e-waste, has been identified as the fastest growing waste stream in the world, forecast to soon reach 50 million tonnes a year, with its generation estimated at three times the rate of municipal solid waste (Osibanjo, 2009). The flow of e-waste and second-hand electronics from developed countries into developing and economy in transition countries which lack the capacity to manage e-waste in an environmentally sound manner, is taking place faster than the development of policies, safeguards, legislation, and enforcement, leading to serious human and environmental problems in importing countries.

From 2010 through 2012 IPEN launched a program designed to advance national chemical safety policies related to international chemical safety policies. The program is known as ISIP, the International SAICM Implementation Project (ISIP), which enabled small-scale strategic actions that illustrate critical chemical safety concerns by IPEN Participating Organizations and linked these concerns to the Strategic Approach to International Chemicals Management (SAICM) policy framework. PAN Ethiopia is an IPEN Participating Organization.

In 2010 Pesticide Action Nexus-Ethiopia received an IPEN ISIP small grant for an e-waste management awareness-raising project. This proved to be an eye opener for stakeholders from the government, NGOs, academia, research, and private sectors. During the project, Pesticide Action Nexus-Ethiopia carried out a one-month consultation and assessment of the e-waste situation in the country and Ethiopia's national stand regarding e-waste management; a one-day national stakeholders' workshop; and visits to a computer refurbishment center. They also, by request of the government, developed a two-year project proposal on e-waste management in four cities of Ethiopia (Addis Ababa, Bahirdar, Diredawa and Hawassa). The small ISIP grant ended up creating a bridge between Pesticide Action Nexus-Ethiopia and the national SAICM focal point, the federal Environmental Protection Authority (EPA) of Ethiopia. The IPEN ISIP activity catalyzed special attention to the emerging issue of e-waste, and motivated development of the larger, four-city e-waste project in Ethiopia.

Based on this initiative, the Federal Environmental Protection Authority of Ethiopia provided PAN-Ethiopia with funding from the African Adaptation Program (AAP) to carry out an e-waste management project including a basic survey to obtain the data for an inventory in four major cities of Ethiopia (PAN-Ethiopia, 2012).

PAN Ethiopia conducted the e-waste inventory in four cities using the UNEP Inventory Assessment Manual as a reference to select the appropriate method. This guide, therefore, has been developed based on the Ethiopian experience so that other developing countries facing similar problems can use it as a guide and adapt it for their local situation in conducting e-waste inventories as well as lobby for the formulation of policies to regulate the lifecycle management of e-products in their respective nations.

1.2 GENERAL DEFINITION

E-waste comprises wastes generated from used electrical and electronic devices and household appliances, which are not fit for their original use and are destined for recovery, recycling or disposal. Such e-wastes encompass a wide range of devices such as computers, handheld cellular phones (mobile phones), personal stereos, as well as household appliances such as televisions, refrigerators, air conditioners, etc. E-wastes contain over several hundred different chemicals substances many of which are toxic and potentially hazardous to the environment and human health if they are not handled in an environmentally sound manner.

The increasing "market penetration" in developing countries, "replacement market" in developed countries and "high obsolescence rate" of the e-products has identified e-wastes as one of the fastest growing waste streams. The presence of valuable recyclable components attracts the attention of the unregulated informal and unorganized sector. The unsafe and environmentally risky practices adopted by these groups pose great risks to human health and the environment. Given the high toxicity of the component materials in e-wastes especially when burned or recycled in an uncontrolled manner, the Basel Convention identified e-waste as a hazardous substance and developed a framework for control of trans-boundary movements of such wastes.

Globally it is recognized that there is a lack of reliable data on the generation, collection, import and export of e-wastes, and management schemes for handling it in general. Environmental issues and trade associated with e-waste at local, trans-boundary and international levels have driven many countries, particularly developing countries, to introduce control mechanisms. Ethiopia ratified the Basal Convention and has put in place some start up measures for the manage-

ment of e-waste. However, the rate of e-waste generation in Ethiopia was not well understood or documented so that an inventory was needed to understand the present situation in order to determine further measures needed to ensure its environmentally sound management. For this reasons, PAN (Pesticide Action Nexus) Ethiopia developed a proposal to carry out an inventory of e-waste in four urban centers in Ethiopia and implemented it under the financial support, general guidance and direct supervision of the Federal Environmental Protection Authority (EPA) of Ethiopia.

1.3 SCOPE

The preparation of this guide is based on the Ethiopian experience in adapting information from secondary sources which generally reflect internationally used methodologies. It further explains the drawbacks of some methodologies if these are to be used for developing countries, especially those lacking an import registry and databases of e-products' owners, producers (BCRC SEA, 2007) original equipment manufacturers (OEMs), EEE importers and exporters, waste managers, refurbishers and recyclers.

The purpose of this guide is, therefore, to share the Ethiopian experience not only in carrying out and compiling the results of the inventory of e-waste but also emerging issues in the up-stream and mid-stream aspects of the lifecycle management of electronics, which are needed because of the high investment opportunity being exploited by companies being set up for electronics and electrical equipment production[1] in developing countries like Ethiopia.

Taking this into consideration this guide explains the e-products issues identified in Ethiopia and shares the Ethiopian experience in developing an e-waste inventory methodology that could be adopted and/or adapted and improved for use in similar developing countries. The guide will be of interest to managers of environmental and human health, planners, analysts, and civil society interest groups for better understanding why inventories are required; basic study concepts and methodologies; and the time, effort and budgetary implications required to plan, develop, and implement inventories. Planners and analysts who have little experience with carrying out an e-waste inventory will benefit from the detailed review of the basic concepts and the practical considerations related to specific types of e-waste (PAN-Ethiopia, 2012) found with user groups such as Households, Academic (public and private) and Research Institutions, Governmental and Non-governmental Organizations, Business Sector Enterprises, Wholesalers

1 Production and producers means the international and local manufacturer or importer of new and used EEE to be placed on the market at first invoice by sale.

and Retailers, and, very importantly, Maintenance and Repair Shops. It is hoped that the guide will prove equally useful to readers who already have experience with carrying out such studies, by confirming that their practices have been reasonable and by providing advice and insights to augment their experience.

This Guide will evolve via IPEN's E-Products Working Group, with the aim to build capacity among NGOs in developing countries on how to conduct a rapid e-waste assessment as well as how a more comprehensive inventory, similar to the Ethiopia experience, could be conducted.

1.4 OBJECTIVE

The main objective of this guide is to share the Ethiopian experience with other developing countries intending to conduct a national e-waste inventory so as to link this with the life cycle approach for the sound management of e-products.

CHAPTER 2: THE ETHIOPIAN EXPERIENCE

2.1 SOLID WASTE MANAGEMENT SITUATION IN ETHIOPIA

Attempts to have any kind of waste collection in Ethiopia are only found in urban areas, as rural wastes are mainly organic and hence get returned to their local ecosystem one way or another. In Addis Ababa and other major towns, almost all households have the habit of separating out certain types of solid waste that have direct value for reuse or recycling, such as plastic containers, but otherwise there is no waste separation at household and very little at institutional level. Some individuals and informally organized groups called 'quorales' carryout waste collection and separation of items that can be reused or recycled in different places including at the municipal disposal site. This activity creates job opportunities for otherwise unemployed people by organizing them to have waste collection points to purchase the sorted waste from those who bring it to them. Similarly, individuals or groups will collect one type of waste, such as plastic water bottles, or a range of wastes, usually a mixture of old plastic and metal, that can be sold on for artisans that create other items out of the waste, for example old floor polish tins that are given a handle and then become a standard household item for roasting coffee beans. But there are no well-organized or formal systems that frequently collect sorted solid waste items.

On the other hand, in Addis Ababa different institutions are available that can use specific categories of the sorted waste. For instance, the paper making factories, plastic factories, iron and steel factories, glass factory and others have a high demand for separated waste as raw materials for producing some of their products. For example, nearly all the printing houses collect paper waste (trimmings) from the printing process and this is packaged and collected by the paper factory that uses it to make corrugated cardboard for boxes. Plastic factories collect discarded plastic items made from broken items of heavy plastic, such as crates for drinks, and use these to make pipes for electrical conduits and waste water in buildings.

With regard to e-waste, however, households and institutions have a habit of storing non-functional items and the inventory of PAN-Ethiopia in 2011 noted that most of the institutions also store non-functional e-products because they are in the institutions' property registers as assets.

2.2 DATA ON STOCKS AND VOLUMES

In this era of rapidly advancing technologies, electrical and electronic equipment has become a necessity for all segments of society ranging from the individual to business entities, institutions and industry. Combined with the projections for an increase in population and economic status as reflected in continued GDP growth, the volume of e-wastes in Ethiopia is going to continue to increase into the future and will require a concerted effort by both authorities and the public to properly manage its flow.

The rate of e-waste generation in Ethiopia was not well understood or documented until 2011. Hence, an inventory was needed to decide on further measures to design and set up an environmentally sound management system for e-waste. Therefore, a survey was conducted in four major urban centers of Ethiopia (the capital city Addis Ababa, the regional capitals of Bahir Dar, Dire Dawa and Hawassa) focusing on four (4) selected types of electrical and electronic equipment (EEE); i.e. computers of different types and their accessories, televisions and their accessories, mobile phones, and refrigerators. PAN-Ethiopia carried out the work with financial and technical assistance of the Federal Environmental Protection Authority (EPA), Ethiopia.

Respondents were identified from various segments of the society which were considered as e-waste stream sources; i.e. households, business entities, academic and research institutions, wholesalers and retailers, government offices and non-governmental organizations (NGOs), and maintenance/repair shops.

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. The possession of electrical and electronic equipment such as computers increased with the size of entities for running their businesses effectively and efficiently, whereas refrigerators, televisions and mobile phones were found to be higher in star hotels and restaurants due to the type of services provided, the number of customers served and the number of hotel rooms they had.

Regarding government offices and NGOs, ownership of computers and refrigerators increased in governmental organizations whereas bilateral organizations owned more TVs and mobile phones. In academic and research institutions, the number of computers was high in higher institutions, possession of televisions was high in development institutions and a high number of refrigerators and mobile phones were found in research institutions.

Regarding volumes and flows of e-products and e-waste, the study yielded relevant information regarding registered import volumes (Table 3), stocks and penetration (Table 4), and estimates for annual e-waste generation for the four types of equipment (Tables 1 & 2).

Table 1: Total number of imported e-products through Addis Ababa Customs Authority, 2004-2011 inclusive

Year	Computers & their accessories	TVs & their accessories	Mobile phones	Refrigerators
2004	41,974	21,388	17,179	5,620
2005	387,642	204,672	310,633	55,662
2006	331,939	342,201	1,051,048	77,051
2007	520,889	390,677	50,507	89,306
2008	260,025	333,683	193,728	116,921
2009	331,303	411,307	379,980	98,245
2010	284,005	490,779	429,644	122,641
2011	263,116	177,047	346,084	53,368

Source: PAN-Ethiopia, 2012.

Table 2: Number of devices recorded as present during the inventory in the various types of entities in the four surveyed urban area (sample number in brackets)

Location, category of user and number of respondents in brackets		Computers & their accessories	TVs & their accessories	Mobile phones	Refrigerators
Bahir Dar	Households (#422)	76	585	840	240
	Research institutions (# 32)	13,828	254	38	104
	GOs & NGOs(#105)	7,723	219	296	92
	Businesses Bahir Dar (#233)	1,206	612	53	412
	Wholesalers & retailers (#58)	589	157	1,960	222
Dire Dawa	Households (#422)	699	331	920	298
	Research institutions (#15)	588	14	32	29
	GOs & NGOs (#60)	1,461	165	68	127
	Businesses Dire Dawa (# 301)	2,934	128	2,703	599
	Wholesalers & retailers (#34)	370	539	2,020	131
Hawassa	Households (# 422)	375	636	901	222
	Research institutions (# 33)	3,508	151	41	44
	GOs & NGOs (# 155)	10,086	237	276	191
	Businesses Hawassa (# 450)	2,947	928	486	534
	Wholesalers & retailers (#89)	315	558	1,674	109
Addis Ababa	Households (# 409)	169	265	647	243
	Research institutions (# 272)	43,614	1,385	126	654
	GOs & NGOs (# 123)	33,510	792	578	241
	Businesses (# 403)	2,126	711	47	130
	Wholesalers & retailers (#251)	8,740	2,667	7,196	591
Total (all 4 areas)	Households (#1675)	1,319	1,817	3,308	1,003
	Research institutions (# 352)	61,538	1,804	237	831
	GOs & NGOs (#443)	52,780	1,413	1,218	651
	Businesses (#1387)	9,213	2,379	3,289	1,675
	Wholesalers & retailers (#432)	10,014	3,921	12,850	1,050
Grand total	(#4289)	134,864	11,334	20,902	5,210

Source: PAN-Ethiopia, 2012.

Table 3: Annual estimated number of e-waste items generated in 2011 from four selected types of equipment in three cities

Location	Computers	TVs	Mobile phones	Refrigerators
Bahir Dar	4,908	451	912	97
Dire Dawa	6,531	1,188	3,040	886
Hawassa	2,839	328	637	151

Source: PAN-Ethiopia, 2012.

Table 4: Annual estimated weight of e-wastes generated in 2011 from four selected types of equipment (kg) in three cities[2]

Location	Computers	TVs	Mobile phones	Refrigerators
Bahir Dar	147,240	15,785	91	6,790
Dire Dawa	195,930	41,580	304	62,020
Hawassa	85,170	11,480	64	10,570

Source: PAN-Ethiopia, 2012.

These figures suggest that Ethiopia's generation of e-waste is still relatively low. As government bodies as well as other types of offices (banks, businesses, NGOs) have until recently been the dominant consumers of electrical and electronic equipment, they are currently the most important source of e-waste in the country. Nevertheless, the rapid penetration of electrical and electronic equipment in the Ethiopian society will soon alter this picture to a more heterogeneous e-waste situation, particularly with regard to mobile phones in number, and computers and their accessories in volume and weight.

Furthermore, it can be asserted that e-waste is mostly generated in urban areas and not in rural settlements. One exception from the urban-rural disparity in the use of e-products is battery powered devices such as torch-lights and radio/cassette players. It has been reported that more than 300 million dry cell batteries are consumed in Ethiopia annually (UNIDO 2010). It is known that many households not connected to an electricity supply make use of low-price non-rechargeable standard batteries. These batteries often have short lifetimes and contain heavy metals such as lead and/or cadmium.

In addition, efforts to promote decentralized rural electricity supplies often use solar panel installations coupled with lead-acid battery storage systems. Once

2 The Addis Ababa inventory team did not compile totals for the 4 categories of e-waste

obsolete, these systems (and in particular the lead-acid batteries) are of high environmental and health concern (Manhart A. & Amera T 2012).

2.3 MANUFACTURING AND IMPORTS

There are a variety of producers of electrical and electronic equipment located in and around Addis Ababa as well as in Bahir Dar. These productions mostly entail assembly of mobile phones from imported parts and components. The following producers are of particular relevance (Manhart A. & Amera T. 2012):

Tecno Mobile Ethiopia: Tecno Telecom Ltd is a Hong Kong based mobile phone manufacturer, which launched operations in Ethiopia in September 2011 with a capital investment of more than one million US dollars. Recently, the company announced the production of the first smartphone model in Ethiopia, which was meant to be available for consumers by mid-2012. The company employs around 300 local and 15 foreign persons. The Ethiopian production of Tecno focuses on providing mobile phones with applications using the Amharic language, which has been developed by the Ethiopian company Information Technology Transfer Services (ITTS) (2Merkato.com 2012; extensia 2012).

Tana Communications is an Ethiopian investment to provide mobile phones with Amharic software for the Ethiopian market. Software development and manufacturing are based in Bahir Dar. Production started in the first quarter of 2011 and the company had produced 50,000 handsets up until February 2012. Currently, the plant employs around 200 people with 80% women, The phones are sold for 370 Birr ($20) on the Ethiopian market, thus targeting the low income segment of the population (Ezega 2012).

Smadl is a Chinese company that started mobile phone manufacturing operations in Ethiopia in July 2011. The facility is located in the Gerji area of Addis Ababa and employs around 100 local workers in the assembly process (extensia 2012).

Geotel is manufacturing mobile phones. It started production in Ethiopia recently. The first domestically produced mobile phones from Geotel were planned to be out on the market in late August 2012.

Until some years ago, Vestel maintained a TV-assembly facility in Alem Gena in the southwest of Addis Ababa. The production was terminated because of declining demand for CRT-TVs.

Apart from the devices provided by manufacturers located in Ethiopia, the vast majority of electrical and electronic equipment is imported. The following companies and structures characterize this influx:

Glorious is the exclusive authorized Ethiopian distributor of many electrical and electronic products manufactured by brands such as Ariston, Sony, Hitachi and Philips. It imports and distributes electrical and electronic equipment and maintains a wholesale center and six retail showrooms in Addis Ababa as well as one in Nazareth. In addition, the company supports subsidiary branches in Harar and Dire Dawa as well as a network of sub-agents. Today, the company directly employs around 250 workers at various professional levels (Glorious 2012).

Garad is the exclusive authorised Ethiopian distributor of Samsung products and maintains various distribution and retail shops in the country.

According to Ezega (2012), about 80% of the mobile phones on the Ethiopian market are *smuggled* illegally into the country, partly because of high import taxes. According to independent sources, other types of electronic equipment have until recently routinely been imported illegally from Djibouti and Somalia (via Jijiga). Stricter customs enforcement along the transport routes might have reduced illegal import flows recently.

Many brand name items of companies such as LG, Philips and Samsung are imported and distributed via agents, which maintain shops and showrooms in all major cities.

ICTs are also imported and distributed within the scope of *ICT4D-projects*[3] on a significant scale: As an example, the One Laptop Per Child (OLPC) Project imported and distributed 5,900 XO-laptops to Ethiopian schools[4].

Regarding import and refurbishing of used computers, the *Computer Refurbishing and Training Centre (CRTC)* managed by the Ministry of Communication and Information Technology (MCIT) deserves special attention. The center is located in Akaki, 20 km south of Addis Ababa. It was built by the Government of Ethiopia in consultation with IBLF-digital partnership. The center imports used high quality computers from Europe and North-America and carries out refurbishing operations to supply the Ethiopian market with affordable ICT equipment. By the end of 2012, more than 10,000 used computers will have been imported by this initiative and several thousands of them refurbished and provided to Ethiopian organizations (e.g. schools). Between September 2011 and June 2012, the center delivered 1,229 complete computer systems to Ethiopian organizations.

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3 ICT4D = Information and Communication Technology for Development

4 The One Laptop Per Child Project (OLPC) was initiated in Ethiopia in 2008 and is run by a US non-profit organization of the same name. It focuses on the development, construction and distribution of robust, low-cost laptops to be used in developing countries. In Ethiopia the project was implemented by former GTZ (now GIZ) and the Engineering Capacity Building Program (ECBP) (OLPC 2011). Since June 2010, the project was taken over by the Ministry of Civil Service (formally Ministry of Capacity Building)

The project is supported by vocational training on hard- and software, as well as on business management. In addition, a de-manufacturing facility (DMF) has been established next to the refurbishing center in order to provide a solution for waste ICT equipment put onto the Ethiopian market.

The project of establishing the center was carried out between 2006 and 2010 and was financed by the World Bank and the Ethiopian Government. As the refurbishing center achieved full cost-recovery conditions in 2010, operations are now continuing beyond the pilot project phase. Recently, the center expanded its activities on refurbishing to accept used computers from domestic sources. This effort is synchronized with the e-waste collection activities organized by Ministry of Communication and Information Technology (MCIT), which led to an influx of 7,800 used and obsolete e-products mostly from Ethiopian government offices between October 2011 and June 2012. Almost 400 out of these 7,800 products could be refurbished. The remaining 7,400 devices were dismantled in the nearby De-manufacturing Facility.

2.4 DISTRIBUTION OF E-PRODUCTS

Electrical and electronic products are sold mostly via small shops distributed all over urban Ethiopia. In Addis Ababa, major sales outlet clusters are mostly in business areas with the biggest ones located in Merkato and Kazanchis areas. There, more than 100 shops are selling new and used electronic products such as printers, photocopy machines, computers and mobile phones.

2.5 MAINTENANCE / REPAIR SHOPS

According to the study conducted by PAN-Ethiopia, there is a significant flow of the four categories of electrical and electronic gadgets to informal repair shops. Most of the repairing process is done manually by repair shops using common hand tools such as screw drivers, voltmeter, hot guns, fans or suckers and soldering tools. The process starts by conducting tests to identify the problem with the equipment. The repairer takes off the casing of the equipment to expose the internal components that need to be repaired or changed.

When the repair has been done, the equipment is then tested before being reassembled to be returned to the owner. If the item cannot be repaired, the repair shops usually negotiate to buy it from the owners to use it as a source of spare parts for other equipment. The only method for handling non-functional computers and other electrical and electronic equipment that could not be used anymore was either to keep it stored or throw it away with municipal wastes.

Most of the maintenance shops said that they were willing to pay for collectors to take away their non-functional electrical and electronic equipment and most

of them were also willing to pay for a pickup service only, but they do not care about whether or not the collectors give a guarantee of proper (safe) disposal.

2.6 E-WASTE COLLECTION

There are three formal e-waste collection systems operating in Ethiopia. They can be described as follows:

- The manufacturers of mobile phones in Ethiopia partly maintain service centers where damaged phones can be handed in for repair or exchange (extensia, 2012). As Ethiopian mobile phone production did not start before September 2011, no significant return volumes could yet be reported.
- The Computer Remanufacturing and Training Centre (CRTC) set up a refund system for all computers distributed by the center in Ethiopia. When one of the computers is brought back to the center, the owner will receive a payment of around USD 10. As the CRTC started the distribution of computers only about four years ago, no significant backflow has been registered so far.
- With the efforts to make the De-manufacturing Facility (DMF) operational, the MoFED[5] wrote a circular letter to all federal ministries to hand over stored end-of-life electronic equipment to the MCIT, which is operating the De-manufacturing Facility.

There is no significant informal e-waste collection developed in Ethiopia. This might be due to the fact that general e-waste volumes – in particular from private households – are still moderate, combined with the common consumer behavior of not giving away obsolete devices as they are considered still having value (PAN-Ethiopia, 2012).

Nevertheless, observations in the Merkato (the biggest market area) in Addis Ababa, as well as research carried out by PAN-Ethiopia (2012) suggest that some moderate volumes of e-waste is collected and managed by scrap metal collectors and recyclers (often referred to as 'scavengers'). These persons do not specifically focus on e-waste but on any type of metal-containing waste. This also means that some e-waste is channeled to existing scrap metal markets which often operate under informal conditions. In the case of e-products like cables and radios, it was also observed that collectors are working together with local repair and second-hand shops in order to increase the resale value from the collected items.

From observation of the items in the official municipal dumps, some e-waste is collected together with the household waste collected in urban areas. In Addis

5 MoFED = Ministry of Finance and Economic Development

Ababa, it is estimated that 85% of the solid waste is collected by the formal waste collection scheme (Kuma 2004). In addition, PAN-Ethiopia has observed irregular e-waste dumping in open unregulated spaces in some Ethiopian towns (PAN-Ethiopia, 2012). In rural Ethiopia, there is no kind of waste management let alone e-waste collection. Toxic e-waste produced, particularly torch and radio batteries are thrown away totally uncontrolled.

In summary, e-waste is currently being handled by the following routes:

- Prolonged storage in households, offices and government warehouses (office equipment, mobile phones TVs, etc);
- Formal collection from government offices and delivery to DMF;
- Informal refurbishing and recycling in and around scrap metal markets (cables, radio, etc);
- Irregular dumping (particularly of all kinds of batteries, lamps, and bulky items such as refrigerators);
- Disposal with household waste.

2.7 LEGAL FRAMEWORK

The Federal Environmental Protection Authority (EPA) of Ethiopia formulated a new regulation on the Management and Disposal of Electrical and Electronic Waste which will be a regulation under the Environmental Pollution Control Proclamation of 2002. This regulation is planned to be presented to the Ethiopian parliament by the end of this Ethiopian budget year (June 2013).

The issue of e-products has been taken up even regionally at the third International Conference for Chemicals Management (ICCM3) in which the African region became the main negotiator for inclusion of the lifecycle approach of management of e-products in the Global Plan of Action (GPA) of ICCM3. This got full acceptance by the parties and was also reflected in the African resolution from the Conference.

Ethiopia is a signatory of most of the international conventions including the Basel, Bamako, Rotterdam, Stockholm and other conventions for most of which the Federal Environmental Protection Authority (EPA) is the Designated National Authority (DNA).

Other national policies and regulations in relation to waste management and environmental protection are listed in the following Table 5.

Table 5: Ethiopian policies and regulations related to waste management and environmental protection

Policy item	Main theme	Remarks
Article 44 of the Constitution of Ethiopia	Environmental Rights	All persons have the right to live in a clean and healthy environment
The Health Policy of 1993	health system issues	Very few items are related to solid waste problems in terms of environmental hygiene
Establishment of EPA in 1995	The need for an independent body dealing with environment	National government body responsible for the environment
Environmental Policy of Ethiopia, 1997	High priority for waste management	Community participation and environmental economics in development activities
Environmental Pollution Control Proclamation of 2002	The management of Municipal Waste	All urban administrations shall ensure the collection, transportation, and appropriate recycling, treatment or safe disposal of municipal waste through the institution of an integrated municipal waste management system
Solid Waste Management Proclamation No. 513/2007	Promotes waste as a resource	Enhance at all levels capacities to prevent the possible adverse impacts while creating economically and socially beneficial assets out of solid waste
Addis Ababa City Solid Waste Management Regulation, 2004	Solid waste management	Addis Ababa solid waste management, collection and disposal system

2.8 RECOMMENDATIONS

Compared to other African countries such as Ghana and Nigeria, end-of-life volumes are still quite moderate and – even more important – there are no indications that unsound recycling and disposal is practiced systematically. Al-

though there are some indications that e-waste is disposed-off in an uncontrolled manner, the majority of obsolete e-products is currently stored in government premises, offices or households awaiting future solutions.

Ethiopia is one of the fastest growing economies in Africa so that consumption and disposal patterns will rapidly change in the near future. Once devices such as computers, mobile phones and TVs are not regarded as luxury goods any more, the willingness to store obsolete devices will also decrease. In addition, urban centers – and in particular Addis Ababa – are already host to active informal collection and scrap metal businesses, which typically also take over e-waste recycling once sufficient quantities are available. In case an informal e-waste collection and recycling system develops in an uncontrolled manner (as was the case in Ghana and Nigeria), severe negative environmental and health effects have to be anticipated.

Therefore, it is advisable to take proactive measures, including the following:

2.8.1 FURTHER DEVELOP THE SYSTEM FOR E-WASTE COLLECTION FROM OFFICES AND BUSINESSES

As e-waste volumes rapidly increase and disposal habits are likely to change, the current situation should be regarded as a unique chance to design thorough appropriate collection and recycling systems. A first official recycling center has already started operating in Akaki and a properly authorized system for approved collection from federal government offices in Addis Ababa has been developed in 2012. These initial activities should be maintained and scaled out step-by-step to other government offices (e.g. those of the regional governments in other cities), non-government offices and businesses. The strength of this strategy is that collection from government and non-government offices is typically less demanding to organize than collection from private households, thus providing the opportunity to collect experiences in e-waste management.

While, in particular, government offices, once properly authorized, are willing to give away obsolete e-devices free of charge, households (and possibly also some small businesses) might perceive these goods as valuable and ask collectors for money to pick-up e-waste[6]. Therefore, e-waste collection from private households and businesses requires different strategies, which are closely tied to the economics of e-waste recycling and any potential financing mechanism. An initial focus on e-waste collection from offices allows for a collection and recycling infrastruc-

6 This is typically the case in many other African countries where e-waste is already collected from private households on a larger scale.

ture to be built up and to learn about the economics of e-waste recycling, which is a prerequisite to develop a financing mechanism for household collection.

2.8.2 OPTIMIZE PRE-PROCESSING AND STORAGE IN THE DE-MANUFACTURING FACILITY

The De-Manufacturing Facility (DMF) in Akaki has made considerable progress over the months since government e-waste started to be sent to it. Nevertheless, the activities are still focused on collection, dismantling and storage and to date no recycling output has been delivered to any downstream market. In order to improve effectiveness of dismantling, the DMF should strive to interlink with downstream markets as soon as possible by offering its outputs (steel, printed circuit boards, cables, aluminum, plastics, etc) to national and international markets. This networking with downstream markets should also be done in order to receive feedback on quality aspects of output fractions, which will in the medium-term help to improve the recycling process and to increase economic returns.

2.8.3 WIDEN THE SCOPE TO OTHER E-PRODUCTS

While the e-waste collection from government institutions primarily yields office equipment, the DMF already receives a broad variety of non-office equipment such as fans, hoovers and fridges. If collection efforts are to be expanded to other offices, particularly businesses, and in the long term also to private households, this influx of other types of electrical equipment will further increase. Therefore, it is recommended for the DMF to expand its recycling capabilities to handle these types of equipment and their components.

Furthermore, electronic office equipment in Ethiopia is often associated with the use of uninterruptible power supplies (UPS) to protect data and equipment from losses of data and damage from power-cuts. Each UPS contains a lead acid battery, which should be removed and recycled in parallel to starter batteries found in all types of vehicles.

2.8.4 DEVELOP SOLUTIONS FOR NON-VALUABLE FRACTIONS

E-waste recycling does not only yield profitable output fractions, but also material that has a negative cost for sound end-of-life management due to the high concentration of pollutants with a relatively low material value. While some of these fractions accumulate quite slowly (e.g. mercury switches, PCB-capacitors), others are mass-fractions (e.g. CRT-glass, plastics) and will soon challenge the present and future storage capacities of the DMF. For these fractions, viable and environmentally sound solutions have to be identified and made operational. It has to be kept in mind that some solutions, such as export for treatment in other

countries, might be very costly for mass fractions and that these costs might quickly challenge the overall profitability of recycling.

Generally, it is advised to identify economically feasible national hazardous waste management solutions. In light of Ethiopia's rapid economic development, such solutions will also be necessary to manage other types of industrial waste.

2.8.5 DEVELOP A NATIONAL E-WASTE STRATEGY

Experiences from many other countries show that e-waste management requires more than just a collection system and recycling plants. Recycling and pollution standards are needed in order to define the mode of operation of all actors in the management chain and additional financial sources might be needed to cover the collection costs and possibly the management of certain hazardous fractions. Enforcement mechanisms are also needed to make sure that all the actors adhere to the established rules. Furthermore, collection and information on the fate of different e-wastes will have to go in line with appropriate awareness measures.

In addition, the principle of extended producer responsibility has to be set up in such a way that enables both importers and local producers to play an effective role in e-waste management, such as is indicated for the new mobile phone manufacturing companies that have started production since 2011.

2.8.6 TAKE INTO ACCOUNT THE WHOLE LIFE-CYCLE OF ELECTRICAL AND ELECTRONIC PRODUCTS

As indicated above, mobile phone manufacturing started in Ethiopia since the latter part of 2011. Other manufacturers may also start production of different e-equipment in Ethiopia in the future. This together with the constantly rising import volumes calls for a wide approach to be taken on all aspects of sustainability of electrical and electronic equipment in Ethiopia. In particular, such an approach should target the handling of hazardous substances in the production phase as well as energy-efficiency aspects in the use phase. This could be achieved by aligning with regulations and initiatives in place in other parts of the world such as the European Union. Here, the RoHS-Directive (Directive 2002/95/EC) as well as the implementing measures under the Eco-design Directive (Directive 2009/125/EC) are of particular relevance and require manufacturers and importers to be in line with energy-efficiency standards and to phase out the use of lead, cadmium, mercury, hexavalent chromium, polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PBDE). By aligning with international efforts and standards, Ethiopia can prevent in-country production and/or receipt of equipment with below-average environmental performance.

2.8.7 DEVELOP A FINANCING MECHANISM

E-waste management systems are not economically self-sustaining and require additional financing. While such financing could be secured by import or product taxes, such measures should bear in mind that, as reported earlier, a significant portion of e-products are smuggled into the country to evade taxes. An increase of import-taxes might further aggravate this problem.

Financing mechanisms can be based on non-tax measures such as legal obligations on producers and importers within the framework of Extended Producers Responsibility schemes (EPR). As an example, producers and importers can be obliged to care for the environmentally sound management of an annual e-waste volume that is equivalent to the volume of new products brought onto the Ethiopian market during the same time. Such system design can also help to increase cost-effectiveness as importers and companies have a direct incentive to design and support efficient collection and recycling systems. Such systems also require standards for collection and recycling as well as independent licensing, monitoring and control.

CHAPTER 3: INVENTORY CONCEPTS

3.1 ROLE OF INVENTORY IN E-WASTE POLICY, PLANNING AND MANAGEMENT

An effective e-waste management needs to quantify and characterize the waste stream, identify major sources of e-waste, and assess the risks involved in the existing management system. If a proper e-waste inventory with its sources is conducted in a city/country, it can be used to predict the trends in e-waste generation over the years and help responsible authorities to become proactive in formulating national regulations on how to handle the problem. Moreover, this will be a base from which to develop a framework and infrastructure for investments in relation to companies manufacturing e-products so that a holistic approach of the lifecycle management of electrical and electronic equipment can be thought of, designed and set up. The inventory also provides a base-line for assessing progress and identifying challenges.

3.2 MAIN STEPS OF E-WASTE INVENTORY

Based on UNEP's e-waste inventory assessment manual (UNEP, 2007), the following steps are of paramount importance in planning and carrying out an e-waste inventory in a country.

Step 1: Determine the e-waste item(s) of interest, such as computers, televisions (TVs), mobile (cellular) telephones, and refrigerators[7]. Compile a list of the brands in the market, including variations in spelling and names that can easily be confused with each other, the year they entered the market and also whether the items are produced/assembled locally, nationally or internationally. The existence of unbranded / un-named items also needs to be noted for recording in the inventory.

The end-of-life electronic appliances vary depending on the type of products and the technology for which they are employed. In developing countries, some products' life time could be longer than stated in the guarantee or certification card from the manufacturer, such as a refrigerator and a TV set due to the existence of service repair shops and the purchasing power of the users to replace such items. In contrast, the life time of some e-products such as mobile phones, tends to be less than stated by the manufacturers due to rapid changes in the life style and fashion of the users as well as the very rapid development in technology. In some African and Asian countries, the market for second hand mobile phones is the fastest growing market for electronic equipment.

Step 2: For each category of interest by item and brand, determine the average weight and size in relation to where they are produced, i.e. locally, nationally and internationally. For example, the capacity of refrigerator (liters)/ washing machine, size of monitor/ TV/ cellular phone. The variation in size of each item should be documented under each brand. Average weight and size along with percentage composition of major categories of materials, such as plastic, glass, etc should be estimated if possible.

Step 3: Determine the range of e-waste items likely to be available from different sources, like service industries such as hotels for TVs, fridges and air conditioners, educational institutions and businesses for computers, etc.

Step 4: Establish the geographical boundary / system boundary of the inventory area (city/ region). Procure maps of the general area and prepare base maps of

7 Other important items that could be included, such as air conditioners, will depend on the climate of the country and prevailing socio-economic status of the urban inhabitants. It is also important to compile a list of accessories associated with each electronic or electrical item, such as external hard discs, decoders, DVD players, power stabilizers and back-up batteries.

the areas to be included in the inventory with physical features marked on them. If detailed maps are not available, procure and use a general city map and fix and mark the municipal boundaries.

Step 5: Identify the different users of the categories of electronic and electrical equipment and other important stakeholders like importers, manufacturers, businesses, government offices, and retailers, all of whom are consumers who would also be e-waste generators, and mark them on the base map, may be on an over-lay transparent layer.

Step 6: Prepare a tentative e-waste trade value chain.

Step 7: Identify e-waste dismantling sites, recycling sites and landfills as well as other uncontrolled dump sites.

Step 8: Identify the data needed to be collected from these stakeholders based on their activity areas and where they come in the trade value chain. These include:

- Production and import data for the identified electrical and electronic equipment
- Sales and export data for electrical and electronic equipment
- Local e-waste generation data
- Imported e-waste data and
- Data of e-waste transferred for disposal/ treatment/ reuse.

3.3 SOME ISSUES FOR CONSIDERATION

The inventory should ideally include all types of e-waste from all possible sources or products. However, due to the technical and human resources capacity limitations, the scope of the inventory could be restricted to cover a limited list of products found in e-waste flow, such as:

- Computers of various types, such as PCs, laptops, notebooks, 'pads', and their accessories;
- Television-sets and their accessories;
- Mobile (cellular) phones and their accessories such as batteries;
- Refrigerators; and
- Washing machines, air conditioners, and different types of lamps, particularly incandescent power efficient ones.

As a reflection from the e-waste inventory process in several African and South-east Asian countries (Osibanjo, 2009), it has been found that an e-waste inventory

is relatively more complex and difficult to perform accurately compared to common industrial hazardous waste streams' inventory. Some factors include:

- Broad range in the lifetime, official and unofficial, of e-products;
- Longer chain of ownerships and uncertain/unrecorded fate;
- Involvement of repair or refurbishment;
- Economic value of e-waste components;
- Scarcity or lack of records or reliable information;
- No single estimation method appropriate for all cases.

E-waste management problems in developing countries and countries in transition may be specific and varied due to:

- Level of economic development;
- Legal basis for e-waste management;
- Inter-sectoral coordination, or lack thereof;
- Law enforcement;
- Monitoring and evaluation mechanism and capacity.

Some countries have conducted a preliminary e-waste inventory as a project to assess the respective country's situation. It is very important to conduct the preliminary inventory properly as the result of the activity will be used as reference to set up permanent national e-waste inventory and record systems.

Based on analyzed primary and secondary data from the preliminary study, national permanent e-waste inventory will have an adequate basic working mechanism and support system.

CHAPTER 4: THE MAIN INVENTORY MODELS

Global experiences indicate that there are five models developed to carry out an e-waste inventory at national or sub-national level. The common feature of these models is the use of the "Material Flow" model. However each method differs in terms of data requirements and sources of data. The five models, which have been used for e-waste inventory globally, are: 1) time step method, 2) market supply method, 3) Carnegie Mellon method, and 4) Approximate 1 formula, and 5) Approximate 2 formula. The selection and application of any of the five models

is based on the type of data required to be collected and sources of data for estimation of e-waste generation (Table 6), as well as the constraints and advantages in the different data collections methods (Table 7).

Table 6: Data required and sources of data matrix for the application of different models

Models	Data Required	Sources of Data
Time step method	Private stock (import/production) and sales data	From importers/ production, wholesalers and retail sales
Market supply method	Information about domestic sales Average life of new and second hand items, the average life of new goods (active life) and second-hand appliances/reused (passive life)	From importers, wholesalers and retail sales
Carnegie Mellon method	Information on Purchased/Storage: not used, old or outdated Information on Reuse: possibly passed on or gifted/donated to another user without extensive modification Information on Recycled: defined as the product being taken apart and individual materials or sub-assemblies being sold for scrap Information on land fill: disposed of items	From consumers/ end users / households
Approximate 1 formula	Stock and average lifetime (consumption and use method)	From consumers/ end users / households
Approximate 2 formula	Information on sales statistics (sale of a new appliance, an old appliance)	From sale of a new appliance, an old appliance in saturated market

Source: UNEP 2007, E-waste Inventory Assessment Manual, Vol. 1

Table 7: Constraints and advantages matrix for the application of models

Models	Constraints for data availability	Advantages
Time step method	Household saturation levels are based on predetermined stock levels Industrial stock levels are assumed in the calculations Assumption that all the WEEE/E-waste generated is collected and transferred to treatment and disposal facility.	Calculations can be carried out very easily. Method gives good results in a saturated market
Market supply method	The average life is, to a large extent, subjective because in most of the developed countries electrical and electronic equipment is often replaced and disposed of before it reaches its technical end-of-life. WEEE/ e-waste are often stored for years Assumed that all appliances produced in the same year will be in line for disposal exactly at the end of their average functional life. Assumption that the average variance in life of items of EEE does not change very much, whereas, in reality, lifetimes may become shorter in the future.	Necessary data need not be very wide-ranging Calculations can be carried out very easily using a simple formula Sales data is derived from official statistics from market research institutes or trade organizations and are of good quality and available for a large number of products.
Carnegie Mellon method	Assumptions are made regarding the pathways or "material flow" during reuse, storage, and recycling. These assumptions are both product and country specific and therefore demand a good knowledge of consumer behavior and the disposal position. This model also requires a full coverage of sales data as early as possible in the e-waste trade value chain.	The model allows for an electrical and electronic equipment item to be purchased, reused, stored and finally recycled or representing "material flow" more precisely. This method is ideal for more extensive examination of individual products. Because of the larger amount of input data, the calculation of e-waste is clearly more extensively structured.

Approximate 1 formula	A product's constant mean lifespan is assumed in this method. This method is suitable for estimating WEEE in widely saturated markets with no major deviations from the mean lifespan, which is a subjective variable.	This method is particularly useful when reliable stock data for an appliance are available
Approximate 2 formula	This method is only suitable in a fully saturated market where the purchase of a product leads to the same quantity of waste from the old product. Therefore, this method has limited application in dynamic and developing markets because in these markets a larger part of the sales serves to increase stock and does not initially contribute to waste. This method is unsuitable if the temporary storage or second use of old appliances plays a significant role in consumer behavior.	This method is suitable for carrying out an initial assessment. Very limited range of input data required for application of this method. No historical data is required, only sales figures for a particular period of time are required.

Source: UNEP 2007, E-waste Inventory Assessment Manual, Vol. 1

E-waste inventory and its future projections are the basis of any intervention for e-waste management. However, as in many developing countries, Ethiopia also lacks reliable data. Therefore, the study design used was a cross sectional method for collecting both quantitative and qualitative data from different users of four main categories of electrical and electronic equipment. The generated data from the Ethiopian inventory should be considered as providing primary information to be used as an input to one or other of the above mentioned methods for a more extensive inventory.

CHAPTER 5: INVENTORY GUIDE

5.1 PLANNING THE INVENTORY

5.1.1 DEFINING THE PURPOSE

It is important to clearly define the purpose of the inventory. To be useful, an inventory should yield results that are actionable. This approach suggests that

policy makers first consider the actions they want to take and the decisions they want to make on the basis of the inventory results, determine the information that will be required to make those decisions, and only then start to consider the target population and questions that will provide the necessary information (Getu D & Fasil T, 2005).

This approach also helps to prevent errors of omission and commission. An error of omission, often not discovered until the end of the study process, has occurred when someone asks, "Why didn't we ask that question?" and when the unasked question represents information important to the making of a decision or to another use of the inventory results.

An error of commission occurs due to a poorly worded question or other problem with the way the inventory is performed. Typically, an inventory's purpose will be articulated using goals and objectives. Goals are broad, general statements of the information the study is intended to obtain; objectives are more specific.

5.1.2 SELECTING THE INVENTORY METHOD

A key step in planning an inventory is choosing the appropriate inventory method. The inventory methods discussed in this guide include Time step method, Market supply method, Carnegie Mellon method, Approximate 1 formula and Approximate 2 formula (UNEP, 2007).

Choosing the appropriate method for any inventory involves consideration of a wide variety of factors. Perhaps the key tradeoffs, however, are data required, sources of data, constraints in time, budget and data availability, and the relative advantages of each of the methods. The inventory required in most developing countries like Ethiopia is, however, baseline information in order to assess the magnitude of the problem and direct the requirement of international/national policy frameworks.

Other issues that should be considered when selecting the inventory method include the following:

- **Speed:** How quickly does the study need to get done?
- **Complexity:** How complicated are the inquiries? The more complicated the questions, the more important it becomes to have a person available to clarify issues the respondent may have and provide assistance, such as interpreting an interview.
- **Flow control:** Does the order in which questions are asked need to be controlled?

- **Confidentiality:** How important is confidentiality to the study? In many cases, e-waste inventories are not asking particularly sensitive questions and confidentiality is not a major issue.

5.1.3 INVENTORY FREQUENCY AND TIMING

Several aspects related to timing and frequency need to be considered in planning an e-waste inventory. The pattern of e-waste generation within most urban settings may vary from one set of generators to another. Performing an e-waste inventory at only one time of the year for a given generator will not reflect the variation in e-waste characteristics over 12 months and thus may give a biased picture of the composition of e-waste over the whole year (UNEP, 2007).

On the other hand, if data on e-waste characteristics are needed for planning and management the study can be performed for most generators dealing with a variety of electronic and electrical equipment considering the "possibility" of increase using an extrapolation method based on the available factors. The technology variation and changes in the composition of the e-waste should also be considered when the inventory data are updated.

5.1.4 PREPARING THE INVENTORY BUDGET

Part of the planning process is preparing the inventory budget. Ideally, this takes place after defining the inventory purpose, determining the inventory method and considering the inventory frequency. The budget will need to consider the tasks involved in further planning and then implementing the study project. If a budget has already been set, it is important to check whether it is realistic. If not, the project manager may have to change the scope of the study or seek additional funding.

5.2 INVENTORY PLANNING TEAM

By this stage of the project, the goals of the inventory have been set, an initial budget has been defined and, most important, approval has been obtained to go ahead with further planning of the inventory. Until this stage, it is likely that the work on the inventory has been confined to a few people, perhaps only one person. The time has come to create an inventory planning team. This team will be responsible for designing a refined methodology, conducting the inventory and reporting of the results.

5.2.1 PRELIMINARY SCHEDULE AND TARGET DATES

Certain components of the inventory project will define the critical path. Information to be derived from the inventory is often needed for a specific e-waste

planning and management application and therefore is required by a certain time to fit into that process.

Given a target date for starting the inventory, the inventory planning team should work backwards through the steps in the process, including the entering into a subcontract or full contract, and having the contractor undertake the required activities to prepare for the inventory. If contract support involves more than just providing temporary staff, such as assisting with the detailed inventory planning and design, this needs to be reflected in the schedule.

Depending on the size of the inventory and the extent of contract support required, the target date may be several months to more than a year in the future. A number of considerations must be taken into account when forming a preliminary schedule and these must be resolved by the inventory planning team. The following is a list of points to consider in scheduling and target dates:

- Date when the information derived from the inventory is required for input into planning or other processes—relates to the purpose and goals of the inventory.
- Lead time—the time required to complete all the inventory preparation, design, contracts and other details.
- Other inventories—whether other agencies are planning to conduct routine or one-time inventories during the period under consideration. If possible, such dates should be avoided to reduce the "inventory burden" on the study population and the potential for confusion.
- Special events—dates of any known major events, such as large conferences or electronic exhibition events, should be considered.
- Pre-tests and pilot tests—if planned for the inventory, the time required for these must be factored into the schedule.
- Time to enter, clean, and analyze the data; document the findings; and prepare any required presentations as well as the report.

Thorough discussion of each of these constraints will be needed to develop a realistic target date for the start of the inventory. Setting a target date with very tight timelines is generally not advisable, especially if the inventory is one of the first of its type to be done. The risk of unanticipated events causing slippage in the schedule is very high. With the target date set for the output of the inventory, the inventory planning team can work backwards and forwards from that date and set other key dates for the project.

5.2.2 SURVEY LOCATION AND SECURITY CLEARANCE

The choice of site to perform an inventory will depend on the information that the inventory is designed to obtain and the practicalities of identifying/selecting the desired respondents. This issue primarily affects e-waste inventory of residential areas, government and non-governmental agencies.

It has become fairly standard practice to perform e-waste inventory in the locations where more electronic and electrical equipment is used. This has the advantage that these are the places where more e-wastes are also generated. To facilitate this process, a local government authority may be required to designate an authorized staff member to coordinate with the inventory contractor and approve the security clearance for inventory field staff.

5.2.3 CONTRACTING EXTERNAL RESOURCES

All or part of the work of an inventory project may need to be contracted out for a number of reasons, including the following:

- The lack of specialized expertise in inventory design or implementation within the organization
- Internal personnel may not have enough time to design and implement an inventory project.
- The need for objectivity and a fresh viewpoint that a contractor can provide.
- The lack of an in-house team of trained and experienced inventory interviewers.

5.3 STATISTICAL CONCEPTS

An understanding of the underlying concepts of sampling and statistical accuracy is fundamental to understand issues like the size of the sample to be taken and the accuracy of inventory findings.

5.3.1 CONCEPTS OF SAMPLE INVENTORY

In general, an inventory will collect information from a sample of e-waste types from the target e-waste generators/e-material handlers. In some cases, it may be appropriate to study the e-waste generators/e-material handlers, in which case the inventory is termed a census inventory.

A census inventory is generally appropriate for collecting information on small populations when a very high level of accuracy is required and when there are no significant constraints due to budget, inventory resources, or the time when individuals are available to be studied. A census inventory might be appropriate,

for example, for an inventory of widely generated types of e-waste, but not for an inventory that follows each and every type of e-waste.

For a sample inventory, a sample of respondents is selected from the target population in such a way that the characteristics of the population can be inferred from the corresponding characteristics of the sample.

5.3.2 STATISTICAL ACCURACY AND CONFIDENCE INTERVAL

The characteristics of interest of the population being studied, such as households, government and non-government organizations, business community, factories, etc will vary across the members of the population. Aggregate measures of the population, such as the proportion of electronic producers and sellers/distributors and consumers can be estimated from the corresponding values for the sample.

However, when drawing a sample from a population, the distribution of the characteristics of interest across the members of the sample will generally be different from the corresponding distribution across the population, and thus measures of this distribution, such as the average value, will also be different. This difference between the sample average and population mean is referred to as the error of the estimate.

With very small samples relative to the size of the population, it is unlikely that the distribution of the characteristics across the sample will correspond exactly to the distribution across the population as a whole, since the opportunity for the sample to include the full range of values that exist in the population is limited by the small sample size. As the size of the sample increases, it becomes more likely that the distribution of any given characteristic will correspond to that of the population.

The degree to which the distribution of a given characteristic in a sample of a given size, corresponds to the distribution of the characteristic in the population as a whole depends on how variable the characteristic is in the population as a whole. In statistical terminology, this variability is termed the variance of the characteristic. In the extreme case in which every member of the population has the same value for a given characteristic, a sample of only one respondent would provide a completely accurate estimate of that value. At the other extreme, if every member of the population has a different value for a given characteristic, a sample of the entire population (a 100% sample) would be required in order to include every possible value of the characteristic occurring in the population. If a sample of a given size is drawn randomly from a population multiple times, a slightly different distribution would be expected of any given characteristic in each sample, except in the special case where every member of the population

had the same value of the characteristic. The greater the variance of the characteristic in the population, the more variation there would be in the distribution of the characteristic across the different samples. Therefore, the average value of a given characteristic in a sample of a given size, although it is a specific value for any particular sample, will vary across the different samples.

5.3.3 SAMPLING METHODS

For a sample inventory, the sample of respondents should be selected from the population in such a way that the probability of any e-waste generator respondent being selected can be estimated. This method allows generalizations to be made about the entire population from the characteristics of the sample and estimates to be made of the likely accuracy of the estimated characteristics of the population based on the size of the sample. The most straightforward approach to obtaining a representative sample from a population is to select the members of the sample randomly from among the members of the population. In addition to random sampling, systematic sampling, non-probabilistic sampling, stratified sampling, or cluster sampling can be used. In order to select which sampling method or mix of methods to follow for a specific target population, the inventory team should review the details of the sampling methods and reach to consensus.

In some of the Ethiopian cases, for example, a probability sampling technique was used to select the sample of households from an urban kebele (smallest division of urban administration). Kebeles from four cities were selected randomly and households from selected kebeles were also selected randomly. Then, the e-waste inventory assessment considered the three tiers of economic status: high, medium and low income status of the households, which was used to cluster the households for selection of those to be interviewed (Burt G., 2008).

5.3.4 SAMPLE SIZE DETERMINATION

The inventory purpose influences the required sample size in three ways: (1) by determining the key characteristics of the e-waste generators/ handlers and the precision to which they need to be known, (2) by establishing the level of disaggregation to which the results need to be expressed, and (3) by identifying the value to be gained from improved precision.

For any desired degree of precision in the inventory results, the need to consider subgroups of interest—such as households; academic, research institutions and high schools; governmental and non-governmental organizations; the business sector—wholesalers and retailers; and maintenance and repair shops.

The required precision and the credibility of results influence the size of the confidence interval and the acceptable margin of error. Larger samples are required to reduce the margin of error and/or increase the confidence level for a given margin of error.

For the household inventory in the four cities of Ethiopia, the sample size determination equation used was:

$$n = \frac{(z\alpha/2)^2 P(P-1)}{d^2}$$

Where: n = Sample size

$(z\alpha/2)$ = Reliability coefficient = 1.96 (It can also be found in statistical tables which contain the area under the normal curve)

P = 50% population proportion (p= 0.5) which indicates maximum variability in a population, and it is often used in determining a more conservative sample size (Yamane T. 1967), that is, the sample size may be larger than if the true variability of the population attribute were used .

d=5% desired precision (d=0.05) with 95% desired level of significance.

In this case, the non-response rate should also be thought of, which was taken to be 10% in the Ethiopian study.

For business institutions, repair shops, government institutions and NGOs in some of the cities, however, we took 100% of the population because of the fact that they were limited in number and we were able to include all of them.

5.4 QUESTIONNAIRE DESIGN AND STRUCTURE

The design and structure of the inventory questionnaire, including the wording of individual questions, is crucial to the success of an inventory. Issues to be considered include what information to request, the order in which the questions are asked, how much detail to try to obtain, and the amount of time that respondents can be expected to spend completing the inventory (Chap T Le. 2007). A further consideration is the language to use, which may be different for the administration of the questionnaire from that needed for the final report. This was the case in Ethiopia where the questionnaire was developed in English, and then translated into Amharic for the interviews, while the final report was prepared in English. This required that the translated questionnaire was piloted and the answers tested for validity. Also, during the collection of the data, there were supervisors available to help in answering problems encountered by the enumerators, and to check the questionnaires filled each day for completeness.

5.5 ANALYSIS AND REPORT WRITING

At the same time as the sampling method and questionnaire are developed, it is important to identify and agree on the statistical package that will be used to analyze the data. In the Ethiopian survey, the survey teams used a revised version of SPSS version 16 and Excel spread sheet software.

In order to prepare a report that can be used by a wide audience, it is important to develop a check list of the contents and agree on the sequence and form in which the data are to be presented. Even summarized data can be bulky. Hence a combination of tables and charts is useful. The tables present the complete summarized data for each category of electronic and electrical equipment user that provides validity and detail for planners. Simple charts can then be used to highlight key findings for policy makers, and the general reader. It is important to include a complete list of acronyms and abbreviations as well as to decide on the terms to be used throughout the report for each type of equipment. For example, the name for portable handheld phones varies from country to country. After completing the report, an executive summary should be included that provides the reader with an overview of the process and main findings.

The following Figure illustrates the sequence in the development and administration of the inventory, including evaluation of the inventory program to identify areas for improvement in subsequent inventory exercises.

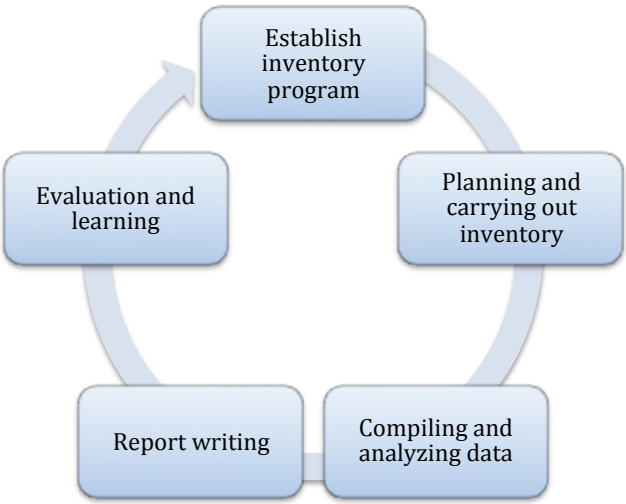

Figure 1: Waste Inventory Development Methodology Sequence,

Source: BCRC SEA (2007)

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