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Chapter 7

Electronic Waste Management in Ghana – Issues and Practices

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Additional information is available at the end of the chapter

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1. Introduction

Man has always been proficient producer of waste; however, towards the end of the 20th century saw the upsurge of a new, noxious clutter: the electronic detritus that has come to be known as e-waste. The consumption of electronics: televisions, computers, cell phones, video games, iPods, etc has increased over the last few years, making the electronic industry the world's largest and fastest growing enterprise [1]. The boom in the consumption of electronic products also come with a price to be paid –the management of the end-of-use products, or the e-waste. According to UN estimates, between 20 to 50 million tonnes of e-waste are generated worldwide annually, accounting for about 5% of all municipal solid waste. Not only is the figure representing the fastest growing municipal waste stream, it also has the potential of increasing further. In the case of mobile phones, for example, 98 million phones are said to be discarded in America annually [1].

The increased consumption and production of EEE have been facilitated by rapid economic growth, an increasing urbanization and globalization [2]. These have become major drivers of change, providing forceful leverage to socio - economic and technological growth in most developing societies, and contributing significantly to the digital revolution worldwide. Indeed, new electronic gadgets and appliances have infiltrated every facet of live today, providing society with more comfort, health, security and easy information acquisition and exchange [3]. Ironically, e-waste has become an emerging challenge as well as a business opportunity of tremendous significance. This is due to the volumes being generated and the content of both toxic and valuable materials in them. The fraction of iron, copper, aluminium, gold and other metals in e-waste is over 60% while plastics account for about 30%, with hazardous pollutants comprising about 2.7% [4].

Some recent studies [5,6] indicate that the society is 'unconsciously' creating its own toxic footprints. A research by Swerts argues that "the same hyper-technology that is hailed as a

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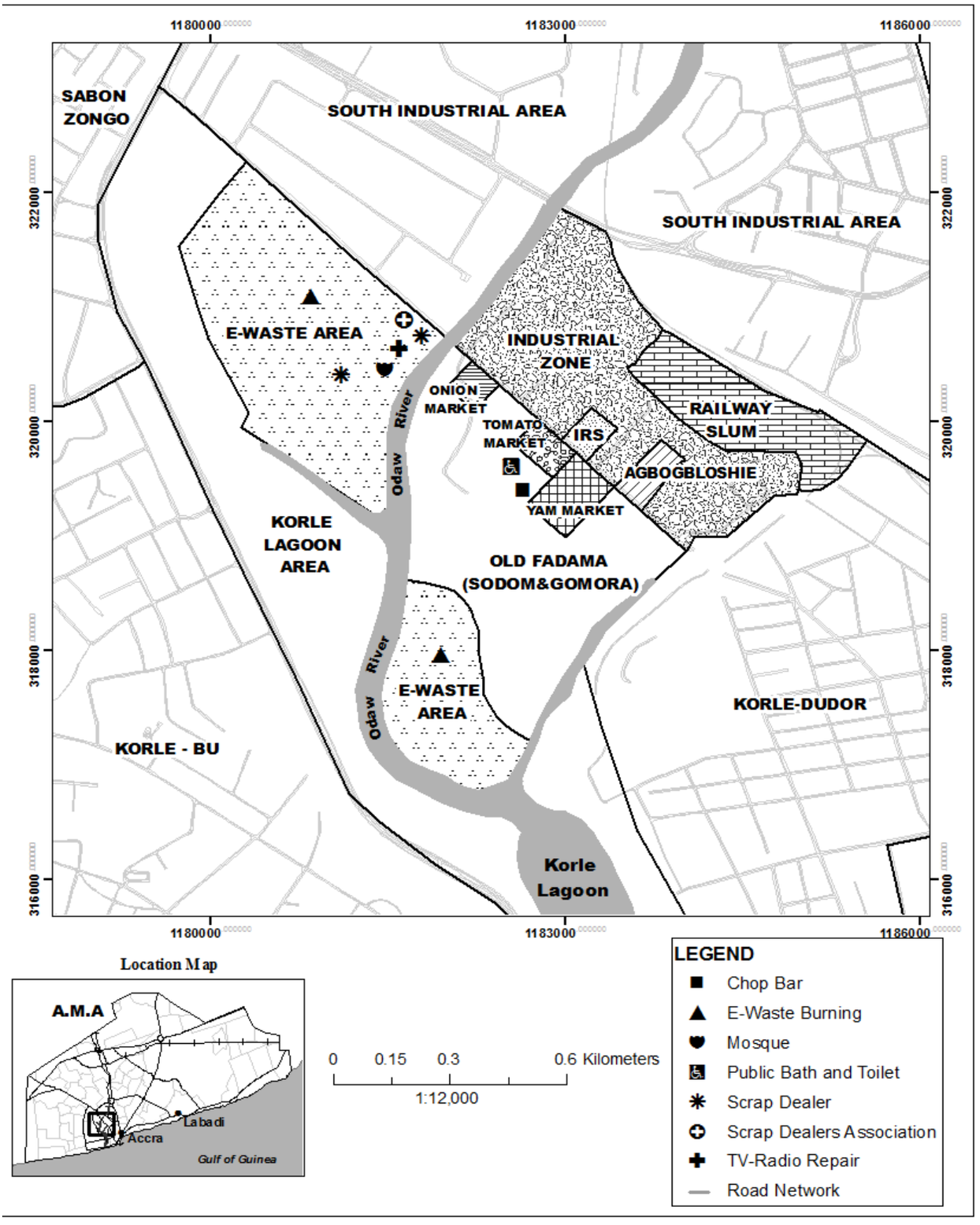
'crucial vector' for future modern societal development has a not-so-modern downside to it: electronic waste" [7]. The fact is that the increasing 'market penetration' in the developing countries, 'replacement market' in the developed countries and 'high obsolescence rate' make e-waste one of the fastest growing waste streams. Currently, the average life span of a computer has shrunk from 6 years in 1997 to less than 2 years as at 2005, generating a flourishing export trade in used computers from developed to developing countries through up to 75% of such shipments are normally unusable [8].

The resultant waste is posing a serious challenge in disposal and recycling and creating ugly solid waste management (SWM) scenes in most developing societies. The fact is that, managing the normal waste from households in these countries already appears to be an insurmountable task [9]. It is therefore seen as more complicated if the so-called e-waste invasion from developed countries finds an easy entry into the developing countries all in the name of free trade [10]. Admittedly, the absence of proper mechanism, regulations and standards of disposal make these high-tech products often end their lives in the 'normal' waste stream meant either for recycling or landfilling [9]. The situation becomes worrying in situations where studies in China and India have shown that unregulated disposal of such wastes can contaminate soil, groundwater, and air, as well as affect all those involve in their processing, as well as the nearby communities [11,5].

Without doubt, most of the e-waste disposed of in developed countries eventually arrives in African countries through both legal and illegal means [9], where it is processed under risky conditions by poor and marginalised population. This condition of risk includes toxic health and environmental dangers. However, at the same time, access to livelihoods, access to technology, upgrading of technical skills and know how, the extension of useful life of electronics and material reuse also occur [12,13]. The e-waste processing sites in Ghana exemplifies the challenges Africa policy makers face with respect to e-waste and its impacts on health and the environment.

This paper looks at the magnitude e-waste trade in Ghana by analyzing the growing trade in electronic products ostensibly "to bridge the digital divide". It also examines its current management practices. The goal is to help raise awareness about the growing e-waste menace and encourage critical debate around the issues and hopefully, enable further action. The objectives of the study were achieved through years of research in the subject area [see 9,14,13,15]. The data were further updated by in-depth interviews with the key stakeholders in both public and private sectors, especially at Agblgbloshie which is the hub of e-waste activities in the country (see Figure 1).

The paper is structured as follows. The next section explores the meaning of e-waste and poses the question whether e-waste is a reality or myth. The third section examines the global dynamics of e-waste and presents an overview of the Ghanaian situation. This is followed by a discussion on the e-waste circuitry in Accra including the limitations that confront the current management system. The conclusion examines a way forward on how to make the e-waste recycling in the Ghanaian economy in particular and possibly, other developing countries in general more environmentally friendly without compromising its economic virtues.



Source: Oteng-Ababio, 2012

Figure 1. Map showing the study area

2. What is e-waste?

In general, e-waste describes old, end-of-life electronic and electrical equipments (EEE) or waste generated from any equipment running on electricity or a battery including computers, laptops, TVs, DVD players, mobile phones, MP3 players, etc., which have been disposed by their original users. It has been categorized into three main groups, and these are; large household appliances like refrigerator and washing machine; information technology (IT) and telecom like a personal computer (PC), monitor and laptop; and consumer equipment like television sets. Each of these e-waste items has further been classified with respect to 26 common components which form their 'building blocks' and are therefore readily 'identifiable' and 'removable.' These include metals, compressors, plastics, glasses, wiring/electrical, transformer, circuit board, fluorescent lamp, brominated flamed retardant (BFR), etc.

E-waste also contains more than 1000 different substances, which make it either 'hazardous' or 'non-hazardous'. The presence of elements like lead, mercury, arsenic, cadmium and flame retardants beyond threshold quantities in e-waste classifies them as hazardous waste. Generally, EEEs are largely classified under three major heads, as: 'white goods,' like household appliances (air conditioners, dishwashers, refrigerators and washing machines); 'brown goods,' like TVs, camcorders, cameras, and 'grey goods,' including computers, printers, fax machines, scanners, etc. The grey goods are comparatively more complex to recycle due to their toxic (hazardous) composition.

2.1. The e-waste blues – A myth or reality?

The literature is replete with conflicting statements on whether e–waste is 'stunning whitewashed of reality' or otherwise. Greenpeace for example argues that e-waste is being exported often illegally to Ghana from Europe and the U.S [5]. In the e-waste yards, unprotected workers many of them children dismantle computers and T.Vs with little more than stones in search of metals that can be sold. The remaining plastics, cables and casing are either burnt or simply dumped. Brook as long ago as 1988, had also revealed that as safety laws in Europe and the USA push toxic waste disposal cost up to $2,500 a ton, waste brokers are turning their attention to the closest, poorest, most unprotected shores – West Africa [16]. Jim Puckett, a former Toxic Director of Greenpeace paints a glimmer picture of the main recycling site in Ghana. He writes:

> *It [Agbogbloshie] is a place where the developed world's old techno-crash waste has been tossed up by the hidden currents of today's consumerism and commerce, and has found a strange resting place..... In these global waysides, questions beg for answers; they cry out from the bone yards where these fallen icons of our proud information age lie as rotting fruit the progeny of centuries of technological advancement. Machines which months ago could process a billion instructions per second have found their end as metal and plastic skeletons in the world's most sorrowfully poor communities, to be subjected to hammer and fire, emitting deadly smoke and fume [6].*

However, Larry Summers, a former Economist of the World Bank in 1991, reportedly justifies the economic sense of the exportation of e-waste to developing countries. According to Summers:

> *the less developing countries especially those in Africa, are seriously under polluted and thus can stand to benefit from pollution trading schemes as they have air and water to spare; environmental protection for health and aesthetic reasons is essentially a luxury of the rich, as mortality is such a great problem in these developing countries that the relative minimal effects of increased pollution would pale in comparison to the problems these areas already face [cited in 4].*

Incidentally, a former Deputy Minister of Local Government in Ghana in 2008 subtly collaborated Summers' assertion, by emphasizing that, 'there is no dumping of e-waste in Ghana' [17]. Reacting to the *Daily Graphic* report, an Officer of the EPA in Ghana in 2008 ranted during a local radio discussions that 'there is no need for people to be concerned; … the situation is not as scary as the media is making it look like'.

Notwithstanding the many negative commentary and contestation about e-waste, recent studies have demonstrated succinctly that e-waste contains valuable metals like copper, gold, and silver that are lost if not recovered properly, and which have to be compensated for by intensified mining activities, which ultimately lead to severe sustainability impacts. A conundrum is created as to whether e-waste recycling is an "economic boom or an environmental doom". The nexus becomes more complex particularly at Agbogbloshie, the hub of e-waste activities in Ghana, where there is nothing like "waste"; where every object, component, and material has "value". On the daily basis, computers and televisions are regularly bought and sold, assembled, disassembled, and reassembled. They disintegrate into their constituent materials-plastics, glass, and metals. Plastic printer cases are smashed with rudimentary tools including hammer, spanner, chisel and even the bare hands.

3. The global dynamics of e-waste

Millions of computers purchased around the world every year become obsolete and leave behind lead, cadmium, mercury and other hazardous wastes. Recent studies have shown that a workplace computer has a life span of about 2 -3 years, whilst that of a household is 3 – 5 years [18]. Additionally, Mundada et al, revealed that in 2004, 315 million computers became obsolete while 183 million new ones were sold [19]. They also noted that since 2005, for every new computer put on the market comes with an obsolete one. The US EPA estimates that in 2007, 29.9 million desktops and 12 million laptops were discarded in the USA; that is over 112,000 computers were discarded daily [20]. In the same year, a total of 205.5 million units of computer products were disposed of out of which only 48.2 million or 18% was recycled while the rest was trashed – in landfills or incinerators (see Table 1).

Similar studies concluded that only about 10% of the total waste generated are recycled while about 80% are exported into developing countries, most of which end up in landfills and incinerators [21,22,23]. In the European Union (EU), the volume of e-waste is expected

to increase by 3 to 5% a year while developing countries are expected to triple their output of e-waste by 2010.

Products	Total disposed (millions on units)	Trashed (millions on units)	Recycled (millions on units)	Recycle ratio (by weights)
Television	**26.9**	**20.6**	**6.3**	**18%**
Computer products	**205.5**	**157.3**	**48.2**	**18%**
Cell phones	**140.3**	**126.3**	**14**	**10%**

Source: US Environmental Protection Agency, July 2008.

Table 1. E-waste generation and handling processes in the USA (2007).

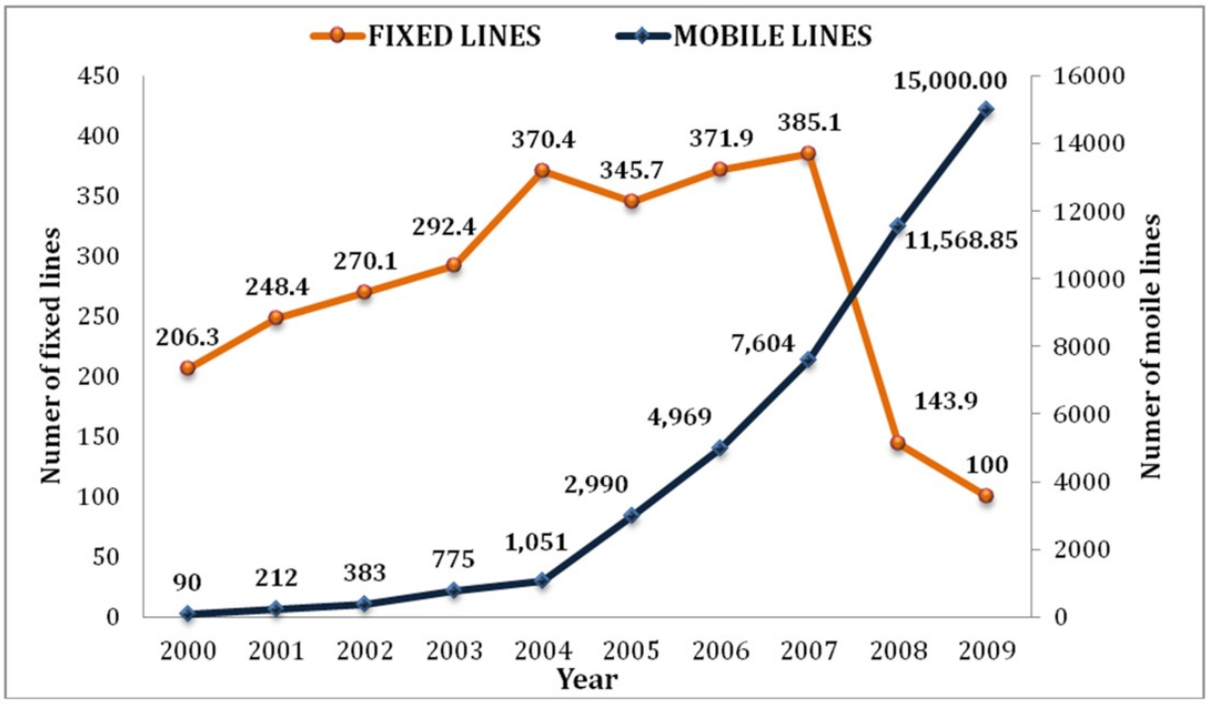
Proportionately, e-waste is currently not a large part of the waste stream though it shows a potentially higher growth rate than any other category of municipal waste. In the USA for example, between 2005 and 2006, the total volumes of municipal waste increased by only 1.2%, compared to 8.6% for e-waste [20]. Some studies have also revealed that about 90% of e-wastes in some developed countries end up in landfills [23]. Such a tendency has increased the agitations by civil society groups over the negative environmental impact of improper handling of e-waste. Today, beyond doubts a large proportion e-waste from the developed world is being exported – in some cases illegally – to developing countries including Ghana [24], where the appropriate end-of-life management systems are non-existent [9].

4. Ghana and e-waste: an overview of the issues

Beyond doubt, there has been a phenomenal growth in the ICT sector in Ghana in the last decade due to its application in the national growth process (schools, internet cafes, etc) [25]. Probably the single most relevant and comprehensive document on ICT and development in Ghana is the ICT for Accelerated Development Policy, which hopes to "transform Ghana into an information-rich, knowledge-based and technology driven high income economy and society" [26]. It aims to introduce computers into all schools to allow children who might otherwise not have access to quality educational opportunities to use the laptops to access knowledge and provide them the opportunity to engage their own capacity for learning, regardless of their physical location or financial limitations. Between 2010 and 2011, the Ministry of education, in conjunction with rlg Communications Limited, a local private computer assembling company successfully distributed 60,000 laptops to school pupils throughout the country.

The introduction of the Global System for Mobile Communication (GSM) has also increased the preference for mobile telephony. This has reduced fixed telephone services from 206,300 lines in 2000 to 143,900 by 2008 and thus creating large quantities of obsolete telephone sets which are being thrown away or stored for perceived value. Figure 2 shows the trend in the

number of mobile and fixed telephone lines in the country from 2000 to 2009. From the figure, mobile phone subscription increased from 90,000 in 2000 to more than one million in 2004 and to almost 15 million by the end of 2009. The teledensity (in respect of mobile phone alone) thus grew from about 5 phones to 100 people in 2000 to 49 phones in 2008, an increase of about 190%.



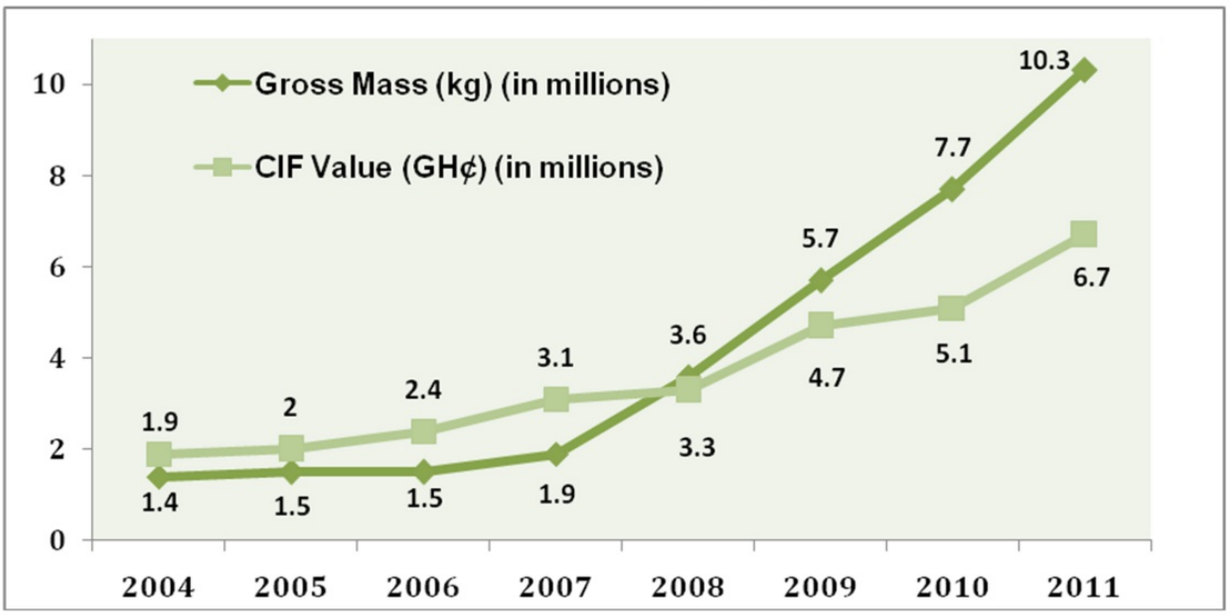
Source: Oteng-Ababio 2010; **2009 data from National Communication Authority (NCA) Records 2010

Figure 2. Number of Mobile and Fixed Telephone Lines in Ghana 2000 – 2009 (in thousands)

One important characteristic of e-waste scenario in Ghana is the fact that the rate at which electronic gadgets became obsolete is also not known. This is because of inappropriate data management practices and the fact that a number of them come in already old. Additionally, Ghana's land frontiers are porous, particularly along certain stretches of its three land borders (Cote d'Ivoire, Togo and Burkina Faso), making shipments through unmonitored routes possible. Figure 3 presents the trend of used computers imports into Ghana between 2004 and 2011, which until 2004, had been unattractive due to the then associated high import duty. Trade blossomed only when the government zero-rated (tax exempted) the importation of computers and computer accessories in 2004, primarily to make the product affordable and promote the use of ICT in the Ghanaian economy. From figure 3, a total of 1.3 million kg of used computers and accessories were imported to Ghana in 2004, reaching 10.3 million by 2011.

A major characteristic about the advancements in ICT in Ghana is the increased dependence on used or refurbished products, due mainly due to financial considerations. The reality is that although the poverty rate in the country fell from 51% in 1991/92 to 28.5% in 2005/06, yet an estimated 44.8% of the population still live on less than one US dollar per day [27]. It

goes without saying that a large segment of the population could not genuinely afford a new computer if they were to join the global ICT revolution. During the studies, some used computers could be obtained for as low as 30% of the cost of a new product of similar brand in Accra. For example, while a new Toshiba A110 series laptop computer cost $1,200, a refurbished one of the same make was going for about $150 [9].



Source: Oteng-Ababio 2012

Figure 3. Trends of Used Computer Imports into Ghana: 2004-2011

Computers are playing a huge role in the Ghanaian socio-economic developmental agenda. Yet, the authorities lack the technology and infrastructural capacity to handle such waste. Accordingly, crude (open) dumping and recycling have become the lot of most local authorities who are constitutionally mandated, and responsible for waste management. This task is expected to be executed in a society where majority seem to lack appreciation of the threat pose by improper disposal practices. The need for a conscious public awareness (creation) campaign, which may culminate in the promulgation of the appropriate legislations regarding the proper handling of e-waste, has been long overdue. Ultimately, the quest to satisfy potential and actual human consumption demand should not necessarily lead to negligence of ecological and health concerns or to blatant dumping of junk products on the stakeholders as being claimed by some environmental NGOs and other media houses.

5. Think Globally, Act locally: Accra's e-waste circuitry

5.1. The legal framework for e-waste management

Despite a wide range of environmental legislation in Ghana, there are no specific laws for e-waste recycling [28,9]. In recent times, the Government in conjunction with its

development partners has initiated processes through workshops and seminars, to enhance awareness creation about environmentally sound e-waste management. In 2005, a National Working Group was constituted by the EPA to help formulate a strategy for e-waste recycling but the outcome of their deliberations is yet to be made public. Ghana is however a signatory to the Basel convention which seeks to provide a framework for the international regulation for e-waste.

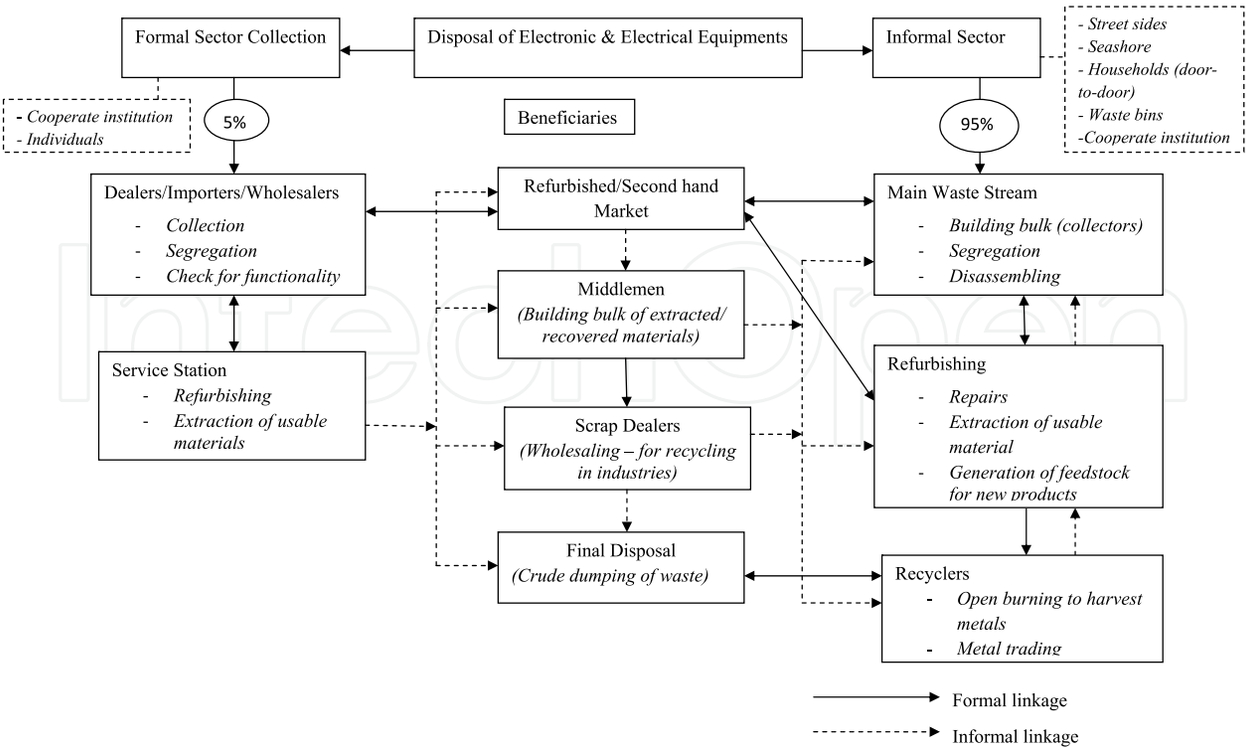
Research shows that in the 1970s and 1980s some developed countries used to export hazardous wastes to developing countries for final disposal which before long culminated in serious environmental pollution [29]. To remedy this problem, the Basel Convention came into effect in 1992. The Basel Convention requires that prior notice of any proposed export of certain hazardous items should be given to the government of an importing country and approved by it. But the Basel Convention does not regulate secondhand items and some e-waste scrap (including printed-circuit boards).

In principle, the Convention does not solve the new environmental problem caused by the recycling of e-waste. To solve the new problem, it is argued that the Basel Convention should be amended in such a way that hazardous wastes must not be exported from developed countries to developing countries for any purpose (even for recycling). In 1995 such a statement was presented as the Basel Total Ban, but it has yet to be agreed upon.

The convention also prohibits trade between Annex VII countries (OECD, EU and Liechtenstein) and non-Annex VII countries. The convention contains language that exempts prohibited trade in cases where an Annex VII country has signed a bilateral trade agreement with a non-Annex VII country so long as that agreement contains equivalent provisions for "environmentally sound" treatment of waste (the convention however fails to define "environmentally sound"). Despite the ratification, the convention becomes operational and applicable only when it has been properly "domesticated" which the government of Ghana has failed to do till date.

5.2. Informal e-waste recycling

In the main, the collection and re-cycling of e-wastes is by the informal sector [25,13]. The practice however exhibits a highly stratified system, comprising collection, recycling, refurbishment and reuse activities and eventually the disposal of the residuals. Generally, the EEEs are processed informally in small workshops using rudimentary methods such as manual disassembly and open burning. The appliances are stripped of their most valuable and easily extracted components which are processed to directly reusable components or secondary raw materials in a variety of refining and conditioning processes. There are also indications that some selected components like printed wiring board are selected for export probably to Asia for recycling [13]. The remaining parts are dumped or stockpiled directly. Figure 4 gives an overview of the current end-of-life management practices in Ghana.



Source: Oteng-Ababio: 2012

Figure 4. The current recycling and disposal practices in the study area

5.2.1. Collection

The collection process is the first point of entry into the e-waste economy. The collectors are mostly youthful and constitute majority of the workforce in the e-waste trade. They are the actors who execute door-to-door collections of used electrical and electronic equipments (EEE) from private homes, institutions, dump sites and transfer stations. It can thus be concluded that waste collectors "make a living" by creating their own jobs as opposed to "earning a living" in regular formal employment. However, they do not operate in a separate economic realm since their operations depend on both the local and international formal economy. Moreover, there can be various loops from informal activities back to formal industry in terms of supplying recycled inputs. The challenge however is that like most informal activities, they operate in a subordinate position within global and local economies.

Initially, collectors did not have to pay anything for items dumped at street corners, neighbourhoods or dump sites. However, with increasing competition occasioned by increasing youth unemployment and the entrance of more prospective scavengers, the "waste" has begun to attract a competitive price. During the fieldwork, it was learnt that a collector has to pay $1–2.5 for an obsolete desktop computer. Some collectors also directly engage in the dismantling and recovery of metals including the burning of cables and wires to liberate copper, but there are a few who "sell their booty" to middlemen, who also serve as the intermediaries between the collectors/recyclers and scrap dealers.

An emerging dynamic in the collection of e-waste is the increasing spatial extent that collectors have to explore. Initially, many collectors operated within Accra and its environs and commuted daily between Agbogbloshie and their targeted mining neighborhood for the day. With increasing competition, the city appears fully mined and collectors have to increase their orbit for scavenging, spend days in targeted areas, build bulk before returning to base at Agbogbloshie with their booty. This has implication for the sustainability of the enterprise. For example, collectors now need huge "financial capacity" in order to spend days at a targeted destination and build bulk.

5.2.2. Refurbishment and reuse activities

Generally, reuse of older electronic products is a common practice in Ghana and the most environmentally preferable option in dealing with e-waste. It is also economically the means through which many people can access electronic products. It further conserves energy and raw materials needed to produce new once and reduces pollution associated with energy use and manufacturing. Unfortunately, since most used electronic imports are rarely tested for functionality, there is high level of refurbishment and repair, and this serves as a disincentive and time-consuming.

Additionally, repairing and refurbishing have emerged as important segments of e-waste (mis)management. Refurbishers transform old/nonfunctioning products by replacing defective components. They engage in cleaning and repairing activities in order to make the refurbished product more appealing and affordable to the populace. The findings reveal that the cost of a secondhand desktop computer at Agbogbloshie which hovered around $60 in 2010 had dropped considerably 2012. Table 2 presents the current price list of the value chain of some of the electronic items on offer at Agbogbloshie.

Prices (GHC)	Cell phone	CRT monitor	Desktop computer	Laptop	Fridge	Air conditioner
Consumers	1.5 - 5	2 - 5	2- 10	5 - 10	10-20	10 – 40
Refurbished	15 - 50	5 -10	10 - 50	10 - 50	20-50	30 – 90

Source: Field work, 2012

Table 2. Prices of some selected refurbished electronic equipments at Agbogbloshie

The area is also seen as having extensive inventories of accumulated parts to service the reuse cluster while the city refurbishers travel to the area to source parts. Local re-users capitalize on available stocks and so have "earned" reputations as the most rapid installers of reused components in the country. Accordingly, reuse traders, shopkeepers, and "individuals in the known" send devices from all over the country to be repaired in Agbogbloshie. It was also established that some of the refurbishers have also opened outlets outside Accra, especially in the Northern regions where they also coordinate the repairs and sale of refurbished electronics. Figure 5 shows some refurbishers of computer system units at the study area.

Source: Field work, 2011

Figure 5. Electrical refurbishing shops in Agbogbloshie

5.2.3. Crude recycling

Informal dismantling and recycling of e-waste aimed at material recovery is emerging as 'a lucrative business' in Ghana. At the Agblobgloshie e-waste management site, their primary activities include manual disassembly of obsolete computers, monitors, televisions, etc to isolate metals (copper and aluminium). There is also open burning of certain components to isolate copper from plastics in which they are encased, particularly from plastic coated wires and cables (see figure 6).

Source: Field work, 2011

Figure 6. An open burning of e-waste to harvest copper at Agbogbloshie

Much of the work is carried out by children, using only rudimentary tools and with no protective equipment. The recovered materials have ready market; copper is sold at 22 US cents (0.22 USD) per half kilo while plastic is sold at 1 US cent (0.01 USD) per kilo (see 13). Admittedly, this crude practice results in some loss of resources and environmental pollution yet it remains a major source of livelihood for many of the urban poor, especially the displaced youth from the North, who are compelled to choose between living in perpetual poverty or working in "perceived poison".

5.2.4. Disposal

Ironically, most obsolete electronic devices are usually stored for a while for a perceived value (physical or emotional) before disposal. Even in both public and private establishments, these items are usually stored until directives are issued for their disposal. Until recently when 'crude informal recycling' became prominent in areas like Abglogbloshie, most of these products end up in the landfills. This is not unique to developing countries as even in the US, 3.2 million tonnes of e-waste were sent to landfills in 1997 [23]. In recent years however, courtesy the informal recycling practices, only residues like ashes from other recycling operations [30] and casing are dumped. Some of these materials without doubt, contain toxic chemicals which have the potential to pollute the soil and groundwater through leaching.

5.3. Formal e-waste recyclers

Even though the informal e-waste activities are highly visible and have indeed established a circular flow within the Ghanaian economy, valuable resources are lost through the current process. Several causes including insufficient collection efforts and resources; inappropriate recycling technologies; and above all, illegal 'imports' (or movement) streams of e-waste into regions with inappropriate recycling infrastructures have been identified. With the burgeoning trade in e-waste and the growing public environmental consciousness, there have been clarion calls on the government to institute formal recycling system. It is envisaged that the formal sector would be able to manage e-waste in an environmentally friendly manner, using "state-of-the-act-technique" that will ensure better environmental management and enhanced resource recovery [31].

The Government is in the process of formulating a e-waste management bill and a draft has been sent to cabinet for consideration. It is however not clear what role the proposed legislation has carved for the informal sector; whether it is going to be at the expense of the well mesh-worked system or would complement it. From all indications, the latter might potentially be the case, even though majority of Ghanaians engage with second hand electronics. The planned policy is to be rolled out at a time most of the local authorities lack the financial resources to acquire the needed sophisticated capital-intensive recycling technologies or provide appropriate landfills. Furthermore, very few of the well established electronic companies operate official collection and take-back facility/services.

One of the very few companies operating a semblance of a take-back system is rlg Communications, a private Ghanaian company established under the companies code of 1963 (ACT179) on the 23rd day of February 2001. The company begun as a sale and service centre for mobile phones, but currently assembles mobile phones and laptops not only for the Ghanaian market but has offices in China, Nigeria and The Gambia. It has a monthly production output of 10,000 mobile phones and 8,000 laptops.

In terms of end-of-life operations, the company occasionally advertises for its customers to bring old (not necessarily non-functional) for an upgrade. The company has branch offices

in all the ten regions in Ghana which undertake phone and computer repairs and sales. They also receive old products for upgrade or refurbishment. Thus, people do not return a product because it has reached end-of-life but their desire to upgrade it. Even that, there are instances where upgrading becomes problematic when the product was sourced not directly from rlg office or where the customer misplaces the purchase receipt and/or warranty card. The company has no recycling facility so the "unwanted electronics" are sent to China for processing and/or reuse. Averagely, the company exports 1, 300 pieces of mobile phones every 2 months and about 100 pieces of computers every four months.

Even though the operation of rlg is commendable, it is nonetheless limited in scope and geo-spatial extent. The company at best operates only from the 10 regional capitals even though its products are visible at all nooks and cranny in the country. Meanwhile, there is not enough incentive for people to voluntarily deposit the used electronics to the 'pseudo collection centers'. Above all, the company does not "take back" its own used product let alone those from other companies. It could therefore not be a proper yardstick to advocate for the complete disbandment of the informal sector. Suffice to state that at the present level of the country's development, the formal sector cannot solely be depended on in terms of managing e-waste in Ghana, at least not in the immediate future.

6. Limitations to proper e-waste management in Ghana

Although government seems to be demonstrating some readiness to improve on the status quo, the major obstacles to safe and effective management of e-waste remain. First, the absence of appropriate legislation dealing specifically with e-waste appears to be the main challenge. The current laws guiding the management of hazardous, solid and radioactive waste including local Government Act (1994), Act 462 and Environmental Sanitation Policy of Ghana (1999) were passed before the e-waste problem emerged. The EPA in 2005 announced it was developing guidelines to regulate the importation of used electronic gadgets but nothing has happened since. The government is a signatory to the Basel Convention but has failed to rectify it till date. The earlier a e-waste regulatory policy is enacted the better will be the drive towards sustainable e-waste management process [32].

Secondly, the increasing importation of second-hand computers, at times illegally, most of which are not tested for functionality, is equally posing a serious challenge. This has been facilitated by the government's unfettered open-door policy (duty free and lax regulations) coupled with the high incidence of poverty as well as chronic institutional corruption. Additionally, lack of reliable data (difficulty in inventorisation) poses a challenge to policy makers wishing to design an e-waste management strategy and to an industry wishing to make rational investment decisions. There is also a lack of safe e-waste recycling infrastructure in the formal sector and thus reliance on the capacities of the informal sector pose severe risks to the environment and human health. Additionally, the existing e-waste recycling systems are purely business-driven that have come about without any government intervention.

Finally, there also appears to be a high level of ignorance of the toxicity of e-waste not only among the general public but even within government circles. The public might not be

wholly ignorant but for economic reasons, people are being challenged to choose between 'poverty and poison'; i.e. working in such recycling facilities and being exposed to health hazards but making a living or remaining unemployed. Educating the general public on the impact of improper management practices will go a long way in the fight for environmental and human-friendly practices.

7. Conclusion

Generally, this study has demonstrated how e-waste scavenging has emerged and become embedded in specific networked places within highly differentiated circuits that produce geographically uneven development. The findings show that e-waste has also emerged as a challenge for local authorities especially in terms of its end-of-life management which is currently driven by the informal sector. At the same time, it has turned out to be a 'saviour' for not only those who depend on the survival economy for livelihood, but also who are economically challenged to join the ICT revolution. That notwithstanding, the informal sector or the survival economy remain marginalized and excluded from the waste management system.

Indeed, participants in the sector currently represent the basis of Ghana's e-waste management system. They are the reason for its effectiveness, but occupy the weakest position in the waste management system in general, with minimal income and precarious working and living conditions. In the absence of a well developed formal sector, it is important that the local authorities and government machinery in general have knowledge about the role of informal economy in the e-waste recycling and processing system. The institution of friendly policies and regulations cannot only help abate the negative tendencies inherent in the practice but more importantly, improve productivity and working conditions without compromising the sector's flexibility traits.

The government also has the responsibility to enforce the tenets of the international treaties like the Basel convention which have not been rectified. The 'extended producer responsibility' (EPR) for example focuses on the responsibility that producers assume on their products at the end of its useful life. The government has to ensure that the obvious dereliction of duties by agencies like the Standards Board, Customs, Excise and Preventive Service as well as environmental regulators, etc are halted. The present lethargic attitude of handling of municipal wastes should encourage the promulgation and enforcement of apposite legislations. Ultimately, the government should focused on technical and policy-level interventions, implementation and capacity building, and increase in public awareness such that it can convert the challenges of e-waste into opportunities.

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