INFORMAL E-WASTE RECYCLING SECTOR IN GHANA: AN INDEPTH SOCIO-ECONOMIC STUDY

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Abstract: Debate on impacts of e-waste has gathered pace in many developing countries, which are recently experiencing an exorbitant increase in the consumption of electronic goods. While the impacts on environment and health have so far dominated this debate, there are various other significant implications. Amongst others, refurbishing and e-waste recycling generates jobs and therefore could contribute towards overcoming urban unemployment. Political decision-making requires a sound analysis of all positive and negative impacts, including income generation, working conditions, contribution to economy and impacts on the neighboring communities and society as a whole.

In this context, the VROM-Inspectorate and the NVMP commissioned the German Öko-Institut e.V. to assess the socio-economic impacts of the informal refurbishing and e-waste recycling sector in Ghana and to elaborate its role in the sustainable e-waste management.

This paper presents key findings from this study, including the sector's size, characteristic working conditions and contribution to the economy.

1. INTRODUCTION

I Consumption of electronic and electrical equipments (EEE) has been increasing exponentially worldwide. This trend can be attributed not only to declining prices of EEE [1], but also to their relatively short and decreasing useful life [2], owing to rapid innovation in equipment features and capabilities [3], migration from analogue to digital technologies and to flat screen TVs and monitors [4]. Increased consumption, short useful life and high replacement rate have led to fast-growing obsolescence, hence causing large volumes of electronic and electrical waste, commonly referred to as e-waste. E-waste is believed to be one of the fastest growing waste streams [1] with the US EPA estimating a 5%–10% increase in the generation of e-waste each year globally [4]. It is estimated that current e-waste arising across EU-27 amounts to around 8.3–9.1 million metric tons per year for 2005 [5], while globally the amount goes up to 40 million metric tons per year [6]. Environmentally sound management of e-waste is an extremely complex task due to several reasons: (1) e-waste is composed of several hazardous substances, such as lead, cadmium, mercury among others, which if not disposed properly, lead to severe impacts on human health and environment, (2) e-waste entails a series of valuable and scarce metals, such as gold, silver, and copper, which can be recovered and fed back to the closed loop global recycling economy, and (3) dissipative application and final end-use of EEE, often in emerging or developing countries, sets enormous challenges for collection infrastructure and logistics. Especially, developing countries are facing daunting challenges in the management of e-waste, mainly due to lack of technology and skills, unexplored business and financing opportunities, and absence of e-waste related national policies and legislations. Nevertheless, economic benefits related to the recovery of metals even with low-level skills has made e-waste recycling business quite an attractive source of livelihood for the poorest strata in developing countries [7]. However, use of crude and inefficient recycling techniques have not only led to severe health hazards and environmental damage for the workers, local communities and society as a whole, but at the same time, they have resulted in the loss of important metals embedded in e-waste.

In recent years, several studies and media reports have highlighted the problems of uncontrolled dumping from industrialized countries and e-waste recycling in West Africa. Particularly, the film, The Digital Dump – Exporting Re-use and Abuse to Africa, by the Basel Action Network (BAN) gave

first insights into the rapidly increasing trade with used and obsolete e-products from industrialized countries to port cities like Lagos in Nigeria [8]. In 2008, Greenpeace published a report on the e-waste recycling activities in Ghana and highlighted its adverse impacts on human and environmental health [9]. Also in Ghana, e-waste problem is aggravated by an ongoing stream of used and obsolete electronic equipment from industrialized countries entering Ghanaian ports. Although a certain portion of this imported equipment is refurbished, many devices and components prove unsuitable for reuse and further add to the domestic e-waste generation problem, leading to the accumulation of large hazardous waste volumes in port cities and major refurbishment centers. Estimates suggest that between 10,000 to 13,000 metric tons of e-waste is treated annually by the informal sector in Ghana [10].

In order to address the problem of e-waste in Ghana, environmental enforcement authorities in the Netherlands (VROM-Inspectorate) and Ghana (Ghana Environment Protection Agency, Ghana Customs Excise and Preventive Service, and Ghana Ports and Harbour Authority) signed a bilateral collaboration agreement in 2009, the so called Joint Working Programme. Within this framework, the VROM-Inspectorate along with the Dutch Association for the Disposal of Metal and Electrical Products (NVMP), commissioned the German Öko-Institut e.V. (1) to conduct an in-depth socio-economic study on the functioning and the sustainability impacts of the informal refurbishing and e-waste recycling sector in Ghana, and (2) to analyze the feasibility of incorporating the informal sector in international recycling co-operations to achieve sustainable e-waste management in Ghana (feasibility study) with significant employment and income opportunities for the urban poor. The scope of this paper is limited to the socio-economic study, while the feasibility study has been dealt with in a separate paper [11].

The socio-economic assessment, conducted by the Öko-Institut e.V in close cooperation with the Green Advocacy Ghana, the Ghana Environment Protection Agency and the Swiss Federal Laboratories for Materials Testing and Research (EMPA), was done using methodologies developed by the UNEP/SETAC "Guidelines for Social Life Cycle Assessment of Products", commonly referred to as S-LCA guidelines [12], and Öko-Institut's sustainability toolkit "PROSA – Product Sustainability Assessment" [13]. The S-LCA guideline and PROSA entail a list of socio-economic indicators segregated according to pre-defined stakeholder categories. The following table 1 illustrates the allocation of different socio-economic indicators to stakeholder categories workers, local communities and society.

Due to the limited scope of this paper, it describes only the bold-highlighted socio-economic indicators from table 1. Detailed description of all the socio-economic indicators is available in Prakash et al. 2010 [10].

Table 1: Socio-economic indicators used in the study

Stakeholder Categories	**Local Communities**	**Workers**	**Society**
Socioeconomic indicators	- **Safe & healthy living conditions** - Human rights - Indigenous rights - Community engagement - Socioeconomic opportunities	- **Safe & healthy working conditions** - Freedom of association and right to collective bargaining - Equality of opportunity and treatment and fair interaction - Forced labor - **Child labor** - **Remuneration** - **Working hours** - Employment security - Social security - Professional development - **Job satisfaction**	- Unjustifiable risks - **Employment creation** - **Contribution to national economy** - Contribution to national budget - Impacts on conflicts

Accra, being the focal point of refurbishing and recycling of e-products in Ghana, was chosen for the primary data collection. In total, 70 interviews were conducted to generate information on socio-economic impacts of refurbishing and e-waste recycling sector in Ghana. The interviews with collectors (also known an scavengers) and recyclers were conducted primarily at the Agbogbloshie metal scrap yard in Accra, a major hotspot for e-waste activities in Accra. The interviews with refurbishers were conducted at various locations in Accra as these businesses are not located at a central place, but rather scattered all over the city of Accra. The product scope of the study is shown in table 2.

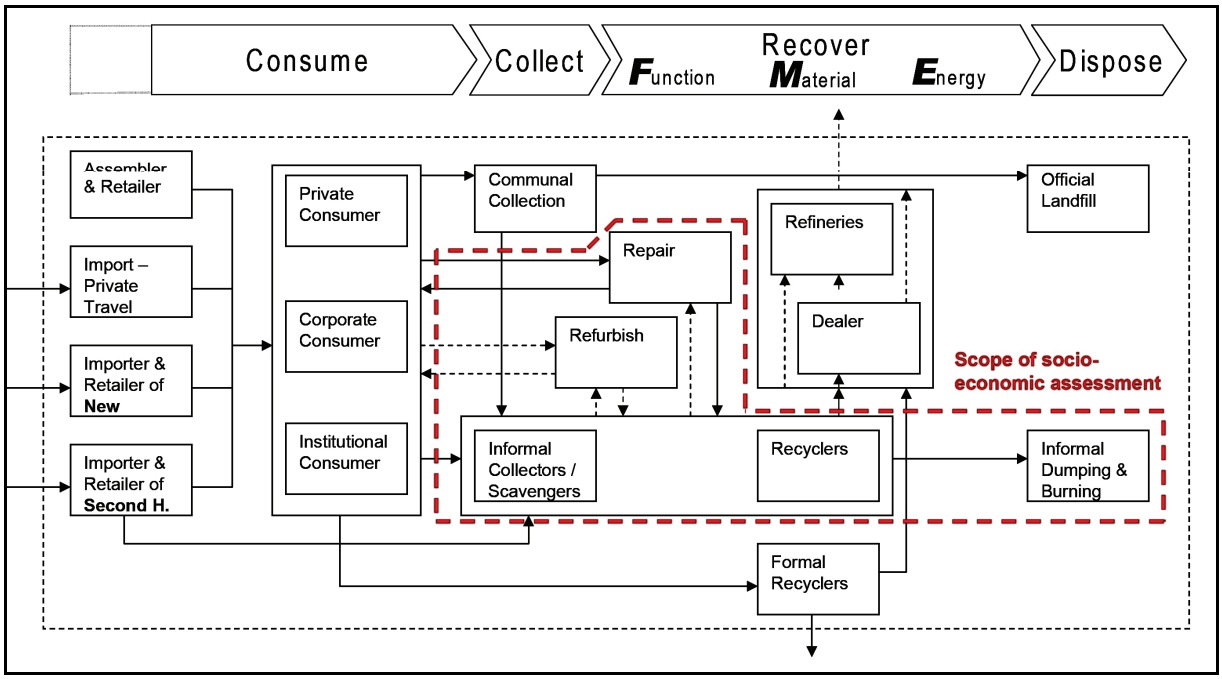
Table 2: Product scope

Large household appliances
- Fridges (cooling and freezing) - Air conditioners
Small household appliances
- Irons - Kettles
IT and telecommunication equipment
- Desktop-PCs & notebook-PCs - CRT monitors & flat screen monitors - Mobile phones
Consumer equipment
- TVs - Radios (including HiFi-systems)

2. OVERVIEW ON THE INFORMAL REFURBISHING AND E-WASTE SECTOR IN ACCRA, GHANA

In Ghana, e-waste processing and recycling is almost entirely managed by the informal sector. The economic motivation behind e-waste recycling in Ghana is the possibility to recover base metals, such as aluminium, copper and iron/ steel using simplest of tools, such as hammers, chisels, stones etc. Often, fire is used to burn cables and wires to recover copper. Wet chemical leaching processes, often associated with the recovery of precious metals from printed wiring boards (PWB) have not been observed in Ghana. However, separation, collection and trade of PWBs from Ghana to Asia have already started to happen at an increasing pace. Perceived to be a lucrative economic activity by the poorest strata of the society, people from the northern part of the country – a region where the poorest people in Ghana live and suffer from chronic food insecurity – have, therefore, migrated to Accra to adopt e-waste recycling as an alternative livelihood strategy. They have settled centrally in and around the area of Agbogbloshie, thus making it the major centre of e-waste recycling activities in Ghana. On the other hand, a large number of refurbishing and repair operations – in few cases, also belonging to formal businesses – are scattered all around the city of Accra. A large section of the refurbishing operations can be found near the port of Tema as many refurbishing units have close business linkages with importers and retailers of second hand EEE, also located near the Tema port. Role of refurbishing and repair sector can not be underestimated, especially considering the widespread poverty and largely low-income households in Ghana. In Ghana, about 54% of the total population lives with less than US$ 2 per day, while GDP per capita (in current US$) was only US$ 713 in 2008 [14]. Thus, role of and access to low cost second-hand equipments of ICTs gain enormous importance. A basic refurbished second hand desktop PC in Ghana costs between US$ 60 to 100, while a second hand notebook between US$ 200 to 300. Compared to the costs of new equipments the prices of second hand equipments indicate that they are available at affordable prices for the lower and medium income groups of Ghana. This is also in line with the national policy of the Ghanaian government of information and communication technologies for development (ICT4D). Data from the Ghana Customs Excise and Preventive Service indicate that more than 400,000 second-hand computer units were imported in Ghana between 2006 and 2009 [15]. However, with increasing utilization of second hand EEE, e-waste volumes in Ghana are also increasing rapidly. According to the ongoing E-Waste Africa project of the Secretariat of the Basel Convention (SBC), currently, there are about 425,000 metric tons of installed and stored ICT and consumer electronics in Ghana; when large and small household appliances are also included, total installed and stored (W)EEE amounts to 1,26 million metric tons [15]. Generally, e-waste is passed by the end-consumers and refurbishing/repair businesses via formal & informal collection agents to formal & informal material recovery & end-disposal operations. The mass flow chart, as illustrated in the following figure 1, shows the flow of EEE between different actors involved in refurbishing and e-waste recycling chain in Ghana.

Figure 1: Mass flow chart of the refurbishing and e-waste recycling sector in Ghana



The scope of this paper (dotted line in figure 1), i.e. socio-economic assessment of the informal refurbishing and e-waste recycling sector in Ghana comprises following stages: collection, refurbishing/ repair, recycling (involving dismantling, also burning, in order to recover base metals) and final disposal at dump-sites. Thus, the primary data collection for the socio-economic assessment took place for informal collectors, refurbishers/repairers and recyclers. Generally, informal collectors and recyclers can be found at dumping and burning sites. Therefore, the analysis of dumping and burning sites corresponds to that of informal collectors and recyclers.

Informal collectors refer to those e-waste actors who execute door-to-door collection of e-waste from private, corporate and institutional consumers. In this paper, this group is generally referred to as collectors. Generally, collectors pay a little amount of money to the consumers to buy e-waste. For instance, a collector pays on an average about US$ 1.0 to 2.5 for an obsolete desktop PC, and about US$ 1.5 to 5.0 for an obsolete refrigerator to the consumer. In many cases, collectors do not pay anything for these items as they find them dumped at street corners and even at the dump-sites by importers. Occasionally, collectors also perform the function of dismantling and metal recovery themselves, as for instance, by burning cables and wires to recover copper.

Recyclers in Ghana disassemble (also incinerate) obsolete EEE to recover basic metals, such as aluminium, copper and iron. The data collected at the Agbogbloshie metal scrap yard indicated that each recycler at the metal scrap yard processes about 5.2 metric tons of e-waste per year. Considering that about 1,500 out of total 3,000 members of the Agbogbloshie Scrap Dealer Association focus primarily on e-waste, and relying on the expert judgment that Agbogbloshie contributes about 40%–60% to the total e-waste processing in Ghana, it can be roughly estimated that about 10,000 to 13,000 metric tons of e-waste are treated in Ghana annually. The average weight of various devices, such as PCs, refrigerators etc. is given in Schluep et al. 2009 [6]. In few cases, recyclers deal directly with end-processing units, such as remelters and refineries, for selling the recovered metals while often middle-men are responsible for the collection of recovered fractions from the recyclers, and bringing them to end processing units. During the primary data collection, recyclers reported of getting following (average) prices for the recovered fractions: Steel/iron US$ 0.46 per kg, aluminium US$ 1.07 per kg, copper US$ 4.6 per kg.

Refurbishers or repairers transform old and/ or non-functioning EEE into second-hand and functioning EEE either by replacing or repairing defective components and/or by performing cleaning activities in order to make second hand EEE appealing to the customers. Although there is sometimes a distinction made between refurbishers and repairers, the bound-

ary between the two groups cannot be drawn exactly. In this paper, this group is generally referred to as refurbishers.

In the following, results of the socio-economic impact of refurbishing and e-waste recycling sector on local communities, workers and Ghanaian society are presented.

3. IMPACTS ON LOCAL COMMUNITIES

3.1. Safe and healthy living conditions

Recent studies have confirmed the presence of numerous toxic and persistent organic chemical pollutants, as well as very high levels of many toxic metals in the soil at the Agbogbloshie scrap yard in Accra [9]. The concentrations of copper, lead, zinc and tin were found to be in the magnitude of over one hundred times typical background levels [9]. For instance, the concentration of lead in the soil was found to be as high as 5,510 mg/kg dry weight [9], thus exceeding the limits set for residential and industrial areas. For example, French recommendations for lead limits are set at 400 mg/kg and 2,000 mg/kg for residential and industrial areas respectively [16]. It is known that children, due to their hand-to-mouth behavior, are one of the most vulnerable groups in areas where soils and dusts are contaminated with lead [17], [18]. Exposure to lead dust or fumes leads to the underdevelopment of brain in children, hence causing intellectual impairment [9], [17]. Apart from that, lead is known to cause a wide range of disorders, such as damage to the nervous and the blood system, impacts on the kidneys and on reproduction [9]. Similarly, negative health impacts of flame retardants, such as PBDEs used in the plastic components of EEE, occurs also though food contamination [19]. In China, high levels of PBDEs have been reported in the blood of local residents around e-waste recycling activities [20]. A similar effect can be expected for the Agbogbloshie scrap yard as well. PBDEs have been known to cause abnormal brain development in animals [21], endocrine disruptive properties [22] and anomalies in the immune system [23]. Furthermore, combustion of PBDE containing or PVC coated cables and wires – a common practice at the Agbogbloshie scrap yard - produces dioxins and furans (PCCD/Fs) [24], [25]. Brigden et al. (2008) measured 359 pg/g of toxicity equivalent value (TEQ) for PCCDs and 629 pg/g TEQ for PCCFs in the sediment samples of the lagoon adjacent to the Agbogbloshie scrap yard [9]. The background levels of PCCD/Fs in soils and sediment have not yet been defined in Ghana, but the above mentioned PCCD/Fs values indicate extremely high contamination. Commonly, in unpolluted or lightly polluted areas, including urban and industrial soils in other countries, the values are below 1 pg/g TEQ and rarely above 10 pg/g TEQ [26].

According to local residents, the lagoon, adjacent to the Agbogbloshie scrap yard, used to be a common fishing ground for the local communities until some years ago. However, improper e-waste recycling and disposal activities have eliminated all kind of lives in the lagoon. Many interviewees reported that large quantities of unusable waste, such as broken CRT glass, is frequently dumped in the lagoon in order avoid over-accumulation in the scrap yard, and also to prevent injuries to the workers. Moreover, it is expected that during rainy season when a major portion of the site in flooded, contaminated soil and dust from the burning sites, is carried to the adjacently low-lying lagoons and also into the sea close by.

4. IMPACT ON WORKERS

4.1. Safe and healthy working conditions

As described above, the e-waste recycling industry in Ghana is widely associated with severe health and safety risks for workers involved in this sector [9]. These risks emerge primarily due to improper and crude recycling techniques used for the recovery of raw materials, as for instance, open incineration of cables and wires to recover copper (figure 2).

Figure 2: Burning of cables at Agbogbloshie Metal Scrap Yard, Accra (Source: Öko-Institut 2010)

While exposure to lead fumes or dust is known to cause multiple disorders, including neurological, cardiovascular and gastrointestinal diseases [17], exposure to cadmium fumes or dust leads to malfunctioning of kidneys [27] and respiratory system [28], and possibly lung cancer [29]. On the other hand, even in Europe, workers in electronics recycling facilities have been found to have higher blood levels of PBDEs than other workers [9], [30]. Consequently,

it is assumed that in the absence of protective gear and other workplace standards, the levels of PBDEs in the blood of the recycling workers in Ghana would be much higher. Apart from open incineration, inappropriate dismantling techniques to recover basic metals, such as copper, aluminium and iron, also represent enormous risks to the workers. For example, breaking of CRT-monitors using stones, hammers, heavy metal rods and chisels, to recover copper, steel and plastic casings, could result in the inhalation of hazardous cadmium dust and other pollutants by the workers.

On the other hand, a job of an informal e-waste collector involves about 10–12 hours of pulling of handcarts, made from boards and old car axles, in order to transport obsolete EEE from e-waste shops and warehouses to the dismantling site at the scrap yard. Often such a rigorous activity leads to spinal injuries and back pains due to lifting and transportation of heavy appliances, and consequently to a relatively short career spanning not more than 6–7 years. Also refurbishers reported the inhalation of fumes during electrical soldering operations as a major health threat. As metallic lead had been used in electrical solder, commonly as an alloy with tin, it is estimated that refurbishers could also suffer from lead-borne diseases. Many workers complained of mucus and pain in the eyes, which probably can be attributed to the fumes from the soldering activities.

Discussions with various workers of the Agbogbloshie scrap dealer association revealed that refurbishers and recyclers are aware of existing health risks as they complain of headaches, respiratory problems, chest pains, rashes, burns and cuts. Attempts to encourage them to use donated inhalation masks have not been effective as they complain that they do not feel comfortable wearing the masks or hand gloves.

4.2. Child labor

Ghana ratified the ILO fundamental convention C182 on Worst Forms of Child Labour not until year 2000. The other ILO convention related to child labor, i.e. C138 on Minimum Age, has not yet been ratified by Ghana. Under the convention C138, the general minimum age for admission to employment or work is 15 years (13 for light work). Additionally, there is the possibility of setting the general minimum age at 14 (12 for light work) in regions where economic and educational facilities are insufficiently developed. Furthermore, minimum age for hazardous work has been set at 18 years (16 years under the condition that "the health, safety and morals of the young persons concerned are fully protected and that the young persons have received adequate specific instruction or vocational training in the relevant branch of activity" – Article 3, paragraph 3). However, Article 3, paragraph 1 of the convention C138 specifically states that "the minimum age for admission to any type of employment or work which by its nature or the circumstances in which it is carried out is likely to jeopardize the health, safety or morals of young persons shall not be less than 18 years". Considering severe health hazards associated with the e-waste recycling activities, inappropriate e-waste recycling activities carried out without adequate instruction, training and sensitization, would be classified as hazardous work.

Field observations and recent studies [9] have proved the employment of children, mostly boys, sometimes as young as 5 years old and mostly between 11 and 18 years in the informal e-waste recycling sector in Ghana. However, also young girls of ages between 9 and 12 were also observed as working as collectors, and in many cases as vendors of water sachets, at the Agbogbloshie dumpsite. Most of the recyclers and collectors are aged between 14 and 40 years. Average recycler and informal collector are in their early 20s. Children were seen to be involved primarily in burning activities, but also in manual dismantling of hazardous nature, such as that involved in the recovery of copper containing deflection coils in the CRT monitors.

4.3. Remuneration

Due to the informal nature of the e-waste recycling sector in Ghana, most of the workers are remunerated by their employees on the basis of output generated per day, and not on the basis of a fixed monthly salary. In the case of collectors, the income depends upon the amount of e-waste collected from different parts of the city and subsequently sold to recyclers. On an average, a collector earns between GHS 100 to 200 (US$ 70 to 140)[1] per month. In worst cases, collectors are not able to collect any obsolete equipment in the whole day, and hence end up earning nothing after a whole day's work. This income reflects the profit margin generated by a collector at the end of the month, i.e. the investment for buying obsolete equipments deducted from the money earned after reselling them to recyclers. Average income of a recycler lies between GHS 250 to 400 (US$ 175 to 285) per month. Other sources indicate that incomes of recyclers as well as of collectors could lie below US$ 60 in most cases [31]. Furthermore, incomes of children between 5 and 14 years, performing metal recovery activities, could lie as low as US$ 20 per month. Average income of a refurbisher lies between GHS 275 to 350 (US$ 190–250)

[1] 1 GHS = 0,71153 US$ (www.oanda.com; Interbank rate, 01.01.2010–01.06.2010)

per month. However, in some cases, interviewees suggested of a low income of less than US$ 100 per month in the refurbishing business [31]. It has to be noted that in many cases, the income showed above is used to partially or fully sustain a family of about 6 people (considering a Total Fertility Rate (TFR) of 4.0[2] for the urban regions in Ghana). Table 3 below summarizes the income, also on daily basis.

Table 3: Remuneration (in US$) for the people engaged in refurbishing and e-waste recycling business in Ghana

Remuneration	Refurbishers	Collectors	Recyclers
per day in US$	(3.3)* 6.3–8.3	(2.0)* 2.3–4.6	(2.0)* 5.8–9.5
per month in US$	(100)* 190-250	(60)* 70-140	(60)* 175-285

* Figures in brackets indicate the information from other sources

It is necessary to interpret the above mentioned income data in the whole context of the Ghanaian economy. The GDP per capita (current US$) in Ghana rose dramatically from US$ 255 in year 2000 to US$ 713 in 2008 [14]. However, in terms of poverty head count ratio regarding purchasing power parity (PPP), about 30% of the population of Ghana lived with less than US$ 1.25 per day in 2006–2007, whereas about 54% of the total population survived with less than US$ 2 per day in 2006–2007. Therefore, the income data implies that if the Total Fertility Rate (TFR) of 4.0 for Ghana is considered (which would mean at least 6 family members), most of the workers engaged in informal refurbishing and e-waste recycling sector continue to live under the internationally defined poverty lines. This is a significant revelation, especially considering the fact that most of the workers of informal e-waste recycling sector originate from the northern part of the country where majority of the poor facing chronic food insecurity live [32]. Thus, even though engaging in informal e-waste recycling and refurbishing sector does not necessarily ensure higher incomes, the workers still prefer this sector because of access to regular income in the form of a rapid cash flow – an aspect which is largely absent in agriculture-driven households in northern Ghana.

[2] Total Fertility Rate (TFR) in Ghana means that a woman who is at the beginning of her childbearing years will give birth to an average of 4.0 children by the end of her reproductive period if fertility levels remain constant at the level observed in the three-year period before the 2008 Ghana Demographic and Health Survey (GDHS) (GSS 2008).

4.4. Working hours

There are several conventions of the International Labour Organization (ILO) that deal with the issue of working hours, overtime, overtime compensation and rest periods: C1 – Hours of Work (Industry) Convention, 1919, C30 – Hours of Work (Commerce and Offices), Convention, 1930, C106 – Weekly Rest (Commerce and Offices) Convention, 1957, C14 – Weekly Rest (Industry) Convention, 1921. These conventions demand that workers shall not, on a regular basis, be required to work in excess of 48 hours per week and shall be provided with at least one day off for every 7 day period on average. Overtime shall be voluntary, shall not exceed 12 hours per week, shall not be demanded on a regular basis and shall always be compensated at a premium rate, generally one and one-quarter times the regular rate. Although Ghana has been a signatory to all the above mentioned conventions, their implementation in the refurbishing and e-waste recycling industry in Ghana is difficult due to its informal character. Thus, most of the workers do not have any fixed working time in terms of hours per day or per week. Recyclers in the Agbogbloshie scrap yard were found to work between 10–12 hours per day, even on the weekends. This implies 30 work days or 300 to 360 work hours per month. They reported to take a day off occasionally in cases of health or family related matters albeit without getting paid for those specific days. The rest periods or breaks rarely exceed 30 minutes per day. Similarly, collectors were also found to work for about 10–12 hours per day, i.e. 300 to 360 hours per month. Collectors, who also engage in recycling activities, spend about 6–8 hours per day with the collection of e-waste from various parts of the town, and 2–4 hours per day for recycling. The refurbishing and repair workers seems to have more regular working hours, generally ranging from 8–10 hours per day. Refurbishers also reported to take a weekend, mostly Sundays, as a holiday. Furthermore, most of the interviewees mentioned to be able to have holidays on Ghanaian national holidays. This fact is related especially to the aspect of sales of refurbished and repaired EEE to private and corporate consumers and pre-defined opening and closing times for the shops in residential and commercial areas in Ghana. Furthermore, mid-day meal breaks of 30 minutes to 1 hour per day were found to be prevalent. Therefore, monthly working hours for refurbishers can be assumed to lie somewhere between 210 to 260 hours.

As a comparison, reports on labor conditions of workers employed in the computer manufacturing in China, have revealed similar trends. In computer manufacturing in China, workers were found to work between 10–12 hours per day, 6–7 days per week,

which implies about 80 to 200 overtime hours per month [33].

4.5. Job satisfaction

It was observed that workers were not overly positive about their working conditions, but still indicated a certain level of satisfaction with their incomes. One of the most cited reasons was the ability to send remittances regularly to their families in the northern part of Ghana. Many interviewees, however, emphasized that they have to cut their costs, for instance by avoiding costs related to housing and education, in order to save ample money to send to their families. Interviewees mentioned that engaging in the refurbishing and e-waste recycling business provides them access to rapid cash flow, which was often not the case in their traditional modes of livelihoods, such as agriculture. In terms of employment turnover rates, the data suggests high rates ranging between 3 to 7 years. This could be attributed to the fact that apart from low incomes, rigorous and hazardous working conditions and lack of employment & social security, many workers seek to set up their own businesses after gathering enough experience and skills of refurbishing and e-waste recycling.

5. IMPACT ON SOCIETY

5.1. Employment creation

Till date, there has not been any statistical information, either from government or non-government sources, on the number of people employed in the refurbishing and e-waste recycling sector in Ghana. The Labour Market Information System (LMIS) of the Ministry of Employment and Social Welfare, and the Ministry of Trade and Industry of Ghana do not provide any employment information based on business activity. Similarly, employment data for Ghana was not specified in international information sources, such as the Data Bank of the World Bank Group and the CIA – the World Factbook. Therefore, it is necessary to make certain assumptions based on the interview data, expert opinion and other sources, such as membership in market associations etc. in order to estimate the size of the sector.

According to the information from the President of the Agbogbloshie Scrap Dealers Association, the association boosts a membership of about 3,000. Expert opinion suggests that about half of the members, i.e. about 1,500 people, focus primarily on e-waste, while the other half on automobile dismantling and material recovery [35]. The data reveals that on an average 3–4 workers are employed by one recycler (including arrangements with collectors, who are given some money to go around the city to collect and buy e-waste). Considering that Agbogbloshie builds the major part of recycling (informal) industry in Accra, it can be assumed that about 4,500 to 6,000 people are involved in informal e-waste collection and recycling operations in the region of Accra. In the refurbishing/repair sector, expert opinions suggest that only 20% of the businesses are registered with any local or national body [34]. On the other hand, the Repairers Association (GESTA) lists about 500 registered members in Accra and Tema region. Thus, it can be estimated that at least 2500 refurbishing/ repair businesses can be found scattered in the region of Accra and Tema, if not more. The socio-economic data revealed that each refurbishing/repair business employs between 4–6 employees, suggesting an employment creation for about 10,000 to 15,000 people in Accra. Expert opinion suggests that refurbishing and e-waste recycling sector in Accra might account for 40%–60% of the total size of Ghanaian refurbishing and e-waste recycling activities [31], [34], [35]. This would imply that about 6,300 to 9,600 people are engaged in e-waste collection and recycling operations in whole Ghana, in refurbishing/repair sector, the number lies at about 14,000 to 24,000. Thus, in total, about 20,300 to 33,600 people are employed in refurbishing and e-waste recycling sector in Ghana, constituting about 0.19%–0.32% of total labor force in Ghana.

Furthermore, on the basis of the survey from the Ghana Demographic and Health Survey (GDHS) 2008, which suggests the total fertility rate (TFR) of 4.0 for Ghana, it is assumed that refurbishing and e-waste recycling sector partially or fully sustains about 87,000–126,000 people in the region of Accra, in the whole country of Ghana, the number goes between 121,800 and 201,600. This represents about 1.04%–1.72% of the total urban population in Ghana, or 0.50%–0.82% of the total Ghanaian population. Table 4 summarizes the findings on the employment creation.

Table 4: Number of people employed and dependent on refurbishing and e-waste recycling in Ghana

	Refurbishers	**Collectors / Recyclers**	**Total**
Employed in Accra	10,000–15,000	4,500–6,000	14,500–21,000
Employed in Ghana	14,000–24,000	6,300–9,600	20,300–33,600
Dependent on refurbishing and e-waste recycling in Accra	60,000–90,000	27,000–36,000	87,000–126,000
Dependent on refurbishing and e-waste recycling in Ghana	84,000–144,000	37,800–57,600	121,800–201,600

5.2. Contribution to national economy

Estimates based on the socioeconomic data collected in Accra reveal that in Ghana between 10,000 and 13,000 metric tons of e-waste are treated annually. Till date, there is no quantitative information on the role refurbishing and e-waste recycling sectors play in the development of other sectors. However, it is still possible to estimate the contribution of refurbishing and e-waste recycling sector to the Ghanaian economy on the basis of average salaries and the number of workers (table 5).

Table 5: E-Waste's contribution to the Ghanaian national economy

	Refurbishers	**Collectors**	**Recyclers**	**Total**
Remuneration/ month (US$)	190–250	70–140	175–285	435–675
Remuneration/ year (US$)	2,280 -3,000	840–1,680	2,100–3,420	5,220–8,100
Number of people employed in refurbishing & e-waste recycling sector in Ghana	14,000–24,000	6,300–9,600	20,300–33,600	
Contribution to national economy per year (US$)	Remuneration per year * Number of people employed in refurbishing & e-waste recycling sector in Ghana		105,966,000–268,128,000	

Thus, it is estimated that total value of the refurbishing and e-waste recycling sector in Ghana could range between US$ 105 and 268 million annually. Due to the informal nature of the refurbishing and e-waste recycling sector in Ghana, this contribution is not reflected in the national GDP. Assuming that the contribution of this sector is added to the national GDP, it will make about 0.29%–0.55% of the total GDP of Ghana.

6. CONCLUSIONS

Results of the socio-economic assessment indicate that a large number of people in Ghana rely, either as workers or as family members of workers, on informal refurbishing and e-waste recycling sector for their livelihoods. In the e-waste recycling sector, focus is on recovery of base metals, such as iron, aluminium and copper from e-waste. However, in the absence of adequate technology, skills, business and finance opportunities, and legislation, refurbishing and e-waste recycling sector causes enormous damage to human health and environment. Simultaneously, engagement in informal refurbishing and e-waste recycling sectors is associated with rigorous working conditions and a life below internationally defined poverty lines. Also, there are no employment or social security mechanisms available to the workers. However, people, mostly migrants from the northern part of Ghana, continue to engage in these sectors due to access to relatively regular income opportunities in the form of rapid cash flow. This has helped them to be able to send regular remittances to their families members staying in the north of Ghana. It can be expected that in the wake of increasing obsolescence of EEE, triggered by modern consumption patterns and short useful life of EEE, even much larger volumes of e-waste will be generated in the near future, hence giving ample employment opportunities to many more people, albeit with poor health, social and environmental standards.

Recently, many studies [6], [7], [10] and [11] have highlighted several options to improve social and environmental standards in the informal e-waste recycling sector. Such improvement options aim at facilitating an efficient recovery of precious and base metals from e-waste, and at the same time, managing hazardous substances in an environmentally sound manner. Thus, apart from promising higher end-value and incomes, such options would help in reducing negative environmental impacts of informal e-waste recycling sector, however only to a certain extent as they focus solely on those e-waste fractions that have a good market value. Here, other options gain importance as they highlight the implementation of e-waste specific national legislations in order to deal with those e-waste fractions which do not offer any market value and incentive for recyclers. These options should go hand-in-hand and be tested in a pilot phase in Ghana as soon as possible, especially considering the current dynamics of e-waste debate in the country.

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