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The global impact of e-waste
Addressing the challenge

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Preface

Electrical and electronic waste (e-waste) is currently the largest growing waste stream. It is hazardous, complex and expensive to treat in an environmentally sound manner, and there is a general lack of legislation or enforcement surrounding it. Today, most e-waste is being discarded in the general waste stream.

Of the e-waste in developed countries that is sent for recycling, 80 per cent ends up being shipped (often illegally) to developing countries to be recycled by hundreds of thousands of informal workers. Such globalization of e-waste has adverse environmental and health implications.

This paper explores the volumes, sources and flows of e-waste, the risks it poses to e-waste workers and the environment, occupational safety and health issues, labour issues and regulatory frameworks, and links this growing global problem with the International Labour Organization's current and future work.

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Executive summary

Electrical and electronic waste (e-waste) is currently the largest growing waste stream. It is hazardous, complex and expensive to treat in an environmentally sound manner, and there is a general lack of legislation or enforcement surrounding it. Today, most e-waste is being discarded in the general waste stream. Of the e-waste in developed countries that is sent for recycling, 80 per cent ends up being shipped (often illegally) to developing countries such as China, India, Ghana and Nigeria for recycling. Within the informal economy of such countries, it is recycled for its many valuable materials by recyclers using rudimentary techniques. Such globalization of e-waste has adverse environmental and health implications. Furthermore, developing countries are shouldering a disproportionate burden of a global problem without having the technology to deal with it. In addition, developing countries themselves are increasingly generating significant quantities of e-waste.

This paper explores the volumes, sources and flows of e-waste, the risks it poses to e-waste workers and the environment, occupational safety and health (OSH) issues, labour issues and regulatory frameworks, and links this growing global problem with the International Labour Organisation (ILO)'s current and future work. It is clear that the future of e-waste management depends not only on the effectiveness of local government authorities working with the operators of recycling services but also on community participation, together with national, regional and global initiatives.

The solution to the e-waste problem is not simply the banning of transboundary movements of e-waste, as domestic generation accounts for a significant proportion of e-waste in all countries. Fundamental to a sustainable solution will be tackling the fact that current practices and the illegal trade provide economic stimulus. It is important to recognize local and regional contexts and the social implications of the issue; implementing a high-tech, capital-intensive recycling process will not be appropriate in every country or region. Effective regulation must be combined with incentives for recyclers in the informal sector not to engage in destructive processes. Cheap, safe and simple processing methods for introduction into the informal sector are currently lacking; hence, it is necessary to create a financial incentive for recyclers operating in the informal sector to deliver recovered parts to central collection sites rather than process them themselves. Multidisciplinary solutions are vital in addition to technical solutions, as is addressing the underlying social inequities inherent in the e-waste business.

Recycling operations in the informal sector of the economy enable employment for hundreds of thousands of people in poverty. A possible entry point to address their negative impacts is to address occupational risks, targeting poverty as the root cause of hazardous work and, in the process, developing decent working conditions. More generally, solutions to the global e-waste problem involve awareness-raising among both consumers and e-waste recyclers in the informal economy, integration of the informal sector with the formal, creating green jobs, enforcing legislation and labour standards, and eliminating practices which are harmful to human health and the environment. It is also imperative to target electrical and electronics manufacturers by introducing Extended Producer Responsibility (EPR) legislation and encouraging initial designs to be green, long lived, upgradeable and built for recycling.

In considering solutions to the e-waste problem, this paper focuses on worker protection through appropriate legislation, formalization of the informal recycling sector and the opportunities represented by cooperative organization of e-waste workers.


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Introduction

In the last two decades, the global growth in electrical and electronic equipment production and consumption has been exponential. This is largely due to increasing market penetration of products in developing countries, development of a replacement market in developed countries and a generally high product obsolescence rate (United Nations Environment Programme [UNEP], DTIE, 2007a), together with a decrease in prices and the growth in internet use. Today, electrical and electronic waste (hereafter referred to as e-waste) is the fastest growing waste stream (about 4 per cent growth a year). About 40 million tonnes of e-waste is created each year (Schluep, M. et al. 2009). E-waste comprises electrical appliances such as fridges, air conditioners, washing machines, microwave ovens, and fluorescent light bulbs; and electronic products such as computers and accessories, mobile phones, television sets and stereo equipment.

As environmentally responsible waste management options are highly technological and require high financial investment, there is currently a high level of transboundary, often illegal, movement of e-waste into developing countries for cheaper recycling (Strategic Approach to International Chemicals Management [SAICM], 2009). Transboundary movement of e-waste is primarily profit driven. Recyclers and waste brokers are taking advantage of lower recycling costs in developing economies and at the same time avoiding disposal responsibilities at home. It is estimated that up to 80 per cent of all e-waste sent for recycling in developed countries ends up in informal e-waste recycling sites in developing countries, primarily in Africa and Asia. In receiving countries, crude and hazardous methods of recycling are used, jeopardizing people's health and the environment (Smith, Sonnenfeld & Naguib Pellow, 2006). This raises an equity issue of developing countries receiving a disproportionate burden of a global problem, without having the technology to deal with it. Globalization of e-waste has adverse environmental and health implications as developing countries face economic challenges and lack the infrastructure for sound hazardous waste management, including recycling, or effective regulatory frameworks for hazardous waste management (SAICM, 2009).

There is no standard definition of e-waste. The Organisation for Economic Co-operation and Development (OECD) defines e-waste as "any appliance using an electric power supply that has reached its end-of-life" (UNEP, DTIE, 2007a). The most widely accepted definition of e-waste is as per European Commission Directive 2002/96/EC: "electrical or electronic equipment, which is waste … including all components, subassemblies and consumables, which are part of the product at the time of discarding" (European Commission, n.d.(a)). The differences in definitions of what constitutes e-waste have the potential to create disparities in both the quantification of e-waste generation and the identification of e-waste flows. The lack of a precise definition of e-waste is one of the key issues that need to be addressed on an international level.

In general, large household appliances represent the largest proportion (about 50 per cent) of e-waste, followed by information and communications technology equipment (about 30 per cent) and consumer electronics (about 10 per cent)1. The composition of e-waste is very diverse and differs across product lines and categories. Overall, it contains more than 1000 different substances which fall into "hazardous" and "non-hazardous" categories; significantly, the

1. This paper focuses on consumer electronics. This is because most of the e-waste literature focuses on consumer electronics – perhaps because household appliances generally have a longer use time.

toxicity of many of the chemicals in e-waste is unknown. Broadly speaking, electronic products consist of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50 per cent of e-waste followed by plastics (21 per cent), non ferrous metals (13 per cent) and other constituents (UNEP, DTIE, 2007a). Electronic products often contain several persistent, bioaccumulative and toxic substances including heavy metals such as lead, nickel, chromium and mercury, and persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs) and brominated flame retardants (see section 3). The urgency of the problem is evident: worldwide, in the decade between 1994 and 2003, about 500 million personal computers containing approximately 718,000 tonnes of lead, 1,363 tonnes of cadmium and 287 tonnes of mercury, reached their end-of-life (Smith, Sonnenfeld & Naguib Pellow, 2006).

There is generally low public awareness of the hazardous nature of e-waste and the crude waste management techniques used in developing countries. The focus on science, service and software has distracted the public, who see those employed in the consumer electronics industry as mostly "white-collar" workers (op. cit.).

An additional, somewhat hidden, aspect of e-waste is that the loss of scarce metals present in e-waste has to be compensated for by intensified mining activities, and it is well known that the rapid increase in demand for raw materials used in electronic products has given rise to conflicts over resources worldwide. The e-waste recycling industry could play an important role in reducing such conflict risks by lowering the pressure on primary mining sites, such as those of gold, palladium and tantalum (Prakash & Manhart, 2010).

This paper will elaborate on the issues posed by e-waste, the scale of its use, destinations for the transboundary trade flow in e-waste, risks to workers, labour and employment issues, chemicals of concern, occupational safety and health (OSH) aspects, and the legal framework. It will take a systems analysis approach to the problem, explore solutions and suggest possible pathways for ILO intervention.

1.1 Main issues

The main issues posed by e-waste are as follows:

- **High volumes** – High volumes are generated due to the rapid obsolescence of gadgets combined with the high demand for new technology (Basel Action Network [BAN], 2011).
- **Toxic design** – E-waste is classified as hazardous waste (Tsydenova & Bengtsson, 2011) having adverse health and environmental implications. Approximately 40 per cent of the heavy metals found in landfills comes from electronic waste (Montrose, 2011).
- **Poor design and complexity** – E-waste imposes many challenges on the recycling industry (Smith, Sonnenfeld & Naguib Pellow, 2006) as it contains many different materials that are mixed, bolted, screwed, snapped, glued or soldered together. Toxic materials are attached to non-toxic materials, which makes separation of materials for reclamation difficult. Hence, responsible recycling requires intensive labour and/or sophisticated and costly technologies that safely separate materials (BAN, 2011).
- **Labour issues** – These include occupational exposures, informal sector domination causing health and environmental problems, lack of labour standards and rights.
- **Financial incentives** – In general, there is not enough value in most e-waste to cover the costs of managing it in a responsible way. However, in line with EPR policies, new opportunities can be realized with the rise in the price of many of the materials in electronics, such as gold and copper (Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmann & Böni, 2005). Furthermore, with rising e-waste quantities, formal recyclers are increasingly entering the e-waste recycling sector (Raghupathy, Krüger, Chaturvedi, Arora, Henzler, 2010).
- **Lack of regulation** – Many nations either lack adequate regulations applying to this relatively new waste stream, or lack effective enforcement of new e-waste regulations (BAN, 2011).

1.2 Scale of the e-waste problem[2]

Some of the major stakeholders in the life cycle of e-waste (see fig. 1) include producers/manufacturers, retailers (businesses/government/others), consumers (individual households/businesses/government/others), traders, exporters and importers, scrap dealers, disassemblers/dismantlers, smelters and recyclers (UNEP, DTIE, 2007a). In developing countries, traders resell for reuse or, if equipment is unfit for reuse, often sell it to recyclers in the informal economy. Intermediaries collect functional items and sell them to repair shops. The recyclers are often specialized in recovering specific materials (Smith, Sonnenfeld & Naguib Pellow, 2006). The European Union (EU) countries have the highest rates of e-waste recycling, followed by Japan. It is estimated that between 50 per cent and 80 per cent of e-waste collected for recycling in developed countries each year is being exported. Much e-waste, however, is unaccounted for. It is either discarded into the general waste stream or, perhaps, illegally exported to crude e-waste recycling hotspots which have been identified in Asian countries, such as China, India, and Pakistan, and in some African countries, such as Ghana and Nigeria. There is a lack of information on how much e-waste is generated and where, and on where it is moving to. This situation is made worse by the current system of gathering information, in which secondhand, used and waste products are, by and large, invisible to national statistics on production, sale and trade in goods (SAICM, 2009).

The demand for e-waste began to grow when scrap yards found a way of extracting valuable substances such as copper, iron, silicon, nickel and gold during the recycling process. The fast-growing economies of China and India are in need of vast amounts of materials (Prakash & Manhart, 2010). Domestic e-waste generation in China, Eastern Europe and Latin America is also increasing rapidly. Indeed, worldwide, all countries have increased their e-waste over time – a trend that seems unlikely to be reversed (op. cit.). E-waste recycling now provides employment to thousands of poor people. It is a booming, often illegal business, which frequently attracts migrant workers.

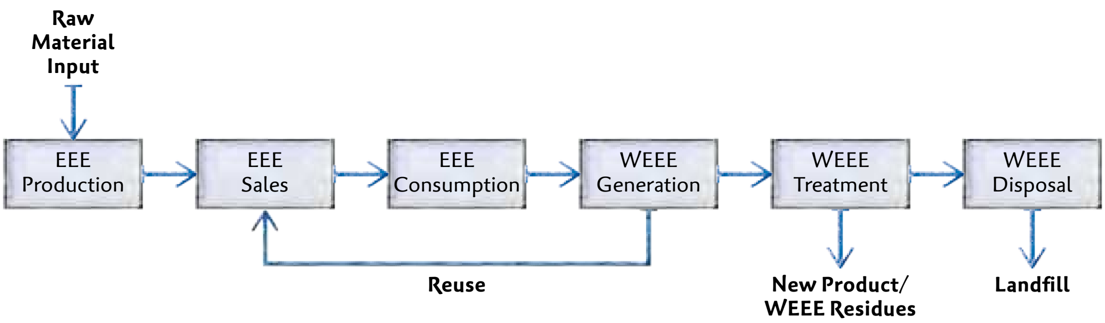

Fig. 1. Life cycle of e-waste (UNEP, DTIE, 2007a).

2. EEE=electrical and electronic equipment, WEEE=waste electrical and electronic equipment

2 The flow of e-waste

2.1 The e-waste trade

It is estimated that global e-waste generation is growing by about 40 million tonnes a year (Schluep et al., 2009). A primary obstacle to making estimations is that flows of secondary and waste products are, by and large, invisible to national statistics on production, sales and trade in goods. In addition, the differences in definitions of what constitutes e-waste create disparities in the quantification of e-waste generation as well as in the identification of e-waste flows. Despite a lack of statistical data on flows of e-waste and hazardous waste in general, there is a consensus that the purpose of shipments is gradually shifting away from final disposal towards recovery and recycling operations. Recycling rates are currently believed to be growing at an average rate of 18 per cent per year.

In general, e-waste flows to disadvantaged and historically marginalized areas. Nonetheless, some people have the economic and political wherewithal to benefit from the trade at different points along the value chain. The complexities of decision-making such as whether to treat e-waste domestically or through export, or to dispose of or recycle it, raise legal, environmental, political, economic and ethical issues. A study commissioned by the US Environmental Protection Agency (EPA) revealed that it was 10 times cheaper to export e-waste to Asia than it was to process it in the United States (US). The incentives for e-waste movement, both legally and illegally, are thus enormous.

Analysis of data also shows that the trade in e-waste has grown not only between the developed and developing countries but also among the developing countries themselves, reflecting a continuous growth and tolerance for cross-border movement (Ray, 2008). The flow of e-waste encompasses more than movement from developed to developing countries, as regionalized, intra-regional flow accounts for most of the trade. Furthermore, the trade is open ended and contingent depending upon value assigned during the exchange of waste. E-waste flow is a complex issue; in 2001, Africa exported most of its e-waste to Korea and Spain, for example. Since 2006, the growth in global trade overall has been primarily in two areas: in internal markets and in Asia becoming the dominant recipient of global exports. Clearly, one has to think carefully of the linear assumptions, such as e-waste simply being shipped from developed to developing countries, as there is substantial internal and regional trade (Lepawsky & McNabb, 2010).

2.2 The international flow of e-waste

The main sources and destinations of the e-waste trade are demonstrated in figure 2.

E-waste recycling operations have been identified in several locations in China and India. Less-investigated locations are in the Philippines, Nigeria (in the city of Lagos), Pakistan (Karachi) and Ghana (Accra) (Ni & Zeng, 2009). In general, small-scale exports go to West Africa while the larger and sometimes more structurally organized transports go to South-East Asia (Basel Convention. n.d.(a)). It is estimated that China receives the highest proportion of all e-waste – about 70 per cent and rising. However, there are no confirmed figures available on how substantial these transboundary e-waste streams are (Ni & Zeng, 2009). In addition, due to the recent tightening of regulations in Asia, it is estimated that more e-waste will flow into West African countries in the future.

Common Asian destinations for e-waste include China, India, Pakistan, Malaysia, the Philippines, Singapore, Sri Lanka, Thailand and Vietnam. Exporters of e-waste to China can avoid detection by

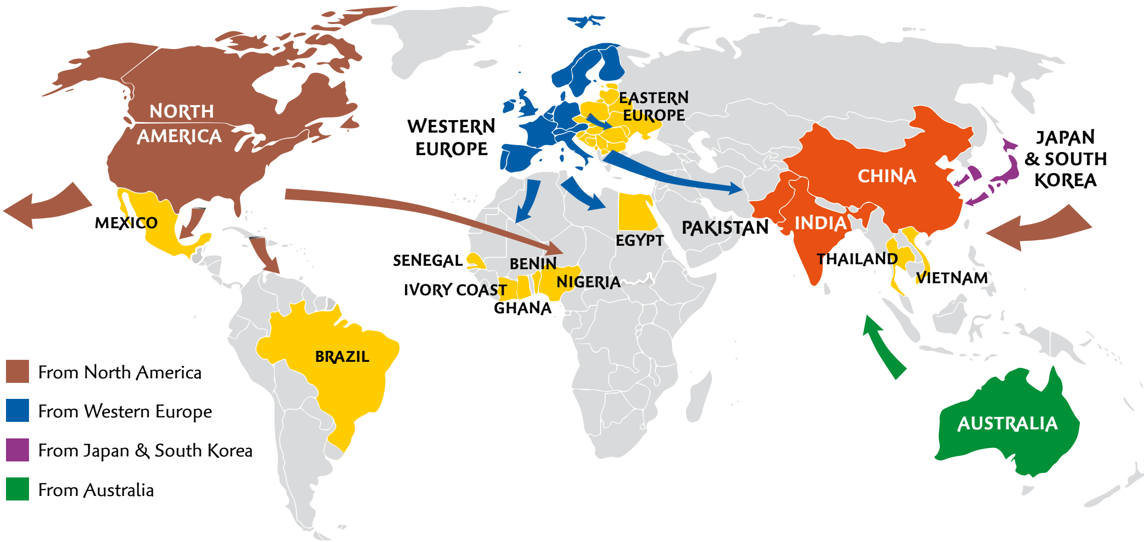

Fig. 2. Export of e-waste (Lewis, 2011)

Fig. 3. Known and suspected routes of e-waste dumping (University of Northampton, n.d.)

routing container ships through Hong Kong, Taipei or the Philippines, and then transshipping them to smaller ports in mainland China, where customs officials are willing to look the other way in exchange for a share of profits. Dubai and Singapore often serve as transit points for e-waste from developed countries (Kalra, 2004).

E-waste imported into China is often re-exported to other South-East Asian countries. A common e-waste trade system in South-East Asia includes shipments received in China, rebuilt or refurbished mainly in the Guangzhou region, and then re-exported to other countries including Cambodia and Vietnam through the Dongxin border area. There are numerous reasons for the trade to be concentrated in this area. First, the province is adjacent to Hong Kong; second, it contains several big cities, such as Guangzhou and Shenzhen, where huge amounts of domestic e-waste are generated; third, it is located near South-East Asia (Shinkuma & Minh Huong, 2009). The most prominent area in which informal processing takes place is the southern Guangdong Province, the major centres being Guiyu, Guangzhou, Dongguan, Foshan, Shunde, Zhongshan, Dali, Longtang and Shenzhen. From here, e-waste is distributed to other provinces and towns hosting processing centres, such as Hunan, Jiangxi, Fujian, Zhejiang, Shanghai, Taizhou, Shandong, Tianjin and Hebei, (Ni & Zeng, 2009).[1]

1. See Fig.5. on p.37.

The town of Guiyu has attracted much attention from non-governmental organizations (NGOs) and scientists as a booming e-waste town. It is probably the largest e-waste recycling site in the world; it employs about 100,000 people in this activity (Zhao et al., 2010), representing about 80 per cent of the town's population (Ni & Zeng, 2009). In addition, the towns of Luqiao and Wenling around the city of Taizhou in eastern Zhejiang Province have also received attention (Zhao et al., 2010; Wang et al., 2011). The town of Luqiao started recycling e-waste as early as the late 1970s, while Wenling has taken over since the late 1990s as environmental regulations became more stringent in Luqiao (Zhao et al., 2010). Although China enforces many laws and signed the Basel Convention (it was even one of the first global proponents of a total ban on the hazardous waste trade between developed and developing countries), the number of illegal shipments of e-waste to China continues to rise. Clearly, the reason illegal importation and handling of e-waste in China has been able to escalate is not due to the lack of laws and regulations but, rather, to ineffective enforcement (Ni & Zeng, 2009).

Due to stricter environmental policies being enforced by local governments in southern China, e-waste recycling activities there are in decline. As a consequence, e-waste might be diverted to the northern parts of China, remote rural villages, and to Vietnam and other countries of South-East Asia, such as Cambodia. Hong Kong's role as a big port hub for e-waste and used electronics also seems to be changing, and recent investigation shows that used mobile phones imported by Hong Kong traders over the last few years are now being sold to African buyers who come primarily from Nigeria and Tanzania (Nordbrand, 2009).

Statistical data and field research suggest that West Africa serves as the major trading route for e-waste into the African continent, with Ghana and Nigeria the main import hubs. Nigeria dominates the region in the total amount of e-waste it imports and almost all of the collected material reaches the informal recycling sector (Basel Convention, n.d.(a)).

There is also a growing e-waste trade problem in India. It is estimated that, by 2020, India could see a 500 per cent rise in the number of old computers dumped (Schluep et al., 2009). E-waste scrap yards have been found in Meerut, Ferozabad, Delhi, Chennai, Bangalore and Mumbai (BAN, 2011). In neighbouring Pakistan, Sher Shah in Karachi is another major market for e-waste, where all sorts of electronic and electrical goods, spare parts, computers and smuggled goods arrive by sea and land for sale or further distribution to other cities (Ray, 2008).

The countries of South-East Asia have various restrictions on transboundary movements of hazardous wastes. The Philippines makes active use of the prior notification and consent system whereas Singapore encourages imports of e-waste by deeming it non-hazardous (and thus not subject to regulation). Singapore has further announced a policy to become the recycling centre of the Southeast Asian region. Thailand and Indonesia ban importation of hazardous wastes completely and Indonesia has ratified the BAN Amendment. Thailand's cautious stance can be explained by repeated instances of hazardous waste being dumped after import. In 1988, for instance, it was revealed that hazardous waste imported from Singapore, Japan and the US was being dumped in areas around Klong Toey Port (Kojima, 2005). Vietnam prohibited both import and export of hazardous wastes in 2001. However, e-waste imports still occur in practice, owing to loose control and management. Since 2006, the enforcement of the ban on e-waste imports has been tightened and Vietnam also banned the dismantling of e-waste scrap. In Cambodia, e-waste has not been regulated, except for computers, which were banned for import in 1996 because of concern about the possibility of spreading a virus infection into domestic computer systems (Shinkuma & Minh Huong, 2009). Illegal trade in hazardous wastes continues to be a problem in South-East Asia and the various countries will need to strengthen their controls on imports and exports of recyclable wastes and to get tougher in enforcing them (Kojima, 2005).

The global e-waste trade is growing exponentially. Countries such as Senegal and Uganda can expect e-waste flows from computers alone to increase four- to eightfold by 2020 (Schluep et al., 2009). Increasingly, Morocco, Colombia, Peru, Kenya, South Africa, Cambodia and Iraq are also destinations for e-waste (op. cit.; Ni & Zeng, 2009). If there is a "race to the bottom" (as discussed in section 7.5), West Africa might become a more common destination in the future, together with Eastern Europe (Zoeteman, Krikke & Venselaar, 2010).

2.3 The illegal e-waste trade

In recent years, the media and environmental groups have regularly exposed the smuggling and dumping of e-waste. The illegal trade is primarily driven by profit, with a multimillion dollar turnover, and the globalization of the illegal e-waste trade has intensified corporate, or "white-collar", crime. The lack of reliable data on illegal waste activity is recognized to be a problem as the most common methods of illegal export are to disguise ”secondhand goods”, mislabel containers and mix waste with legitimate consignment.

The primary driver of this trade is that e-waste contains valuable components, is easy to source and relatively cheap to ship, and the risk of being caught is generally low (INTERPOL, 2010). An investigation carried out by a UK-based NGO, the Environmental Investigation Agency (EIA), revealed criminal groups trafficking e-waste. These groups were found to be also involved in other crimes such as theft, human trafficking, fraud, drugs and firearms trafficking, and money laundering (EIA, 2011). In response to this, INTERPOL set up a Global E-waste Crime Group in 2009 to develop a multinational enforcement strategy to control the illegal trade and investigate links to organized crime (INTERPOL, 2010). In Europe, customs and police forces have discovered “waste tourists” coming from developing countries to collect e-waste and profit from illegally shipping it to their home countries (Nordbrand, 2009). Brokers and traders are key players in this regard.

Generally, the e-waste export market is quite diverse, ranging from small family-based networks to large and well-organized trading firms. Often, immigrants or temporary residents from African countries engage in creating small trading businesses serving the Europe–Africa trade routes. The ports of Amsterdam and Antwerp, for example, are used as gateways for this trade. In order to disguise illegal exports, even the labelling of used electronics is sometimes manipulated and customs declarations are given to the competent authorities only on the day an ocean carrier is due to leave the port. Both the Dutch and Belgian port authorities emphasize that personnel and financial limitations are severe obstacles to achieving better export control. It has also been found that the UK is the dominant European exporting country, followed by France and Germany (Basel Convention, n.d.(a)).

Another example of the value driver of the e-waste trade is the corruption scandal which broke out in Singapore in 2005 after the e-waste recycling firm Citiraya acknowledged it was under investigation by the authorities. It later emerged that computer chips meant to be recycled were being diverted for sale overseas and that the level of precious metal extracted from waste was falsely declared. The investigation covered up to 1,554 suspect Citiraya transactions in 2004, with about $161 million in fake sales created between 2003 and 2005 (Vijayan, 2008).

The recent emergence of the field of “green criminology” uses e-waste as an example of a trade which poses an environmental risk and yet, although constrained to some extent by expectations of regulatory compliance, is not necessarily criminalized (Gibbs, Gore, McGarrell & Rivers, 2009). The global character of the e-waste trade also creates complexities for law enforcement. International cooperation in law enforcement requires a range of responses including regulatory harmonization, physical inspection of transports, and dissemination of information on offending export companies. Therefore, a “smart regulation” approach, which consists of a combination of prevention, third-party regulation and state intervention, could be applied to the problem of e-waste. This approach does not necessarily criminalize e-waste transportation but, instead, enhances regulation of the recycling market (Sinha, Mahesh, Donders & Van Breusegem, 2011).

2.4 Security implications

End-of-life computers often contain sensitive personal information and bank account details which, if exported without being deleted, leave opportunity for fraud. In the investigation carried out by the EIA, mentioned earlier, it was found that illegal traders had contracts with governmental institutions, hospitals and fire services, and it is unlikely that hard drives were correctly wiped before they were sold on (EIA, 2011).

In conclusion, more research is needed in order to find out more about the networks behind the illegal export that is taking place.

3 Risks to human health and the environment

The main risks to human health and the environment arise from the presence in e-waste of heavy metals, POPs, flame retardants and other potentially hazardous substances. There are three main groups of substances that may be released during recycling and material recovery, and which are of concern: original constituents of equipment, such as lead and mercury; substances that may be added during some recovery processes, such as cyanide; and substances that may be formed by recycling processes, such as dioxins.

If improperly managed, such substances may pose significant human and environmental health risks. Toxic substances can be found within the following types of emissions or outputs:

- leachates from dumping activities
- particulate matter (coarse and fine particles) from dismantling activities
- fly and bottom ashes from burning activities
- fumes from mercury amalgamate "cooking", desoldering and other burning activities
- wastewater from dismantling and shredding facilities
- effluents from cyanide leaching and other leaching activities (Sepúlveda et al., 2010).

An environmentally sound e-waste recycling chain contains the following steps:

- **demanufacturing into subassemblies and components** – this involves the manual disassembly of a device or component to recover value.
- **depollution** – the removal and separation of certain materials to allow them to be handled separately to minimize impacts, including batteries, fluorescent lamps and cathode ray tubes (CRTs)
- **materials separation** – manually separating and preparing material for further processing
- **mechanical processing of similar materials** – this involves processing compatible plastic resins, metals or glass from CRTs to generate market-grade commodities
- **mechanical processing of mixed materials** – this involves processing whole units followed by a series of separation technologies
- **metal refining/smelting** – after being sorted into components or into shredded streams, metals are sent to refiners or smelters. At this stage, thermal and chemical management processes are used to extract metals (Luther, 2010).

E-waste is a complex and difficult form of waste to recycle, and problems such as elevated concentrations of heavy metals in the air have even been found in state-of-the-art facilities in developed countries. Workers and local residents are exposed to toxic chemicals through inhalation, dust ingestion, dermal exposure and oral intake. Inhalation and dust ingestion impose a range of potential occupational hazards including silicosis (Lepawsky & McNabb, 2010). They are particularly important routes of human exposure to dioxins, lead, copper, cadmium, polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyl (PCB), chromium (Mvo Platform & GoodElectronics, 2009; Nimpuno & Scruggs, 2011), mercury and other metals and carcinogens (Lepawsky & McNabb, 2010). Electrical shocks are another occupational hazard (Prakash & Manhart, 2010).

Overall, human health risks from e-waste include breathing difficulties, respiratory irritation, coughing, choking, pneumonitis, tremors, neuropsychiatric problems, convulsions, coma and even death (Yu, Welford & Hills, 2006). E-waste workers are also exposed to other hazards leading to physical injuries and chronic ailments such as asthma, skin diseases, eye irritations and stomach disease (Raghupathy, Krüger, Chaturvedi, Arora, Henzler, 2010). Particulate matter collected from e-waste recycling areas can lead to inflammatory response, oxidative stress and DNA damage (Yang, Jin, Xu & Lu, 2011).

3.1 Workers' exposure in developing countries

The e-waste recycling sector in developing countries is largely unregulated and the process of recovering valuable materials takes place in small workshops using simple recycling methods. The main components of interest for recyclers are materials containing copper (wires and cables, CRT yokes), steel (internal computer frames, power supply housings, printer parts), plastics (housings of computers, printers, faxes, phones, monitors), aluminium (printer parts), printer toners and printed circuit boards.

Of most concern is the manual disassembly and recovery of valuable components from wires and cables, CRTs and printed circuit boards. Excessive levels of metals, including dissolved arsenic, chromium, lithium, molybdenum, antimony, selenium, silver, beryllium, cadmium, cobalt, copper, nickel, lead and zinc, have been attributed by researchers to acid-leaching operations taking place. A particular hazard associated with the disassembly stage is the possibility of accidental release and spillage of hazardous substances upon breakage of the shell, such as mercury, which is found within light sources as well as switches. CRTs present the risk of implosion due to the vacuum inside the tubes and inhalation hazard due to phosphor coating on the inner side of the glass. The primary hazards of mechanical treatment methods are associated with the size reduction and separation steps, which can generate dusts from plastics, metals, ceramics and silica. The dusts and the surrounding ambient air may pose an inhalation hazard (e.g. from polycyclic aromatic hydrocarbons ([PAHs]) and dermal exposure hazard to workers, as well as the risk of environmental contamination. Open-air storage raises concerns regarding the possibility of lead and other substances leaching out into the environment. (Tsydenova & Bengtsson, 2011). In addition, with lack of access to running water, toxins are transmitted orally via people's hands when eating.

In Ghana, methods employed for recovery of valuable materials include the manual disassembly of e-waste to isolate metals (mainly copper and aluminium) and the open burning of certain components to isolate copper from plastics in which they are encased, particularly from plastic-coated wires and cables (op. cit.). Copper is a catalyst for dioxin formation and copper electrical wiring is coated with chlorine-containing polyvinyl chloride (PVC) plastic which also contributes to the formation of dioxins (Sepúlveda et al., 2010).

In India and China, where more complex processes are employed, recycling practices include manual disassembly, heating printed circuit boards to recover solder and chips, acid extraction of metals from complex mixtures, melting and extruding plastics, and burning plastics to isolate metals. Mixtures of concentrated nitric acid and hydrochloric acids have been reported to be used in Guiyu and Delhi for the extraction of gold and copper respectively. Various volatile compounds of nitrogen and chlorine are known to be emitted during such processes. The heating of printed circuit boards for desoldering and removal of chips exposes workers to fumes of metals, particularly those in solder (often lead and tin), and other hazardous substances that can be potentially released (Tsydenova & Bengtsson, 2011).

The practices used in developing countries often exacerbate pollution by creating hazardous chemicals and additional pollution. For instance, open fires burn in relatively low temperatures in comparison with incinerators and the release of pollutants is significantly higher (Mvo Platform & GoodElectronics, 2009). India, Brazil and Mexico are among countries which have been identified as facing increasing health problems and environmental damage if e-waste recycling is left to the vagaries of the informal sector (Schluep et al., 2009).

Where formal facilities exist, measures can be taken to improve health and safety during exposure to most heavy metals and other chemicals. The ILO code of practice, *Safety in the use of chemicals at work* (ILO, 1993) already provides the framework. Such measures include provision of an enclosed and fitted work area with exhaust ventilation. When adequate ventilation is impossible to maintain, respirators should be carried and air should be sampled to determine substance concentrations. In areas with hazards of flying particles, chemical splashes, radiant heat and so on, workers should wear appropriate safety equipment, such as eye, face, hand and arm protection and impermeable clothing. Adequate sanitary facilities should be provided, and workers should be encouraged to wash before meals and to wash thoroughly and change clothes before leaving work. Smoking, eating and drinking in work areas should be prohibited (op. cit.). Unfortunately, ILO guidelines and practices are often not followed or acknowledged in the e-waste recycling sites in the developing world. For the most part, the participants in this sector are not aware of environmental and health risks, do not know better practices or have no access to investment capital to finance safety measures (Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmann & Böni, 2005).

Currently, there are no viable alternative, safer methods and/or OSH practices being explored as most projects and studies are in the early stages, looking at problems, pollution, risk and so on in the context of informal e-waste recycling. Local, simple methods and solutions to minimize risks in the short term must be explored (Prakash & Manhart, 2010).

3.2 Long-term effects on human health and the environment

The degree of hazard posed to workers and the environment varies greatly depending on the individuals involved and the nature of operations. What is known is that the pollution generated by e-waste processing brings about toxic or genotoxic effects on the human body, threatening the health not only of workers but also of current residents and future generations living in the local environment (Liu et al., 2009).

It is evident from several studies in China that the rudimentary recycling techniques coupled with the amounts of e-waste processed have already resulted in adverse environmental and human health impacts, including contaminated soil and surface water (Zhao et al., 2010; Wang et al., 2011; Frazzoli, Orisakwe, Dragone & Mantovani, 2010; Tsydenova & Bengtsson, 2011). Health problems have been reported in the last few years, including diseases and problems related to the skin, stomach, respiratory tract and other organs (Nordbrand, 2009). Workers suffer high incidences of birth defects, infant mortality, tuberculosis, blood diseases, anomalies in the immune system, malfunctioning of the kidneys and respiratory system, lung cancer, underdevelopment of the brain in children and damage to the nervous and blood systems (Prakash & Manhart, 2010). However, long-term health studies of e-waste workers have yet to be conducted.

Long-range transport of pollutants has also been observed, which suggests a risk of secondary exposure in remote areas. Atmospheric pollution due to burning and dismantling activities seems to be the main cause of occupational and secondary exposure (Sepúlveda et al., 2010). Informal sector e-waste activities are also a crucial source of environment-to-food-chain contamination, as contaminants may accumulate in agricultural lands and be available for uptake by grazing livestock. In addition, most chemicals of concern have a slow metabolic rate in animals, and may bioaccumulate in tissues and be excreted in edible products such as eggs and milk. E-waste-related toxic effects can be exacerbated throughout a person's lifetime and across generations. E-waste therefore constitutes a significant global environmental and health emergency, with implications far broader than occupational exposure and involving vulnerable groups and generations to come (Frazzoli, Orisakwe, Dragone & Mantovani, 2010).

3.3 Child labour at e-waste recycling sites

Of particular concern is the exposure of children and pregnant women to lead, mercury, cadmium and other heavy metals, as even relatively low levels of exposure can cause serious and, in some cases, irreversible neurological damage and threaten the development of the child (WHO, 2010a). It is currently hard to estimate to what extent children work specifically on e-waste disposal sites; however, many studies point to their comprising a significant proportion of all workers on these sites. The difficulty in estimation results largely from a lack of data segregation for e-waste, as a considerable knowledge base exists for child labourers working as "scavengers" or "waste-pickers".

At the Agbogbloshie e-waste site in Ghana, the employment of children (mostly boys, sometimes as young as 5 and mostly between 11 and 18 years old) has been identified. The children are primarily involved in burning activities and manual dismantling. Young girls aged between 9 and 12 have been observed working as collectors, and in many cases as vendors of water sachets (Prakash & Manhart, 2010).

The ILO has conducted several studies and led multiple action programmes for child scavengers who participate in "manual sorting and picking of recyclable/reusable materials from mixed wastes at legal and illegal landfills, dumpsites, street bins and piles, transfer points, as well as waste collection trucks" (ILO, 2004). Based on this definition, it is likely that a substantial number of children may work directly on e-waste sites or come into contact with e-waste while scavenging on various waste sites.

According to a thematic evaluation conducted by the ILO's International Programme for the Elimination of Child Labour (IPEC), these children often suffer from poor labour conditions and face various risks and hazards, varying from occupational accidents to heavy metal and chemical poisoning, and ergonomic and psychosocial problems. They often live

CASE STUDY 1. Health impacts of e-waste recycling on child waste pickers in Managua, Nicaragua

Athanasiadou and others conducted a cross-sectional study to investigate the serum level of PBDEs in 64 children aged 11–15 living and working at a municipal domestic and industrial waste disposal site in Managua, La Chureca, Nicaragua (Athanasiadou, Cuadra, Marsh, Bergman & Jakobsson, 2008). Approximately half of all waste pickers at this dump site were children (less than 18 years of age). The PBDE concentrations in the children's serum were found to be among the highest ever reported. These study results demonstrate that childhood exposure to PBDEs is strongly influenced by dust inhalation and ingestion at the waste disposal site, rather than by contamination of food as commonly assumed. At the waste disposal site, high levels of dust were generated as waste was burned.

While the research team specifically reported on the high PBDE levels of the scavenging children, they also found elevated levels of heavy metals in these children. This type of cumulative exposure evidence implies a need for an integrated risk evaluation due to the fact that the common critical organ, susceptible to the greatest level of harm from these pollutants, is the young, developing brain. A high prevalence of malnutrition was also found within the scavenging child population. Evidence has clearly linked malnutrition to increased uptake of heavy metals and other toxic hazard substances present at the waste disposal site, deeming the children exposed to be particularly vulnerable to this type of co-morbidity (op. cit.).

One study that specifically investigated heavy metals exposure of child scavengers was led by Cuadra in 2005 in Managua, La Chureca, Nicaragua. Blood analysis of children who worked as scavengers demonstrated that overall, the children working at the waste disposal site had higher levels of lead in their blood compared with the non-working referents groups. Among child workers at the waste disposal site, as many as 28 per cent had blood lead levels greater than the community action level of 100 ug/l recommended by the Centers for Disease Control and Prevention (CDC). The children working at the waste disposal site also had higher levels of blood mercury and blood cadmium when compared with the non-working referents groups. However, unlike for lead, the levels of mercury and cadmium observed were much lower than those levels at which adverse health effects have been observed (Cuadra, 2005).

Generally, the injury risk to child workers at waste disposal sites is very high (Cuadra, 2005). Cuadra conducted an interview-based study on children aged 6–15 years working and living at La Chureca waste disposal facility in Managua, Nicaragua, in order to determine the magnitude of work-related injuries in this sector. Children working in the facility (n=102) and a control group (n=101) were assessed. In summary, the research team found that 66 child workers and 20 referents reported at least one injury during the previous 12 months (odds ratio 7.4; 95 per cent CI 3.9 to 14). In total, 110 and 22 injuries, respectively, were reported. Among the child workers, most of the injuries occurred at the waste disposal site (n=79; corresponding incidence rate of work-related injuries was 2.2 per 1,000 person-days. Seven (9 per cent) of the work-related injuries resulted in persisting functional impairment or pain (Cuadra, 2005).

in poor sanitary conditions, and suffer stigmatization, harassment and exploitation (van Eerd, 1996).

Due to their particular characteristics, children are more vulnerable to the threats posed by informal e-waste activities, and effects – including more fatal and non-fatal accidents, permanent disabilities and/or ill health, and psychological, behavioural or emotional damage – can often be more devastating and lasting. Children's bodies, minds and judgement are still developing, even in their late teens, and their reproductive systems and brain functions are particularly susceptible. Exposure to neurotoxicants, endocrine disruptors, allergens and carcinogens during this critical period can be highly unsafe. In addition, lack of work experience, supervision, awareness of the hazards and status exacerbate the situation.

Article 3(d) of ILO Convention on the Worst Forms of Child Labour, 1999 (No. 182), specifies such labour as including "work which, by its nature or the circumstances in which it is carried out, is likely to harm the health, safety or morals of children" (ILO, 1999). Working as a waste picker is considered hazardous as child workers jeopardize their health, chance of normal development, and even their lives, when performing such tasks. Working with e-waste recycling is, by its nature and circumstances, likely to harm the health, safety and morals of children, and the conditions in which the work is carried out exert an extremely negative impact on a child's health status. Child workers are exposed to a variety of hazards, e.g. falling objects, chemicals, abusive employers, along with the many other social problems related to human survival in such a harsh environment. Injuries and heavy metal exposure constitute two of the greatest threats for child workers (IPEC, 2011).

In recent years, there has been a reinvigoration of research concerning the specific hazardous exposures that scavengers face, specifically for children and adolescents who may be exposed while employed in this sector. Research on this subject has focused on metal exposures and occupational injuries, though exposure to PBDEs – a flame retardant used in electric appliances and electronic devices – has been of particular interest for occupational health research (Cuadra, 2005).

Children at e-waste recycling sites are reported to be suffering from medical problems such as breathing ailments, skin infections and stomach diseases. Infants, due to their hand-to-mouth behaviour, are one of the most vulnerable groups in areas where soils and dusts are contaminated with lead (Prakash & Manhart, 2010).

In Guiyu, for example, it is estimated that about 80 per cent of children suffer from respiratory diseases (Sepúlveda et al., 2010), there has been a surge in cases of leukemia and concentrations of lead in blood are high (Tsydenova & Bengtsson, 2011). According to the *China Labour Bulletin*, e-waste recycling activities have contributed to elevated blood lead levels in children and high incidence of skin damage, headaches, vertigo, nausea, chronic gastritis, and gastric and duodenal ulcers (*China Labour Bulletin*, 2005).

Chemicals of primary concern in e-waste

4

Components and substances commonly found in e-waste include mercury in relays, switches and gas discharge lamps; batteries containing mercury, cadmium, lead and lithium (Tsydenova & Bengtsson, 2011). Printed circuit boards contain a number of substances of concern such as lead, antimony, beryllium and cadmium. Plastics often contain brominated flame retardants and PVC in wire insulation releases dioxins and furans when burnt. CRTs (found in older desktop computers and television sets) contain the greatest amount of all substances of concern, such as 2–3 kilograms of lead in each device. However, the newer liquid crystal display (LCD) screens contain a mixture of 10–20 substances in each liquid crystal which are suspected to be hazardous (such as indium); however, few studies have been made on their toxicity (op. cit.). Furthermore, LCD screens are difficult to dismantle without causing mercury emissions from broken backlights. To date, the optimal recycling of these devices is still unresolved (Prakash & Manhart, 2010). A list of chemicals of concern, their distribution in electronic goods, and associated health concerns is provided in Annex I.

4.1 Unknown chemical properties

Little is known about the toxicity and environmental properties of over 1,000 of the chemicals identified in the e-waste streams. This is largely a result of rapidly changing manufacturing processes and the chemicals employed within certain sectors (Mvo Platform & GoodElectronics, 2009). Some potential contaminants in e-waste are uncommon, even in other contaminated sites; consequently, there has been little work done on their environmental effects. Examples include lithium (used in batteries), beryllium (a contact material), antimony (a flame retardant), and gallium and indium (used in silicon chips and LCD monitors).

In addition, e-waste composition is changing with technological development and pressure on manufacturers from regulators and NGOs. The replacement of CRT monitors with LCD displays will reduce the concentration of lead from CRTs; however, LCD displays contain mercury, indium and zinc. Likewise, fibre optics, which may replace some copper wires, can contain fluorine, lead, yttrium and zirconium. Rechargeable battery composition has also changed dramatically, from nickel–cadmium to nickel metal hydrides and lithium ion batteries (Robinson, 2009). In addition, concerns are raised on the large amounts of epoxy resins, fibreglass, PVC, thermosetting plastics, lead, tin, copper, silicon, beryllium, carbon, iron and aluminium, and the trace amounts of germanium, tantalum, vanadium, terbium, gold, titanium, ruthenium, palladium, manganese, bismuth, niobium, rhodium, platinum, carbon, americium, antimony, arsenic, barium, boron, cobalt, europium, gallium, indium, lithium, manganese, nickel, palladium, ruthenium, selenium, silver, tantalum, molybdenum, thorium and yttrium (Chi, 2011).

4.2 The cocktail effect and metabolites

The "cocktail effect" of the interaction of chemicals can be greater than the effect of the chemicals individually. In addition, even if individual components in a mixture do not each separately have harmful effects, the mixture itself may produce harmful effects (Kemi, 2011). There are examples of the impact of mixed chemical exposure such as to multiple pesticides, diesel fumes, and other fumes and mixed solvents.

CASE STUDY 2. Pollution and the "cocktail effect" in Luqiao and Wenling, Taizhou region, People's Republic of China

Many e-waste recycling sites have been studied in China based on concerns that the primitive e-waste recycling methods cause pollution, and that toxic heavy metals released from activities are threatening the health of local people. The majority of e-waste shipments have China as a final destination and e-waste recycling has been ongoing in the Taizhou region since the 1970s.

In this region, the majority of the dismantling and recovery processes are usually carried out in small household workshops in rural villages, where most of the residents are directly or indirectly involved in e-waste-related activities (Wang et al., 2011). In the e-waste recycling centres around Luqiao and Wenling, researchers studied the impact of heavy metals in 349 people and compared results with a control group of 118 people. Questionnaire surveys for risk factors were also performed and analysed. It was found that urinary levels of lead, cadmium, manganese, copper, and zinc were considerably elevated. Results of the study indicated that the levels of urinary cadmium in both workers and people living in the area were significantly higher than in the control group. The primitive e-waste recycling activities are therefore the cause of the changes of urinary heavy metal levels and indicate increased health risk for those permanently working in e-waste recycling (Wang et al., 2011).

In the same region, Zhao and others studied possible dual pollution of PCBs and PBDEs. This was because the recycling of e-waste in Luqiao began in the late 1970s, where a large number of PCBs-containing transformers and capacitors were treated, whereas recycling of e-waste in Wenling began in the late 1990s, where various PBDEs-containing e-wastes were disassembled. Because Luqiao is 25 km away from Wenling, it was suggested that a "cocktail effect" of PCBs and PBDEs could be occurring in the human body within the region. Blood samples were collected from the two e-waste recycling sites and presented dual body burdens of PCBs and PBDEs at high levels. It is suggested that dual burdens of PCBs and PBDEs at such high levels pose health risk for local residents. This raises concerns about human health risk of dual exposure in relation to developmental neurotoxicity, high cancer risk and thyroid-disrupting activities deficits (Zhao et al., 2010).

However, a major gap remains in understanding the potential impact of mixed chemical exposures and how they may interact with non-work exposure, such as cigarette smoking (ILO, 2010).

The average consumer's daily "cocktail" of chemicals has been shown to potentially disrupt hormonal systems, adversely affect reproductive functions and cause certain types of cancer (Goyens, 2011). Worryingly, due to current informal e-waste recyclers' practices, recyclers have much higher exposure than does the average consumer. Nonetheless, almost all toxicity testing of pollutants is done on a chemical-by-chemical basis and almost none of the testing involves multiple pollutants in combination. This is particularly true when the chemicals are mixed with water, exposed to sunlight in the air or dispersed within the complex chemistry of the soil (SciTechStory, 2010). If chemicals are not stored in the body, they are metabolized and excreted. This occurs mainly in the liver, but also through the skin, lungs, gut and kidneys. The products of metabolism are known as metabolites, and these can be more or less toxic than the original chemical. In fact, many of the adverse effects of chemical exposure are due to the effects of metabolites. However, the effects of metabolites' toxicity have not been sufficiently studied.

4.3 Classification and labelling of chemicals

A variety of laws are in force regarding the identification of the hazardous properties of chemicals and dissemination of information about these hazards to users around the world. This wide diversity of information can be confusing because the same chemical can have different hazard descriptions in different countries. The United Nations drew together experts from various countries to create the Globally Harmonised System of Classification and Labelling of Chemicals (GHS). Its aim is to establish, worldwide, common criteria for classifying chemicals according to their health, environmental and physical hazards, and common hazard communication requirements for labelling and safety data sheets. The GHS provides for the chemical hazard communication requirements of the work place, in the transport of dangerous goods, for consumers and regarding the environment. As such, it is a harmonized and universal technical standard that has a far-reaching impact on all national and international chemical safety regulations (ILO, 2009).

Labour and employment issues

5

In most developing countries, e-waste is viewed as a resource and income-generating opportunity. Labour is still the major driver of the informal recycling chain as it maintains the chain's low operating costs. E-waste management can generally be divided into that which takes place in the formal or informal sectors. However, one should be aware that these terms could mean different things in different contexts. This section will primarily look at employment conditions and whether an employment relationship exists in the informal e-waste recycling sector in developing countries.

According to the ILO's Employment Relationship Recommendation, 2006 (No. 198), the employment relationship is the legal link between employers and employees. It exists when a person performs work or services under certain conditions in return for remuneration. The existence of an employment relationship is the condition that determines the application of labour and social security legal provisions. It is the key point of reference for determining the nature and extent of employers' rights and obligations towards their workers (ILO, 2011a). As discussed below, in the informal e-waste recycling sector an employment relationship is often absent or sporadic. In addition, organization among e-waste recyclers differs between countries. It has been observed to be the most sophisticated in China and India, although, when an employment relationship does exist, it is often in the partly formalized refurbishing workshops or in formal enterprises.

In the informal sector, e-waste recycling is, in general, labour intensive, involves low earnings and unrecorded and unregulated work, and is often undertaken by self-employed people or family groups using rudimentary technology. The e-waste recycling system often operates as a trade value chain characterized by a hierarchy of traders, collectors, physical dismantlers and metal extractors. The chain starts from the illegal e-waste trade, or from the formal sector where obsolete electronic items are traded on the organized market and passed from one level of traders and refurbishers to another of informal recyclers. In an environment with a large number of small, informal actors handling a complex waste stream, assessing quantities of e-waste, labour and employment conditions, job and business opportunities, and risks to health and the environment is a demanding task. The information available indicates that most workers are not covered by health insurance or unemployment and pension schemes (Nordbrand, 2009).

The informal e-waste recycling sector generally employs the poor, who have little or no formal training and are marginalized within their countries. The extent of their organization varies greatly; in some countries such business activities are prohibited while in others they are authorized by the public authorities. In some countries these people operate in a legal grey zone where their activities are illegal in principle but accepted in practice (Nimpuno & Scruggs, 2011). The marginalized include social groups from ethnic or religious minorities, rural migrants and immigrants. Women and children also constitute a significant proportion of the workforce. Such groups frequently rely on informal employment for basic survival. Generally, it is found that workers only stay for a few years in the job and as soon as they are offered better jobs in other sectors they abandon e-waste recycling (Nordbrand, 2009).

CASE STUDY 3. India's informal e-waste recycling sector

India is the second most populous country in the world, with over 1 billion people, and one of the major e-waste producing and importing countries. Moreover, India is one of the fastest growing economies of the world. The growth in PC ownership per capita in India between 1993 and 2000 was about 604 per cent, compared with the world average of 181 per cent (Babu, Parande & Basha, 2007). There are no public waste service systems for municipal waste. The formal recycling sector is still small; currently there are 16 units licensed by the Central Pollution Control Board (CPCB), and most of them do only partial processing and recycling. However, while the waste sector overall is highly informal, it is also highly organized.

Informal e-waste recycling dominates the industry, accounting for about 95 per cent of all recycling (Kalra, 2004). The informal e-waste sector is well networked but unregulated. The financial flow in the sector is highly organized and the huge network of collectors, traders and recyclers make financial gain through re-use, refurbishment and recycling. The low infrastructure set-up and operational costs enable them to make profit and dominate the market. It is reported that each player in the trade value chain makes at least a 10 per cent profit. The size of the informal sector continues to grow. Informal recycling centres have tended to move away from major cities such as Delhi, Mumbai, Bangalore, Chennai and Kolkata, and are quickly spreading into smaller peripheral towns (Sinha, Mahesh, Donders & Van Breusegem, 2011).

While the majority of Indian e-waste is generated domestically, imports still account for a substantial, although decreasing, amount. About 80 per cent of imported e-waste is imported from the US and the remaining share comes mainly from the EU (Skinner, Lloyd, Dinter & Strothmann, 2010). Delhi hosts one of the major sites for e-waste recycling, in various locations (see table 2).

Delhi's status as the capital and its good transport links to all parts of the country has made it an ideal site for waste collection. As a result, there has been a large increase in the number of small units treating e-waste although, due to a recent crackdown on informal activities, only a few centres have survived in central Delhi. Activities have recently shifted to satellite towns such as Saharanpur and Meerut; however, the trade continues in the city (*Waste Management World*, 2011).

In India, the informal recycling sector employs mostly unskilled migrant labour and those from marginalized groups. Most migrants come from poorer Indian states such as Uttar Pradesh, Bihar, Orissa and West Bengal or are immigrants from neighbouring countries such as Bangladesh. Women and children also constitute a significant proportion of the workforce. Although deemed illegal by Indian authorities, the informal sector is believed to survive through local political patronage systems. Work carries on for 12–14 hours a day with workers sitting on the ground amongst piles of electronics parts. Most work is carried out with bare hands, without the use of masks, cleaning, crushing or heating the parts (Kalra, 2004). Many workers also sit cramped in unventilated rooms with inadequate lighting and no clean drinking water or toilets. Many of these workers complain of eye irritation, breathing problems and constant headaches. Most people involved in informal recycling are the urban poor with low literacy levels, and hence have very

Table 2. Delhi recycling locations (Jha, 2008; Lakshmi, 2010)

Location	Processes and components recycled
Turkman Gate	Computer and CRT breaking
Mundka	Various electrical goods
Seelampur	Various electrical goods
Shastri Park	Computer dismantling, recharging of CRTs
Loni (Ghaziabad)	Various electrical goods
Mandoli (Ghaziabad)	Various electrical goods
Mandawali	Metal recovery work
Bawana	Various electrical goods
Narela	Various electrical goods
Meerut (near Delhi)	Gold recovery
Geeta Colony	Various electrical goods
Tila Byetha (village in the outskirts)	Various electrical goods

little awareness regarding the hazards of e-waste and the recycling processes (Sinha, Mahesh, Donders & Van Breusegem, 2011).

The complexity of the e-waste flow within India is shown in figure 4. Not only does the e-waste originate from a number of different sources, but the different stakeholders involved in the value chain are also interlinked with each other. Consequently, the e-waste does not follow one set path. The green areas and flows in fig. 4 indicate the formal recycling sector, the red indicate the informal one, and the yellow stakeholders and flows are semi-formal. The status of semi-formal stakeholders depends very much on their interaction with the other stakeholders. They represent the link between the formal and informal sectors. Direct relations between the informal and formal sector occur as well, but are less common (Skinner, Lloyd, Dinter & Strothmann, 2010).

Most e-waste ends up with scrap traders and dealers who, for economic reasons, commonly transfer it on to the informal sector. The flow of e-waste follows a path involving preliminary, secondary and tertiary stages. Preliminary e-waste workers obtain e-waste from the formal organized market composed of manufacturers, importers, offices and so on. These stakeholders are mainly scrap dealers and dismantlers who have the ability to bid for and store large amounts of e-waste (Sinha, Mahesh, Donders & Van Breusegem, 2011). As they have limited interest in dismantling the e-waste, it is segregated and dismantled by secondary e-waste workers, who have limited financial capacity. Finally, tertiary e-waste workers not only dismantle and segregate the e-waste but also try to extract the valuable materials from it. While this situation describes the most common practice, there is a broad variety of other routes by which e-waste might travel. The e-waste may change hands among several of the above stakeholders and one stakeholder might be engaged with more than one activity (Skinner, Lloyd, Dinter & Strothmann, 2010).

It is commonly found that actors at the top of the chain derive the highest profits whilst the tertiary workers subsist on less than a couple of US dollars a day (Kalra, 2004). It is argued that the formalization of e-waste recycling would decrease environmental damage and increase worker welfare. In India, working conditions in the informal recycling sector are only slightly worse than in the formal sector. While waste pickers' wages are significantly lower than those of other workers in the recycling sector, in the formal sector workers and collectors earn roughly the same as each other, while workers in the informal sector may even earn more. Pickers earn approximately US$1.20, lower than the minimum wage in Delhi of about US$1.68. Attero, the only formal recycler in India to use state-of-the-art technology, pays unskilled workers 30–40 per cent above the minimum wage. This amount is comparable with wages earned in informal recycling (although discrimination and ethnic segregation hinder social advancement in the informal sector, and changes in metal prices cause fluctuations in wages). Adult male workers in the informal sector are estimated to earn almost twice as much as women and children (Skinner, Lloyd, Dinter & Strothmann, 2010).

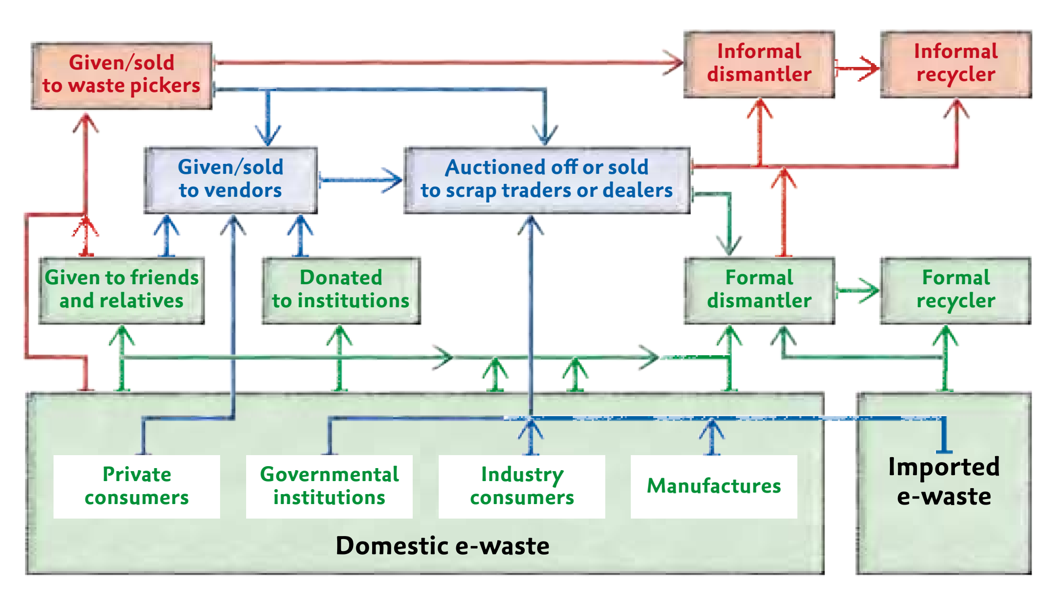

Fig. 4. E-waste flow within India (Skinner, Lloyd, Dinter & Strothmann, 2010)

CASE STUDY 4. Employment in the informal e-waste recycling sector in Ghana

In some African countries (e.g. Benin and Liberia), e-waste activities are undertaken by individuals, with low material throughput. However, Côte d'Ivoire, Nigeria and Ghana each has an organized informal sector with medium to high volumes of processed materials. The main centre for e-waste in Ghana is the Agbogbloshie metal scrap yard outside the city of Accra. It is situated by the banks of the Korle Lagoon, one of the most polluted bodies of water on earth. Most of Ghana's e-waste is imported from developed countries, disguised as secondhand electronic goods which are, however, are often dysfunctional.

It is estimated that the e-waste management sector employs about 25,000 people in Ghana and sustains about 200,000 people. Male workers dominate the sector. The refurbishing and repair sector is partially formalized. Collection, disassembly, material recovery and final disposal take place almost only in the informal sector. Informal collection of e-waste, both door to door and from warehouses and dump sites, is widespread. Informal collectors buy obsolete electronics from the end consumers at relatively low prices and bring them to the scrap yard for dismantling. It is common for collectors themselves to conduct the dismantling, or they pass on the e-waste to informal recyclers. Metals recovered from recycling are sold either to traders or directly to refinery units. While there are several aluminium remelters and electric steel plants in the city of Tema, there is no copper refinery in Ghana. Therefore, copper is exported, mostly to the Middle East via Dubai and to Asia via Hong Kong. Occasionally, foreign traders buy printed wiring boards in Ghana which are then shipped to Asian destinations (Prakash & Manhart, 2010).

E-waste recycling in Ghana is organized into abundant small and informal enterprises. Recyclers in Accra are mostly from the poor northern part of the country, a region facing chronic food insecurity. E-waste recycling has been found to be a more reliable livelihood strategy, despite severe environmental and health hazards. Most of the people employed in the e-waste recycling sector are between 14 and 40 years of age, work for 10–12 hours per day and produce 108–168 overtime hours per month. However, most of the workers do not have any fixed working hours per day or per week.

In addition, workers tend to stay in the job for a short period of time (from 3–7 years), primarily because of low income but also due to lack of employment security, hazardous working conditions and poor health. It is rare for workers in the e-waste recycling sector to have any kind of employment security or social security (they often rely on family support), as the sector does not have formalized workers' participation mechanisms. Nevertheless, some informal collective bodies exist, such as the Agbogbloshie Scrap Dealer Association.

Due to the informal nature of the e-waste recycling sector, official figures on income are not available. However, most of the people employed in e-waste refurbishing and recycling continue to live in extreme poverty as most are remunerated on the basis of output generated per day. Monthly incomes of collectors are estimated to be US$70–140, of refurbishers US$190–250, and of recyclers US$175–285. Collectors represent the most vulnerable group because of their low incomes, which could fall further if regular supply or collection of e-waste is hindered. It is also common for refurbishing enterprises to employ interns for certain tasks ranging from learning and conducting technical work to typical household tasks. Commonly, interns are not provided with any remuneration. It has also been confirmed that children, mostly boys, are employed on e-waste sites. Children are generally self-employed, rarely work for any superior and earn, on average, less than US$20 per month (op. cit.).

5.1 Formalization of the informal e-waste recycling sector

The formalization of the informal e-waste recycling sector into a transparent system is crucial in order better to control its environmental and human health impacts. At the same time, the formalization process should take into account the informal sector's extensive reach and protect related employment. Intervention and economic support to transform and integrate the informal e-waste sector into the formal sector can present a way forward and create sustainable employment.

While formal sector facilities are arguably unable to eliminate all pollutants, they produce significantly lower impacts and have better recycling efficiency when compared with the informal sector. Therefore it can be argued that the prevalence of formal facilities in the recycling sector is highly desirable. However, experience shows that it can be highly counterproductive to establish new formal waste recycling systems without taking into account the informal systems that already exist. The current preferred option is to integrate the informal sector into waste management planning, building on its practices and experience, while working to improve methods and the living and working conditions of those involved. It is found that less organized recyclers in the informal recycling sector are more vulnerable to exploitation from intermediate dealers. Small enterprises involving groups of up to 10 or 20 people, operating with low capital investment, can induce many positive effects.

Organizing informal recyclers into small enterprises is a very effective way to upgrade their recycling business and practices (Wilson, Velis & Cheeseman, 2006). Identified building blocks for formalization include facilitating the formation of collectives, capacity building, development of appropriate legal frameworks and elaboration of applicable business structures, together with appropriate monitoring. The creation of an association, small business or cooperative would allow for formal registration and certification as an e-waste recycler. Too little is known of the diversity of networking amongst informal recyclers, and their distribution of tasks and financial mechanisms amongst the various stakeholders. A multi-level approach is therefore required to develop a way forward to their inclusion in the formal recycling market. Experiences and lessons learned from other formalization processes with informal sector groups can be useful, for instance, in the development of an adequate means of forming and registering associations, and professionalizing their businesses.

Due to the limited access of the informal sector to financial resources, financial incentives need to be considered to allow informal sector stakeholders to formalize the financing/investment process and improve its practices. Specific allocation of funds for environmental surveillance and evolving public–private partnership (PPP) model-based systems could be introduced. Additionally, financial aid or access to credit, incentives, subsidies and insurance schemes are further measures that may need to be made available.

One of the best methods to improve recycling practices is to offer incentives to those complying with environmental and health norms (Raghupathy, Krüger, Chaturvedi, Arora, Henzler, 2010). Access to finance is crucial to continuation of the formalization process; indeed, access to credit and financial gain should be one important outcome. The most likely sources of finance for e-waste recyclers identified to date include private investment and local credit mechanisms such as microfinance schemes, although little work has yet been done to evaluate experience with such schemes. In general, successful formalization strategies tend to incorporate simple approaches and implementation efforts, and foster positive economic conditions for workers and local communities.

CASE STUDY 5. China's e-waste recycling sector: The challenges of formalization

The thriving state of China's informal e-waste recycling sector is mainly due to supplies being brought in by illegal importation, individual domestic collection, low treatment costs maintained by applying simple methods, highly specified dismantling processes which maximize materials recovery, and steady downstream demands which ensure the purchase of the majority of products from informal workshops (Chi, 2011). In addition, China's growing appliance manufacturing sector requires large amounts of raw materials and components, and recycled materials are regarded more favourably than they are in Europe or North America (Hicks, Dietmar & Eugsterb, 2005). Several legal, economic and social factors support the current pattern of recycling in China, such as the big disparity between rural and urban China in terms of income and living standard. For instance, an electronic appliance that is obsolete but not yet designated waste can still find a user in a rural area. The growing rural demand for electronics, together with the shortened urban lifespan of these products, stimulates the collection and movement of secondhand electronic appliances from urban to rural areas. In China, the task of waste collection is undertaken by young and old of both sexes, both the urban poor and rural migrants.

Informal collectors often remove e-waste from the waste stream before the formal recycling companies can obtain it, and divert it to informal processing workshops in poorer regions of China. As a result, formal recyclers can scarcely afford competitive prices for obsolete electronic equipment since the costs for collection and treatment often exceed the income gained from materials recovery. The low profitability of formal recyclers further limits their ability to compete with informal collectors whose rudimentary techniques "squeeze" formal operators out of the market (Chi, 2011). Therefore, modern recycling and treatment facilities still rely on government co-financing and preferential policies (Hicks, Dietmar & Eugsterb, 2005).

In 2005, Nokia and Motorola jointly initiated the Green Box programme with China Mobile to collect consumer's obsolete cellphones and accessories in 40 cities across China. Another six cellphone producers, including LG, Lenovo and NEC, joined the programme in 2006, making it one of the most influential e-waste take-back programmes in China. However, these government pilot projects and producers' take-back programmes have not, as yet, seen any success, being unable to compete with the informal sector, most notably in collecting e-waste and covering the costs of processing (Chi, 2011). Consumers' habits are another factor in support of informal recycling. Chinese citizens traditionally regard their obsolete electronic appliances as valuable goods and would prefer to sell them rather than pay for their treatment as waste. About 60 per cent of generated e-waste is passed into informal recycling processes, and more than 90 per cent of Chinese citizens are reluctant to pay for the recycling of their e-waste (Liu, Tanaka & Matsui, 2006).

China's key e-waste recycling centres are shown in figure 5.

There is a noticeable increase in domestic and foreign investment in e-waste recycling in China, accompanied by encouraged transfer of international recycling technologies and western waste management principles (Chi, 2011).

The informal recycling chain must, therefore, be thoroughly investigated, and technical and safety improvements researched in order to obtain better environmental, health and safety performance without sacrificing the economic and social benefits the sector currently offers to the local community. More information and discussion is urgently needed, especially concerning the structure and organization of the informal recycling industry, production procedures and product outflows, market relations between stakeholders, and the links between the formal and informal sectors throughout the recycling chains. Key issues for China's e-waste management strategy are introducing incentives for informal recyclers to reduce improper recycling activities and diverting more e-waste flow into the formal recycling sector network (op. cit.).

China has new investments in the e-waste recycling industry and registered formal recy-

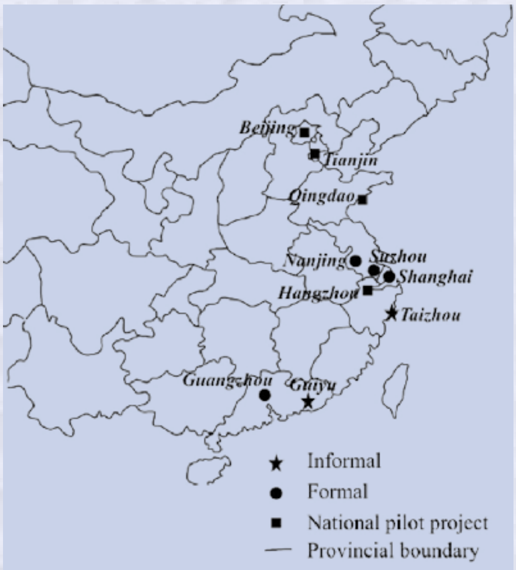

Fig. 5. E- recycling centres in China (Chi, 2011)

clers, whose treatment facilities, environmental standards and recycling efficiencies vary. These facilities are now present in regions dense with electronics manufacturing, such as Beijing, Tianjin, Shanghai, Jiangsu Province and Guangdong Province. In parallel with construction of private recycling plants, four national pilot projects (Hangzhou Dadi, Beijing Huaxing, Qingdao Haier and Tianjin Datong) were launched in 2004 in order to gain practical experience in collection network design, e-waste management standards, regulations and recycling technologies. In general, the Chinese Government assigns the main management responsibility to local governments (op. cit.).

Local government intervention in Guiyu

The town of Guiyu is located in the Chaoyang District, Shantou City, in Guangdong Province in south-east China. Guiyu occupies a total area of 52 km² and has a population of 150,000. Since 1995, the traditionally rice-growing community of Guiyu has turned into an intensive informal e-waste recycling centre, probably the largest in the world. Over 75 per cent of the 300 individual workshops are involved in the recycling of e-waste, with nearly 100,000 migrant labourers fuelling the business. Those engaged on dismantling and processing e-waste earn an average wage equivalent of US$1.50 per day. About 150 million tons of electronic components are being recycled with an output value of nearly 1.56 billion yuan (CNY), accounting for more than 90 per cent of the town's industrial output value (Wong et al., 2007). Valuable parts are sold to big electronics centres in neighbouring cities such as Shenzhen. Iron, copper and aluminium fractions are supplied to metal refineries, and shredded plastics are locally recycled to low or medium grade and offered cheaply to toy manufacturers in nearby Shantou city (Chi, 2011).

Guiyu is infamous among researchers and NGOs, who have observed many health effects in relation to the rudimentary recycling techniques (Sepúlveda et al., 2010). A study by the Medical Sciences College of Shantou University revealed that 88 per cent of Guiyu's e-waste workers suffered from skin diseases or had developed neurological, respiratory or digestive ailments. Another aspect of particular concern is the presence of children in the workplace, both as dependants and as workers. Reports from Guiyu make frequent mention of young mothers sifting through toxic refuse dumps for salvageable materials with babies strapped to their backs (China Labour Bulletin, 2005). Soil contamination is particularly important in Guiyu, where rice is still cultivated. High concentrations of PBDEs in Guiyu rice field soils indicate that, as these compounds are persistent in soils and vegetation, slow uptake may be occurring over extended timescales. In addition, besides the direct impact of dioxins and furans on the human population and the environment of Guiyu, there is evidence of transport of dioxins and furans from the e-recycling site of Guiyu to the nearby area of Chendian (Sepúlveda et al., 2010). Under pressure from media and superior environmental bureaus, notable efforts have been made by the local authorities to close down dismantling workshops and illegal recovery sites.

Guiyu local government authorities have also taken many other measures, such as the remediation of environmental pollution, planning and construction of landfill and strong improvement in infrastructure. However, it did not take long for local authorities to recognize that banning informal recycling is very challenging, as its household production approach, with barely any requirement for labour skills and facilities, means the whole recycling operation is highly relocatable. While the economic stimulus which drives the business of informal recycling persists, mandatory removal merely resulted in either a change in the site of operations or a shift in the time of operation from day to night.

In summary, authorities have often found it difficult to achieve the objective of banning informal recycling through radical government interventions aimed at the enforced removal of operations. Guiyu's experiences have already challenged how enforceable and effective regulations can be in controlling or formalizing informal e-waste recycling. Providing incentives, through approaches such as offering fixed prices for certain e-waste types, may help to divert some e-waste flows from the informal to formal sector, but unless the incentive system offers prices equal to or higher than the profits accrued by current processing operations, the informal recyclers will not deliver e-waste to official collection spots. Then the question arises of how to afford such a price system in the long run when the formal treatment of collected e-waste may not be able to generate sufficient profit.

China has recently taken the approach of a policy of accommodation, often through setting up an industrial park. The focus is on concentrating scattered individual recycling activities and improving treatment processes through central management of production and pollution control. Industrial recycling parks with impressive treatment capacities have been established, for example, in Tianjin, Taicang, Ningbo, Taizhou and Zhangzhou. In these parks most of the recycling work is still done by manual dismantling. However, legal prohibition of a local industry must be sensitive towards the resulting social impacts. Training courses which ensure job security, occupational safety and skill improvement for informal workers are invaluable in this context (Chi, 2011).


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International, regional and national regulatory frameworks

6

In the context of increasing globalization, concerns over the environmental impacts of international trade are mounting. One particularly controversial issue, discussed in section 2, is the international trade in hazardous wastes, including e-waste, causing damage to both the environment and human health. A range of legislation tries to control the transboundary movements of hazardous substances.

The international conventions seeking to control the shipping of waste are the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989), Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998) and Stockholm Convention on Persistent Organic Pollutants (2001). Subsequent to these, various regional conventions have been signed to regulate hazardous waste movements. Complementing international and regional conventions, international organizations also have an important role to play, for example, in monitoring the transport of toxic substances and running programmes to reduce the impact of e-waste on human health and the environment. This section introduces the three international legal instruments regulating the transboundary movements of hazardous substances, then discusses regional and national legislation. Related ILO labour standards are discussed in section 9.

6.1 Multi-lateral environmental agreements

6.1.1 The Basel Convention

The Basel Convention controls the transboundary movement of hazardous wastes and their disposal, and is the most significant multilateral environmental agreement (MEA) in relation to tackling the issues surrounding e-waste and its management. As of September 2010, the Convention had 178 signatories (Basel Convention, n.d.(b)). However, the US, a major actor, has not ratified it.

The Convention largely relates to trade measures, although it includes several non-trade measures. It presents four main aims related to the waste hierarchy of prevention, reduction, recovery and final disposal. Thus it attempts: first, to reduce hazardous waste generation at its source; second, to promote and ensure the environmentally sound management (ESM) of hazardous waste; third, to promote the proximity principle, advocating disposal as close to the source as possible; and fourth, to regulate and monitor the remaining transboundary movements of hazardous waste.

With regard to those hazardous materials deemed to require transboundary movement, the Basel Convention imposes a series of trade restrictions as set out by the aim of regulating and monitoring. Provided no outright ban on hazardous wastes has been implemented by the importing country, wastes may only be exported should the exporting state lack ESM capacity or should the wastes be destined for recycling and recovery operations. Should all these criteria be met, the hazardous waste shipment must undergo the prior informed consent (PIC) procedure. Under Article 6 of the Convention, this system requires exporters to notify the destination country, as well as any intermediary countries, of its intent to conduct trade in hazardous waste, through a notification of consent prior to the transboundary movement.

The Basel Convention also provides for the development of tools and training activities through the Green Customs Initiative (GCI), to assist Parties to enforce the Convention and to combat illegal traffic. This initiative also involves the secretariats of the relevant MEAs with trade-related components involving hazardous chemicals and wastes (Basel, Rotterdam, and Stockholm Conventions, and the Montreal Protocol on Substances that Deplete the Ozone Layer), endangered species (Convention on International Trade in Endangered Species of Wild Fauna and Flora, CITES) and biosafety (Cartagena Protocol on Biosafety to the Convention on Biological Diversity). The partnership also includes INTERPOL, the Organization for the Prohibition of Chemical Weapons (OPCW), United Nations Environment Programme (UNEP), United Nations Office on Drugs and Crime (UNODC) and World Customs Organization (WCO).

The Third Conference of the Parties (COP3) in 1995 adopted the "BAN Amendment" or "Basel BAN", the Decision to ban shipment of hazardous wastes from OECD to non-OECD countries for the purposes of final disposal. It was adopted on the grounds that exports to developing countries were unlikely to undergo ESM. However, for many years there were few signatories to the BAN Amendment and it has therefore not come into force (op. cit.]). In October 2011, during COP 10, all 178 Parties agreed to allow an early entry into force of the BAN Amendment, a major breakthrough decision (BAN, 2011).

In 2006, COP8 adopted the Nairobi ministerial declaration on the environmentally sound management of electronic and electrical waste, and called for urgent global action on e-waste with the aim to "create innovative solutions through the Basel Convention for the environmentally sound management of e-waste" (UNEP, 2006). This also provides the mandate for a roadmap for future strategic action on e-waste.

6.1.2 The Rotterdam Convention

The Rotterdam Convention promotes shared responsibility between exporting and importing countries in protecting human health and the environment, and provides for the exchange of information about potentially hazardous chemicals that may be exported and imported. The Convention creates legally binding obligations for the implementation of the PIC procedure. The Rotterdam Convention covers pesticides and industrial chemicals that have been banned or severely controlled by Parties (Rotterdam Convention, n.d.).

6.1.3 The Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants was adopted in 2001 and entered into force in 2004. The Convention requires Parties to take measures to eliminate or reduce the release of POPs into the environment (Bell & McGillivray, 2006). E-waste contains many chemicals classified as POPs. The Convention aims to protect human health and the environment from chemicals that remain persistent in the environment for long periods, are distributed globally and accumulate in the fatty tissue of humans and animals. There are three identified categories of POPs: pesticides, industrial chemicals and unintentionally produced by-products. To date, 176 countries are Parties to the Convention (Stockholm Convention, n.d.).

6.1.4 Synergies among the Basel, Rotterdam and Stockholm conventions

A major disadvantage of most MEAs is that they are designed to protect one particular medium without addressing others, which leads to inconsistencies. Proliferation and diversification of MEAs should be avoided as there is a risk of treaty congestion, overlaps and conflicts (Beyerlin, 2002). The Synergies Decision among the three chemicals conventions is, in part, a response to this issue. Synergy will promote a life-cycle approach to chemicals management as each convention targets different stages of the chemicals life cycle. The overarching aim of the Synergies Decision is to develop programmatic cooperation and support for the implementation of the three conventions in areas of common concern, such as e-waste. Currently under discussion is the potential inclusion of SAICM and the upcoming Minamata Convention (*Synergies among the Basel, Stockholm and Rotterdam Conventions*, n.d.).

6.1.5 A global instrument on mercury under negotiation

The decision to prepare a global, legally binding instrument on mercury was taken by the UNEP Governing Council in February 2009. It called for immediate action to protect human health and the environment from releases of mercury and its compounds, facilitated by technical assistance and capacity building. An intergovernmental negotiating committee (INC) was established and is expected to complete its work by 2013. The INC is mandated to reduce the supply of mercury, enhance capacity for environmentally sound storage, reduce demand in products and processes such as electronics, international trade and atmospheric emissions, address mercury-containing waste and address compliance (UNEP, n.d.).

6.1.6 The Montreal Protocol

The Montreal Protocol on Substances that Deplete the Ozone Layer entered into force in 1987 with the objective of protecting the ozone layer from chemicals destroying it. Ninety-six chemicals are currently controlled by the Montreal Protocol (UNEP, Ozone Secretariat, n.d.). These chemicals are commonly found in articles such as old fridges.

6.1.7 The Strategic Approach to International Chemicals Management

SAICM is an international policy framework to promote chemical safety with the overall objective of achieving sound management of chemicals throughout their life cycle. The goal is that, by 2020, chemicals are produced and used in ways which minimize significant adverse impacts on human health and the environment. Objectives are grouped under five themes: risk reduction, knowledge and information, governance, capacity building, technical cooperation and illegal international traffic. SAICM has a multi-stakeholder and multi-sectoral character and emphasizes chemical safety as a sustainability issue (SAICM, 2009). Furthermore, the second international conference on chemicals management, ICCM2, agreed to initiate a project on chemicals in products, one being electronics (Nimpuno & Scruggs, 2011).

6.1.8 The London Guidelines for the Exchange of Information on Chemicals in International Trade

The London Guidelines (1989) aim to assist governments in the process of increasing chemical safety in all countries through the exchange of information on chemicals in international trade. They aim to enhance the sound management of chemicals through the exchange of scientific, technical, economic and legal information, and assist states in the process of developing future instruments (UNEP, 1989).

6.1.9 The Code of Ethics on the International Trade in Chemicals

The Code of Ethics on the International Trade in Chemicals (1994) complements the London Guidelines. It addresses industry and other private sector parties in all countries with the aim of setting out the principles, guidance and governing standards of conduct for the promotion of ESM of chemicals in international trade. Through the implementation of this code, the private sector parties are expected to enter into voluntary commitment (UNEP, 1994).

6.2 Regional legislation

Article 11 of the Basel Convention allows Parties to enter into bilateral, multilateral or regional agreements regarding transboundary movements of hazardous waste. Thus, three regions – Africa, the EU and the South Pacific – have instituted agreements concerning such movements of waste and, in particular, e-waste. Relevant agreements have also taken shape and come into force in Latin America.

6.2.1 Africa

The Bamako Convention

The Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa was signed in Bamako, Mali, in January 1991 and entered into force in 1998. This Convention aims to prohibit the import of all hazardous waste, for any reason, to Africa from non-contracting parties. Even parties which are not signatories to the Basel Convention are prohibited from exporting e-waste to Africa.

The Convention was implemented in order to impose a stronger message about trade in hazardous waste and management within Africa (Tutu, n.d.). However, enforcement remains a challenge because of the lack of adequate and predictable resources. Moreover, the extent to which the instrument has been streamlined within national legislation has not been formally documented and there is a need for stronger cross-border cooperation (Munyua, 2010). According to the African Union, in 2010, 24 of the 52 countries which form the African Union have ratified the Bamako Convention (African Union, 2010).

The Durban Declaration

The 2008 Durban Declaration on e-Waste Management in Africa followed the 2006 Nairobi ministerial declaration on e-waste developed from COP8 of the Basel Convention. It requires countries to follow their own process to define their responses and formulate actions in relation to the e-waste problem (Marriott, 2011). It calls for the establishment of an African regional platform and/or an e-waste forum in cooperation with established African networks and international bodies. It requires countries to review existing legislation, improve compliance with existing legislation and amend existing waste management legislation to allow for regulation of e-waste management (Durban Declaration, 2008). As a result, several African countries are in the process of drawing up policies regarding e-waste. Nevertheless, policies centering on banning or regulating imports or practices such as open burning have so far been weakly enforced (Marriott, 2011).

The Libreville Declaration

The Libreville Declaration on Health and Environment in Africa recognizes that there is a need for further research and policies to increase understanding of the vulnerability of humans to environmental risk factors, particularly in Africa. Risk factors identified in relation to e-waste are chemicals, poor waste management practices and new toxic substances (WHO Regional Office for Africa, 2009).

6.3.2 European Union

The Aarhus Convention

The Aarhus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, which links environmental rights with human rights, entered into force in 2001. It acknowledges that we owe an obligation to future generations and that sustainable development can only be achieved through the involvement of all stakeholders. The Convention grants rights to the public and imposes on Parties and public authorities obligations regarding access to information, public participation and justice. Under the Convention, the Aarhus Protocol on Heavy Metals was one of eight protocols intended to address air quality issues within the EU (United Nations Economic Commission for Europe, 2011).

The Waste Electrical and Electronic Equipment (WEEE) Directive

The WEEE Directive of the European Parliament and of the Council (2002/96/EC) entered into force in 2003. The aim of the legislation is the prevention of e-waste generation, and to promote the reuse, recycling and other forms of recovery of such waste so as to reduce disposal. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment and, in particular, those operators directly involved in the treatment of e-waste (European Commission, n.d.(a)). It is based on the principle of producer responsibility and promotes the green design and production of electronic products. It includes separate collection of e-waste, and the use of best available treatment, recovery and recycling techniques, and makes producers responsible for financing the take-back and management of e-waste (Dickenson, n.d.). The global electrical and electronics industry has come under increasing pressure to adopt EPR policies because of the European Directives (Yu, Welford & Hills, 2006).

However, despite extensive legislation targeting the e-waste problem, experience in the first few years of implementation of the WEEE Directive has shown that it is facing difficulties. Less than half of the collected e-waste is currently treated and reported according to the Directive's requirements. The prevalence of loopholes and difficulties in enforcement have reduced the effectiveness of the EU legislation. It has been found that, of the vast majority of e-waste, 67 per cent is completely unaccounted for, being either landfilled or destined for illegal export to developing countries (ComputerAid International, 2010). In addition, the collection target of 4 kg per person per year does not properly reflect the amount and growth of e-waste arising in EU Member States. As a response to these unsatisfactory outcomes, the European Commission started revising the Directives in 2008 with the aim of increasing the amount of e-waste that is appropriately treated and reducing the volume that goes to disposal. Another overall aim is to better control the illegal trade of e-waste. The proposals also aim to reduce administrative burdens and ensure coherence with newer policies and legislation such as the new legislative framework for the marketing of products. The new proposals set a mandatory collection target equal to 65 per cent of the average weight of e-waste placed on the market over the two previous years in each Member State. As a result, Member States with a high consumption of electronic equipment would have more ambitious collection targets. Overall, the objective of the proposed directives is to develop a better regulatory environment – one that is simple, understandable, effective and enforceable (European Commission, n.d.(a)). On 7 June 2012, the EC adopted a directive that both increases the amount of e-waste which must be collected annually by member states and establishes producer responsibility. In addition, the scope of the legislation was widened so as to cover all e-waste in principle.

The RoHS Directive

The Restricting the Use of Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive (2002/95/EC) has been in force since 2003. Its purpose is to restrict the use of hazardous substances in electrical and electronic equipment and contribute to the protection of human health and the environmentally sound recovery and disposal of e-waste (European Commission, n.d. (b)).

REACH

The Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) entered into force in 2007 with the main aim of ensuring a high level of protection of human health and the environment from the risks that can be posed by chemicals. REACH makes industry responsible for assessing and managing the risks posed by chemicals and providing appropriate safety information to their users (European Commission, n.d.(c)).

The EU Waste Framework Directive

The overall aim of the EU Waste Framework Directive of 2008 (Directive EU2008/98/EC) is that the EU become self-sufficient in waste disposal capacity (European Environment Agency, 2009).

6.2.3 Latin America

Most countries of Latin America still lag behind in drafting a legal framework for e-waste management. However, there have been some recent developments, for example in Costa Rica, the first country in the region to develop specific, national e-waste legislation. In terms of regional agreements, the Mercosur Policy Agreement of 2006 mandates its member states, Argentina, Paraguay, Uruguay and Brazil, to take national actions to ensure post-consumer responsibility by producers and importers. It is an attempt to introduce the concept of EPR as an environmental policy principle. In addition, the Organization of American States (OAS), at its conference in Santo Domingo in 2006, declared its readiness to prevent and mitigate negative effects associated with the use of ICT throughout the whole product life cycle. A regional platform for the management of waste from computers in Latin America and the Caribbean has recently been developed in partnership with the Swiss Government (Boeni, Silva & Ott, 2008). In addition, the Central American Integration System (SICA) is developing a model waste law discussing possible common hazardous wastes rules for Central America, possibly including e-waste (Ripley, 2009).

6.2.4 South Pacific

The Waigani Convention

The Waigani Convention bans the importation of hazardous and radioactive waste and controls the transboundary movements and management of hazardous waste within the South Pacific region. It was signed in September 1995 and entered into force in 2001. Its objectives are to prohibit the importation of hazardous wastes into Pacific Island Developing Parties and to regulate and facilitate the ESM of such waste generated within the convention area, which covers the territories of the 24 Pacific Islands Forum countries. As of June 2008, there were 13 Parties to the Convention. Other countries (including the Marshall Islands, France, the UK and the US) can be added to the Pacific Islands Forum through an instrument of accession deposited with the Secretary-General of the South Pacific Secretariat; however; they have not yet done so. Electronic and electrical waste is included in Annex A of the Convention which lists hazardous waste, although there is no specific reference made to e-waste. However, Annex A does include waste having constituents such as cadmium and lead compounds (Secretariat of the Pacific Regional Environment Programme, 2008).

6.3 National legislation in selected countries

The definition and legislation of e-waste varies considerably between countries. It is usual for each country to establish its own legal definition and have a range of uses and interpretations. Among the general challenges this presents are the limited capacity and capability of responsible institutions, poor implementation of legal instruments, poor participation among stakeholders, and a lack of specific definition, legal instrument, policy or strategy. Discussion of selected countries' national legislation follows.

6.3.1 Ghana

Ghana has ratified the Basel Convention, the BAN Amendment and the Bamako Convention. As at July 2011, the Government of Ghana is finalizing the Electronic Waste (Disposal and Recycling) Regulations which will control the importation of e-waste (*Ghana Business News*, 2011). The Regulations will require importers of e-waste to pay an e-waste recycling fee on importation. A complete ban on the importation of electronics more than five years old is also being considered (Marriott, 2011). Non-compliance is subject to a fine, with the revenue invested in an e-waste recycling trust fund. Other measures include the designation of disposal assembly points and a code of conduct for the safe disposal of e-waste (Basel Convention. n.d.(a)). Despite these recent actions, the country is increasingly becoming a major destination for e-waste and is also one of the top sources of cyber crime in the world. The risk of identity theft is increasing as is the loss of intellectual property (Mvo Platform & Good-Electronics, 2009).

6.3.2 India

India has ratified the Basel Convention but not the BAN Amendment, and officially opposes its enforcement (BAN, 2011). In addition, despite a wide range of environmental legislation in India, there are no specific laws or guidelines for e-waste. The regulations banning the importation of hazardous waste for disposal are weak and imported e-waste still finds its way into the country (Montrose, 2011). The first comprehensive environmental law was the Environment (Protection) Act, which was enacted in 1986, after the Bhopal gas tragedy (Kalra, 2004).

The Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008, do apply to e-waste but deal primarily with industrial waste and lack elements to deal with the complexities of e-waste. The Rules are recognized as being inadequate. In addition, their lack of clarity and ambiguity makes their application impossible and encourages malpractice. In 2007, separate guidelines on e-waste management were implemented, but they were voluntary and had limited impact. As a result, many stakeholders draw attention to the need for a separate regulatory framework for e-waste (Sinha, Mahesh, Donders & Van Breusegem, 2011). Furthermore, although various laws regulating areas such as importation, the environment, labour and factories could have an impact upon e-waste in India, virtually none apply to the informal sector. The provision of environmental protection is delegated among India's various states, also, and this is known to give rise to lax enforcement. For instance, although the central government claims that no mandatory clearance has been given to any importer of e-waste, e-waste is regularly being imported through ports and passing through customs (Smith, Sonnenfeld & Naguib Pellow, 2006). In addition to a lack of funds and government capacity for enforcement, this situation also originates in low awareness of issues, low literacy levels, poverty, highly bureaucratic structures and attitudinal issues (Sinha, Mahesh, Donders & Van Breusegem, 2011). As a result, India may become a more popular spot for the e-waste trade in the future.

The absence of specific legislation is one of the biggest stumbling blocks in India.[1] A task force on e-waste was established with the aim of proposing new legislation (Finlay, 2005), and the Government announced on 4 October 2010 that the new e-waste legislation would enter into force on 1 *May* 2012. New rules call for the registration of all those dealing with e-waste, irrespective of whether they are in the informal or formal sector. The legislation also imposes provisions for EPR and the reduction of hazardous substances (based on the European Commission's RoHS Directive). It further provides the possibility of achieving formalization of informal sector stakeholders (Raghupathy, Krüger, Chaturvedi, Arora, Henzler, 2010).

1. Related national legislation includes: Hazardous Wastes (Management and Handling) Amendment Rules (1989), Control of Industrial Major Accident Hazards Rules (1990), Manufacture, Storage and Import of Hazardous Chemicals Rules (1989, with Corrigendium, in 1990) (available: http://www.ilo.org/safework/info/WCMS_112575/lang--en/index.htm).

6.3.3 Mexico

Mexico generates a high volume of e-waste per capita and there is growing concern regarding its management, particularly since a national inventory of e-waste generation in 2006 (Gavilan-Garcia, Román-Moguel, Almada-Calvo & Aburto-Mejía, 2009). Waste collection systems have been required by law since 2006, but there is a lack of infrastructure. Framework legislation also exists but with little enforcement, and landfills are still the main disposal option (Gonzalez Llera, 2004). E-waste recycling companies do exist but the majority limit their operations to disassembly of equipment, recovery of useful parts, and the grinding and separation of materials. As a result, national recycling activity focuses on reprocessing of plastic, glass and copper, while valuable material is sent abroad for the recovery of precious metals.

The Mexican General Law on the Prevention and Integral Management of Wastes (LGPGIR) defines electronic waste, although it is not considered hazardous (Gavilan-Garcia, Román-Moguel, Almada-Calvo & Aburto-Mejía, 2009). The general waste law requires industry to submit an "environmental management plan system" for certain "technological waste", including electronics. Several states have proposed new waste chapters to their framework environmental law to include "special wastes" such as e-waste. Responsibility for product take-back is currently allocated to the municipalities. However, Mexican municipalities have neither the legal infrastructure nor the economic or human means to address the mounting waste problem.

On the other hand, Mexico has ratified the Basel Convention. UNEP cited Mexico as a country with great potential to introduce state-of-the-art e-waste recycling technologies because of its small informal e-waste sector (Schluep et al., 2009). In 2006, in cooperation with the US State of California, one of the few state-of-the-art electronic recycling facilities in Latin America was installed in Monterrey, the first major electronic recycling operation in Mexico (BusinessWire, 2006).

6.3.4 Nigeria

Nigeria has ratified the Basel Convention, the BAN Amendment and the Bamako Convention (Wanjiku, 2008). The National Environmental (Electrical Electronics Sector) Regulations and the Harmful Waste (Special Criminal Provisions) Act entered into force in 2011. The law restricts the import of hazardous wastes for final disposal in the country (Lagos State Environmental Protection Agency, 2011). In addition, a multi-stakeholder Consultative Committee on e-waste has been established to prepare national policy guidelines on e-waste management and an action plan. The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established in 2007 to enforce all environmental laws, regulations and guidelines, including monitoring and control of e-waste (Benebo, 2009). The National Toxic Dump Watch Programme (NTCWP) has recently been reactivated. It requires importers of e-waste to be registered with NESREA (Lagos State Environmental Protection Agency, 2011).

Overall, control of e-waste in Nigeria is inadequate. There has been insufficient enforcement of environmental laws and difficulties in implementing EPR and producer take-back, together with a general lack of awareness and funds. With no material recovery facility for e-waste and/or appropriate solid waste management infrastructure in place, waste materials often end up in open dumps and unlined landfills (Wanjiku, 2008).

6.3.5 People's Republic of China

China has ratified both the Basel Convention and its BAN Amendment. However, the situation is grave in China due to widespread illegal activity. There is no lack of laws and regulations[2] but, unfortunately, they are very often enacted without adequate resources allocated for enforcement. The Ministry of Environmental Protection (MEP) is designated as the competent authority to supervise and administer the prevention and control of pollution caused by e-waste (Ni & Zeng, 2009).

The Regulations for the Administration of the Recovery and Disposal of Electronic Waste (2011) require any disposal of e-waste to comply with State requirements for comprehensive resource utilization, environmental protection, labour safety and safeguarding of human health. It is required that e-waste is sent to a government-authorized facility for processing before being recycled. Imported e-waste must comply with regulations on pollution control information and hazardous or toxic content should be provided. Illegal activities are fined, and both manufacturers and importers shall contribute to a fund for the recovery and disposal of e-waste (People's Republic of China. State Council. 2009). The informal sector has not yet been included in the legislative framework, and the effectiveness of available regulations on informal recyclers seems to be rather weak. China should take the informal sector into account, as informal recycling operations are strong, pervasive and influence the pattern of e-waste recycling in the country. How the funding programme will work remains to be seen, especially considering the fact that some crucial points of the regulation such as product coverage, financing mechanisms and ministerial responsibilities are yet to be specified (Chi, 2011).

The Measures for the Administration of Prevention and Treatment of Pollution by Electronic Information Products (China RoHS) (2006) limits six hazardous substances in the production of electronics – lead, mercury, hexavalent chromium, cadmium, polybrominated biphenyl flame retardants and polybrominated diphenyl ether flame retardants – and promotes green product design, mandatory labelling, and provision of information on components, hazardous substances and recycling (People's Republic of China. State Council. 2009).

The Ban on Importation of Electronic Waste (2000) includes scrap computers, panel displays and kinescopes, and is updated annually (op. cit.). The Environmental Protection Law (1989) introduced principles for pollution control and prevention, and the "polluter-pays" principle. The Clean Production Promotion Law (2003) introduced "producer responsibility" to encourage eco-design and life-cycle approaches. The Law on the Prevention of Environmental Pollution from Solid Waste (1995) places responsibility on producers, retailers, importers and consumers, and introduces the "3Rs": reduction, recycling and reuse.

A number of local administrative measures have also been introduced in major regions such as Beijing, Shanghai, Nanjing and Guangdong Province to regulate the behaviour of enterprises, dealers and customers, and to build the local system of e-waste take-back, reuse and recycling (Chi, 2011).

2. For related national labour laws, see: http://www.ilo.org/safework/info/WCMS_112575/lang--en/index.htm.

6.3.6 Serbia

In Serbia, waste management infrastructure is seriously underdeveloped, with few regulated landfills. Large amounts of e-waste are being stored in warehouses and homes. There is also an active informal sector, consisting mainly of disadvantaged people such as the Roma (Tosic, 2010). In general, collectors have low interest in e-waste due to its complexity and the lack of potential buyers; as a result, their top priorities include paper, plastic and scrap metals. However, there are highly unorganized, informal e-waste recyclers who use rudimentary techniques such as burning cables to extract copper. These practices are unregulated, with no employment contracts (Balkan e-Waste Management Advocacy Network, 2010).

In Serbian law, e-waste is categorized as special waste, and hence, hazardous. The National Law on Waste Management was passed in 2009 (the country had banned the importation of used electronic equipment in 2003) (Tosic, 2010). In addition, the Law on Environmental Protection, 1991, applies to e-waste. However, lack of resources has resulted in inadequate monitoring and minimal awareness in society. These laws were revised in 2010, with the goal of harmonizing them with EU legislation (Stankovic, 2011).

6.3.7 Sweden

In Sweden, almost 17 kg of e-waste is collected per person per year, making the country the second best in the world (after Norway) at collecting e-waste. A culture of producer responsibility for hazardous waste has been present for several years and, for electronic products, since 2001 (WEEE, n.d.). During 2001, a cooperative programme between producers and local authorities, named Elretur, was initiated. Local authorities manage and fund information, outreach and collection points, whereas producers fund transportation, treatment and recycling. This cooperation has been considered a success (Elretur, 2010).

In 2005, the National Ordinance on Producer Responsibility for Electrical and Electronic Equipment was enforced (WEEE, n.d.). The main requirements under the Swedish WEEE legislation are that producers must register and submit information to the Swedish EPA, finance the collection, recovery and recycling of e-waste, and label new electronic equipment put onto the Swedish market. In addition, a fine may be imposed on any stakeholder who fails to fulfil obligations. The success of the Swedish system is mainly due to successful dialogue over a long time between municipalities and producers, to grassroot organizations, recycling centres and the Swedish waste culture, with households' high awareness of waste sorting. On the other hand, challenges have been identified, including information availability, collection of small electric waste, collection in blocks of flats and small businesses, collection points at points of production, labelling and follow-up, harmonized treatment requirements, additional contacts between producers and recyclers, and tracking the illegal trade (Swedish Environmental Protection Agency, 2009).

6.3.8 United States

The US is one of the few countries that are not signatories to the Basel Convention. It is therefore legal to export e-waste from the US to developing countries. The US also lacks coherent and consistent federal legislation on most e-waste apart from CRT monitors. CRTs are considered hazardous because of their lead content; hence, an exporter of CRTs is required to notify the EPA of its intention to export and obtain consent from the importing country for shipment. Some states have implemented e-waste legislation, although differences between states' legislation have increased compliance costs and decreased their effectiveness. So far, 25 states have passed legislation mandating state-wide e-waste recycling using the EPR approach and banning e-waste in landfills. There are also certification systems for e-waste recyclers in place, such as the e-stewards standard which requires companies to eliminate exports of e-waste to developing countries and ban e-waste in municipal landfills or incinerators (Electronics TakeBack Coalition [ETBC], 2011). Recently, the EPA added the disposal of e-waste to its list of top priorities; however, it still allows that e-waste can be safely disposed of in municipal solid waste landfills. The EPA has also promoted the Electronic Product Environmental Assessment Tool (EPEAT), a voluntary environmental performance standard for desktop computers, notebook computers and monitors. The Agency is working towards a roadmap for developing the standard, including clearly defined categories of product recommendations, potential areas of concern, a stakeholders list, potential funding sources for future standards development and recommendations on possible implementation (Zero Waste Alliance, 2011).

In 2010, President Obama commissioned a Task Force on Electronics Stewardship to create "a national strategy for electronics stewardship, including procedures for how the agencies manage their own e-waste" (ETBC, 2011). In 2011 the

Responsible Electronic Recycling Act was proposed in the House of Representatives. It would restrict e-waste from being exported to India, China, Nigeria and other nations, and has a high chance of being passed (BAN, 2011).[3]

In summary, it is clear that adequate legislation is lacking in many countries. Insufficient enforcement and illegal activities are common problems. However, it is evident that the tightening of regulations alone will not solve these problems. Soft measures, such as financial incentives and eco-labelling, can play a role. Furthermore, regulations should be designed in conjunction with the establishment of formal recycling infrastructure (Zoeteman, Krikke & Venselaar, 2010).

3. Other relevant federal legislation includes: Toxic Substances Control Act (2000), Occupational Exposure to Lead Act (1995), Hazardous Materials Transportation Authorization Act (1994), Hazardous Waste Operations and Emergency Response Rule (1994), Hazard Communication Rule (1987), Hazardous Waste Operations and Emergency Response Rule (1991), National Environmental Education Act (1990), Hazardous Substances Rule (1990), Polychlorinated biphenyls (PCBs) – Disposal and Marking (1978) (available: http://www.ilo.org/dyn/natlex/natlex_browse.country?p_lang=en&p_country=USA).

7 Possible solutions to the complex e-waste problem

E-waste is a significant cross-cutting issue with global significance and it therefore requires cross-sectoral implementation. Many stakeholders are involved, including industry players, governments, customs authorities, regulatory agencies, intergovernmental organizations, non-governmental organizations and civil society (see Annex III). What is needed is a range of interventions, international cooperation and goal-oriented actions on e-waste.

7.1 Local solutions

Experience shows that simply prohibiting or competing with informal recyclers is not an effective solution. The future of e-waste management depends not only on the effectiveness of local government and the operators of recycling services but also on community participation, together with national, regional and global initiatives.

As discussed in section 3, informal recycling enables usually hazardous employment for thousands of people in poverty. Therefore, a first, vital step should be to attempt to address occupational risks in the sector. Most importantly, actions should be taken to mitigate existing problems at the local level (Williams, et al., 2008). In addition, workers need to be informed of the effects of e-waste processing on environmental and human health (Wang et al., 2011). Awareness-raising programmes and activities are also needed on issues related to ESM and OSH, and on how to form cooperatives and integrate into the formal sector. It has to be noted, however, that a common feature of the informal waste sector is that it consists of poor people with little or no formal education; many are illiterate. This should be kept in mind when considering the role of information and education (Nimpuno & Scruggs, 2011).

The economic stimulus driving the growth of the informal industry represents a key challenge. While there is a need to enforce appropriate legislation which specifically targets e-waste, enforcement is a challenge in areas of the world with limited resources for governance (Hicks, Dietmar & Eugsterb, 2005). Cheap, safe and simple processing methods appropriate for introduction into the informal sector are lacking, and researchers are only just beginning to look into this (Sepúlveda et al., 2010). As a consequence, regulation has to be combined with incentives for informal recyclers not to engage in destructive processes, such as a financial incentive to deliver parts to central collection sites rather than processing them themselves (Williams et al., 2008). Integrating the informal sector into the formal, together with the creation of cooperatives, could result in reduced pollution and better resource management.

7.2 International solutions

A possible international solution would be facility-based shipment whereby any company seeking to export e-waste would have to sign a contract with a facility in the receiving country. However, for this to be workable, the countries involved must have national e-waste legislation in place. Capacity training plays a key role, and a wide variety of stakeholders in both importing and exporting countries need to be trained and educated on the issue.

Another solution would be to stimulate two-way flow between developed and developing countries, which would encourage manual, employment-intensive operations in developing countries and material recovery operations in developed countries (Vasudev & Parthasarathy, 2007). In 2009, UNEP analysed

11 countries for their sustainable e-waste recycling potential. Kenya, Uganda, Senegal and Peru were deemed promising in terms of the introduction of pre-processing technologies with a focus on capacity building. India and China have potential for the introduction of pre- and end-processing technologies with strong support in capacity building in the informal sector. South Africa, Morocco, Colombia, Mexico and Brazil have potential to adapt pre- and, to some extent, end-processing technologies to their own needs, following a technology and knowledge exchange. UNEP identified that facilitating exports of critical e-scrap fractions such as circuit boards and batteries to certified end-processors is vital for future success. It also identified barriers to sustainable e-waste recycling technologies: policy and legislation, technology and skills, business and financing, the strong influence of the informal sector, and low skills and awareness. The UNEP study recognized the need for both individual and corporate initiatives, alternative business models with financial incentives, the development of innovation hubs and inclusion of informal e-waste recyclers. Bearing in mind regional and social contexts, however, it is important to recognize that, given the social implications of implementing high-tech, capital-intensive recycling processes, this will not be appropriate in every country or region (Schluep et al., 2009).

In finding international solutions, inter-agency cooperation is also important. Stakeholders should have an understanding not only of the waste flow but also which government body or bodies are responsible for regulating it (Skinner, Lloyd, Dinter & Strothmann, 2010). Inter-agency cooperation would be enhanced if all countries were to enforce the Basel Convention's global ban on the transboundary movement of hazardous waste.

Producers should also take their responsibility by reducing and eliminating hazardous substances in their products, producing long-lasting products which are simple to recycle and putting in place effective take-back programmes (Joseph, 2007). The disparity between the industrialized and industrializing world in rates of adoption of information technology must also be noted, as it continues to contribute to the gap in wealth. However, it has to be acknowledged that the used computer market in the developing world is robust and growing, and current policies will increase the price of computers for lower income consumers (Williams et al., 2008).

Current policy efforts to manage the end-of-life of electronic products focus on mandating recycling systems, limiting the toxic content of products, and seeking to control or ban trading in e-waste.

7.3 Extended Producer Responsibility

A sustainable electronics life-cycle system should take into account environmental justice, the precautionary principle, and EPR. Most waste-related policies in recent years have been based on the EPR principle which requires electronics producers to take financial responsibility for the disposal of their products.

EPR constitutes a new era of industrial ecology and environmental sustainability (Halluite, Linton, Yeomans & Yoogalingam, 2005), and includes policies from mandatory or voluntary take-back to recycling fees and fees on disposal. It shifts the responsibility upstream from municipalities to producers (Yu, Welford & Hills, 2006). In an effective EPR scheme, the true cost of waste management is internalized within the retail price by the producer. The aim is to provide an incentive to produce less toxic equipment that is cheap and easy to recycle. Companies are further pressured to address the life cycle issues of products, especially end-of-life issues. This, in turn, drives innovation, such as in business models, take-back logistics and design changes, to reduce the environmental impact of products. This policy is radically different from traditional recycling practices as it extends the producer's responsibility throughout the entire life cycle of the product chain from production through to end-of-life waste management (Nimpuno & Scruggs, 2011). Major challenges in setting up a fully functional EPR system have been found in European countries under EU Directive compliance, and include collection, national registry, logistics and financing.

There are two generic categories of e-waste collection systems at national level; the "collective system" and the competition-based "clearinghouse system". The collective system (see fig. 6) is mostly funded though producers' contributions, and involves municipal collection and storage. The clearinghouse system (see fig. 7) involves either retailer or producer take-back and storage. While there are advantages and disadvantages to both systems, the collective system is currently preferred and has been "tried and tested" in various countries. The objective of both systems is to provide e-waste management services at reduced cost to consumers and ensure compliance with national law.

A majority of developing countries have either planned or developed their regulations under EPR. These countries can benefit from the lessons learnt in implementing the EU Directive (Nimpuno & Scruggs, 2011). A study of Chinese companies' responsiveness to EPR policies in the EU, found that

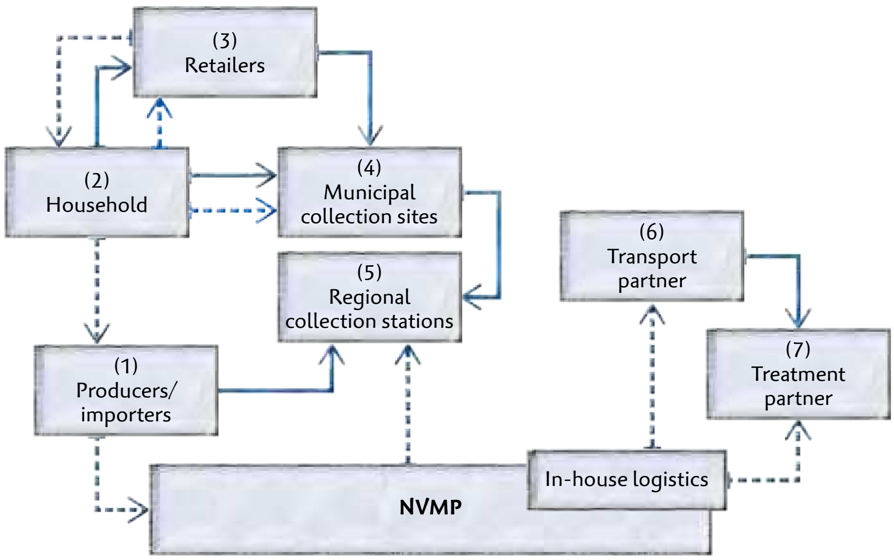

Fig. 6. Financial model of the Netherlands' collective e-waste system
(adapted from UNEP, DTIE, 2007b, p. 83)

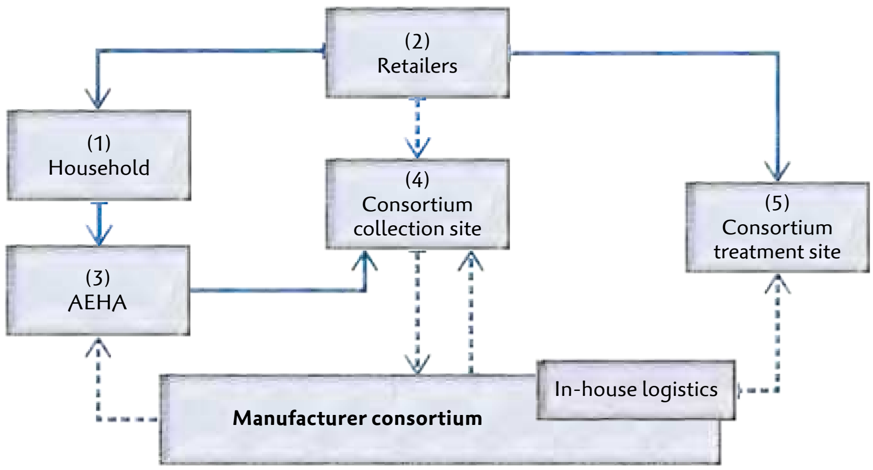

Fig. 7. Financial model of Japan's competitive e-waste system
(adapted from UNEP, DTIE, 2007b, p. 84)

responsiveness largely depends on market structure and client requirements. Chinese companies mostly follow a reactive rather than proactive approach to complying with EPR legislation, unless immediate effects on sales are felt. The extensive outsourcing of production to China is therefore a significant obstacle to efficient EPR (Yu, Welford & Hills, 2006).

EPR policies could drive green design of products because it is assumed that if producers have to deal with their own product waste they will have more incentive to use recyclable materials or materials that will not generate the costs of hazardous waste management (Nimpuno & Scruggs, 2011). Many electronics companies have eliminated substances such as PVC and BFR in their products, reduced the use of lead, arsenic and mercury, and introduced programmes to phase out beryllium and phthalates. However, antimony and other substances and metals are still in use. The increasing volume of products, particularly given the growth in electronic product use in emerging economies and developing countries, will put higher demand on life-cycle management, prolonged lifespan and EPR (Wheeland, 2011).

7.4 Green design

Most companies today design their products for planned or perceived obsolescence. This is reinforced through marketing and retailing practices, and affordability and convenience have taken over from product durability as primary drivers (Clapp, 2005).

The average lifespan of computers dropped from six years in 1997 to two years in 2003 (Mvo Platform & GoodElectronics, 2009). The criteria for green design include factors such as reducing toxicity and energy use, streamlining product weight and materials, and identifying opportunities for easier reuse of components and materials. (Joseph, 2007). Green design policies need to be holistically based, looking at all aspects of electronics production, not only greenhouse gas production or the phase-out of certain chemicals.

The ETBC provides a list of criteria for full assessment to minimize potential environmental, human health and social impacts, including to:

- be carbon neutral
- maximize design for repairability, reuse and durable use
- plan for recyclability and ease of disassembly
- minimize toxicity
- minimize use of raw virgin materials
- invest in solutions that go beyond our current dominant technologies
- actively engage communities and stakeholders
- reuse and apply zero waste policies (ETBC, 2011).

Currently, most focus is placed on phasing out certain chemicals and there is little focus on other aspects such as ease of disassembly—although, one example is the prototype Bloom laptop, designed by a group of students from Stanford University and Aalto University in Finland. It can be completely disassembled by hand without any tools, making upgrading easier by simply replacing parts and, ultimately, recycling the device. Some interest in the product has been shown by electronics companies; however, due to planned obsolescence, it is not likely to be adopted any time soon (Stanford University, 2010). It is also important to note that, even were toxic materials to be entirely designed out of electronics, the environmental and health impacts generated from the rudimentary techniques used in informal recycling processes would still be unacceptably high. Thus, eliminating negative environmental and health impacts through design requires the use of materials which would not generate toxic matter even if processed using the most primitive of methods, such as open burning. (However, designing electronics for safety under open-burning conditions is probably impossible to achieve with current known materials and technologies.) Phasing out precious metals could also provide a disincentive, by impacting on the profit from electronics for informal recyclers, although this is currently not feasible (Williams et al., 2008).

7.5 A systems analysis approach to the e-waste problem

This section will analyse the root causes and effects, drivers and impacts of the e-waste problem with the aim of gaining a holistic perspective in order to go beyond "quick fixes". It applies systems analysis, an emerging tool in sustainability research, policy, economics and management, that can be used as a tool when designing interventions. Systems analysis identifies and maps the interrelated nature and complexity of real-world situations.

Generally, every society can be described as comprising four dimensions: the economic, social, environmental and institutional. Each of these is a complex, dynamic, self-organizing and evolving entity, making the coupled system one of tremendous complexity (Spangenberg, 2005). Problem-solving strategies are often based on linear thinking, which neglects the feedback and behaviour of the problem. The systemic viewpoint is generally oriented towards long-term conditions, which enables the identification of delays and feedback loops that determine the behaviour of the system (Haraldsson, 2000). The systems approach helps highlight those policy issues that warrant more in-depth study. Although the systems model may not provide definitive answers, it raises relevant questions (Chan, Hoffman & McInnis, 2004).

7.5.1 Core theories

The underlying assumption of current analysis of the e-waste problem is that the trade in e-waste is primarily from developed to developing countries, and that this causes the immensity of the problem. (However, it has to be noted that, even without the trade, countries like China produce huge amounts of e-waste domestically.) The theories outlined below provide the basis and underlying assumptions of the systems analysis that follows. They also facilitate better understanding of the problem.

"Race-to-the-bottom" theory

The "race-to-the bottom" hypothesis is a common critique of globalization. It stipulates that increased competition for trade and foreign direct investment could lead to the lowering of environmental and labour standards and regulations. This is because the general view is that high rates of corporate taxation, strict labour laws, or rigorous environmental protection lower profit rates. Governments which attempt to maintain high standards will see their efforts undermined by the existence of less stringent regulations elsewhere and this will lead to an overall lowering of standards internationally (Medalla & Lazaro, 2005).

However, there are complexities and exceptions within this general theory, as some states decide to enforce stringent laws as they view them as improving quality of life and not necessarily being an obstacle to economic development. Also, companies moving production from developed to developing countries sometimes bring advanced environmental and labour practices with them (Konisky, 2007). The "race-to-the-bottom" theory will, therefore, be viewed sectorally, as industries differ. However, it is clear that, with regard to e-waste, there is evidence of a "race to the bottom" and lax enforcement of regulations.

"Pollution haven" theory

This is directly linked to the "race-to-the-bottom" theory but specifically regards environmental law and standards. It states that pollution-intensive economic activity will tend to migrate to those jurisdictions where costs related to environmental regulation are lowest (Lepawsky & McNabb, 2010). This theory overlaps with globalization and north–south issues, the debate over the disparate implications for the developed and developing countries, and whether globalization will lead to "industrial flight" from the north and the growth of "pollution havens" in the south (Medalla & Lazaro, 2005). In the case of e-waste, the "pollution haven" is in developing countries where, in practice, waste handlers face strong incentives to avoid taxes and regulations and dispose of their waste illegally.

Distancing theory

Contemporary consumers are geographically more distant from their waste than in the past, through waste collection services which create little understanding of what happens to the waste after collection and where. This is exacerbated by consumer culture, waste habits, disposability of products and denial (Hawkins, 2006). The characteristics of consumer society, such as excess shopping and wastage, are a symptom of contemporary lifestyles, and abundance and convenience act against more responsible disposal behaviours. Most consumers, therefore, are no longer connected to the environmental meaning of their consumption (Bekin, Carrigan & Szmigin, 2007). With regard to electronics, waste is often both produced and disposed of in developing countries, extending the distance from consumers in developed countries, and consumer information is lacking. It has been remarked that, as a result, the consumer will make decisions that will perpetuate the generation of waste (Vasudev & Parthasarathy, 2007).

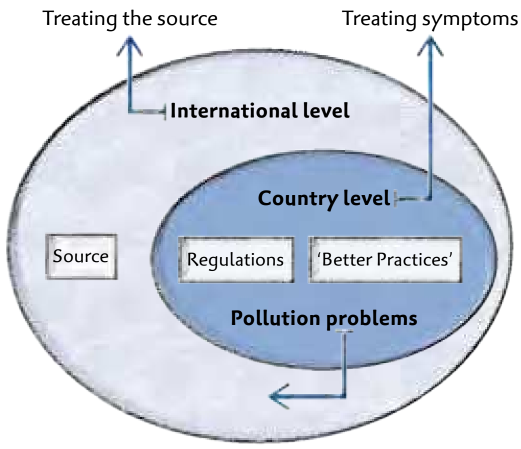

Fig. 8. Framing the e-waste problem

Figure 8 illustrates the e-waste trade problem as an international problem; however, the problem is mostly dealt with on the local and national levels through legislation and so on. The local pollution created by informal e-waste recycling activities can cross borders through international trade and via the atmosphere, among other pathways. Targeting the e-waste trade problem at the international level is targeting its source and, therefore, is more likely to produce a solution to the problem.

7.5.2 Causal-loop diagram

A causal-loop diagram (CLD) is used to understand the complex web of influences that often result in various forms of feedback loops. Such loops add a time dimension to system complexity and often magnify or dampen the intended effect of an action in a non-obvious manner. It is important to understand the causes and effects of a problem, and how different aspects of society and the natural environment interrelate through feedback loops. The concept of feedback shows how actions can reinforce or counteract (balance) each other. With a CLD it is possible to construct circular connections and the feedbacks of the problem. A CLD of the e-waste trade problem is provided as figure 9. The red "Rs" represent a reinforcing system that has an escalating effect due to equivalent influences between the components, which can be either a downward or an upward spiral. The red "Bs" represent a balancing or stabilizing system in which there is an agent that controls the exponential growth or is a limiting factor to the growth.

Key drivers of the system are identified at the top of the diagram: demand, planned or perceived obsolescence, natural resources, internet use and economic growth. The key driver of the shipment of e-waste (at

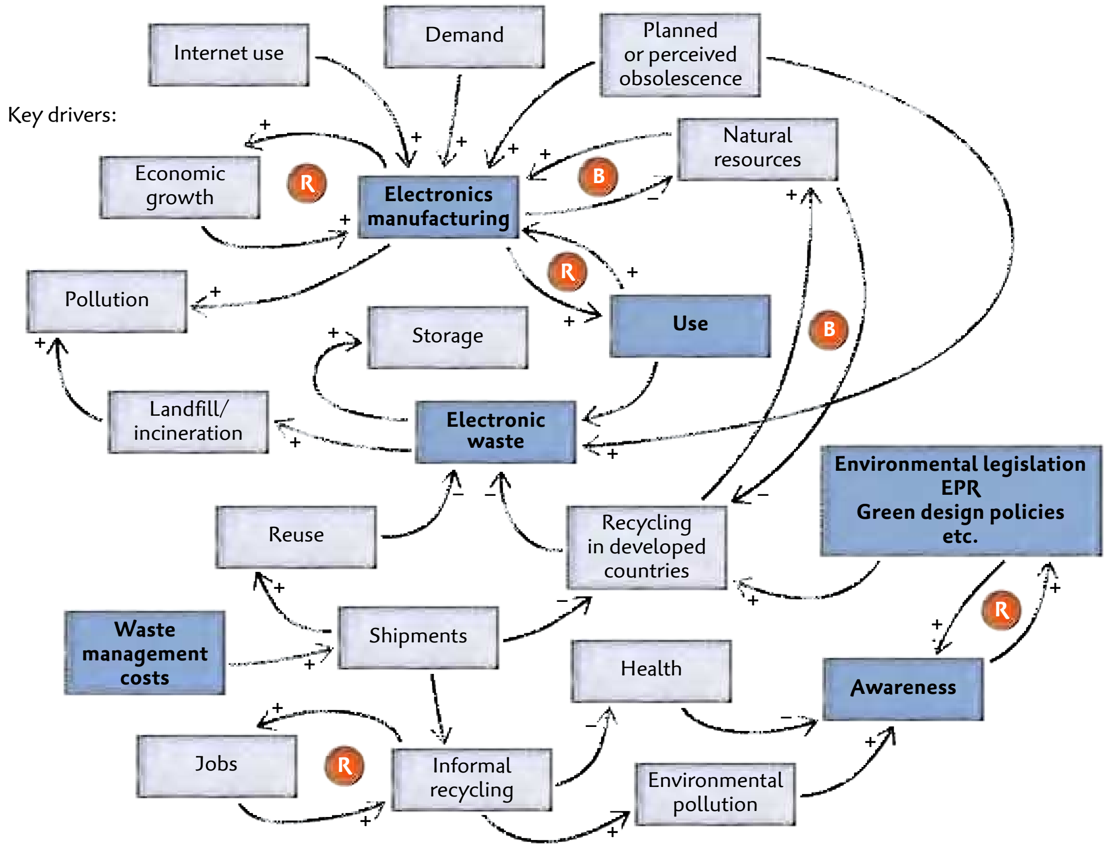

Fig. 9. Causal-loop diagram of the e-waste trade problem

the lower left) is identified as the costs of waste management carried out in an environmentally sound manner (in developed countries). The transboundary movement of e-waste creates jobs in developing countries, although practices are unsafe, jeopardizing health and creating environmental pollution. However, these negative consequences are often delayed in the system. Finally, key factors limiting the creation of e-waste and the enhancement of e-waste recycling in developed countries are identified as natural resource accessibility, awareness and waste management policies. In addition, shipments to developing countries do enhance reuse and recycling, which limits the amount of e-waste to some extent.

Reference behaviour pattern

A reference behaviour pattern (RBP) is a graphical representation of the behaviour of a CLD over time. It forecasts future conditions and trends through looking at the feedback loops of the CLD.

Figure 10 provides an RBP of the CLD of the e-waste trade problem (fig. 9). It indicates many drivers for the future increase of domestic recycling as negative externalities start to unfold. The "problem crossing borders" includes pollution incidents and issues caused by international trade, atmospheric transport and so on. One example is the incidence of lead in products produced in China and sold in the US. In 2007, there were 26 recalls of more than 8 million lead-contaminated items of jewellery, toys and clothing, many of them imported from China. These products have been linked to informal e-waste recycling activities providing manufacturing plants with raw materials (BAN, 2011). In addition, the

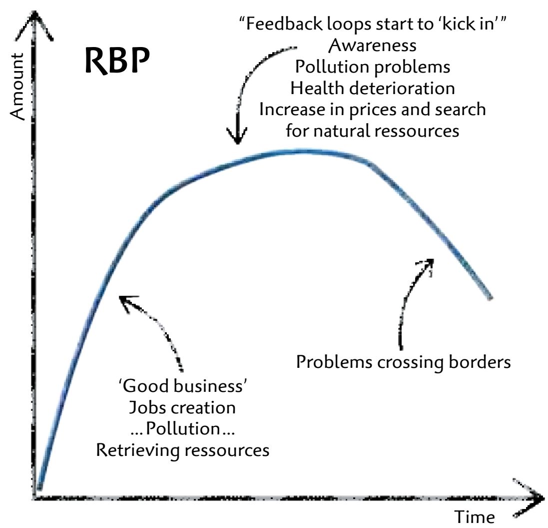

Fig. 10. RBP of the CLD of the e-waste trade problem

electronics industry uses an increasing number of rare materials, and the price of resources required for the production of virgin metals is expected to continually increase, providing an incentive for higher recycling rates. It is estimated, for example, that the economic level for a gold mine is approximately 5 grams of gold per tonne of ore, whilst discarded electronics can yield 150 grams per tonne. In addition, the same amount of ore contains 100 kg of copper and 3 kg of silver (Nimpuno & Scruggs, 2011). Another example is indium, a rare earth mineral common in LCD flat screen displays. Currently, the market holds 1,300 tonnes of indium, 600 tonnes from primary production and the rest from recycling. In the future, access to the metal for use in solar panels will compete with continuous growth in demand for LCDs, which will most likely bring about a push for increased recycling of indium (Desai, 2008).

CASE STUDY 6. E-waste handling in the Pacific Islands region

The Pacific Islands region comprises 14 countries, eight territories and 7,500 islands, of which 500 are inhabited by some 9.5 million people. Pacific Islands countries do not currently have the infrastructure for the recycling of e-waste, in either the formal or informal sectors (Richards, n.d.) and there are no provisions for disposal of e-waste. Disposal is usually done by storage in a back room or container, or by dumping (UNEP, 2011). Open burning of wastes is also a common practice in Pacific Islands countries (op. cit.). Due to the long distances between islands and low population base, the islands are rarely the destination for illegal e-waste shipments. In addition, e-waste generation is minimal, due to small populations, but it is continually increasing.

In the Cook Islands, for example, the biggest user of computers is the Government, closely followed by commercial banks. The amount of e-waste is on the increase partly due to the disaster-prevention programme, in which 20–30 computers will be replaced every 3–4 years. To handle e-waste in a small remote island context is a challenge, and the current open-air storage of e-waste is unsustainable and likely to result in contamination of soils, surface- and groundwater. As a response, the Cook Islands organized "eDay" in December 2010 to collect e-waste to be shipped overseas for environmentally sound disposal. The intention was to establish infrastructural arrangements to form an annual e-waste collection, and to prevent the build-up of future stockpiles (op. cit.). The "eDay" project was able to secure in-country and regional sponsors as well as volunteers to cover the majority of the costs of collecting and packing e-waste into shipping containers. It was highly successful and presented to Ministers as an effective model for small Pacific Islands communities.

Following this success, other countries, including Tonga, Tuvalu and Vanuatu have started to organize e-waste collection days (*Vanuatu Independent*, 2011). Export for environmentally sound recycling is currently the only option because of financial and structural conditions and the relatively low volumes. Low volumes of e-waste also necessitates a regional rather than country-based recycling facility and a particular need for EPR schemes to deal with low volumes and large distances. There is a plan to develop a Pacific subregional programme to collect and ship e-waste, and to establish an EPR scheme through an advanced disposal fee (ADF) payable at the time of electronics import (op. cit.).

Scope and suggestions for ILO intervention

8

8.1 Linking the e-waste problem with the ILO's main objectives

The ILO's main aims are to promote rights at work, encourage decent employment opportunities, enhance social protection and strengthen dialogue on work-related issues. Its tripartite structure consisting of workers, governments and employers provides a unique platform for promoting decent work. The ILO's objectives relate directly to the e-waste problem.

1. Promote and realise standards and fundamental principles and rights at work

As noted above, experience already shows that simply prohibiting or competing with informal recyclers is not an effective solution. Informal recycling enables employment for thousands of people in poverty; therefore, enforcement of appropriate legislation which specifically targets e-waste is needed to provide incentives and decent, safe work. However, in areas of the world with limited resources for governance, enforcement is a challenge. ILO standards and principles, rights at work, and its Decent Work Country Programme (DWCP) could improve working conditions for e-waste recyclers. Child labour interventions and enforcement of other relevant conventions also have a role (ILO, *Decent Work Country Programmes*, n.d.).

2. Create greater opportunities for women and men to decent employment and income

ILO could provide expertise on the integration and formalization of the e-waste recycling sector, combining the integration of the informal sector with the formal, the creation of cooperatives, public–private partnerships and provision of micro-insurance or credit. The informal economy, social dialogue, micro-enterprises, OSH, labour law enforcement, child labour and gender equality are common priority areas in DWCPs and could be linked to informal e-waste recycling.

3. Enhance the coverage and effectiveness of social protection for all

OSH is a necessary entry point when looking at the e-waste problem, as noted throughout this paper. Identifying simple measures for protection of workers' health is highly relevant. Social protection and social security are fundamental for the reduction of poverty and the precarious conditions in which informal e-waste recyclers are living. Commonly, recyclers are poor, migrants, disadvantaged, women and children, with little or no formal education. Through social security coverage, these disadvantaged workers could be provided with a more secure situation.

4. Strengthen tripartism and social dialogue

The promotion of awareness and recognition for e-waste workers in the informal sector, and strengthened social dialogue and tripartite links among all stakeholders in both the informal and formal sectors, could substantially improve the conditions under which e-waste recyclers operate and work. Their recognition as public servants and/or environmental officers, for instance, could also enhance both their skills and personal development. Social dialogue on the issue is currently non-existent and is urgently needed.

8. ILO Conventions and Recommendations

Of all ILO labour standards related to the e-waste problem (see Annex I), the most relevant is the Chemicals Convention, 1990 (No. 170). This Convention applies to all branches of economic activity in which chemicals are used. It stresses the right of workers to information about the chemicals they use at work and imposes responsibility on suppliers and employers to provide information and training. Article 11 states that "employers shall ensure that when chemicals are transferred into other containers or equipment, the contents are indicated in a manner which will make known to workers their identity any hazards associated with their use and any safety precautions to be observed". Article 14 states that "hazardous chemicals which are no longer required and containers which have been emptied but which may contain residues of hazardous chemicals, shall be handled or disposed of in a manner which eliminates or minimises the risk to safety and health and to the environment, in accordance with national law and practice". It also sets requirements for transboundary movements of chemicals. Article 19 states that "when in an exporting member State all or some uses of hazardous chemicals are prohibited for reasons of safety and health at work, this fact and the reasons for it shall be communicated by the exporting member State to any importing country" (ILO, 1990a).

The Chemicals Recommendation, 1990 (No. 177) sets standards for classification, labelling and marking, and chemical safety data sheets, and includes steps for employers to include measures such as monitoring of exposure, operational control, medical surveillance, first aid and emergencies preparedness, and close cooperation between workers and employers (ILO, 1990b). It is highly relevant to the e-waste problem and could be updated by the addition of standards regarding e-waste workers' exposure.

Numerous other labour standards are also of direct relevance to e-waste management. The Occupational Safety and Health Convention, 1981 (No. 155) and Occupational Safety and Health Recommendation, 1981 (No. 164) aim to prevent accidents and injury to health arising out of, linked with or occurring in the course of work, by minimizing, so far as is reasonably practicable, the causes of hazards inherent in the working environment. They put weight on preventative measures and ensure that the national OSH system is continuously improved and capable of addressing issues arising from a constantly changing world of work (ILO, 1981a; ILO, 1981b). The Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) and previous OSH legislation, recommendations and codes of practice are vital entry points in minimizing workers' exposures. Article 4(3)(h) of the 2006 Convention is highly relevant to the e-waste problem and states that "support mechanisms for a progressive improvement of occupational safety and health conditions in micro-enterprises, in small and medium-sized enterprises and in the informal economy [are] needed" (ILO, 2006a).

The ILO Tripartite Declaration of Principles concerning Multinational Enterprises and Social Policy (1977) sets key expectations on the social responsibilities of business. The Declaration is a universal instrument that offers guidelines to multinational enterprises, governments, and employers' and workers' organizations in such areas as employment, training, conditions of work and life, and industrial relations (ILO, 2006b).

Other related conventions include the Worst Forms of Child Labour Convention, 1999 (No. 182), the Migrant Workers (Supplementary Provisions) Convention, 1975 (No. 143) and the Social Policy (Basic Aims and Standards) Convention, 1962 (No. 117) (see Annex II).

The Job Creation in Small and Medium-Sized Enterprises Recommendation, 1998 (No. 189) calls for the inclusion of "specific measures and incentives aimed at assisting and upgrading the informal sector to become part of the organized sector. Also, Members should adopt measures which are appropriate to national conditions and consistent with national practice in order to recognize and to promote the fundamental role that small and medium-sized enterprises can play" (ILO, 1998).

The Promotion of Cooperatives Recommendation, 2002 (No. 193) stresses that "the establishment and growth of co-operatives should be regarded as one of the important instruments for economic, social and cultural development as well as human advancement in developing countries". Governments form enabling policy including for financial aid, grants and tax exemptions. "A balanced society necessitates the existence of strong public and private sectors, as well as a strong cooperative, mutual and the other social and non-governmental sector. It is in this context that Governments should provide a supportive policy and legal framework consistent with the nature and function of cooperatives and guided by the cooperative values and promote the important role of cooperatives in transforming what are often marginal survival activities (sometimes referred to as the 'informal economy') into legally protected work, fully integrated into mainstream economic life" (ILO, 2002a).

The Employment Relationship Recommendation, 2006 (No. 198) states that "members should take particular account in national policy to ensure effective protection to workers especially affected by the uncertainty as to the existence of an employment relationship, including women workers, as well as the most vulnerable workers, young workers, older workers, workers in the informal economy, migrant workers and workers with disabilities" (ILO, 2006c).

In summary, ILO Conventions cover issues relevant to e-waste such as chemical safety, OSH, transboundary movements, training, social policy and social security. ILO Recommendations cover chemical safety, small and medium-sized enterprises, the formation of cooperatives and the employment relationship. The majority of relevant extant ILO codes of practice are OSH related, in particular, *Safety in the use of chemicals at work* (ILO, 1993). In terms of future intervention, a code of practice particularly related to the special situation of e-waste recycling in the informal sector could prove essential in dealing with the issue. Such a code of practice could, for instance, outline occupational health measures, best practices, formalization of the sector and the formation of cooperatives, public–private partnerships and the protection of workers who do not benefit from an employment relationship.

8.3 Decent Work Country Programmes

The Decent Work Country Programmes (DWCPs) is the main vehicle for delivery of ILO support to countries. DWCPs are closely aligned with national development strategies, including poverty reduction strategies and United Nations Development Assistance Frameworks, where applicable. DWCPs have the objective of promoting decent work as a key component of national development strategies. At the same time the programmes organize ILO knowledge, instruments, advocacy and cooperation to advance the Decent Work Agenda. Tripartism and social dialogue are central to the planning and implementation; in individual states, DWCP promotes decent work as a national objective over a period of four to six years. The content of DWCPs varies from country to country based on national circumstances. Country priorities under the DWCP vary. Some examples of priorities related to e-waste include the informal sector, education, environmental protection, support of micro-enterprises and micro-insurance, OSH, social security coverage, strengthening cooperatives, youth employment, child labour, labour law enforcement, capacity building and migrants. Unfortunately, there have not yet been reports on some of the countries identified as e-waste hotspots (ILO, n.d).

8.4 Green Jobs Programme

Green jobs and the advance of the green economy have become the key drivers for achieving economic and social development that is also environmentally sustainable. Jobs are generally considered "green" when they help reduce negative environmental impact and ultimately lead to environmentally, economically and socially sustainable enterprises and economies. There are many definitions of green jobs, and the definition varies between institutions. However, the standard definition adopted by UNEP, the ILO, the International Organisation of Employers (IOE) and the International Trade Union Confederation (ITUC) reads: "Work in agricultural, manufacturing, research and development (R&D), administrative and service activities that contribute[s] substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonise the economy; and minimize or altogether avoid generation of all forms of waste and pollution" (Worldwatch Institute, 2008).

The ILO's Green Jobs Programme has the mandate to promote a practical and coherent strategy that recognizes the strong interdependence between the need for social development and the urgency to act on climate change and environmental degradation. It provides analysis and policy guidance that contribute to the promotion of a fair globalization and the development of sustainable enterprises and economies. It contributes to regional and local initiatives and provides a comprehensive knowledge base as well as tools for applying practical approaches (ILO, 2011b).

It is well known that recycling produces more jobs than any other form of waste management operation. The electronics recycling market is growing, and e-waste management systems have potential for long-term green job creation. The challenge of dealing with e-waste represents an important step in the transition to a green economy. However, it is recognized that many recycling and waste management-related jobs cannot be considered green because they do not match the basic requirements of decent work and considerable environmental and health damage is caused by inappropriate e-waste practices. In terms of the priority indicators of decent work, factors which are not satisfactory in the e-waste sector include child labour, OSH, social protection and freedom of association. Many waste management jobs are currently low end and informal, although they do provide a degree of alleviation from poverty. There are many drawbacks in the informal structures in the sector, including the inability to deal effectively with new and sometimes hazardous materials. Upgrading of the sector is thus desirable. Fundamentally, waste recyclers must be treated with dignity and given recognition as they do contribute to solving an urgent global problem.

The application of national labour laws and OSH legislation to the informal economy is one of the most important challenges, and the latter could possibly provide the easiest entry point for the extension of basic labour protection. Environmental and social policies must work hand in hand and green jobs policies would primarily translate to the pursuit of the implementation of labour standards. This can be achieved through diverse means, including social innovation, technology, formalization processes and specific programmes. Social innovations have proven essential in achieving sustainable outcomes supporting a stakeholder approach.

The ILO's Green Jobs Programme could utilize social and environmental entrepreneurs and/or trade unions to organize informal e-waste workers to improve their working and living conditions. Technological improvements and upgrades are also important, although experiences in this sector demonstrate that technologies must be adapted to local contexts in order to avoid major setbacks (op. cit.). A primary goal of the Green Jobs Programme could be to target informal e-waste actors and convert current practices into green and safe jobs. As regulations become stricter, it is important to ensure that informal actors can stay in employment. A first step would be to organize the informal actors into associations, and integrate these with formal units. In addition, capacity building is one of the main aims of the Green Jobs Programme and, in terms of the e-waste problem, facilitating social dialogue, outreach programmes, training courses and research are imperative.

8.5 Promotion of cooperatives

The ILO Promotion of Cooperatives Recommendation, 2002 (No. 193) incorporates the Statement on the Co-operative Identity of the International Co-operative Alliance (ICA). This defines a cooperative as an "autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise" (ICA, n.d.). The overall purpose of a cooperative is to allow individuals to come together and pool their resources in order to reach a common goal and, in doing so, allow their members to organize and have a voice. Cooperatives currently operate in all sectors of the economy throughout the world, and play an increasingly important role in job creation, economic growth and social development. Cooperatives provide over 100 million jobs today and have a proven record of creating and sustaining employment.

The cooperative is a form of enterprise which meets the needs of its members, balancing economic and social concerns. In doing so, it can improve living and working conditions and make essential infrastructure and services available, even in areas neglected by the state. Guided by values and principles which put people (members and the community in which the cooperative operates) at the heart of enterprise, the cooperative model lends itself to assisting a wide range of people, including entrepreneurs in both the formal and informal sectors. One specific cooperative principle, Concern for Community, is understood to include sustainable development and, in particular, environmental concerns (op. cit.).

If informal workers were integrated into the formal sector through their organization into workers' unions, it would lead to improved working conditions through collective claims and bargaining. However, where there are major constraints to informal operators or workers on joining existing employers' organizations or trade unions, the most effective membership-based organizational structure may be the cooperative (ILO, 2002b). Organizing through cooperatives allows members to respond to three key concepts associated with poverty, livelihood improvement and decent work; that is, they provide opportunity, empowerment and security. They can, for example, facilitate access to credit on favourable terms. In short, cooperatives can transform informal economy activities into legally protected work, fully integrated into mainstream economic life.

Cooperatives are one form of enterprise development. It is difficult to find a country or region that does not have legislation referring to cooperatives and their promotion at national, or even international, level. Cooperatives could, therefore, constitute a means of representation for e-waste recycling workers (Tchami, 2007).

CASE STUDY 6. Women's e-waste cooperative in Mexico

Some years ago, the sole industry in the town of Fronteras, in the Mexican state of Sonora, a Levolor blinds factory, closed down, leaving farming and ranching as the only means for many people to make a living (Herreras, 2009). A group of women in their '50s decided to organize and start an e-waste recycling business. Workers primarily dismantle televisions and computers, and separate the parts into plastic, metal and glass. This is now the facility from which e-waste is transported back to the US or exported for reuse, with piece parts such as plastic shipped to Hong Kong and CRT glass to Malaysia. Members of the cooperative own 50 per cent of the shares and, among other benefits, determine their own compensation (Associated Press. 2008.). The cooperative was initiated when an American electronics-recycling company based in Vermont, American Retroworks, became interested in investing after being contacted by one of the women. The Mexican women received training in Vermont and learnt how to dismantle electronics in a proper manner (Public Radio International, 2009). However, the success story has been hampered by hostility from residents in the town, partly because of the women's refusal to pay bribes. However, the women took on the local government and proudly became known as Las Chicas Bravas, the tough women (Herreras, 2009).

Other examples of e-waste recycling cooperatives include those made up of enterprises active in a particular industry or a group of stakeholders (producers and retailers). These "entrepreneurs' cooperatives" or "shared-services cooperatives" exist in a number of countries to enable industries to more effectively assume the responsibility of disposing or recycling e-waste while creating green jobs.[1]

1. In some jurisdictions – notably, the EU – authorities require manufacturers to collect and dispose of e-waste at the end of the product life cycle. This can take two forms: either manufacturers are required to take individual responsibility, with each company disposing of its own discarded products, or manufacturers are allowed to band together and form cooperatives to collectively gather and dispose of e-waste and share the costs of doing so. See the example of INOBAT (Interessenorganisation Batterienentsorgung), a stakeholder organization for battery disposal which takes the form of a cooperative bringing together battery producers, manufacturers and retailers in Switzerland: http://www.e-waste.ch/en/stakeholders/inobat-5.html.

Conclusion

9

Currently, most waste management strategies are largely technical and focus on environmental aspects, leaving out underlying social problems and relevant solutions. The ILO has the potential to bring a more holistic approach to waste management, contributing its expertise in labour. The ILO could work on social concerns and improve environmental management through building understanding of labour dynamics.

Prior to intervention, it is important to study a country's labour dimensions on the ground to develop sound understanding of key issues. The ILO can intervene in a variety of ways, using technical assistance along with a host of social programmes, and assist in putting in place national tripartite coordinating bodies to assist e-waste recyclers in both the informal and formal sectors. It can also share information through launching an e-waste code of practice and publicizing best practices, cooperate closely with other organizations and promote green jobs. Pilot projects could encourage alternative economic activities and green jobs in the e-waste recycling sector, build organizational capacity such as microenterprises and cooperatives, form public–private partnerships and, at the same time, work on poverty reduction. The ILO could assist in the work of capacity building and the formalization of the e-waste recycling economy, avoiding single-sector approaches. The ILO's work and recommendations regarding the informal economy should be considered in this context of formalization of the waste management sector. The ILO could also work on building appropriate labour standards and regulatory frameworks, OSH interventions and awareness raising in the sector.

9.1 Future challenges and opportunities

The popularity of consumer electronics and home appliances is likely to continue in years to come with a constant stream of iPhones and iPads, other smartphones and computers, refrigerators, e-readers and other devices. Hence, the main challenge is the continuous global growth of e-waste. It is predicted that, by 2018, more PCs will be discarded in countries in the developing than the developed world, and the prevailing assumption that trade is the main driver of informal recycling might soon become obsolete (Betts, 2010). It is predicted that, by 2020, in both China and South Africa, there will be 200–400 per cent more e-waste from old computers than in 2007, and a staggering 500 per cent more in India. The volume of e-waste from discarded mobile phones will be about seven times higher in China and 18 times higher in India. E-waste from televisions will be 1.5 to 2 times higher in China and India, and, in India, e-waste from discarded refrigerators will double or triple. When adding the vast amounts of e-waste that are still being imported to these countries, both legally and illegally, it is evident that the problem is exploding, with many dangers for human health and the environment (McCarthy, 2010).

There are challenges ahead in all the aspects of e-waste covered in this paper. They include the unwillingness of consumers to return and pay for disposal of used electronic products; the uncoordinated, high level of importation of e-waste disguised as secondhand devices; a lack of awareness among consumers; a lack of awareness of the potential hazards of e-waste among collectors and recyclers; a lack of funds and investment to finance improvements in e-waste recycling; the absence of recycling infrastructure or appropriate management of e-waste; the absence of effective take-back programmes; the lack of interest by companies or incentives for e-waste management; and the failure of and/or lax implementation of e-waste-specific legislation (Chi, 2011). In addition to all these challenges is the increase in cyber crime.

However, there are also many opportunities associated with e-waste. The booming demand for rare earth minerals used in the manufacture of electronics could boost e-waste recycling in the future. The cost of recycling is declining in developed countries. There are other opportunities in green design, innovation, life-cycle analysis, public outreach, social policy and so on. Some companies are already starting to design product content for the reality of waste handling operations in developing countries, for instance, by leaving out chemicals that can create hazardous pollutants when burned inappropriately (Nimpuno & Scruggs, 2011).

Annexes

Annex I. Chemicals of primary concern in e-waste

Chemical	Source in electronic products	Health concerns
Antimony	CRTs, printed circuit boards, etc.	Very hazardous in event of ingestion, hazardous in event of skin and eye contact, and inhalation. Causes damage to the blood, kidneys, lungs, nervous system, liver and mucous membranes (Material Safety Data Sheet, 2005)
Arsenic	Used to make transistors	Soluble inorganic arsenic is acutely toxic and intake of inorganic arsenic over a long period can lead to chronic arsenic poisoning. Effects, which can take years to develop, include skin lesions, peripheral neuropathy, gastro-intestinal symptoms, diabetes, renal system effects, cardiovascular disease and cancer (WHO, 2010b)
Barium	Front panel of CRTs	Short-term exposure causes muscle weakness and damage to heart, liver and spleen. It also produces brain swelling after short exposure (Osuagwu & Ikerionwu, 2010)
Beryllium	Motherboards of computers	Carcinogenic (causing lung cancer), and inhalation of fumes and dust can cause chronic beryllium disease or beryllicosis and skin diseases such as warts (Osuagwu & Ikerionwu, 2010)
Cadmium	Chip resistors and semiconductors	Has toxic, irreversible effects on human health and accumulates in kidney and liver (op. cit.). Has toxic effects on the kidney, the skeletal system and the respiratory system, and is classified as a human carcinogen (WHO, 2010c)
Chloro-fluorocarbons (CFCs)	In older fridges and coolers	Found to destroy the ozone layer and is a potent greenhouse gas. Direct exposure can cause unconsciousness, shortness of breath and irregular heartbeat. Can also cause confusion, drowsiness, coughing, sore throat, difficulty in breathing, and eye redness and pain. Direct skin contact with some types of CFCs can cause frostbite or dry skin (US. National Library of Medicine, n.d.)
Cobalt	Rechargeable batteries and coatings for hard disk drives	Hazardous in case of inhalation and ingestion, and is an irritant of the skin. Has carcinogenic effects and is toxic to lungs. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005)
Copper	Used as a conductor	Very hazardous in case of ingestion, in contact with the eyes and when inhaled. An irritant of the skin and toxic to lungs and mucous membranes. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005)
Dioxins	Created when electronics are burnt in open air	Highly toxic and can cause chloracne, reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer (WHO, 2010d)
Gallium	Integrated circuits, optical electronics, etc.	Hazardous in case of skin (may produce burns) and eye contact, ingestion and inhalation. Severe over-exposure can result in death. Toxic to lungs and mucous membranes. Repeated or prolonged exposure can produce target organs damage (Material Safety Data Sheet, 2005)
Hexavalent chromium	Used as corrosion protection of untreated and galvanized steel plates and a decorator or hardener for steel housings (Osuagwu & Ikerionwu, 2010)	Damages kidneys, the liver and DNA. Asthmatic bronchitis has been linked to this substance (Osuagwu & Ikerionwu, 2010). Causes irritation of the respiratory system (asthma) and skin, liver and kidney damage, increased or reduced blood leukocytes, eosinophilia, eye injury, and is a known carcinogen (lung cancer)
Indium	LCD screens	Can be absorbed into the body by inhalation or ingestion. Is irritating to the eyes and respiratory tract and may have long-term effects on the kidneys. Environmental effects have not been investigated and information on its effects on human health is lacking; therefore utmost care must be taken (ICSC database, n.d.)

Chemical	Source in electronic products	Health concerns
Lead	Solder of printed circuit boards, glass panels and gaskets in computer monitors (Osuagwu & Ikerionwu, 2010)	Causes damage to central and peripheral nervous systems, blood systems and kidneys, and affects the brain development of children (Osuagwu & Ikerionwu, 2010). A cumulative toxicant that affects multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular and renal systems (WHO, 2010e)
Lithium	Rechargeable batteries	Extremely hazardous in case of ingestion as it passes through the placenta. It is hazardous and an irritant of the skin and eye, and when inhaled. Lithium can be excreted in maternal milk (Material Safety Data Sheet, 2005)
Mercury	Relays, switches and printed circuit boards (Osuagwu & Ikerionwu, 2010)	Elemental and methyl-mercury are toxic to the central and peripheral nervous system. Inhalation of mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested (WHO, 2007)
Nickel	Rechargeable batteries	Slightly hazardous in case of skin contact, ingestion and inhalation. May be toxic to kidneys, lungs, liver and upper respiratory tract. Also has carcinogenic effects (Material Safety Data Sheet, 2005)
Perfluorooctane sulfonate PFOS/F)	Photoresistant and anireflectant coating	Persistent, bioaccumulative and toxic to mammalian species; linked to increases in the incidence of bladder cancer (OECD, n.d.)
Phthalates	Used to soften plastics	Disrupts the endocrine system, reproduction, fertility and birth, and has developmental effects. Also has organ system toxicity and is linked to liver cancer and effects on the brain, nervous system and immune system (Environmental Working Group, n.d.)
Polybrominated diphenyl ethers (PBDEs) used in brominated flame retardants (BFRs)	Plastic housing of electronic equipments and circuit boards to reduce flammability (Tsydenova & Bengtsson, 2011)	PBDEs are of concern because of their high lipophilicity and high resistance to the degradation processes. Hepatotoxicity, embryotoxicity and thyroid effects seem to be characteristic endpoints in animal toxicity, and behavioural effects have been demonstrated (Darnerud, Eriksen, Jóhannesson, Larsen, & Vileksela. 2001). BFRs in general have been shown to disrupt endocrine system functions and may have an effect on the levels of thyroid stimulating hormone and cause genotoxic damage, causing high cancer risk (Tsydenova & Bengtsson, 2011)
Polychlorinated biphenyls (PCBs)	Insulating material in older electronic products	Linked to reproductive failure and suppression of the immune system (Stockholm Convention, n.d.)
Polyvinyl Chloride (PVC)	Cabling and computer housing plastics contain PVC for its fire-retardant properties	Produces dioxins when burnt; causes reproductive and developmental problems, immune system damage and interferes with regulatory hormones (Osuagwu & Ikerionwu, 2010)
Silver	Wiring circuit boards, etc.	Very hazardous in case of eye contact, ingestion and inhalation. Severe over-exposure can result in death. Repeated exposure may produce general deterioration of health by an accumulation in one or many human organs (Material Safety Data Sheet, 2005)
Thallium	Batteries, semiconductors, etc.	Very hazardous in case of ingestion and inhalation. Also hazardous in case of skin and eye contact. May be toxic to kidneys, the nervous system, liver and heart, and may cause birth defects. Severe over-exposure can result in death (Material Safety Data Sheet, 2005)
Tin	Lead-free solder	Causes irritation in case of skin and eye contact, ingestion and inhalation. Can cause gastrointestinal tract disturbances, which may be from irritant or astringent action on the stomach (Material Safety Data Sheet, 2005)
Zinc (chromates)	Plating material.	Contact with eyes can cause irritation; powdered zinc is highly flammable (University of Oxford, 2005); if inhaled, causes a cough, and if ingested, abnominal pain, diarrhoea and vomiting is common (ICSC database, n.d.)

Annex II. Relevant ILO Conventions and Recommendations

Convention	Relevant sections
Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) Ratifications: 20	Article 2: Each Member which ratifies this Convention shall promote continuous improvement of occupational safety and health to prevent occupational injuries, diseases and deaths, by the development, in consultation with the most representative organizations of employers and workers, of a national policy, national system and national programme. Article 4(3)(h): (The national system for occupational safety and health shall include, where appropriate:) support mechanisms for a progressive improvement of occupational safety and health conditions in micro-enterprises, in small and medium-sized enterprises and in the informal economy.
Worst Forms of Child Labour Convention, 1999 (No. 182) Ratifications: 174	Article 1: Each Member which ratifies this Convention shall take immediate and effective measures to secure the prohibition and elimination of the worst forms of child labour as a matter of urgency. Article 6(1): Each Member shall design and implement programmes of action to eliminate as a priority the worst forms of child labour. Article 8: Members shall take appropriate steps to assist one another in giving effect to the provisions of this Convention through enhanced international cooperation and/or assistance including support for social and economic development, poverty eradication programmes and universal education.
Chemicals Convention, 1990 (No. 170) Ratifications: 17	Article 1(1): This Convention applies to all branches of economic activity in which chemicals are used. Article 11: Employers shall ensure that when chemicals are transferred into other containers or equipment, the contents are indicated in a manner which will make known to workers their identity, any hazards associated with their use and any safety precautions to be observed. Article 14: Hazardous chemicals which are no longer required and containers which have been emptied but which may contain residues of hazardous chemicals, shall be handled or disposed of in a manner which eliminates or minimises the risk to safety and health and to the environment, in accordance with national law and practice. Article 19: When in an exporting member State all or some uses of hazardous chemicals are prohibited for reasons of safety and health at work, this fact and the reasons for it shall be communicated by the exporting member State to any importing country.
Occupational Health Services Convention, 1985 (No. 161) Ratifications: 30	Article 2: In the light of national conditions and practice and in consultation with the most representative organisations of employers and workers, where they exist, each Member shall formulate, implement and periodically review a coherent national policy on occupational health services. Article 13: All workers shall be informed of health hazards involved in their work.
Occupational Safety and Health Convention, 1981 (No. 155) Ratifications: 57	Article 4(1): Each Member shall, in the light of national conditions and practice, and in consultation with the most representative organisations of employers and workers, formulate, implement and periodically review a coherent national policy on occupational safety, occupational health and the working environment. Article 9(1): The enforcement of laws and regulations concerning occupational safety and health and the working environment shall be secured by an adequate and appropriate system of inspection. Article 14: Measures shall be taken with a view to promoting in a manner appropriate to national conditions and practice, the inclusion of questions of occupational safety and health and the working environment at all levels of education and training, including higher technical, medical and professional education, in a manner meeting the training needs of all workers.
Collective Bargaining Convention, 1981 (No. 154) Ratifications: 42	Article 2: For the purpose of this Convention the term collective bargaining extends to all negotiations which take place between an employer, a group of employers or one or more employers' organisations, on the one hand, and one or more workers' organisations, on the other, for-- (a) determining working conditions and terms of employment; and/or (b) regulating relations between employers and workers; and/or (c) regulating relations between employers or their organisations and a workers' organisation or workers' organisations.

Convention	Relevant sections
Working Environment (Air Pollution, Noise and Vibration) Convention 1977 (No. 148) Ratifications: 45	Article 8(1): The competent authority shall establish criteria for determining the hazards of exposure to air pollution, noise and vibration in the working environment and, where appropriate, shall specify exposure limits on the basis of these criteria. Article 9: As far as possible, the working environment shall be kept free from any hazard due to air pollution, noise or vibration-- ...
Migrant Workers (Supplementary Provisions) Convention, 1975 (No. 143) Ratifications: 23	Article 1: Each Member for which this Convention is in force undertakes to respect the basic human rights of all migrant workers. Article 10: Each Member for which the Convention is in force undertakes to declare and pursue a national policy designed to promote and to guarantee, by methods appropriate to national conditions and practice, equality of opportunity and treatment in respect of employment and occupation, of social security, of trade union and cultural rights and of individual and collective freedoms for persons who as migrant workers or as members of their families are lawfully within its territory.
Occupational Cancer Convention, 1974 (No. 139) Ratifications: 39	Article 1: Each Member which ratifies this Convention shall periodically determine the carcinogenic substances and agents to which occupational exposure shall be prohibited or made subject to authorisation or control, and those to which other provisions of this Convention shall apply. Article 4: Each Member which ratifies this Convention shall take steps so that workers who have been, are, or are likely to be exposed to carcinogenic substances or agents are provided with all the available information on the dangers involved and on the measures to be taken.
Workers' Representatives Convention, 1971 (No. 135) Ratifications: 84	Article 1: Workers' representatives in the undertaking shall enjoy effective protection against any act prejudicial to them, including dismissal, based on their status or activities as a workers' representative or on union membership or participation in union activities, in so far as they act in conformity with existing laws or collective agreements or other jointly agreed arrangements.
Medical care and sickness Benefits Convention, 1969 (No. 130) Ratifications: 15	Article 32: Each Member shall, within its territory, assure to non-nationals who normally reside or work there equality of treatment with its own nationals as regards the right to the benefits provided for in this Convention.
Employment Injury Benefits Convention, 1964 (No. 121) Ratifications: 24	Article 4(1): National legislation concerning employment injury benefits shall protect all employees, including apprentices, in the public and private sectors, including co-operatives, and, in respect of the death of the breadwinner, prescribed categories of beneficiaries.
Equality of Treatment (Social Security) Convention, 1962 (No. 118) Ratifications: 37	Article 3(1): Each Member for which this Convention is in force shall grant within its territory to the nationals of any other Member for which the Convention is in force equality of treatment under its legislation with its own nationals, both as regards coverage and as regards the right to benefits, in respect of every branch of social security for which it has accepted the obligations of the Convention.
Social Policy (Basic Aims and Standards) Convention, 1962 (No. 117) Ratifications: 32	Article 2: The improvement of standards of living shall be regarded as the principal objective in the planning of economic development. Article 15(1): Adequate provision shall be made to the maximum extent possible under local conditions, for the progressive development of broad systems of education, vocational training and apprenticeship, with a view to the effective preparation of children and young persons of both sexes for a useful occupation. Article 16(1): In order to secure high productivity through the development of skilled labour, training in new techniques of production shall be provided in suitable cases. Article 16(2): Such training shall be organised by or under the supervision of the competent authorities, in consultation with the employers' and workers' organisations of the country from which the trainees come and of the country of training.

Convention	Relevant sections
C102 Social Security (Minimum Standards) Convention, 1952 (No. 102) Ratifications: 47	Article 7: Each Member for which this Part of this Convention is in force shall secure to the persons protected the provision of benefit in respect of a condition requiring medical care of a preventive or curative nature in accordance with the following Articles of this Part. Article 31: Each Member for which this Part of this Convention is in force shall secure to the persons protected the provision of employment injury benefit in accordance with the following Articles of this Part.
Right to Organise and Collective Bargaining Convention, 1949 (No. 98). Ratifications: 160	
Migration for Employment Convention (Revised), 1949 (No. 97). Ratifications: 49	
Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87). Ratifications: 150	
Labour Inspection Convention, 1947 (No. 81) Ratifications: 142	Article 1: Each Member of the International Labour Organisation for which this Convention is in force shall maintain a system of labour inspection in industrial workplaces.

Recommendations
Employment Relationship Recommendation, 2006 (No. 198)
Promotional Framework for Occupational Safety and Health Recommendation, 2006 (No. 197)
Promotion of Cooperatives Recommendation, 2002 (No. 193)
Worst Forms of Child Labour Recommendation, 1999 (No. 190)
Job Creation in Small and Medium-Sized Enterprises Recommendation, 1998 (No. 189)
Chemicals Recommendation, 1990 (No. 177)
Occupational Health Services Recommendation, 1985 (No. 171)
Maintenance of Social Security Rights Recommendation, 1983 (No. 167)
Occupational Safety and Health Recommendation, 1981 (No. 164)
Special Youth Schemes Recommendation, 1970 (No. 136)
Medical Care and Sickness Benefits Recommendation, 1969 (No. 134)
Employment Injury Benefits Recommendation, 1964 (No. 121)
Vocational Training Recommendation, 1962 (No. 117)
Workers' Housing Recommendation, 1961 (No. 115)
Occupational Health Services Recommendation, 1959 (No. 112)
Discrimination (Employment and Occupation) Recommendation, 1958 (No. 111)
Protection of Migrant Workers (Underdeveloped Countries) Recommendation, 1955 (No. 100)
Protection of Workers' Health Recommendation, 1953 (No. 97)

Annex III. Current initiatives, research centres and organizations involved with e-waste

Basel Action Network (BAN)

Provides up-to-date news stories, media/press releases and reports on e-waste. In five task forces, just and environmentally safe solutions for the e-waste problem are developed through analysis, planning and pilot projects: http://www.ban.org/index.html

Bureau of International Recycling (BIR)

Global recycling industry association representing more than 700 companies and 40 affiliated federations from 70 different countries. Its members are world leaders in the supply of raw materials and a key pillar for sustainable economic development: http://www.bir.org/

Electronic Industry Citizenship Coalition (EICC)

Promotes an industry code of conduct for global electronics supply chains to improve working and environmental conditions: http://www.eicc.info/

Electronics Product Stewardship Canada (EPSC)

Industry-led electronics product stewardship. Vision to work with an array of partners and stakeholders to design, promote and implement sustainable solutions to Canada's electronic waste problem: http://www.epsc.ca/about.html

Electronics TakeBack Coalition (ETBC)

Promotes green design and responsible recycling in the electronics industry. The goal is to protect the health and well-being of electronics users, workers and the communities where electronics are produced and discarded, by requiring consumer electronics manufacturers and brand owners to take full responsibility for the life cycle of their products, through effective public policy requirements or enforceable agreements: http://www.electronicstakeback.com/home/

Global e-Sustainability Initiative (GeSI)

Major telecommunications operators' and their suppliers' organization dealing also with e-waste: http://gesi.org/

GoodElectronics

A network consisting of about 150 organizations and individuals worldwide, including trade unions, labour rights organizations, human rights organizations, environmental organizations, universities, academics and researchers: http://goodelectronics.org/

Greenpeace International

An independent global campaigning organization that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace: http://www.greenpeace.org/international/en/

International Solid Waste Association (ISWA)

Sharing experience and information within its network of waste professionals: http://www.iswa.org/

makeITfair

A European project focusing on the electronics industry, especially on consumer electronics. A focus is to inform and engage young people: http://makeitfair.org/

National Electronics Product Stewardship Initiative (NEPSI)

Multi-stakeholder dialogue in the US. Aims to ensure that all those involved in the lifecycle of a product share responsibility for reducing its health and environmental impacts, with producers bearing primary financial responsibility: http://www.productstewardship.us/displaycommon.cfm?an=1&subarticlenbr=71

Öko-Institut (Germany)

A leading European research and consultancy institution working for a sustainable future: http://www.oeko.de/home/dok/546.php

Partnership for Action on Computing Equipment (PACE)

Established at the ninth meeting of the Conference of Parties to the Basel Convention in June 2008. It is a multi-stakeholder partnership between industry, government, academia and civil society addressing the environmentally sound management of used and end-of-life personal computers: http://www.basel.int/industry/compartnership/

Procure IT Fair
Criteria for sustainable procurement of IT products: http://procureitfair.org/

Silicon Valley Toxics Coalition (SVTC)
A diverse organization engaged in research, advocacy and grassroots organizing to promote human health and environmental justice in response to the rapid growth of the high-tech industry: http://svtc.org/

StEP Initiative (Solving the E-waste Problem)
An initiative of various UN organizations together with prominent members from industry, governments, international organizations, NGOs and the science sector to initiate and facilitate approaches towards the sustainable handling of e-waste: http://www.step-initiative.org/

Strategic Approach to International Chemicals Management, SAICM
Paragraph 15 aims to ensure that: "information on chemicals throughout their life cycle including where appropriate, chemicals in products, is available, accessible, user friendly, adequate and appropriate to the needs of all stakeholders ..."; while paragraph 18 aims "to prevent illegal international traffic in toxic, hazardous, banned and severely restricted chemicals, including products incorporating these chemicals, mixtures and compounds and wastes". Electronic waste was also identified as one of the four emerging issues at the second session of the International Conference on Chemicals Management in 2009. UNIDO is the lead organization: http://www.saicm.org/index.php?ql=h&content=home

Swiss State Secretariat for Economic Affairs (SECO) and Swiss Federal Laboratories for Materials Science and Technology (Empa)
Initiated the Global Knowledge Partnerships in e-Waste Recycling programme. Has published case studies on its work in South America (including Colombia, Peru, Brazil), Asia (including China, India), Africa (including Egypt, South Africa, Kenya, Morocco, Ghana, Senegal) and the Caribbean (Trinidad and Tobago). Primarily undertakes projects on e-waste including inventory, collection and recycling and to establish "knowledge partnerships in e-waste recycling": http://ewasteguide.info/

SWITCH-Asia Network Facility
Works with the sustainable consumption and production (SCP) projects funded by the EU. It helps effectively share knowledge and disseminate successful project practices and intensify networking between its Asian and European partners: http://www.switch-asia.eu/

Toxic Link
An Indian organization with expertise in the areas of hazardous, medical and municipal wastes, as well as in specific issues such as the international waste trade, and the emerging issues of pesticides and POPs. Now focused on e-waste and has already done assessment studies of e-waste scenarios in major metros in India: http://www.toxicslink.org/

UNEP Global Partnership on Waste Management (GPWM)
An open-ended partnership for international agencies, governments, businesses, academia, local authorities and NGOs. The Partnership supports the development of work plans to facilitate the implementation of integrated solid waste management at national and local levels. E-waste Management is a sub-focal area: http://www.unep.or.jp/ietc/SPC/activities/GPWM/activity_global-partnership.asp

WEEE Forum (European Association of Electrical and Electronic Waste Take Back Systems)
Consists of representatives of 39 electrical and electronic waste collection and recovery systems in Europe. Its mission is to provide a platform for co-operation and exchange of best practices and optimize cost-effectiveness: http://www.weee-forum.org/

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