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Recycling of Information and Communication Technology Waste and its Impact on Sustainable Development

Nouiri Samia[1]

[1]Associate Professor Class A, University 8 May 1945 Faculty of Law and Political Science, Department of Law, Laboratory of Legal and Environmental Studies, Research Team: Environmental Policies.

The E-mail Author: nouiri.samia@univ-guelma.dz

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Abstract:

Information and Communication Technology (ICT) equipment is characterised by its short consumption cycle, after which it immediately becomes a significant source of waste due to the rarity and high cost of its raw materials. As a result, many countries around the world have taken steps to recycle this type of waste, resulting in significant economic impact and development at various levels, as ICT is a common element in many sectors.

To this end, numerous international agreements have been established to regulate and cooperate in this field, particularly between developing and developed countries. These agreements consider this waste as part of electronic waste, and indeed as the most significant part of it.

Keywords: Waste recycling - Information and communication technology waste - Economy and sustainable development - International experience.

Introduction:

The current era is characterised by the widespread integration of technology into our daily lives, in particular Information and Communication Technology (ICT). In this context, it is rare to find a home, office or institution without at least one computer, if not different types of computers in different forms.

This diverse and excessive proliferation is expected to generate significant amounts of waste, posing serious risks to the environment and human health. It is therefore essential to rationalise and optimise the use of this waste, especially considering that most of it is

relatively new. As technology develops, people tend to buy the latest equipment and discard the old.

Consequently, it is imperative to focus on the collection and recycling of this waste, given the durability of certain components and their positive impact on the economy and sustainable development.

In this research paper, we aim to highlight the most successful experiences in the recycling of information and communication technology waste. We have chosen to use the term “waste” rather than “garbage” because of the material value of this waste. In this context, the central question is “What is the material value of this waste and what are its implications for sustainable development?”

To address this question, we have tried to answer it through two main axes:

First Axis: The Concept of Electronic Waste Recycling

Second axis: Recycling mechanisms according to international experience and their impact on sustainable development.

For this purpose, we have chosen a descriptive analytical approach, examining several international cases that have successfully recycled this type of waste, exploring its material value and how it can contribute to the economic and social development of countries. We aim to conclude with several findings and recommendations, which will be presented accordingly.

First Axis: The Concept of Electronic Waste Recycling

The term “electronic” refers to everything related to Information and Communication Technology (ICT), specifically technologies limited to computers in their various forms and communication devices. It is therefore much narrower than the broader concept of electronic technologies and equipment.

This waste and related equipment can be summarised as follows: desktop computers, personal computers, laptops, notebooks, printers, scanners, photocopiers, hard drives, electric and electronic typewriters, pocket and desktop calculators, fax machines, telephones, mobile phones, CD players, answering machines, video recorders, audio recorders and loudspeakers.

Statistics show that this waste has become a pressing problem of our time. In this regard, the European Directive PE-CONS 2/12 emphasises the need to classify all electrical and electronic equipment into six categories instead of the ten previously used.

Various Information and Communication Technology (ICT) devices are characterised by a short life cycle and a consumer culture based on "buy, use and dispose". This has led to the generation of huge amounts of information and digital equipment waste.

Before discussing the negative impacts, which can later be transformed into mechanisms for achieving sustainable development, we will first look at the concepts related to this issue.

First: Definition of e-waste

There is no universally agreed term among scientists for this type of waste. Some refer to it as waste from electrical and electronic equipment, while others simply call it electronic waste.

European Union Directive EU/96/2002 defines electronic waste as "waste from electrical and electronic equipment, including all components, parts and materials that are part of the product at the time of disposal". The directive defines electrical and electronic equipment as any device that uses electricity or electromagnetic fields and has reached the end of its life cycle, from large household appliances such as refrigerators and air conditioners to smaller devices such as computers and mobile phones.

The United Nations Environment Programme (UNEP) Waste Problem Office defines electronic waste as "the term used to cover all items and tools, including all types of electrical and electronic equipment and their parts, which have been discarded as waste by the owner with no intention of reuse".

On the other hand, the Basel Network Action, now known as the Basel Convention, defines e-waste as "a wide and growing range of electronic equipment, including large household appliances such as refrigerators and air conditioners, mobile phones, personal audio equipment and consumer electronics related to computers, discarded by their users".

The Organisation for Economic Co-operation and Development (OECD) defines electronic waste as "any device that uses electricity and has reached the end of its life cycle".

Khaled Mustafa defines e-waste as "everything that results from the production and use of electrical and electronic equipment, their parts and accessories in all sectors, including household appliances, office equipment, communication and information equipment, as well as measuring and control equipment, lighting equipment, children's toys, medical equipment and recording and receiving equipment"[1].

From the above, it can be concluded that e-waste includes all electronic and electrical equipment and appliances, as well as their components and parts, which are no longer used by the consumer, or which are broken or defective and no longer compatible with modern technology, or which have been destroyed. In other words, all electrical and electronic equipment becomes electronic waste when it is discarded by its owner for any of the following reasons

- Obsolescence of the equipment due to the emergence of more advanced and modern types.

- Damage, breakage or malfunction of the equipment or some of its parts.

- The end of their productive life cycle.

As mentioned above, the study will focus specifically on electronic waste related to information and communication technology.

Second, the concept of recycling

Recycling refers to any process in which waste materials are processed to make new goods. Instead of throwing away unwanted materials, they can simply be recycled to make new products. In addition, recycling helps to reduce the amount of waste that typically ends up in landfills, thereby minimising the amount of toxic chemicals buried in the ground.

Recycling processes allow materials to be extracted or reused in a way and at a rate that does not lead to their long-term depletion or degradation, while preserving them to meet the needs of future generations[2].

[1]- MalakNour El-Din, The role of environmental management strategies in the management of electronic waste: A Study of Several Algerian Economic Institutions, Faculty of Economic and Commercial Sciences and Management Sciences, Master's thesis, University of M'sila, 2016, p. 17.
[2]- Regional Centre for Training and Technology Transfer for Arab States, Draft Guideline Law on the Regulation of Electronic and Electrical Waste and Used Mechanical Equipment Management and Transboundary Movement.

The recyclable materials specific to information and communication technology (ICT) waste include the following:

- Fluorescent lamps (aluminium, glass, mercury)

- Dry batteries (lead and plastic are reused in the production of new batteries) and rechargeable batteries (cadmium, nickel and iron are reused).

- Televisions (glass and lead are reused).

- Computers (mercury, steel, plastic and gold are reused).

- Computer screens (glass, gold and lead are recycled).

According to Information and Communication Technologies (ICT) data and statistics from the Telecommunication Development Sector of the International Telecommunication Union (ITU), there has been a tremendous growth in the number of users of this technology in developing countries, rising from 501 million in 2006 to over 1.3 billion by the end of 2011. The number of devices used, such as laptops, tablets and smartphones, is growing rapidly: from 44 per cent of internet users in developing countries in 2006, this figure rose to 62 per cent in 2011, an increase of more than half.

According to statistics published by the Union in June 2012, “the total number of mobile subscriptions reached nearly 6 billion by the end of 2011, representing a global penetration rate of 86 percent. Developing countries were the engine of growth, accounting for more than 80 per cent of the 660 million new mobile subscriptions added in 2011.”

Estimating global information and communication technology (ICT) waste, the report “Recycling - From Electronic Waste to Resources”, released at a meeting of stakeholders under the Basel Convention, predicts that by 2020, e-waste from old computers will have increased by 400% in China and South Africa compared to 2007 levels, and by 500% in India. The report also predicts that by 2020, e-waste from discarded mobile phones will be 18 times higher in India than in 2007, and seven times higher in China. According to the United

Nations Environment Programme (UNEP), between 20 and 50 million tonnes of e-waste is generated globally each year, with ICT waste making up a significant proportion of this total[3].

It should be noted that a significant percentage of this discarded equipment is disposed of well before the end of its life cycle, as owners opt to purchase equipment with newer and better features. However, we should not miss the opportunity to repair or refurbish obsolete equipment so that it can be reused or materials can be extracted for the manufacture of new equipment or new production cycles.

What distinguishes the recycling process for equipment related to this technology is the presence of rare metals. A rare metal is one that is uncommon and can only be found in certain regions of the world. Examples include indium, chromium, tungsten, cobalt, manganese, molybdenum and vanadium, of which just five countries account for 90 per cent of global production. Rare metals are widely used in Information and Communication Technology (ICT) products such as computers, mobile phones, tablets, touch screens and LED lighting. A mobile phone contains more than 20 rare metals, including titanium, indium, gallium, barium, tantalum, arsenic, neodymium, zirconium and others[4].

It is widely recognised that this equipment, together with its various types of electronics, poses a significant threat to both human health and the environment, as it contains toxic materials comprising more than a thousand types of chemical elements, including chlorinated solvents, polyvinyl chloride, heavy metals, plastics and gases.

All the materials that make up ICT equipment become a source of hazard when they are damaged, and when stakeholders try to dispose of them in an indiscriminate manner, toxic substances can leach into natural resources such as water, air and soil, which then enter the food chain or are inhaled by humans.

Second axis: Recycling mechanisms based on international experience and their impact on sustainable development

[3]- Press Release, "Basel Conference Addresses the Challenge of Electronic Waste", 27 November 2006, UNEP.
[4]- Mahinaz Al-Baz, "Green Technology and Communication:
The Secret to Sustainable Development in the Language of the Age", published in Al-Ahram for Computing and Communication, available at http://aitmag.ahram.org.eg/News/99882/%D8%A3%D8%AE%D8%A8%D8%A7%D8%B1-%D9

Many countries have successfully recycled information and communication technology (ICT) waste, contributing significantly to their economic development and to achieving sustainable development. This is what we will now discuss.

International Experience:

1. The Colombian experience: In 2000, the Ministry of Information and Communication Technologies and the Ministry of Education launched a social programme aimed at creating development opportunities for underprivileged sectors of the population by reducing the digital divide. One of the methods used to achieve this was the refurbishment of computers that were no longer in use or that had been donated by individuals, public institutions, private companies and international organisations, among others.

These machines go through a process of inspection, classification, repair, cleaning and software updating to ensure that they are in the best possible aesthetic and technical condition for reuse in the educational institutions participating in the programme. After four years of use in their second life cycle, the programme collects the equipment and transfers it to the National Electronic Waste Recycling Centre, which also receives surplus electronic components unsuitable for refurbishment from the repair centres.

The returned equipment is dismantled either manually or industrially, which involves sorting, cleaning and classifying the parts, as well as recovering some ferrous and non-ferrous metals, plastics and clear glass. These recovered items are then sold at public auction for subsequent industrial use.

2. African experience: This experience was sponsored by the Regional Centre for the Basel Convention in collaboration with the Euro-Mediterranean Parliamentary Assembly. The study identifies the flows of end-of-life equipment and electronic waste, particularly from Europe to West Africa, and their subsequent re-export within the region.

An assessment of used equipment, end-of-life equipment and electronic waste in Côte d'Ivoire, Ghana and Nigeria will be carried out to determine the environmental management practices that should be followed by both the formal and informal sectors. The study outlines the requirements for environmentally sound management, as well as the regulatory and legal frameworks for each country.

In terms of metal separation, the report shows that hazardous fractions are being improperly handled and that open-air burning is being used to extract copper. However, there is at least one facility in Ghana that properly manages e-waste and any fractions that cannot be processed domestically are exported to Europe.

A socio-economic study conducted in Lagos (Nigeria) shows that activities related to the collection, refurbishment and recycling of used and obsolete electrical and electronic equipment generate significant employment opportunities. Unskilled workers can be involved in collection and recycling, while refurbishment requires workers with a higher level of expertise.

The project proposes a training programme for port authorities, customs officials, government representatives and accreditation bodies, focusing on tracking and monitoring the cross-border movement of end-of-life information and communication technology (ICT) equipment and preventing illegal trafficking of such waste[5].

3. Korean experience in rare metal recycling

In order to facilitate the recycling of rare metals, it is essential to establish systematically managed recycling procedures, referring to the ITU-T L.1100 recommendation entitled "Method for Providing Information on the Recycling of Rare Metals in Information and Communication Technology Goods". The Republic of Korea has established a rare metals recycling management process that includes four management points for information and communication technology (ICT) products throughout their life cycle: "ICT Goods", "Management Authority", "Customer" and "Recycler".

The Management Authority collects and maintains information on rare metals in ICT products sent to it by manufacturers from different parts of the world, and provides this information to recyclers or other regulatory bodies in different countries or regions upon request. Manufacturers provide ICT products to customers for long-term use, and at the end of the product life cycle, the products are ultimately sent to the recycler. Manufacturers send information on rare metals to the management authority and then to the recycler.

[5]- Previousreference.

For recycling to be effective, the information must be accurate and collected through measurement and diagnostic techniques for elements such as rare metals. Depending on the measurement technology used, the ability to separate elements and quantify their recovery varies.

Case study - touch screen tablet computers

Touchscreen tablet computers were launched in early 2010, combining the features of a mobile phone (compact and lightweight) with those of a computer (with a reasonable screen size), transforming the user experience of information technology.

From an environmental perspective, a tablet computer uses 60-30 times less energy than a desktop computer. In addition, the manufacturing of a laptop or desktop computer produces three to twelve times the amount of greenhouse gases as a tablet.

On the other hand, the battery is usually an integrated component, which means that the life cycle of the tablet computer is the same as that of its battery. To recycle a tablet, the outer casing is broken open and the various components are separated and treated accordingly: the screen, the battery, the plastic (about 55 grams) and the electronic board (about 45 grams).

Glass and aluminium are the easiest materials to recover, unlike the circuit board, which is sent to a “refinery” to extract copper, precious metals and solder. In total, more than 80 percent of the tablet’s weight should be recycled, with the remaining less than 1 percent either incinerated or disposed of.

In many developing countries, the demand for computers is currently low in many sectors of society. For example, primary, secondary and higher education institutions, public libraries and cultural centres, among others, face barriers to access to information and the knowledge society because of the high cost of new equipment or, in some cases, because of the challenges posed by remote, hard-to-reach areas. In general, the equipment needed does not require high processing and storage capacity, as it is mainly used for office applications and Internet access.

Second: The impact of e-waste recycling on sustainable development

As mentioned above, the life cycle of electronic media and equipment is characterised by its brevity. The recycling process therefore ensures that this cycle is completed in an environmentally sound manner, leading to energy efficiency and reducing the need for mining to extract new materials.

The industrial dismantling of e-waste also has social implications, as it creates more job opportunities and a low-cost technical education environment by recovering electrical, electronic and mechanical components from obsolete computers and surplus electronics. These components can later be used to create laboratories and robotics toolkits that allow students to explore different aspects of science and technology.

This approach facilitates their understanding of basic concepts through hands-on training in experiments designed to teach students how to solve everyday problems while developing both logical thinking and their own ideas[6].

All this can provide green job opportunities by using specialisedlabour in waste processing and other professions, which can also help to reduce unemployment rates in the economies of developing countries.

Thus, the recycling of electronic waste, especially from information and communication technology (ICT), is considered a form of investment similar to investment in infrastructure, as it offers new opportunities and innovative solutions to mitigate the risks associated with electronic waste.

In addition, using this waste locally rather than exporting it to developed countries can save transaction costs such as shipping and eliminate the need to store electronic waste[7].

Moreover, this waste, together with the valuable and sometimes rare metals it contains, as mentioned above, is an important source of national wealth. It also contributes to the production of new equipment, which can reduce the cost of raw materials and bring economic benefits to the companies that manufacture this type of equipment. This in turn reduces the final cost of new products, making them more affordable to the public.

[6]- Report on the Management of Waste Electrical and Electronic Equipment (WEEE) from Information and Communication Technology: Strategies and Policies for the Proper Disposal or Reuse of Communication/ICT Waste, 2014.
[7]- SuhelaBoukhmis, AouatifBoutarfa, Recycling Electronic Waste and Its Role in Achieving Sustainable Development, Journal of Legal and Economic Studies, Volume 3, Issue 02, 2020, p. 66.

In addition, it is clear that proper management of e-waste - by improving collection and recycling methods - will help reduce the amount of electronic waste that ends up in landfills. This poses a threat to the environment and human health through the release of polluting gases and toxic elements into the air, water and soil.

The recycling process therefore has a positive impact on improving the surrounding environment by:

- Reducing pollution: By collecting waste before it accumulates in the soil, water or air.

- Reducing pressure on landfill sites: Utilising land earmarked for landfill for other investments.

- Conservation of natural resources: Recycling reduces the need for natural resources used as raw materials in production, minimising resource depletion.

- Generating and improving energy utilisation: Recycling reduces energy consumption.

- Contribution to biodiversity: Provides a suitable and clean environment for living organisms, thereby increasing both animal and plant biodiversity.

- Recovering metals from waste: This reduces the need for mining to extract virgin materials from the earth, which in turn reduces energy and water requirements and reduces environmental impacts such as emissions and discharges[8].

For these reasons, in September 2015, the United Nations adopted the Sustainable Development Agenda for 2030, which includes 17 Sustainable Development Goals and 169 targets to eradicate poverty, protect the planet and ensure prosperity for all over the next 15 years[9].

Conclusion:

Electronic waste, especially information and communication technology (ICT) waste, has significant material and economic value due to the precious and rare metals it contains. This value contributes significantly to improving social and economic conditions through the

[8]- MostafaYusifKafkafi, Environmental Economics, Dar Al-Salaf for Printing, Publishing and Distribution, 2014, p. 407.
[9]- AmalFawzi Ahmed Awad Mahmoud, Electronic Waste: Environmental Impacts, Legislative Challenges, Prevention and Protection Mechanisms, and Regulatory Maturity.

establishment of dedicated recycling factories, which in turn provide employment opportunities. It also helps to reduce the volume of hazardous waste that poses a risk to human health.

The experiences highlighted in this research paper serve as real-world examples to support these claims. We therefore hope that the Algerian government will pay considerable attention to this type of circular economy, promoting it through educational and economic institutions and advocating it through conferences and study days.

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6. Mahinaz Al-Baz, "Green Technology and Communication: The Secret to Sustainable Development in the Language of the Age", published in Al-Ahram for Computing and Communication, available at [http://aitmag.ahram.org.eg/News/99882/%D8%A3%D8%AE%D8%A8%D8%A7%D8%B1-%D97. MostafaYusifKafkafi

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