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Analysing E-waste Management in Finland

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Abstract

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Electronic waste is an increasing global concern due to its harmful influence on the environment and human health. As the demand for electrical and electronic equipment develops, it is necessary to develop effective methods for producing, disposing, and recycling in eco-friendly way. This research comprehensively examines e-waste management in Finland. The study looks at the present legislative framework, existing challenges, and possible opportunities in the waste management industry. The literature review provides an in-depth look at e-waste, covering its composition, lifetime, risks, and sustainable management practices.

The study found that Finland has a strong e-waste management system in place with successful implementation of the EU led directives. It has also been able to meet the target set by the EU to a greater extent. However, despite the country's achievements, there are still issues that must be addressed. These issues include enhancing small electrical and electronic device collection and recycling, raising consumer awareness, and building a circular economy for electronics.

Furthermore, the study concluded that Finland's e-waste disposal system is effective, but it could be better. Enhancing the collecting and recycling of small electrical and electronic equipment, raising consumer awareness, and strengthening the legislation are some of the recommendations for improved EEE management.

Keywords: E-waste, WEEE Directive, composition, lifecycle, recycling, eco-friendly.

Contents

Glossary

EEE	Electrical and Electronic Equipment
EoL	End of Life
GeSI	Global e-sustainability Initiative
ICT	Information and Communication Technologies
IETC	International Environmental Technology Center
NSES	National Strategy for Electronic Stewardship
PCBs	Polychlorinated Biphenyl
REACH	Registration Evaluation and Authorization of Chemicals
ROHS	Restriction of Hazardous Substances
StEP	Solving the E-waste Problem
WEEE	Waste Electrical and Electronic Equipment's

1 BACKGROUND

In recognition of the growing concern for the global need to behave in a more sustainable manner population is shifting towards eco-friendly lifestyles. The increasing population and their demand fulfilment requires the need for the existing use of the energy and resources. One of the growing industries is the Electronic and Electrical Equipment (EEE) industry that utilize the earths non-renewable resources for the manufacturing of products.

The information and technology have engraved the existing society in a way where individuals seek for comfort and accessibility on everyday basis. To satisfy the individuals the technology has stepped in with their discoveries but with a cost of global concern towards environmental sustainability. The EEE sector has gained its popularity in a short span for its impacts in the global warming. The reasons behind are increasing wealth amongst the people has led these products to be more commercialized as a part of elegance in their lifestyle rather than need. This has pressurized the factories to build up something new to fulfil this part of the consumer that yield higher profits while ignoring the cost of impacts it makes on the overall global population.

The developed countries come in first whilst considering the technology development while it has been seen that developing countries are the ones who are suffering from the lack of management. In fear of the stricter regulations and their lack of capacity to meet upgraded legislation in the developed countries the manufacturers are shifting their end-of-life (EOL) responsibility chains towards developing countries where legislation is more lenient. This has put the life in danger as the dumping sites in developing countries are piling up which has raised a concern globally for the electronic industries to strive for more sustainable possibilities.

Waste recycling has been prevailing in the society for a long time in multiple ways. The traditional methods of recycling are no longer effective with the rapidly growing population due to the increase in the waste mass that are found

in complex forms. The new technologies require the need for modern mythologies. In search of eco-friendly approaches globally the countries are implementing different regulations and legislation to oblige the production companies to think differently to reduce the impact that has caused due to the WEEE globally.

Finland's waste management before the enforcement of waste act was handled by public health legislation, which focused more on health impacts due to waste. With the collaboration of Finland with EU during the mid-1990's the waste management was centralized towards reducing, organizing and managing the waste to prevent it from going into the landfills. Now, after several reforms in the acts and laws the waste management is differentiated into different sectors to develop a focused approached based on the requirements of the wastages produced.

To meet the global concern of sustainable development EU has come across with policies and actions that support the economic and social progress with focus on minimizing the human and environmental impact. There are numerous directives under EU which the Finland also follows together in support to operate in more responsible and sustainable manner. Some of the major implementations are producer responsibility, Restriction of Hazardous Substance (RoHS) directives, WEEE directives, The Basel convention which is further elaborated with focus during this study.

2 OBJECTIVE

The main objective of this research is to examine e-waste management in Finland. The report will focus on the available E-waste management practices in Finland. Furthermore, the available legislations of E-waste management in Finland will also be covered in the report. To understand more about the current trend on E-waste management, extended research on the EU regulations in the management of waste electrical and electronical equipment will also fall under the scope of the research.

Since the WEEE products cover a large range of electrical and electronic products, the waste management practices that are being carried out at the present time will also be looked into during the proceeding research. For instance, the trend of recycling and refurbishing the products will also be analysed in depth. The research focuses on analysing the possible sustainable form of e-waste management which could be effective and economic to ensure safe e-waste handling.

The main aim is to study the Finland's waste electrical and electronic equipment (WEEE) management in details with focus on highlighting the current practices and to outline more sustainable approaches for future the e- waste management.

3 E-waste

3.1 Introduction to E-waste

Electronic appliances are an integral part of our daily lives. In the modern era we use a lot of electronic appliances in our home, school & offices after a certain amount of time these devices life or rather useful life comes to an end and must be disposed of which is referred to as E-waste. E-waste is simply defined as the discarded electronic products which requires power supply to function. The most common cases are the old phones that we all have on our selves including their charger and earphones which we do not have any use of, the old mixer & the small TV to be thrown that we replaced for the bigger and better one. The common yet unnoticed electronic products are a major part of today's global e-waste collection. These electronic product harm the environment if not disposed correctly.

According to the data of Statista 2023, every person generates about seven kilograms of e-waste every year resulting in more than 50 million e-waste generated worldwide. Between the years 2010-2019 the production for e-waste increased by almost 60% which by the current trends is not going to decrease

any time sooner rather it is predicted that by 2030 if the preceding situation remains the same, the annual production of e-waste will reach an astounding to 75 million tons. (Statista,2023).

3.2 Categories of E-waste

E-waste is a complex waste containing the most poisonous as well as hazardous elements in it. Based upon the categories of the products consisting in the E-wastages it is grouped under following categories.

Figure 1. Types of E-waste (G,Divanshi, 2022)

1. Screens and Monitors: Devices such as laptop, notebooks, tablets, televisions, desktops, and laptops are included in this category. According to the report of Global E-waste Monitor 2020, monitors and screens generated approximately 6.7 million metric tons of e-waste in the year 2019. In common these kinds of devices have materials like lead, mercury, and cadmium, that end up in the landfills, gets absorbed and release a phosphorous substance that damage the environment leading to chronic illness in human life as well.

2. Small sized IT and Telecom equipment: In this group there are electronics like cables, printer, routers, keyboards and headphones

which usually consist of circuit boards. The data of Global E-waste monitor 2014, estimates 3.0mt production of E- waste by small and short-termed IT equipment's. The harmful components containing in these electronics such as Polycyclic aromatic hydrocarbons (PAHs) when released into the air and soil causes potential damage to the environment.

3. Temperature exchange equipment: In this group there are products which is prevalent in every normal household. Refrigerators, heaters, fans, washing machines, dishwashers, and household electric motors are few of the examples. These materials are also known as thermal exchangers as the elements inside these machines help to regulate the temperature of its own while operating. These devices generate 12.8Mt of small part of the IT annually (The Global E-WASTE Monitor, 2014). Often the devices of this category produce hazardous materials such as PCBs (Polychlorinated biphenyl's) which are harmful to the environment.

4. Small Household used equipment's: Electronics like mixers, coffee machine, toaster, printers including other household devices consist of a mixture of plastics and heavy metals. These kind of metals releases hazardous chemicals such as PCBs (polychlorinated biphenyl) which causes damage to animal and human life. It is estimated that 12.8Mt of small IT waste is generated every year as per the global E-waste monitor of 2014 (THE global E-waste Monitor,2014).

5. Small electronics: Mobile phones is one of the common types of small device which is easily found in most of the houses. In some cases, people might also have two phones for the business and personal purpose. Most of these devices tend to have an active life cycle of three to ten years. With the technology growing and the updates every day, these devices become outdated in a short span adding a pile to world e-waste collection. For instance, cell phones contain various materials which constitute of harmful substances like cadmium or lead. The

amount of harm it can cause is irreversible, as per the reports estimated 200 million units of personal electronic devices are disposed each year.

6. Photography equipment's: fluorescent lights, lenses consist majority of the glass, plastics, and metal components. These instruments when disposed take a long time during which process, they start to release toxic substances that cause massive impact upon the surrounding and the life around them.

The main goal for classifying the e-waste is to enhance proper recycling process. Segregating the e-waste helps to choose the most appropriate technology for recycling. Also, it also helps to manage the wastages by understanding the types of materials and how they could be used or be discarded depending upon the material and condition of the matters inside the electronics.

3.3 Material Composition of E-waste

Composed of several metal and non-metals E-waste creates a diverse substance which creates a challenge for governments all around the world. Consisting of 30% organic material, 30% ceramic and 40% inorganic material on average (Joo et al., 2021) E-waste includes inorganic material such as base metal, precious metal, rare earths & heavy metals which are hazardous elements extracted from the Earth's crust. With the increasing use of electronic devices their sustainable consumption has become a focus. Below are rare earth metals commonly used in electronic products.

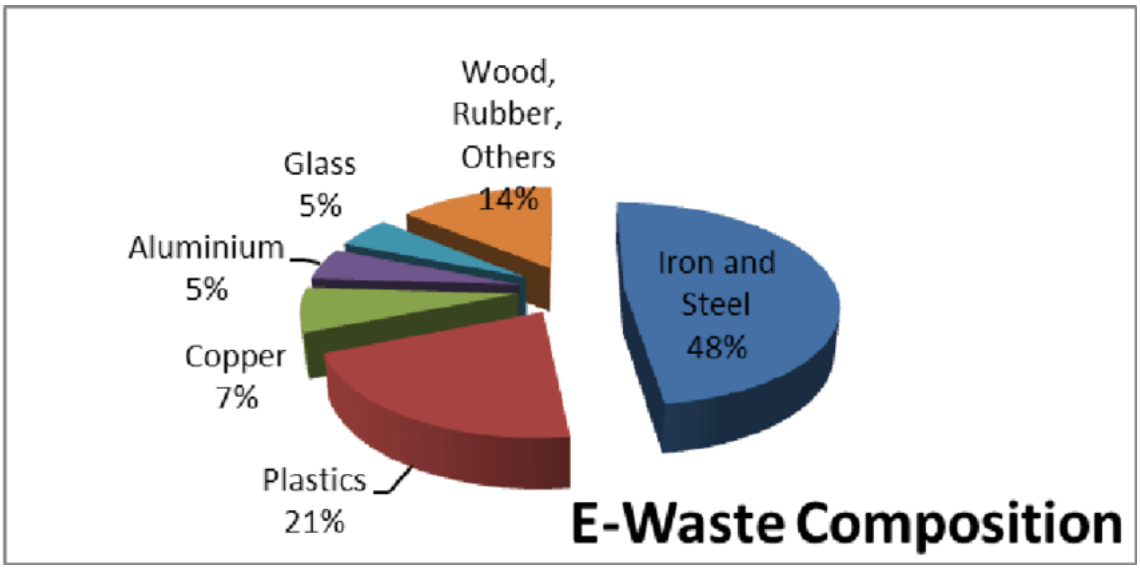


Figure 2: WEEE composition (Abdallah, Lamiaa. 2014)

A common example is a phone, almost all people now-a-days have a smartphone with them which consist of different materials like nickel, plastic, glass, silicon dioxide (SiO2), copper, lithium, cobalt etc. Below is an image that shows the composition of smartphones based on its components.

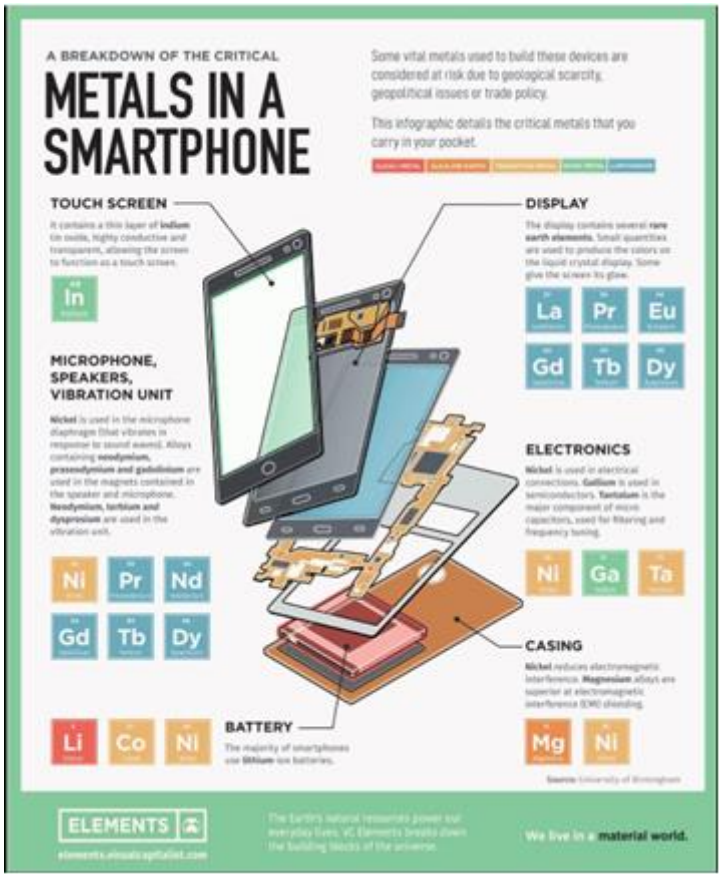


Figure 3: Material Composition of a smartphone (Venditti, 2021)

After these materials gets into the landfills, they cause severe environmental damage impacting the earth's air, soil, water, and the health of humans. On the other side disposal of these materials means increase in demand for more extraction inflaming the ecological impact of mining. The disposed inorganic metals contain mercury, cadmium and lead which complicate and risk the management of E-waste. Thus, this issue raised by electronic waste requires a collaborative effort from all levels of stakeholders from locals to the legislators.

At present, the scarcity of skilled professionals, inadequate infrastructure and lack of funds are some of the challenges faced by E-waste management industry. Therefore, conquering this problem first is important to ensure proper disposal of E-waste.

3.4 Life cycle of Electronics

In the beginning of the technological advancements, the producers estimated that these devices would have a longer life up to 40 years, but with the running pace of changes in the technology industry the active life of the products is reduced to half of the expected devices lifespan. Although the devices are found to be workable the existing public is easily attracted and eager to try new things because of which the need of recycling the products are of utmost importance. The following table below shows the life span of public common choice of products in accordance with its lifespan.

Type of Electronic	Average Lifespan
Desktop Computers	4 years
Laptop Computers	3 years
Phones	4 years
Tablet	7 years
Printer	4 years
Smart TV	7 years
Gaming console	6 years

Figure 4: Average Lifespan of electronics (Quantum, 2021)

Recycling the devices helps in increasing the devices lifespan to make the use to its full extent. Recycling also has positive impact on environment, economy, preservice of natural resources and saves the resources for future generations.

3.5 Hazards of E-waste

Our environment is surrounded with bunch of electronic equipment which later are the source of E-Waste collection. The compounds in the commonly found electrical equipment like heater, phone, sound bars, computers in case of improper disposal these wastages are a severe problem that cause profound damage to the environment as materials like mercury, lead, and sulphur which are commonly found in electricals are considered hazardous to the surrounding environment. In addition to the environmental damage, it also hampers the life around it. It has been found that improper disposal of the e-wastages can result in cognitive, neurological, sensory or memory impairments in humans. (2019, Sinha et al.)

The extent of its hazardous effects also depends upon the recycling method. Improper handling and recycling of E-waste can cause serious environmental pollution. One of the common ways of handling the e-waste is dumping. When the wastages get into the ground then, they get absorbed through the soil and the hazardous materials end up in the nearby water sources which contaminate the water supplies. This contaminated water directly or indirectly ends up in the living beings around it causing the damage. The increased dumping of wastages has resulted in issues of elevated heavy metals concentrations in the environment. (He et al. 2021)

Another most common way of improper handling of E-waste is burning it. Burning the e-waste directly releases the harmful chemicals into the environment. Sometimes there has also been cases that some of the explosive's materials inside the electronics when put on fire results in explosions, poisoning and destructive fires. In co-relation to the environment the living beings also gets impacted by it. In the human health, people can suffer from respiratory problems damaging the lungs and cause other health hazards.

There are several methods of handling the wastages. Physical separation of the wastages into distinct categories based on its compounds such as metals, plastics, or organic compounds. In chemical separation, depending upon the electrical contents they are treated accordingly to safely reform it. While the biological methods although is still new, it is used for the recovery of the heavy metals. (Chen et al. 2017).

Choosing a proper recycling method is important. Improper recycling method not only harms the environment but also the personals involved in the process as well. It is crucial to understand what kind of material it is before choosing the recycling method. As, the material in the e-waste depends upon the production process, quality as well as its physical or chemical properties in it. Improper handling of these wastages can be more dangerous so, it is required to use suitable method for the treatment. (Chen et al. 2017.)

4 Global E-waste Management

Concerns and challenges on management of the e-wastages are on increasing side. This is because the consumption of electronic materials is increasing resulting in decreased disposal spaces. Due to the lack of proper discarding facilities the cost of the existing disposal outlets is increasing, this will be a huge problem as people get demotivated towards proper management of the e-wastes. So, it is important to find some cost-effective, sustainable, and environmentally friendly solutions for the management of the e- waste (US EPA, 2015).

In context to the wastages produced all around the world, Asia generates the highest amount of E-waste with 46.5%. While America follows up Asia with 24.4 %, Europe generates 22. 4%, Africa generates 5.4 % and Oceani 1.3%. An average of per person waste generation is high in Europe with 16.2kg/ person, Oceania with 16.1kg/ person, the Americans with 13.3kg/ person, Asia with 5,6kg/person and Africa with 2.5kg/person. (Forti et al.,2020.)

According to the International Telecommunication Union's report (2019), it is estimated that Europeans generate the highest amount of e-waste per capita While in Asia, 24.9 million metric tons of the electronic waste was generated in 2019, out of which only around 12% was properly in record or was recycled. However, in Europe the highest part of the recorded wastages is collected and recycled (42.5 %) in comparison to other countries. While compared to the EU countries they are behind on the target which is 65% of the e-waste collection. In the Asian side, the Eastern Asia has the highest percentage which is around 20% of recorded E-wastes collection amongst the Asian sub regions. (Tiseo, 2023.)

The first assessment of Latin American countries E-waste management included 13 different countries from Central and South America. According to the data, the E-waste increased by 49% from 2010 to 2019. As of the data of 2010 the e-waste generation per capita was 4.7 kilograms while in 2019 it was 6.7 kilograms. Amongst the wastages, 36,000 tons of the waste have been recorded to have been managed whilst the worth of US 1.7-billion-dollar valuables have been estimated to have gone to waste due to improper e-waste management. The increase in the electronic wastages is also affected by the massively increased availability of the electronic products in the market. (UNITAR ,2022.)

Based on the use of the electronic equipment's, African countries consumption of **ICT** products remains low in compared to other countries. Most of the electronic wastes in the African countries are part of the second-hand electronic products that are imported from the developed countries like European countries and America. The imported near end-of-life used products are repurchased by refurbishing them, due to which the availability of modern electronic products is found in reasonable price in the market. (Schluep et al., 2012.)

This has resulted in the increased use of electronic products which has parallelly increased the e-wastages. According to the available data of 2019,

Africa produced 2.9 million metric tonnes of the electronic debris which would be 2.5kg per capita. Africa has the second lowest per capita waste generation worldwide (Odumuyiwa et al.).

Based on data from 2019, the Oceanic area produced the least quantity of E-waste which is 0.7 million tons amongst all other countries. But the per capita generation of Oceana was second highest after Europe with 16.1kg per capita while Europe has 16.2kg per capita. Oceana recorded collection of the e-wastes was 8.8% only while Europe with the highest collection and recycling rate was 42.5%. (Forti et al., 2020.).

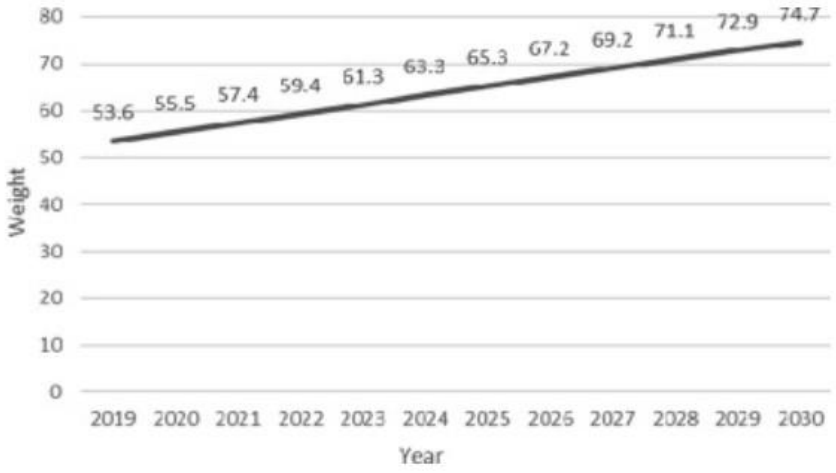


Figure 5: Generation of WEEE between 2019 and 2030 (Forti et al., 2020)

Globally the E-waste generation is higher than the e-waste management. With the increased technology and fast pace changing technology the E-waste is predicted to increase rapidly resulting to approximately 74Mt by 2020. As per the data the E-waste has increased by 21% in 5 years' time frame. The waste generation rate is predicted to increase dramatically in the upcoming years, based on the data presented on the above figure. (*Global e-waste surging: Up 21 per cent in 5 years* 2020.)

4.1 E-waste Management in Finland

The awareness of waste management can be seen highly prevalent amongst the Finnish consumer society. Likewise, the E-waste collection is also higher in compared to other EU countries. The E-waste management in Finland begins from the phase of production. The producers are obliged to manufacture sustainable products and ensure to arrange for the collection, treatment, recycling and recovery once the product has reached their end of life. The accessibility to ICT devices and the rapid innovation technology lures people towards the easy life and need for the luxury gadgets which is the foremost cause of increasing wastes. Despite the availability of conscious consumers, it was found in a research study that almost 55% of the inhabitants in Finland have unused phones at their home. The results of the survey projected towards insufficient availability of Recycling services as well as lack of information to consumers about where and how the materials could be recycled in proper manner. (Jenni Ylä-Mella a et al., 2015). Finland has around 400 electronic waste collection points which are available free of charge, made available by ELKER. ELKER is one of the licensed environmental authorities which handles the proper recycling and refurbishing of the E- wastages. Also, SERTY works together with the consumers as well as business operators to for collection of E-wastages. To achieve effective e-waste management in Finland, several collection groups work towards it, including Mustankorkea Oy, Vaentupa Oy, Sammakkokangas Oy, Lassila and Tikanoja, Kuusakoski Oy, and TKV Finland Oy. These companies collect various types of waste, including e-waste. (Sähkö- ja Elektroniikkalaiteromun (SER) käsittely 2023).

According to the data published by Statistica, Finland’s recycling rate has increased significantly in the past eight years. The recycling rate in 2010 was 28.7 percent which rose to 49.2 percent by 2018, which is nearly 50% more (Statista Research Department & 22, 2023.) In 2021, around 25 thousand tonnes of electronic wastes were collected from both personal and organization. The target of 2021 EU for waste collection was 65% while the SER communities

collected around 60% which is just 5% less than the target (Sähkö- ja Elektroniikkalaiteromun (SER) käsittely 2023).

4.2 Waste Recycling Process in Finland

Sorting out the waste effectively is the first step towards effective management of the wastages. There are different labels at the sorting facility to ensure proper sorting of the electronic and electrical devices. Appropriate selection of sorting places is the first phase to reduce the improper e-waste handling as it helps in forward recycling process.

Figure 6: Waste recycling process in SERTY (Anon, (n.d.)).

The separated waste from the consumers is transported to the approved collection locations, which may be a close residential collection area, or a collection location defined by the permitted companies. When it comes to electrical waste, most large regions or local electronics stores have designated collection points where people can bring their unwanted, outdated goods to be disposed away. It is the responsibility of consumers to bring the unused or the end-of-life electronic products to the collection point after which the wastes are transported to the treatment facilities which are later sorted, recycled, or refurbished accordingly.

In the treatment facility, the wastages are sorted for disposal and recovery. The Electronic wastes are separated based on the materials that eases the disassembling as well as treatment process. The products that cannot be used by surficial maintenance are further sent for processing. The products containing explosive materials such as lead, cadmium, mercury are separated for the processing of hazardous materials. While the other parts such as glass, metals, wires and plastics, cables are sorted out for further processing. Depending upon the quality of the parts of the devices that are separated they are either sent for recycling or crushed mechanically for other industrial usage. The electrical wastages obtained have different usage either by smelting, shielding, or crushing into different forms. (Treatment of weee 2023.)

According to SER kierrätys almost 99% of the collected E-wastages are reused as a raw material in the industries. The devices collected are mostly unusable due to which they are crushed for further processing. The harmful substances from the old refrigerator which are banned nowadays such as chlorofluorocarbons are sent for separate processing classified as hazardous waste for proper disposal of harmful substance. The materials are separated using different technologies such as magnets, floating and immersion of aluminium's for separation. (Murskasta Uusiksi Materiaaleiksi - Näin Ser Kierrätetään.)

5 Legislation In Finland

Finnish legislations are moreover guided by the EU legislations. In addition to the EU regulations, Finland also has its own legislation “Waste Act” which provides regulations for waste management. While in the scenario of waste management, some Finnish waste management regulations cover deeper regulations to minimize the effect of waste globally. The goal of the waste management is to prevent the production of harmful waste, by the producers to make the conscious decisions in the manufacturing time. Another goal is making the most out of the products life cycle, by reusing it. This could be done by passing out to older generations or the most common way in Finland would

be giving out or selling the products in the second-hand markets. It also ensures to recycle the products for more of the industrial use as well by sending them back to the producers via different collection points. The waste products that have no longer demand in the market or if it is not usable then, they are recovered in different ways to use it in various forms of energies. Only, when the products can no longer be reused, recycled, or retrieved into any form then, it is discarded. (Hackman et al., 2023.)

Various regulations are formed to ensure sustainable use of the existing resources. Along with its use they also focus on minimizing its use of impact upon the present and future global environment. Waste Electrical and Electronic Equipment Directives (WEEE), Restriction of Hazardous Substances (ROHS), Energy related Product Directives are some of the important regulations which are working towards waste management.

5.1 Producer Responsibility Legislation

The producer responsibility falls under one of the regulations of Waste Act, the producer takes care of the products during its end of life. The Finnish Waste Act (1072/1993) had to be changed (452/2004) in June 2004 to add a few new provisions on producer responsibility to bring Finnish law into compliance with the WEEE Directive's criteria. During the revision of the Act, a degree on waste electrical and electronic equipment (852/2004) was included in September 2004. In this regulation producer's responsibility includes management of collection, transportation, proper packaging for transport to re-cycling of the product in a managed way for proper disposal. The producer has the right to choose individual arrangement or join arrangement for waste management. According to ELY-keskus, there are 15,000 Finnish manufactures, importer, packers, and remote seller are liable under the producer responsibility. The products such as accumulators and batteries, tires, paper products, packaging, electrical and electronic products come under the producer's accountability for its management. (*Tuottajavastuu on Yksi Kiertotalouden Kivijaloista* 2023.)

5.2 The WEEE Directives

The first WEEE directive was passed in the EU during 2003 after which Finland implemented the EU recycling directive in 2005. After that the WEE directives has undergone several transformation with upgraded regulations. One of the recent is the waste electrical and electronic directive (2012/19/ EU) was applied from August 2012, it became effective as law in EU countries from 14 February 2014. It categorized the WEEE into five different kinds of wastes lamps, screen, temperature exchange equipment, IT equipment and telecommunication equipment. This regulation focuses on minimizing the waste by enhancing the recycler and producer relation to maximize the Eco-design for production. It also ensures that consumer get the chance to return the WEEE products free of charge as well as make consumer aware of the WEEE labels for effective collection. The regulation ensures that WEEE are treated under the guidelines thus check for operation of licensed treatment plants. It also looks towards illegal transportation of WEEE of the European countries to developing countries. The law enforces towards minimizing the unmanaged waste disposal by setting up target plans for the collection rates. (Lex - 200403_1 - en - EUR-lex 2019.)

5.3 The RoHS Directives

The first RoHS/ WEEE was implemented on 27 January 2003. After the review the new RoHS directive 2011/65/EU enter into force on 21 July 2011. The RoHS monitors to ensure and review the implementation of the banned substances. Parallelly, it works to meet the REACH (Registration Evaluation and Authorization of Chemicals requirements. The increasing WEEE wastages has resulted in hazardous waste collection. Most of the Electrical and Electronic products consist of materials such as lead, mercury, cadmium which during the recycling process are released causing environmental and human hazard. Supervision of production and recycling of minimal to no use of hazardous materials is conducted by the RoHS directives. At the moment RoHS prohibits the use of lead, cadmium, mercury, hexavalent chromium,

polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), bis(2-ethylhexyl) phthalate (DEHP), butyl benzyl phthalate (BBP), dibutyl phthalate (DBP) and diisobutyl phthalate (DIBP) in EEE products within the EU countries. The electronics produced or imported to EU countries should be replaced with alternative metals instead of harmful materials to comply with the requirements. (RoHS directive 2021.)

5.4 International Transportation of E-waste and Management

The increased level of E-wastes has caused uncontrolled waste management. The Basel Convention controls the regulation of controlled transboundary transport of hazardous wastes. The main concern is the unsupervised transportation of hazardous waste in countries where the wastes are not managed properly causes negative impact upon the environment and human health. The hazardous WEEE wastes generated in origin of country can only be exported to or imported from other country if the appropriate mechanism of waste disposal is not available or the materials are in use in another country as well as other exceptional reasonings which ensure that hazardous wastes will be disposed or recycled in environmentally friendly manner. (Baldé. et al.,2022.)

Historically, the transboundary movement of waste is seen from Northern part of the world to South. In the name of cheaper disposal facilities, the WEEE's are shipped from developed parts like Europe, US, Australia, Canada to the developing nations like South -Asia especially China, India, Bangladesh, Afghanistan, and African countries. These countries are known to be not bound by stricter environmental regulations which enhances the easier disposal facilities. On the other hand, it creates higher risk from the hazardous substances contained in the WEEE as, the formal disposal method is not guaranteed posing risk to global environment and human health. Warehouses in developing countries that import these WEEE's does not have a well-functioning machinery for extraction of the valuables, as a result they use cost effective primitive techniques such as open fire for extraction which pollutes the environment with release of toxic substances. (Forti. Et al., 2020.)

The illegal network of exporters working for the export and import of E-waste are primary drivers to land hazardous waste in the developing countries. The main reason for illegal transboundary transportation is a cheap labour cost and informal processing, the valuable metals can be extracted in the developing countries as, the cost of processing would go higher compared to cost of metals if they were to be extracted in the country of origin. Also, the liberal government regulations, lack of local and governmental practices on the research and development of sturdy legislation to manage the export of the E-waste has resulted on developing countries becoming the hotspot for the waste disposal. (Shamim et al., 2015.)

The data for the E-waste import and export is limited as, The Basel convention is limited to only hazardous waste. Most of the illegal exports takes places in the form of second-hand materials into the developing countries that eventually most part are the e-wastes being illegally transported. Around 15% of the EU used electrical goods are transported for the purpose of reuse which accounts for part of the e-waste while some due to failure of appropriate transportation will turn into e-waste upon arrival to the destination country. The countering WEEE Illegal Trade Project conducted from 2013 to 2015 which consisted of experts from the WEEE industries provided recommendations on addressing the problem from stakeholder to consumers levels in management of cross-border movement of illegal e-wastes (Huisman et.al., 2015.)

A review on the Europe's export data projected that around 1.5 million tons of electronics wastes were transported amongst which documented used electronic equipment (UEE) were 200,00 tonnes while 900,00 tons were the UEE, and the undocumented export of the wastes accounted for 400,00 tones (Huisman et al., 2015.). All these undocumented exports are littering the developing countries that eventually hampers the global health, so urgent action needs to be taken to manage the flow of E-waste into the developing countries. The workers in the developing countries are bound by financial and labour crises so they are hesitant to fight for their right working conditions due to which they work in the harsh conditions with these hazardous materials. This states

that world needs immediate global intervention to overcome the flooding problem of E-waste management.

5.5 International legislation/Initiatives for the management of E-waste

The purpose of the legislations is to provide guidance for the countries to have effective and controlled approaches towards managing the waste for environmental and economic development. They guide for adopting sustainable development approaches such as working for climate change issues, moving society towards circular economy, increasing information access to the people for guiding towards conscious purchasing. It helps to improve E-waste management from community, national and international grounds by providing standard practices based on the evidence and research.

The Basel Convention was adopted on 22 March 1989, in Basel, Switzerland based on toxic waste accumulation during the time in the African countries. It enforces strict rules on production and recycling of hazardous materials. It provides legislations for legal trans-boundary movement of the wastes to reduce illicit act of existing waste movement to developing countries with poor regulations resulting in uncontrolled recycling techniques. Its major goal is to promote environmentally sound disposal technique. (The Basel Convention at a glance, 2011)

The fundamental aim of WEEE directive is reduction of E-wastes by fostering sustainable production and consumption to ensure efficient use of ongoing resources. It has initiated consumer convenient methods for retrieval of E-waste at home by granting free take back system and initiating suppliers to have their own recycling outlets making it more reachable for the public. It has also setup target to boost the collection of the e-wastes by ensuring separate collection of the WEEE. (Waste from electrical and electronic equipment (WEEE).)

StEP is inaugurated by organizations in the UN to overcome the E-waste problem with the motive of co-operating with international companies,

governments, researcher working constantly for sustainable E-waste management. StEP was founded in 2004 and started its co-relation with UN in 2007, with 35 members from around the world. StEP works under its principle of finding a scientific solution with regards to consideration of maximum optimization and assisting in minimizing illegal trade of wastes to ensure eco-friendly measure globally. With its measure, it contributes to increase raise awareness among member and industry through education and training in E-waste issues. (StEP Initiative.)

NSES was formed under the collaboration of 16 agencies constituting of electronics retailers, producer, and stakeholders from concerned organizations. Its goal is the management of E-waste with the use of research and technology on designing the eco-friendly products. It also works towards ensuring proper waste management within US to minimize the transboundary movement of wastes to developing countries. The results show that around 77% of the state and local governments are purchasing the eco-friendly electronic products that consist of reduced amount of toxic materials, requires less energy and combined more recycled products for its production. (Moving sustainable electronics forward - U.S. environmental protection ... 2014.)

GeSI brings together the ICT companies on a mission to utilize the opportunities of tackling with the global challenges such as management of the e-wastes. GeSI consist of 40 globally leading organizations who are dedicated towards building sustainable ICT around the world. collaboration with the ICT companies, it is focused in using the innovation technology to achieve the longer-term goals of increased energy efficiency, reduce the carbon footprints and manage the risk related to ICT. (Mission & Vision of gesi, n.d.)

As part of the UN’s environmental council IETC was inaugurated in 1992, to focus on managing the chemical and waste hazards with minimal negative impact upon the human and environment. It focuses on working with the developing countries in close with the governments and civil organization to provide technical advice in implementing long-lasting solution for management

of the waste especially the hazardous waste and chemical found and released from the e-wastes. It also reaches public through timely demonstration programs conducting waste prevention and management campaigns focusing on comprehensive waste management. (UNEP International Environmental Technology Centre.)

Countries around the world are aware of the increasing problem of WEEE. In regard to that governments are enforcing stricter policies and regulations which binds businesses, stakeholders and public into following the legal framework for management of e-wastes starting from producing to reusing and recycling.

6 E-Waste and Its Impact

Electronic products are composed of complex materials such as plastic, Fiber glass and metals. In the process of recycling, these raw materials are extracted for industrial use. All the nations do not possess standard machinery for the processing of the raw materials and most of these countries are the developing ones to which the developed countries seek for cheaper reprocessing. The lack of strict regulations for handling these wastes has become a global concern creating an impact on the global environment and human health.

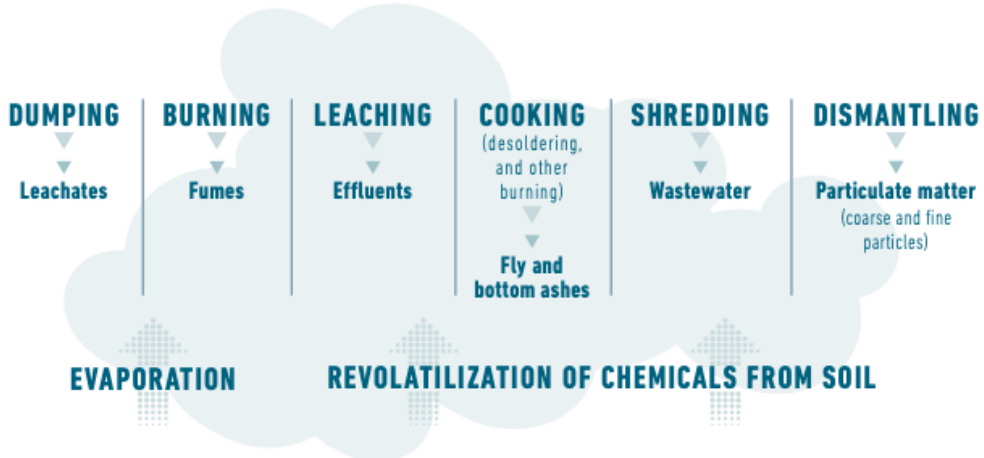


Figure 7: Different ways of exposure of Hazards due to informal recycling (Children and Digital Dumpsites - World Health Organization 2021.)

The figure above demonstrates how the components inside the EEE products are introduced in the environment and its preceding connection to causing the impacts due to release of harmful substances are described below.

6.1 The Environmental Impact

The improper handling of E-waste is the major cause of environmental impact. As we know, that EEE products are made from complex materials consisting of heavy metals, to chemicals which during its active life cycle does not cause harm to the user or the environment but after it comes to its end-of-life cycle if they are discarded improperly its components are released directly or indirectly leaching these chemicals into the environment. E-waste harms the eco-system in a gradual and persistent manner by lighting open-fires, unethical extraction methods and landfill e-waste disposal. (The growing environmental risks of e-waste 2023.)

The toxins from the E-wastes are released into the air through unregulated burning, shredding and melting during the extraction process. Usually, materials such as copper which are of great value are extracted by burning method so, in the process the materials like plastics and metals attached to the electronic device are burned along. This eventually results in the release of harmful chemicals from the substitute materials such as dioxins into the air in miles once they are burned and the substances get suspended through the air. The high-cost materials like gold, silver found in the small chips and motherboards are extracted with the melting process where they use acids such as hydrochloric and nitric acids which emits harmful substances into the environment under the nonstandard recycling conditions. This causes harm to the living organisms of the environment either directly or indirectly. Guiyu, a place in China was once an informal recycling hub which resulted in having a great amount of lead in the environment due to which, the place is no longer reliable for cultivation as well as neither the water sources around it are drinkable. Lead for the living organism like animal and human is dangerous as it impacts the neurological system. (Wilson, Impact of weee 2016.)

The remains of the burned parts of the e-waste, the small pieces of e-waste during the dismantling end up in the land. As the toxins are released into the air, they come in contact with the soil through water during irrigation process or as a byproduct of air particles gets disposed in the vicinity of recycling industries. The unwanted parts of the e-wastes have a high chance of landing on the dumping sites, that in the long run releases its particles into the soil degrading the quality of the soil. The contamination of soil with these toxins and heavy metals will disturb the Ph value of the land. This will hamper the lifecycle of the microorganisms that contribute to regulation of well-functioning eco-system. This impacts upon cultivation due to lack of proper biosphere. Those plants grown with the use of contaminated water and in the toxic air tend to consist of chemical substances inside which when the animal or human beings consume enter the system causing medical issues. (Wilson, Impact of weee 2016.)

Chemicals like lead, arsenic and cadmium reach the water sources by improper disposal of the remains of the recycled e-wastages. From the soil, through the absorption they come in contact with the nearby water sources disturbing the aquatic environment. The toxic water may contain compounds of heavy metals and mercury which are inhaled by the aquatic organisms resulting in improper immune system, gills problems that can immensely hamper aquatic life irreversibly. At the meantime, when these aquatic species are consumed by human and animals, they also cause negative impact on the consumers. Since the eco-system is a lifecycle, affecting the one will have an adverse impact on all the organisms of the system. (Waste & its negative effects on the environment 2019)

Due to lack of proper extraction methods and technological development in the E-wastes recycling industry, the possible valuable resources that could be extracted are not maximized. So, there is loss of the metals which are in high demand now, at the same time globally the availability of natural resources is also decreasing raising the question of possible extinction for future generations. Nevertheless, this has also impacted highly upon global climate

change. (A new circular vision for electronics, time for a global reboot 2019) The huge number of EEE devices production has contributed to an increase in carbon footprint, as approximately 25kg of carbon is released during 1 kg of electronic manufacturing (*Carbon footprint of Electronics* 2022).

6.2 Impact on Human Beings

The harmful substances in the EEE products transform into toxic elements in improper recycling process. The effect of the release of these substances in the environment is diverse and complex. When it is released in the environment fine particles in the air consist of harmful substances which are inhaled by human beings cause several health problems. The extent of risk relies on the chemical and duration of exposure to the chemicals. Shorter exposure has been associated with irritation of eye and throat while extended exposure can result in complications such as lung cancer, asthma, and bronchitis. Age also plays a role upon the depth of impact due to exposure, for example the daily workers and the old people with underlying diseases are more prone towards having higher risk levels due to these chemicals. (Children and Digital Dumpsites - World Health Organization 2021)

According to the report of “Children and Dumpsite 2021”, It is estimated that 64 million people are currently in the waste management sector, including young children and women. The trend is more on the increasing side as e-wastes is increasing and the lack of management has created more informal recycling sites. The workers are in the high-risk category especially in the unmanaged organizations, as they come in direct contact with the substances like lead, mercury which can cause neurological damage, developmental issues, behavioural disorders, and low IQ development. It has been found that exposure to lead will cause headaches, stomach pain and short-term memory loss amongst the adults while in the long-term effects it can disturb the reproductive system leading to miscarriages in pregnant women and damage the sperm functionality in males and cause cardiovascular diseases such as high blood pressure, complication in the kidney functionality.

Indirect contact such as soil, water and food are other pathways for exposure to human beings. People residing nearby the e-waste processing areas are likely having their daily activities in the toxic environment, so they are prone towards developing complex health problems in the future. The livestock and crop farming in these areas also contain toxics substances present in the environment. So, when people consume this locally produced food or are transported for the purpose of business then, they spread in the local cities and transportation hubs. (Wilson, Impact of weee 2016.)

So, the duration of exposure is directly connected to the degree of impact on the human body. Also, the developmental stage of the individual has also a co-relation with its effects. Children exposed to e-waste have resulted in lower lung functional capacity as child organs are underdeveloped so, early exposure to toxic materials from the e-wastes have lifelong impact. Likewise, elderly individuals with a history of respiratory diseases living in the improper recycling facility vicinity will lead to worsening health problems. Since, global warming has also been a concern for the deteriorating the human health word-wide due to climate change which comes from the releasing of fine particles while black carbon burning so, reducing of black carbon will significantly mitigate in reducing the impact on human health. (Parvez et al., 2021.)

6.3 Impact on Economy

The relationship with the EEE waste and the economy is quite complex to describe. It has both advantages and drawbacks in considerably the same proportions. In light of corporate responsibility, it is beneficial but while considering the financial sector it is debatable. It also creates employment opportunities in recycling and other related industries such as waste collection, sorting, or processing. Most of the workers in the recycling sectors in Finland have gone through vocational qualification specialized in their working areas (Circwaste > Employment in circular economy 2020). The materials in the E-waste as we known are of great value but the complex composition of the EEE makes it difficult to extract these valuable while ensuring profitability.

According to the Global E-waste monitor 2020, the E-waste of 2019 contained raw materials such as iron, copper, aluminium worth of 57billion USD. These materials are one of the necessities in the technology industries for production of most of the EEE which gradually with time are becoming scarce. In response to these, technological companies are coming up with more efficient IT and moving forward towards a circular economy which will be profitable for the companies if they are able to reuse the E-wastes materials. Developing practical recycling technology will save upon the company's cost for waste site maintenance. (Forti, et.al.) This could be beneficial for the customers as well as they can have more affordable market prices. It is estimated that approximately the consumers cost could decrease by 7% by 2020 and narrow down by double in 2040 if the precious metals could be successfully extracted this could reduce the irregularity in the prices of raw materials. (Bel et al., A New Circular Vision For Electronics, Time for Global Reboot 2019.)

On the other hand, the cost of proper recycling techniques turns out to be expensive and that discourages the companies. Which is also one of the reasons for illegal transboundary movement of EEE waste in search of competitive recycling. For example: the materials on the cases of the phone and laptops requires a costly separation method so, the useful materials that can be retrieved as a final outcome does not turn out to be profitable for the companies. As the recycling cost surpasses the raw materials cost, the manufacturers prefer to use pure materials instead. According to the data of UN, out of 50 million tons of e-waste in 2019 only 17% was recycled for the raw materials. So, the current measures to address the problem are failing and this raises the question for the future vision of electronic sustainability development. (Forti, et.al.)

The impact of e-waste on the economy depends upon the environment. The developed countries with their secure budgeting system are able to carry out research and develop new technologies to benefit the WEEE. While, the developing countries are becoming trash land generating environmental, health and economy issues. It is worthwhile to consider that, recycling is not only the

solution, but reducing consumption to an extent that its active life cycle is used in maximal level is also necessary in reducing the wastages.

6.4 Impact of Recycling

In the present increasingly sustainable environment, recycling is a core element. WEEE recycling accumulates biased opinion around the globe. The recycling of E-waste requires manual force, chemicals, advanced machines to extract the tiny valuables from it. Proper recycling safeguards the release of chemicals such as toxins in the environment alongside, preserving the rare and precious metals like copper, mercury, silver, aluminium etc.

It promotes the protection of resources and contributes to environmental benefits by minimizing the WEEE into the landfills which can pollute the soil. The compound raw materials in the EEE are a package of long-term toxins if not safely discarded. It prevents the release of toxins into the ecosystem. Extraction of new materials requires investment of energy and resources that release toxins such as emission of glasshouse, recycling has helped in reducing the materials demand, thus less need for extraction. It has played an important role in restoration of natural resources due to the reusing of the rare earth metals from the old products. Recycling has helped in boosting the circular economy with the concept of reduce, reuse, and recycle, EEE products are getting repurpose and their lifespan gets extended by passing down to new users reducing the demand of production upon the manufactures. (Greentec, 2022.)

The recycling entrepreneurs and businesses are growing globally, boosting the economy of the country by creating job opportunities. The “REI report of 2020” states that 681,000 jobs were created in the US in the recycling industry. This eventually increased employment amongst the population generating worth of 5.5 billion in tax revenues from the recycling industry. It helps in boosting the community through building an opportunity through the circular economy. Under the guidance and proper regulations, the expansion of these recycling

approaches will positively impact on the global economy. (Recycling Economic Information (REI) report | US EPA 2023.)

Ensuring proper recycling is a key towards exploiting the benefits of recycling. Improper recycling has an adverse effect upon the ecosystem. It impacts the environment through the poisoning which alongside will have adverse consequence on the firsthand workers and the community through continual exposure arousing health and environmental problem. Increased problems will shift the focus from research on development and divert towards the treatment of the hazards of improper recycling. This slows down the improvement in the E-waste management sector. The WEEE is a valuable raw material in a circular economy. To make the most out of the recycled materials sustainable designing, extending the life through timely repairing and maintaining and adopting new and appropriate technologies for extraction is essential. (*Waste and recycling* 2023.)

7 Research Methodology

Research is a systematic approach of conducting study to gain better understanding and to acquire in-depth knowledge in any subject matter. It is also considered as a problem-solving method with intensive analysis of the collected facts and figures conclusions on several events have been undertaken so far by many researchers. Researchers are those individuals who carry out research in several forms such as literature review, data analysis, data collection, observations, practical demonstrations etc. (Pandey and Pandey, 2021.) In this study, the researcher carries out several forms of studies such as analysing the present and past data reports, reviewing the research papers and articles and comparing the various information to reach the aim of the study.

Depending upon the objective of the research, there are different kinds of approaches some of the basic approaches are qualitative, quantitative methods. In qualitative research, the data is obtained in the form of numbers which are analysed statistically. The data is obtained through a constraint of

figurative questionnaires, polls or surveys which are conducted usually within a fixed quantity and period. Qualitative research is a more descriptive approach where information is gathered based on opinions and observations of a certain case. It is more theory based rather than numerical figures. (Inyang 2017.)

To conduct this research the author has chosen a qualitative approach based on the literature review. The author conducts an in-depth study on the WEEE subject, with focus on E-waste management system in Finland. In the paper, several primary and secondary sources of data journal from various researchers have been studied to gain insights into the research topic and the data is evaluated according to the need of the thesis question.

7.1 Research Philosophy

The research philosophy guides the author to create a profound base of studying the topic. Finding a suitable method initiates in developing data and rationale to support the aim of the thesis. There are different forms of philosophy, some of them are positivism, interpretivism and pragmatism. The positivism focuses on the real data that means it follows the path of facts and figures which are usually in a measurable scale. While interpretivism focuses on analysing the subject based on real experiences and consequences. Pragmatism allows to conduct broader research based on practicality and seek to find the solution based on what is better working for the given study. The author has chosen the interpretivism philosophy for this study which allows the author to utilize the secondary information resources to make a qualitative analysis. (O'Gorman and MacIntosh, 2015.)

7.2 Research Design

The method through which the data is collected in relation to objective of the study determines the research design. A proper plan will help to reach the core of the aim without diverting and executing well. In this study, the author has chosen an exploratory research design which allows the author to be flexible

and gather more data from different perspectives. Exploratory research is an inexpensive method to gain information and develop new ideas in connection to their desired study. The exploratory research can be conducted by various methods some of the main are primary data collection and secondary research. In the primary data collection, the research focuses on discovering new ideas based on sample surveying to gather genuine experiences. While in secondary research the data is collected through published data and literature. (Bairagi et.al. 2019.)

For this study extensive research has been conducted on the related literature of Finland's waste management system in addition to evaluation of other nations actions towards the WEEE issue. The study has used secondary sources in the form of online reports by recognized global organizations, research papers as well as articles and journals from reliable sources.

7.3 Validity and Reliability

The effectiveness of the research is highly influenced by the validity and reliability of the information contained in the study. To ensure the credible validity of the study, the author has carefully considered the resources used in the study by cross-checking it. Government and reputed publications and reports were of first priority in data collection. Second priority for supporting data was given to the peer-reviewed academic publications after which only journals were considered into category. The information used for this study has been carefully considered for its reliability by choosing the recently available data to understand the topic on the present scenario. The data related to the WEEE and E-waste management in FINLAND were considered in high preference. Additionally, the data includes comprehensive information on the impact of E-waste on the eco-system and globally and its impact on political and economic aspects are included throughout the study.

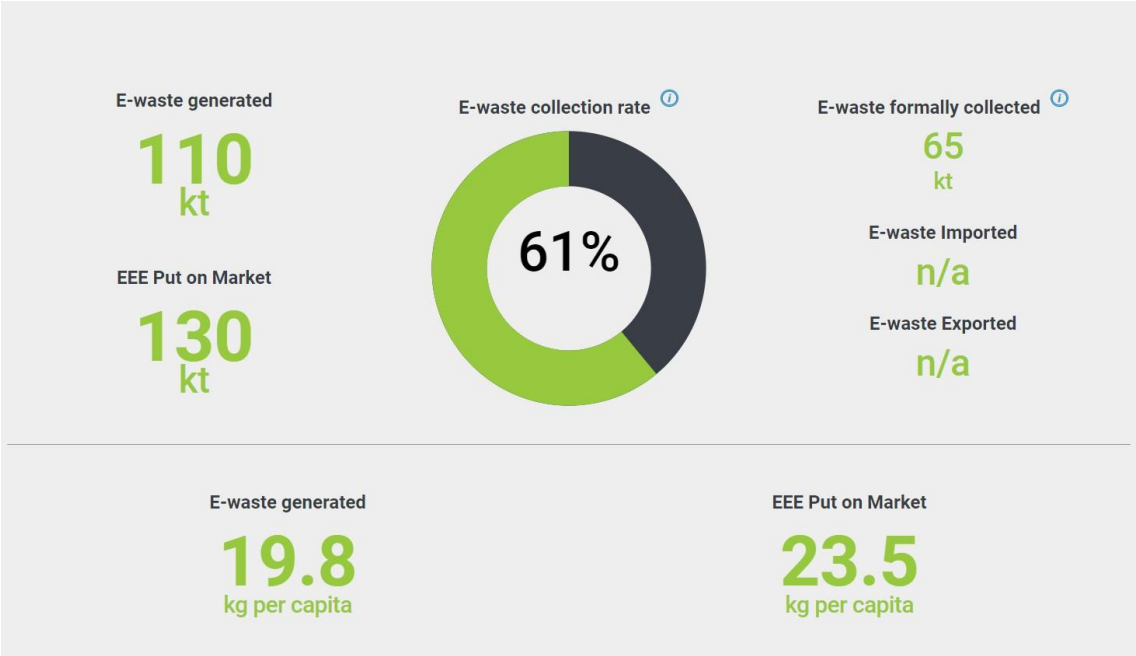
However, the research extensiveness may have been compromised as this study's literature review is solely dependent on data accessible through the

internet. Also, since the most recent report on update regarding E-waste management is not readily available which might influence the conclusions made by the author during the study period. The author aims to focus on Finland only might be unpractical as, some of the reports are not accessible due to the language barriers. Also, there might be misinterpretation on the authors perception of receiving the information as, some of the locally available Finnish website's information were retrieved through the translation as well. Since the literature review is based on secondary data, the quality of the research exceptionally relies on the available information for which the reliability cannot be guaranteed personally by the author. Despite all the limitations, the author has conducted the study with careful analysis of the data and information to produce reliable results.

8 Data Analysis

The E-waste management in Finland is studied by conducting research based on the recent data and the reports analysis of reuse and recycling rates in Finland. In terms of regulations and goals, Finland follows the guidelines from the EU commission. The data of 2020 suggests that around 12.4 million tons of EEE are sold in the market amongst which only 4.7 million tons have been recorded to be collected, which stated that more than half of the EEE wastes end up in the wrong place for recycling. (Waste from electrical and electronic equipment (WEEE) n.d.) To increase the efficiency of recycling, collection, and treatment of WEEE, EU commission has set a target of ensuring reuse-recycling rate of 55% for the municipal waste in its member countries. According to the recent survey in Finland, it is below the target level to reach the target set by the EU commission by 13.4% i.e.in 2020 the recycling rate of municipal waste in Finland was only 41.6%. (The early warning report for Finland 2023.)

Looking at the Finland's data on the waste generation as per the data of 2017, the registered amount of waste generated accounts to110kt amongst which 65% was registered to be collected and recycled (Forti et.al. 2020, 108).



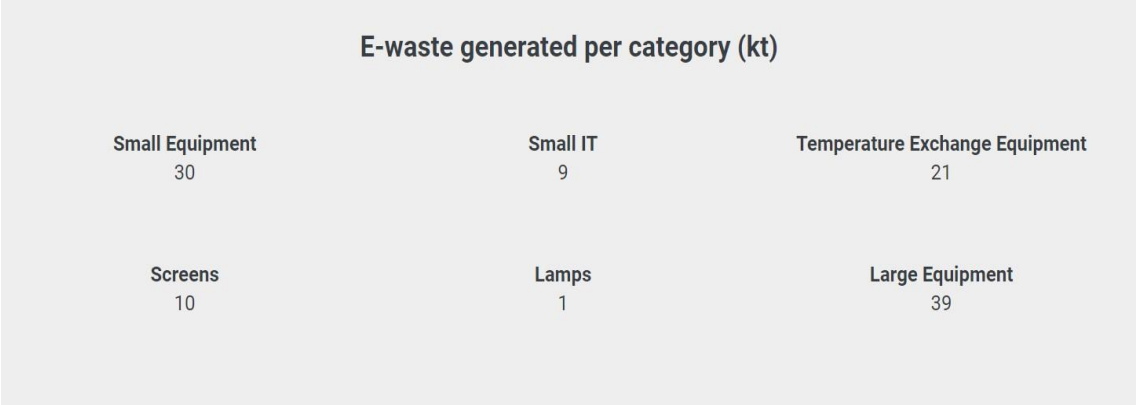


Figure 8: E-waste generation and collection in Finland (The Global E-waste Statistics Partnership, 2019)

In the figure 8, we can see that E-waste generation per capita in Finland is 19.8kg per capita which in terms is higher than the EU per capita e-waste generation that is 10.5kg per capita in 2019. Most of E-waste were created by the large equipment's with 39kt followed by small equipment, temperature exchange Equipment, screens, IT and lastly the lamps. Most of the waste in the municipal waste collection is related to industrial waste. Although legislation has supported recycling of E-waste to some extent due to the high consumption, they have not been proven to be effective to provide the solution.

8.1 Waste Management in Finland

With the increase in the population and industrialization, the waste concerns also increased accordingly. The Finnish population was always vigilant towards the waste management, as the awareness on separation of waste and recycling system existed before the commencement of the Waste acts as well. People were active towards separation of waste such as bio-waste, cardboard, glass, and metals. Implementation of the legislation helped in effective waste management in the municipalities for separation of waste collection, reducing the landfills as well as forwarding towards energy- efficient recycling methods. (History of waste management in Finland 2022.)

The growth in the waste management industry took a massive turn after it extended its co-operation with the EU in the 1990's. The commencement of improvised legislations has led towards producers' responsibility, buyers, and sellers share on aiding the process of recycling. Collection of WEEE and its transportation process to recycling ports is one of the costly processes in the EEE recycling industry. To minimize the cost Finnish WEEE companies has come up with a solution, where an umbrella association is formed who help them in planning the collection and recycling of the WEEE. In Finland waste management is a matter of co-operation between the municipalities, corporation, and producers, as most of the collection points are arranged by the municipalities where the individuals can bring back their electronic products free of charge. While the companies are responsible to arrange their own system of recycling either through cooperation with the regional operator or by joining the producer association to help them in the WEEE management through their processes. (Ylä-Mella et al., 2014.)

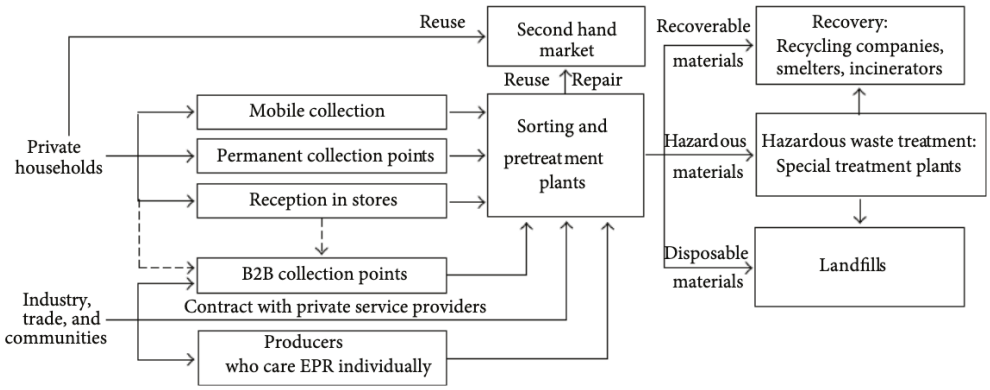


Figure 9: Finnish WEEE recovery network (Ylä-Mella et al., 2014)

The figure above illustrates in brief the process of collection, sorting, and recycling from different consumers of EEE in the market. As shown above, the private consumers return the end-of-life products from their households through different collection points such as local retailers' shops, designated collection points or to the second-hand marketplaces it could be to handover to second consumers or to different repairing companies sometimes with some incentives with reselling value as well. While the private enterprise manages the electrical wastes either through contact with one of the corresponding businesses with the recycling companies such as L&T in Finland or by joining the producer's associations available in Finland such as SERTY, Elker. After the WEEE is collected from the market it reaches the reception center where the EEE are classified into various categories based on their reusability, repairability, and the materials in the electronic products. After careful sorting of the E-wastes, they are sent for processing to designated centers where hazardous materials are handled separately, repairable materials are sent for recovery while the disposable materials end up in the landfills. To minimize the impact due to the landfill disposals, the EU’s landfill directive of 1999 has helped to some extent by reducing the mixed waste disposal in the land (History of waste management in Finland 2022).

8.2 Achievements of WEEE Directive in Finland

Prior to the implementation of the legislation, reports on the collected data were lacking behind. The regulations of WEEE legislations followed up with waste act

obliged the companies to submit the data to keep track on collection and recycling of EEE. This has helped in making decisions to set up realistic goals and improvising the innovative technologies towards recycling to prevent the adverse impacts on the environment and promoting towards circular economy.

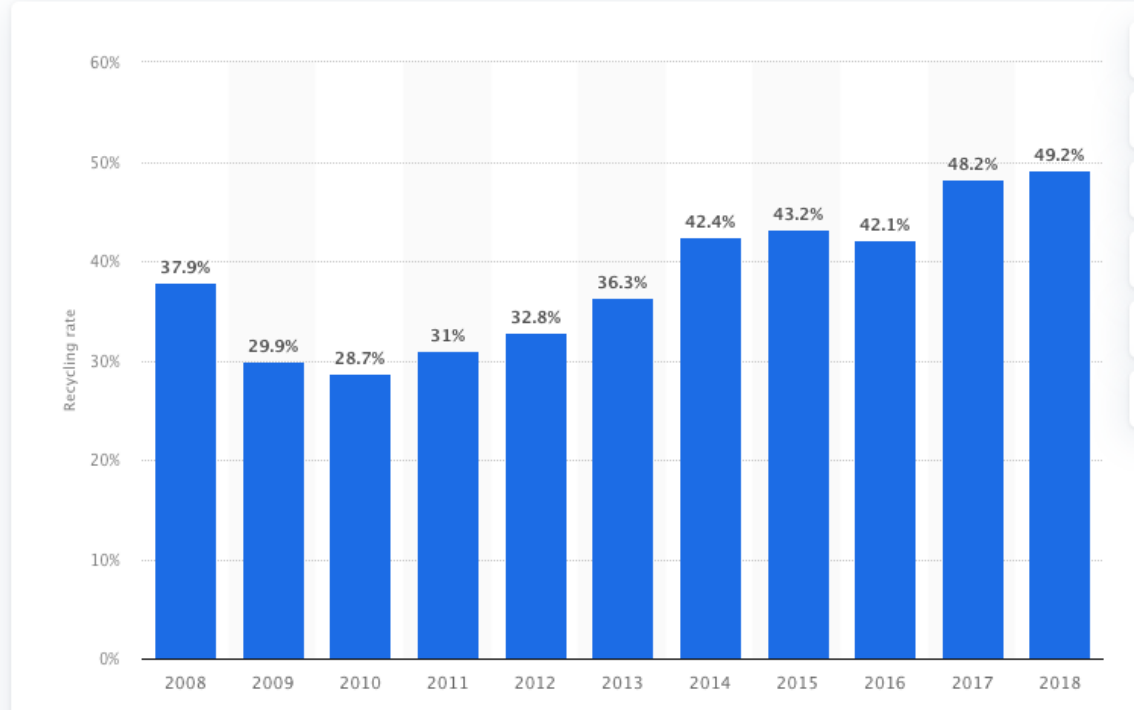


Figure 10: Data showing EEE recycling rate in Finland. (Statista. (n.d.))

The figure above shows the recycling rate over the span of 10 from 2008-2018years in Finland. The recycling rate is quite fluctuating as per the data above in Finland. As per the data, the recycling rate decreased by 8% between the year 2008 and 2009 and the preceding year. The EEE recycling has seen an upwards graph from 2011 with 49.2% in 2018 which is roughly 18 % more in a span of 7 years.

There has been a significant increase in the recycling rate during 2013 to 2014 with 36.3% and 42.4% respectively. After that the rate increased steadily until 2015. While the recycling rate decreased by a percent from 2015 to 2016, which was overcome by a whopping increase of 6% in 2017 with 48.2%. The recent data from the Eurostat of 2021 states that Finland has managed to collect approximately 70% of the WEEE in contrast to its WEEE generation which is an estimated of 14.68 kg per inhabitants (Statistics explained 2023).

The producer association play a major role to contribute for the growth of collection and recycling in Finland. The electronic products in the market are mostly exported products which has resulted in the formation of different associations to sort out the recycling responsibility. WEEE directives have been constantly reforming regulations to minimize the EEE disposal, by enforcing stricter rules towards production, distribution, and disposal regulations.

8.3 Finland's E-waste management: Global Comparison

The generation of E-waste has become a problem globally to manage the balanced eco-system. Globally, European countries are generating the most amount of E-waste per capita while at the same time it also has the highest figure for the collection and recycling rate. Amongst the various kind of waste management such as packages, municipal waste, e-waste recycling rate is found to be lower in Europe with only 39% (Waste recycling in Europe 2023) . The E-waste collection and recycling rate in Finland is higher than in the global context as an average of 17.4% of the e-waste was able to be collected and recycled globally during 2019. In 2019, Finland has been able to rank top on the collection and recycling in Europe with 57.9% i.e. 13.3kg per capita of WEEE collection. While it generated 19.8kg per capita of the WEEE. The Finland's E-waste generation had increased by 11.5% within the period of 2014-2019 while the global e-waste generation recorded accounted for 21%. Finland within the EU directives is still falling sort in overcoming the EU target of waste collection and recycling up to 65%. (Waste from electrical and electronic equipment 2023).

8.4 Challenges of WEEE management in Finland

The common challenge among all the nations after the regulation of waste act was management of finances. It is because the transportation and collection process in the waste management cycle is costly. In case of the Northern parts of the Finland which are sparsely populated, there has not been effective mobile E-waste collection system due to which the electronic products of the market

have not yet reached the recycling system. The proper information about the varieties of electronic products and their disposal methods among the society is also not found to be effective. This increases the burden of sorting process in the reception centre. In Finland the collected EEE products end up in the common site from where they are further processed for the sorting based on their brand, composition and ability to be recycled. Arrangement of product specific transportation facilities is essential to ensure that the products end up in the recycling facility with minimal damage, so it gives the higher possibility for extending their life cycle in different forms. (Román et.al. 2008).

The role of consumers and producers is unnegotiable in the waste management industry. The enterprises are facing a dilemma upon recycling due to its high cost and fear of slowing down of the manufacturing process. Due to the high maintenance of recycling products producers seek second-hand parties such as shipping to other countries at cheaper prices where proper recycling cannot be guaranteed. At the same time, due to the costly recycling process, the market price also rises which impacts the consumers interest upon the company, additionally the high-end companies are concerned about their brand image while working with the recycled products. Implementation of technology in development of innovative recycling ideas would aid the WEEE industry by maximizing the manufacturers production while meeting the high-end demand of the consumers.

9 Conclusion

The study provides a comprehensive analysis of the WEEE management in Finland incorporating the bounding EU regulations that are implemented currently. The implementation of e-waste management laws in Finland is studied from different perspective to analyse its effectiveness and possible improvements on amendments for future studies.

WEEE follows the waste management hierarchy, where the priority falls for the prevention of e-waste generation, reutilizing the generated waste followed by

recycling and recovering and finally reducing waste disposal. The goals of the hierarchy are the reduction of environmental and human impact caused by the adverse effects of lack of WEEE management. Finland with its current awareness status is still lacking behind in keeping with the neighbouring EU countries despite having the prevalent history of its own waste management system. The implementation of waste act has enhanced the e-waste management program. The implications of producers' responsibility shifted the waste management execution to the producers initiating organizations such as ELKER, SERTY which has contributed towards enabling circular economy in Finland as well as provide updated data on the country waste management status. The shift on the responsibility has increased producers' interest towards developing eco-products that are conveniently repairable.

Though Finland is one of the recently introduced countries to the WEEE directives in contrary to its neighbouring country it has made a promising progress towards keeping up with the EU’s sustainable developments targets. Finland’s waste act covers the broad spectrum of strategies for effective handling of the e-waste. They have established several collection points and reception centres free of charge for the public to make a convenient recycling cycle. Finland still is lacking behind in reaching the northern parts of the country which are rural and sparsely populated. To increase the small e-waste collection, more regional operators should be provided authority to handle the e-waste in rural areas which helps to reduce the cost in mobile collection and making it easier for the consumers for easy return facilities. In addition, increase incentive campaign and target audience awareness programs should be held regularly to reach the greater mass. Despite its efforts Finland still can integrate stricter rules and regulations to reduce the illegal transboundary movement of e-waste to informal centres by formulating stricter policies. Government should make the e-waste data collection obligatory to keep update on the e-waste collection and recycling data, which will help to refurbish better regulations in the future.

Finland with one of the highly educated population, individuals are proactively contributing towards the management of waste from different levels. To motivate the recycling entrepreneurs, Finland should increase incentive driven projects from organizational and national level to shed light upon these hidden experts who could bring revolution in the e-waste sector with their ideas. Budgeting from government levels should focus on increasing their finance towards eco-friendly products by providing schemes of tax exemption or lower taxations.

The data's mentioned in the study clearly shows that Finland has been able to come up in the global status with great values in terms of e-waste management. Finland commitment towards expanding recycling centres, constant move to increase the collection centres need to be continues in the future as well. Finland's should retail its efforts towards development of sustainable environment with its waste to energy program boosting the economy waste circle.

The e-waste industry is in constant need for improvement to develop innovative e-waste management system to keep up with the current increasing waste collection trend. The further research on the consumers behaviour, deeper research on the existing and possible innovations in the waste management field could provide insights of waste management from a different perspective in the future.

In summary, to prevent the prevailing e-waste global issue the study suggests the prevention of waste collection by reducing the consumption through maximizing the life of electric products. Individuals need to be aware of their decision and be aware of their actions and its impact on the existing environment and the future. People should feel the responsibility of managing their own waste, to reduce the indirect burden upon the compromised communities. Regulatory bodies need to treat everyone equally as, we should understand that harm upon any part of this eco-system will eventually cause individual damage in any time. Co-operation between all the stakeholders from

the individual to government levels is required to overcome the problem of global e-waste management.

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