**E-waste recycling behaviour: A case study of the City of Johannesburg**

**(Honours Research Project)**

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## List of acronyms

BRT: Behavioural Reasoning Theory

BSNT: Basic Psychological Needs Theory

CoJ: City of Johannesburg

CPU: Central Processing Unit

EBS: Electronic Bonus Card System

ECA Act: Electronic and Communications Act

EPR: Extended Producers Responsibility

ICT: Information and Communication Technology

LCD: Liquid -Crystal Display

PC: Personal Computer

POPI Act: Protection of Personal Information Act

RAM: Random Access Memory

TPB: Theory of Planned Behaviour

WEEE: Waste electrical and electronic equipment

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# Chapter One: Introduction and problem statement

## 1.1 Introduction

E-waste is a rapidly growing waste stream that has been prioritised in the 21st Century in response to the mass consumption of technology (Mulckhusye *et al.*, 2021). The South African State of Waste Report defines WEEE (waste electrical and electronic equipment), also known as e-waste, as any devices or items that were generated by electric currents or electromagnetic fields to function, including the equipment that was used for the generation, transfer, and measurements of such currents (Department of Environmental Affairs, 2018). Many international countries have adopted conventions and global initiatives, including the Basel Convention of 1989, to streamline sustainable waste management (Ogunseitan, 2013). However, gaps in implementing these international agreements into ratified countries' national and local e-waste industries exist (Shaikh *et al.,* 2020). The global management of e-waste has also been reinforced with the 2015 implementation of the Paris Agreement, which focuses on the nature of toxicity held by e-waste and its international transportation (Khan, 2016). The United Nations Organization emphasises the value held by the global e-waste industry, which is approximately €55 billion (Shevchenko *et al.,* 2019). While 66% of the world's countries are said to be legislated for e-waste management, only 20% of the global e-waste generated enters the appropriate recycling industry (Patil & Ramakrishna, 2020).

The regional context of e-waste focuses on banning the transportation of e-waste from more developed countries that attempt to sell their e-waste to less developed countries to avoid the responsibility of managing their waste (UNEP, 2018). This has occurred numerous times in African countries, including Nigeria and Senegal, which creates environmental and health challenges in the destination countries that lack the infrastructure to process recycling of e-waste in the appropriate way (Atasu & Subramanian, 2012). Furthermore, these African countries often do not have the resources to adequately deal with the resulting health effects such as respiratory conditions and environmental conditions, including contaminated crops from the informal burning of e-waste (Ahirwar & Tripathi, 2021). Fortunately, the prioritization of e-waste management has led to more African countries, including Ghana and Madagascar, successfully banning the importation of e-waste and are developing local e-recycling initiatives to provide sustainable waste management (Patil & Ramakrishna, 2020).

The state of e-waste recycling in South Africa is not at the level expected when South Africa has ratified to international conventions such as the Basel Convention, the Paris Agreement, and the 2030 Sustainable Goals Agenda (Strydom, 2018). The e-Waste Association of South Africa (e-WASA) estimates that independent and informal e-recycling practices account for approximately 25% of the total volume of WEEE recycled in the country (Lydall *et al*., 2017:12). The South African State of Waste Report accounts for specific drivers that contribute to the generation and management of e-waste in South Africa, including population growth, economic growth, urbanisation, and globalisation (DEA, 2018). South African cities with higher-earning residents in growing urban environments are said to pressure the waste management system due to increased consumerism (Borthakur, 2020). Lydall *et al*. (2017) share that e-waste has become a prioritized waste stream addressed in the Waste Research Development Initiative Roadmap (2015-2025) to address rising concerns of such waste. The hazard of e-waste has triggered this concern due to its physical, chemical, and toxic nature, leading to environmental damage and impacting human health (DEA, 2018).

The South African State of Waste Report sustains that Gauteng is the economic and waste management core of South Africa as it engages in the different phases of the e-recycling system and directs approximately 55% of the e-waste generated in South Africa into its e-waste industry (DEA, 2018). The official waste management service provider for the CoJ municipality is Pikitup who manages approximately 1.4 million tonnes of waste annually of which, 10% is e-waste (Pikitup, 2015b). Pikitup (2015b) has shared that approximately 70% of the total toxic waste that enters landfill sites is e-waste. Thus, the growing consumption of EEE and gaps in policy implementation has led to the need to prioritize the management of e-waste in South African cities, with a particular focus on the CoJ.

## 1.2 Background

Ichikowitz and Hattingh (2020) sustain that South Africa only has a collection rate of 11% of e-waste as most of it never enters the collection phase of the recycling industry. It is estimated that of this 11% collected, only 9.7% is recycled, leaving 90.3% of the e-waste created to be landfilled, which results in environmental and human health impacts (DEA, 2018). Bob's (2015) research found that only 12.1% of South African respondents knew of e-waste drop-off facilities, and 11% correctly disposed of their e-waste through appropriate recycling avenues. The country's e-waste industry is estimated to have a market value of approximately R280 million, but only R38 million is being earned (Mulckhusye *et al.*, 2021:16). Shevchenko *et al*. (2019) has predicted that e-waste will grow to 6.8 kg per inhabitant on a global scale by 2021. This prediction was made before the COVID-19 pandemic, where a significant shift to internet streaming services and devices, along with the world of work, has changed with large proportions of the global population working from home during strict lockdown measures, and most non-essential workers who have continued to work on virtual platforms (Brem *et al.,* 2021). The particularly alarming component of e-waste is that the remaining toxicity of past e-waste that has been landfilled or disposed of illegally is already part of a hazardous cycle contaminating the natural environment, which emphasizes the need to prevent further e-waste contamination (Ismail & Hanafiah, 2020). These components of the discussion of e-waste emphasise a drastic need to address the growth and challenges of the e-waste industry because if it remains neglected, the impacts will lead to significant environmental and health effects while missing an opportunity to turn waste into an economic resource.

Aboelmaged (2021) argues that consumers are one of the factors limiting South Africa's e-waste sector, which is triggered by their lack of consumer knowledge regarding the recycling of WEEE. Bob *et al.* (2017) argue that consumers and the collection process remain an immense challenge to the South African e-waste industry while they are, in fact, essential stakeholders in the e-recycling system. Therefore, this research plays a role in investigating the presence of consumers who are thought to be limiting the South African e-waste industry, particularly in the CoJ, where large volumes of e-waste are increasingly created due to mass consumption in its urban context. This research project aims to fill the gap in research on e-waste recycling within South Africa and, to a more specific extent, the metropolitan City of Johannesburg. E-waste exists in many households, but consumers choose to hibernate these devices and materials rather than recycling them (Bimir, 2020). This prompts the need to understand the rationale behind their waste practices and what influences them to hibernate devices or dispose of them in other methods rather than through formal recycling. Through understanding their practices, consumers' predisposition towards environmental, economic, and health impacts of e-waste can be determined. In turn, if consumers' attitudes and behaviours towards different elements of e-waste recycling can be determined, then the challenges and ways to decrease these challenges and incentives to motivate e-recycling behaviour can be identified.

## 1.3 Problem statement

E-waste is a waste management problem that is being experienced at an international level. Global cities and African cities are finding waste management of WEEE (otherwise known as Waste electrical and electronic equipment) challenging in the $21^{st}$ Century characterised by mass consumerism (Ogunseitan, 2013). Electronic items become obsolete as newer versions are released, increasing the number of electronic items being disposed of (Labuschagne, 2020). Most of the time, these electronic items are disposed of informally, illegally, or incorrectly, such as through informal incineration of devices (Ádám *et al.*, 2021). This leads to e-waste becoming a hazardous waste management problem as incorrect disposing leaches toxic components into the environment (Ahirwar & Tripathi, 2021). This introduction of hazardous e-waste into the environment also provokes human health concerns and can lead to respiratory illnesses, neurological changes, and skin conditions (Kumar & Singh, 2019). This e-waste disposed of also carries economic value in the single components of these devices that can be returned to their raw state to be recycled and have the potential to be reused while also creating employment through this process (Bob *et al.*, 2017).

One of the main challenges preventing the e-waste industry from developing is the low volume of e-waste entering the recycling stream (Forti *et al.*, 2020). The volume of e-waste that enters the waste stream is significantly based on the consumers of electrical and electronic equipment who currently hibernate their devices rather than recycle them (Gilal *et al.*, 2019). The need to understand consumer behaviour in CoJ households provides the rationale for this research project. Therefore, this study is tasked to identify current e-waste recycling attitudes and behaviours practices by households in the CoJ, a core e-waste management area in South Africa (Lydall *et al*., 2017).

## 1.4 Aims and objectives

The main aim of this study is to investigate e-waste streams and the e-waste recycling behaviour of households in the City of Johannesburg. In order to achieve this research aim, the following research objectives have been set out:

- Determine household recycling behaviour concerning the ICT e-waste stream.
- Identify challenges and incentives influencing household e-waste recycling behaviour.
- Investigate the relationship between e-waste recycling behaviour and the demographic variables of income level and age.

## 1.5 Research outline

Chapter 1 has introduced this research project by providing background into the e-waste industry at the global, regional and local level. Additionally, it has provided the rationale for the study as current literature on e-waste recycling is limited in understanding consumer behaviour regarding e-recycling. A problem statement highlighting the problem of interest for this project has been provided. Lastly, the aim and objectives that drive this study have been stated.

Chapter 2 is a literature review that synthesises and discusses the current literature on e-waste recycling through a funnel approach from an international stage to the local South African stage. This chapter defines the e-waste industry and its phases. The duality of e-waste possessing economic and waste reduction opportunities, along with health and environmental risks are discussed. The main challenges and incentives that influence e-waste recycling behaviour by households that can be addressed to streamline more positive e-recycling perceptions and practices are shared. Some innovation in the industry, such as introducing applications for managing e-waste collections, is also addressed in this chapter.

Chapter 3 focuses on the research project's methodology and discusses the methods used for data collection and analysis of the data with motivations for these choices. This chapter also provides a description of the study area, namely the CoJ, the sampling technique used, and the pilot study

Chapter 4 provides analysis and interpretation of the data collected, as discussed in Chapter 3. Graphs, tables, and figures are used in this chapter to provide a visual representation of this study's findings. The three objectives of this study are answered through analysis, namely determining household recycling behaviour concerning the ICT e-waste stream, identifying challenges and incentives influencing household e-waste recycling behaviour, and investigating the relationship between e-waste recycling behaviour and the demographic variables of income level and age.

Chapter 5 provides a conclusion on this study regarding the e-waste recycling practices in the CoJ. A summary of the main findings of this study is shared. This chapter concludes with recommendations for future research on the e-waste recycling discussion.

# Chapter 2: Literature Review

## 2.1 Introduction

Electronic waste is one of the fastest growing waste streams in the world with a growing estimate of 54 million metric tonnes of waste electrical and electronic equipment entering the system each year which emphasizes the need for intervention (Mulckhusye *et al.*, 2021). As stated in Section 1.1 WEEE is electronic and electrical equipment that has been discarded, damaged, stored and is no longer in use (Shaikh *et al.*, 2020; Ichikowitz and Hattingh, 2020). "This includes small and large household appliances, information and communication equipment, entertainment and consumer electronics, lighting equipment, electric and electrical tools, security and health equipment, and mixed WEEE" (Department of Environmental Affairs, 2018:19). Ichikowitz and Hattingh (2020) and Bob (2015) argue that e-waste acts as both a danger and an opportunity to South Africa's development. Moreover, provided the electronic waste is disposed of in a well-structured procedure for the dismantling of used items into their raw materials, the original value of these items is maintained while reducing the impact that e-waste has on the environment (Bimir, 2020).

An e-waste system is divided into four phases: collection from consumers and business, pre-treatment, treatment, and then disposal (Chandrasekaran *et al.,* 2018). Collection refers to the first stage of the system, which is the input process whereby the e-waste is collected in various ways. Thereafter, the e-waste items are dismantled into their original singular components and separated into waste categories such as plastic, ferrous and non-ferrous metals as the second phase (Wang *et al*., 2012). The last two stages focus on agglomerating these categories into mass collections, commonly done through hydro-metallurgical processes (Abafe and Martincigh, 2015). Thereafter, any waste that is unrecyclable is discarded usually by entering a landfill (Han *et al*., 2010).

While e-waste exists in many households, consumers usually choose alternatives to recycling (Shaikh *et al*., 2020). Waste electrical and electronic equipment should be disposed of when a device is no longer functional, when an individual no longer desires the device, or when it is replaced by a newer version (Zeng & Li, 2016). Other reasons for the need to dispose of appliances are if it is not functioning, and repairing it is not feasible or if the device in question is a digital accessory to a device that has been stolen or misplaced (Shaikh *et al*., 2020). Often, e-waste is hibernated, meaning it is kept within the household out of fear of losing the value of the item by recycling it (Gilal *et al*., 2019). Otherwise, e-waste is often given to family members or colleagues, added to regular waste collection, sold to informal waste pickers, or, if functional, sold as a second-hand device or donated to a charity (Ichikowitz & Hattingh, 2020). Informal and formal e-waste pickers usually collect this waste from municipal landfills, shopping centres, and refuse bins in suburban areas and then sell the waste to 'entry-level recyclers' (Lydall *et al*., 2017).

Thus, e-waste plays an important component of both the global and South African waste industries as the majority of WEEE does not enter the formal waste stream to maximize its use and value. The following section will discuss the status of waste electrical and electronic equipment at both a global and local level. While many countries have subscribed to conventions such as the Basel Convention of 1989 for sustainable waste management, many countries do not implement these policies or experience other challenges preventing the effectiveness of their e-waste industries. The following section is tasked with discussing the various legislations and acts policing e-waste management in the international context followed by the context of South Africa.

## 2.2 Global state and regulation of WEEE

To understand the background of the e-waste industry, it is necessary to make enquiries into the global and local state of WEEE. The generation of e-waste and current level of recycling is important to identify and understand current practices and priorities towards waste. Drivers also exist which highlight the reasons behind increased waste generation. There are numerous legislations and guidelines set by organizations to guide countries in their e-waste practices (Khan, 2016). Globally, such policies include the Basel Convention of 1989 and the Paris Agreement for 2015 (Ogunseitan, 2013). Locally, these policies include the Waste Amendment Act of 2014, National Environmental Management Waste Act (Act 59 of 2008), Protection of Personal Information Act, and the new addition of the Extended Producer Responsibility (EPR) Regulations.

The Basel Convention of 1989 governs the worldwide toxic nature of waste electrical and electronic equipment, particularly in terms of the transportation of hazardous e-waste regionally and internationally (Purushothaman *et al.*, 2021). Khan (2016) explains that The Basel Convention has become an international policy to guide the transboundary movement of waste as it has been strengthened by the Paris Agreement adopted in 2015. Ogunseitan (2013) further supports that the Basel Convention of 1989 has made an attempt to better manage the transportation of hazardous e-waste and its disposal and additionally promote accountability of hazardous waste generated by countries. Due to the increasing consumption of electronics and rapid obsolescence of devices, e-waste is one of the internationally prioritized waste streams (Otto *et al*., 2018). Additionally, the United Nations Organization emphasises the value of global e-waste with an estimated current value of waste electrical and electronic equipment is at €55 billion (Shevchenko *et al*., 2019). Global e-waste legislation at present differentiates broadly across different continents and countries. However, they primarily include limitations on the import and export of WEEE (Xavier *et al.*, 2020). Furthermore, many countries also have legislation regulating the recycling of specific categories of e-waste, such as those that are more valuable and which hold personal and corporate data (Liu *et al.,* 2021). Global regulations also attempt to promote Extended Producer Responsibility promoting producers of electronic products to be more proactive in management of e-waste; however, these are often not effectively practiced (Atasu &

Subramanian, 2012). Each country's e-waste regulations are also inculcated to address country-specific concerns and goals regarding WEEE recycling or lack thereof in the country and are usually a holistic management approach (Chung *et al.*, 2011). However, Shittu *et al*. (2021) argue that legislation and actual e-waste management practices are inconsistent due to existing law enforcement. This is supported by the fact that although 66% of the world's population are legislated for e-waste management, only 20% of the global e-waste generated is recycled (Patil & Ramakrishna, 2020).

However, numerous challenges are preventing the global e-waste industry from reaching its potential. Firstly, the failure to harmonize e-waste definitions has led to confusion worldwide on what exactly encompasses the e-waste recycling system (Bakhiyi *et al.*, 2018). Another constraint to the industry is the remaining toxic potential of the e-waste that has already entered the system but was disposed of incorrectly and illegally and currently wreaking havoc on the environment (Ismail & Hanafiah, 2020). Additionally, the lack of infrastructure for the various phases of e-recycling is a limitation for both current and potentially larger inputs of e-waste entering the system. It is, therefore, vital for regional e-waste sectors around the world to expand their infrastructure to support the higher inputs that are being encouraged and to meet the continuous growth of the waste problem (Nanath & Kumar, 2021). Lastly, the trend of informal and illegal e-waste collection and processing poses issues in strengthening the illicit e-waste industry. Arya and Kumar (2020) propose that this problem should be managed by strengthening the formal e-recycling sector and collaboration and training of informal waste pickers.

Another important contributor towards the global state of e-waste is The Global E-waste Monitor which emphasises the importance of monitoring the amount and movement of e-waste around the world. This assists in monitoring the development of e-waste towards a sustainable society and circular economy (Sarkar, 2021). The Global E-waste Monitor 2020 specifically focuses on introducing the international challenge of e-waste to the general public to achieve the prospects of a more sustainable future (Forti *et al*., 2020). This aligns to the global efforts to promote the sustainable development goals, specifically the goals for good health and well-being, clean water and sanitation, decent work, economic growth and life below water (Thakur & Kumar, 2021). According to the Global E-waste Monitor 2020 "5.6 million metric tonnes of WEEE was generated in 2019" (Mulckhusye *et al.*, 2021:2). As predicted by Shevchenko *et al*. (2019:2), "by 2021, e-waste is expected to grow to 52.2 million tonnes or 6.8 kg per inhabitant" on a global scale. As stated before, this prediction was made prior to the COVID-19 pandemic, which has demanded more online presence from global citizens as school and work have shifted to a remote platform. This has raised the amount of technology consumption, ranging from health devices to monitor temperature to information and communication technology for work and school purposes and other devices for consumer entertainment. This has only emphasized the new era of the Fourth Industrial Revolution that the world has entered (Mapbosa, 2021). Brem *et al.* (2021:3) share that there was a significant shift to internet streaming services and devices, with the world of work changing drastically as "90% of Americans worked remotely", "110 million in the European Union," and "200 million Chinese citizens by the end of January 2020" were working from home during strict lockdown measures, and the majority of non-essential workers are still working online.

As argued by Patil and Ramakrishna (2020:14419), "Most of the African countries are economically under-developed, and almost all the [WEEE] (used and new) is imported from developed countries in the Americas, Europe, and China." This is supported by the Africa Waste Management Outlook (UNEP, 2018) which highlights an increase in illegal transportation of WEEE into African countries such as Nigeria, Kenya and Senegal, where hazardous processing methods of e-waste are implemented, such as informal incineration. This mostly occurs in countries where there is limited or no legislation governing WEEE, largely present in West Africa where a major trading route has been developed (UNEP, 2018). However, with the rise of development in the 21st Century and more conversation on sustainability and health, many countries are concerned about these hazardous processing methods and are attempting to create stricter regulations to decrease the illegal processing of WEEE (Bimir, 2020). African countries that have been able to succeed at this are Ghana, Madagascar, and Nigeria, which have banned importing WEEE from developed countries and are practicing the Extended Producer Responsibility principle (Patil & Ramakrishna, 2020).

## 2.3 The South African state and regulation of WEEE

South Africa is one of the various countries that have ascribed to the Basel Convention of 1989 and is therefore expected to abide by its guidelines on the movement of e-waste within the interior and exterior of the national boundaries (Ogunseitan, 2013). This is one aspect that guides e-waste practices in South Africa. However, other legislations also inform the current and future management of WEEE in the country. Furthermore, there are numerous factors that have influenced waste generation in South Africa such as the rise of urbanisation and globalisation (Uhunamure *et al.*, 2021). Ultimately, while the existing literature provides background into e-waste recycling behaviour in the City of Johannesburg and South Africa, it is evident that gaps of knowledge exist.

### 2.3.1 E-waste generation

According to The Global E-waste Monitor 2017, 321 000 tonnes of e-waste was generated by South Africa in 2016 (Forti *et al*., 2020). Additionally, Mulckhusye *et al.* (2021:5) share that "South Africa produced 416 000 tonnes of e-waste", which averages 7.1 kg of e-waste generated per person. However, the estimated amount of e-waste generated by South Africa annually is seen as unreliable in the context of Africa. Since such a low volume of e-waste is recycled, there is room to significantly increase these volumes (Lydall *et al.*, 2017). Ichikowitz and Hattingh, (2020) sustain that South Africa only has an 11% collection rate of e-waste as most of it never enters the first phase of the e-recycling system, namely, collection. Furthermore, it is estimated that of this 11% collected, only 9.7% is recycled or refurbished, which means that around 90.3% of the e-waste generated is landfilled, which leaves the environment in a toxic state (DEA, 2018:vi). Bob (2015:10) also maintains that the e-waste recycling system's low input is burdened by a high concentration of residents who prefer to store their dormant electronics as 62.6% of his respondents chose to hibernate their e-waste rather than dispose of it. In the past decades, developing countries have become infamous for disposing of e-waste through informal and illegal methods; however, this is commonly due to a lack of resources and infrastructure for correct disposal (Nahman, 2010). This informal disposal usually occurs through informal incineration and acid-based processing, which negatively affects the environment and community health (Arya & Kumar, 2020).

### 2.3.2 Drivers of growing e-waste

According to the South African State of Waste Report, specific drivers are contributing to the generation and management of e-waste in South Africa, specifically, "population growth, economic growth, income, levels of urbanisation and globalisation of the recyclables market" (DEA), 2018:iv). Solid waste is associated with the rise of urbanisation in South African cities, and the more urbanised a region is, the more waste it tends to produce as a result of the era of mass consumption of goods and services (Forti *et al*., 2020). With population growth comes an increase in the depletion of natural resources resulting in more waste produced (Kubanza & Simatele, 2020). Since waste generation is associated with the production and consumption of services and products, regions that significantly contribute to the Gross National and Gross Domestic Product tend to contribute more to waste generation than other areas (DEA, 2018). South African contexts with higher-earning residents in a dominantly urban environment are also said to pressure the waste management system (Borthakur, 2020). In recent years, the recycling market's globalization has been a core aspect in the national discussion of waste management due to the large volume of previously ignored recyclable waste (UNEP, 2018).

### 2.3.3 Legislation of E-waste in South Africa

South Africa is considered a developed country compared to other African countries and has its own legislation regarding waste management and environmental and consumer protection, which address e-waste challenges (Strydom, 2018). At present, there are numerous legislations generally governing South African e-waste. However, most do not guide the implementation of e-waste management at a functional level. First, the Waste Amendment Act of 2014 classifies WEEE as hazardous waste due to its physical, chemical, and toxic profile, leading to environmental damage and consequences to human health (DEA, 2018). Lydall *et al*. (2017) have stated that e-waste is one of the prioritized waste streams addressed in the Waste Research Development Initiative Roadmap (2015-2025). This is mainly due to the environmental impact that the incorrect disposal of e-waste has had, the need to abide by global e-waste legislation, and the current development of effective local legislation (Lydall *et al*., 2017). The National Environmental Management Waste Act (Act 59 of 2008) has ignited the need for change in South African waste management to allow the country to enter a circular economy as well as reaffirm the importance of appropriate disposal of e-waste that contains hazardous waste such as batteries with chemicals (Andeobu *et al.*, 2021; Labuschagne, 2020). Mulckhusye *et al.* (2021) also add that the National Waste Act focuses on three key categories, namely, waste minimisation, waste prevention, and waste as a resource. The new addition of Extended Producer Responsibility (EPR) Regulations introduces a new approach towards waste management in South Africa which aims to divert waste from entering landfills (DEFF, 2021). Additionally, the new EPR Regulations to be implemented from May 2021, requires manufacturers and importers of goods to become significantly more responsible for the impact of their products by constructing their own EPR programmes (DEFF, 2021). This highlights the idea of minimizing waste that enters landfills which is vital to decrease the current stress of e-waste in landfills (Figure 2.1).

Figure 2.1: E-waste in Johannesburg landfill (Waste Plan, 2018).

The Protection of Personal Information Act promotes both households and businesses performing deletion of personal data on e-waste to protect data that may still exist on devices that are to be recycled (Labuschagne, 2020). This clearance of personal data is usually performed if requested by registered e-waste recycling companies, and a certificate on request is also provided to the consumer; this entire process is known as data destruction (Ceballos *et al.*, 2020). Patil and Ramakrishna (2020) support that the South African Electrical and Electronic Enterprise Development Association have been collaborating with the national government to update legislation that aligns with global e-waste standards. This assistance includes regulating consumers behaviour, encouraging the EPR principle, and developing legislation that can be implemented in South African reality.

The South African State of Waste Report maintains that Gauteng is the economic and waste management core of South Africa as it manages all four phases of the e-recycling system and manages approximately 55% of the e-waste volume produced in South Africa (DEA, 2018). For example, Desco provides consumers with accessible collection spots in the CoJ (Figure 2.2).

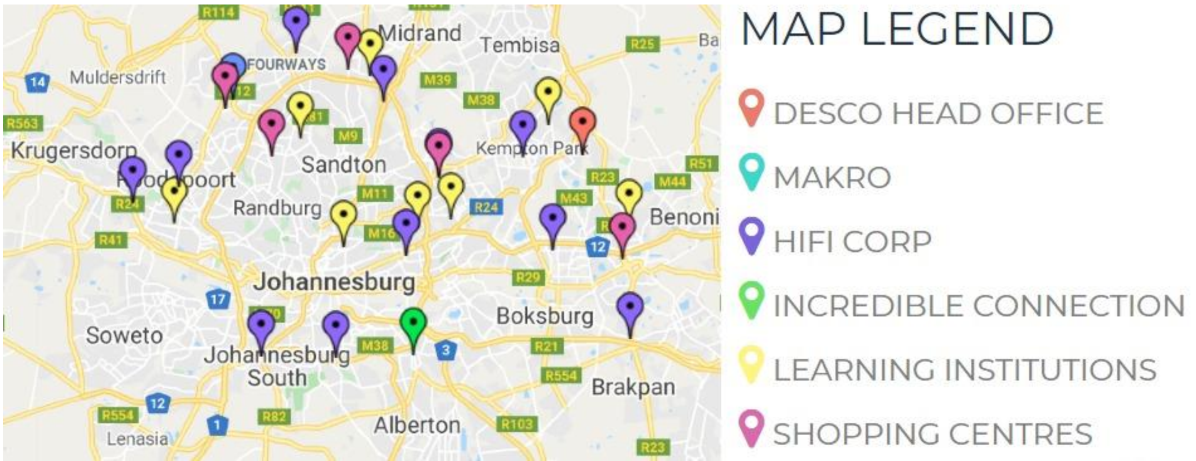


Figure 2.2: Drop-off points (Desco, 2021).

In terms of comparing hazardous waste production between 2011 and 2017, an increase of approximately 460% has occurred, which emphasizes the importance of developing a functional waste management system in South Africa. However, the limited resources of waste collection services of the National Domestic Waste Collection Standards are not feasible to provide regular e-waste collection services for the low volumes currently collected (DEA, 2018). The majority of South African e-waste is stored within state departments, private businesses, and households, and much of the waste disposed of enters municipal landfill sites (Lydall *et al*., 2017). At this point, informal waste pickers salvage the valuable components of e-waste (Coletto & Bisschop, 2017). According to Mulchkhusye *et al.* (2021), 70% of the toxic material found in landfills originates from WEEE. The South African State of Compliance separates waste management into private and public waste management facilities and argues that the informal sector has primarily been able to develop due to the lack of accessible formal e-waste management; however, this dynamic holds many opportunities for the relationship between consumers and waste recyclers (DEA, 2018).

It is important to remember that while the e-waste recycling system is being developed in Johannesburg, the waste hierarchy promoted is "avoid, reduces, reuse, recycle, recover, treat and dispose of," which advocates for conscious and responsible consumerism and recycling behaviour (DEA, 2018:71). Pikitup is the official waste management provider for the City of Johannesburg metropolitan municipality (Pikitup, 2015b). Pikitup collects approximately 1.4 million tonnes of waste in this area annually of which, 10% consists of WEEE (Pikitup, 2015b). According to Pikitup (2015b), approximately 70% of the total toxic waste that enters landfill sites is waste electrical and electronic equipment. This organization has a recycling programme that allows CoJ households to dispose of non-functioning and undesired devices, which are then recycled through original refurbishing components (Pikitup, 2015b).

This process has also led to further job creation and skills training for citizens within the area (Pikitup, 2015b).

It is essential to acknowledge that there is a lack of research regarding the e-waste behaviour of Johannesburg households. Lebbie *et al.* (2021) also highlight this lack of information and research as a challenge in understanding the behaviour of household e-recycling in this industry. In summary, this section has highlighted the current status of e-waste at an international and local South African context, and where possible, at a local level of the CoJ. The various legislation governing both global cities and the local area has also been debated, along with the lack of enforcement. The following section will discuss the different e-waste streams of the generated e-waste that has now been discussed and prioritized by the various policies at a South African level.

## 2.4 E-waste streams

Widmer *et al.* (2005) prioritize the e-waste streams into information and communication technology, consumer electrics, lamps, and small and large household appliances. Smartphones, laptops, and tablets are the most valuable e-waste due to the high concentration of valuable components for their weight (Rathore, 2020). Each of the various streams produces different parts once dismantled (Lydall *et al*., 2017). Ahirwar and Tripathi (2021) sustain that WEEE can be any device that provides comfort and luxury to our contemporary lives in the 21st Century and has become crucial in the age of the Fourth Industrial Revolution. These multiple components also widely range in value, mineral content, volume, environmental damage, and the ability to process it for reuse (Ikhlayel, 2018). This section will discuss the different waste streams such as consumer and ICT equipment, small and large household appliances, lighting, and battery WEEE and will provide examples of such items that can be found in households.

### 2.4.1 Consumer, information and communication equipment

Consumer equipment can range from end-of-life computers, laptops, tablets, notebooks, servers, uninterrupted power supply units, any computer accessories such as cables and screens, car entertainment and portable audio equipment, cameras, and recording devices, as well as fitness and healthcare devices (Ahirwar & Tripathi, 2021). This stream dominates the e-waste industry as e-waste grows with the development of information technology. Therefore, after each update or a newer version of a device is released, the e-waste associated with that device increases significantly due to it becoming obsolete (Leblanc, 2020). This stream provides e-waste rich in single WEEE components such as circuit boards (Figure 2.3).

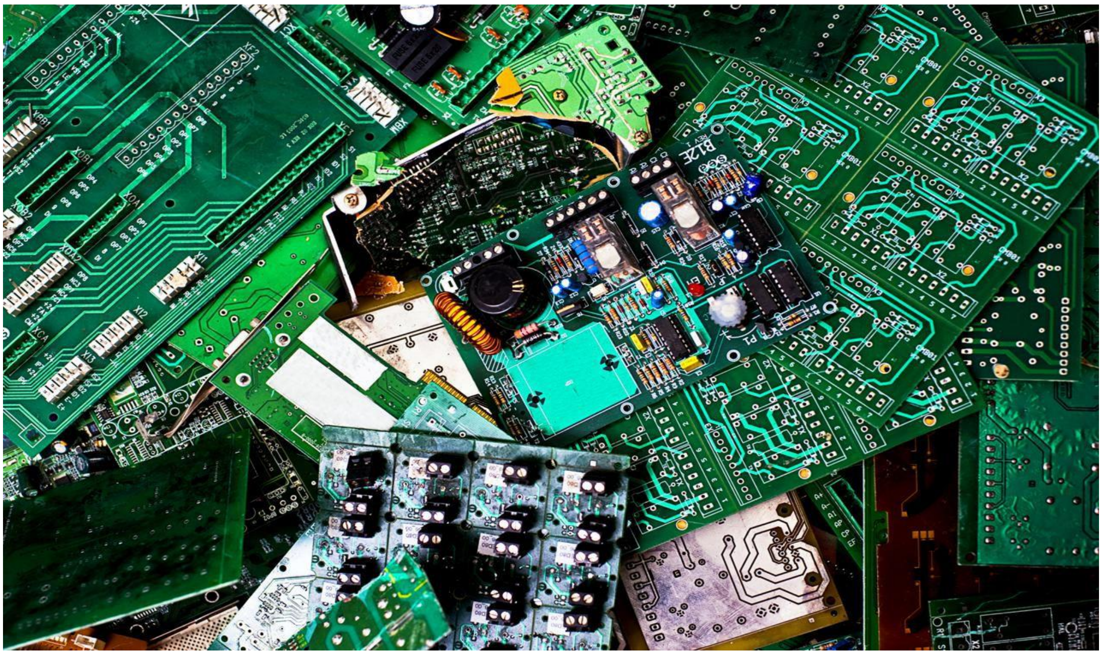

Figure 2.3: E-waste circuit boards (The Balance: Small Business, 2019).

**2.4.2 Small and large household appliances**

Small household appliances compose of irons, toasters, and similar appliances such as waffle/jaffle makers, clocks and watches, coffee machines and milk frothing devices, blenders, food processors, and juicers (Manhart *et al*., 2011). Any small household items powered by an electronic means or battery will become e-waste once it becomes dysfunctional or is no longer used.

In comparison, large household appliances consist of items such as refrigerators, washing machines, heating and cooling systems, and Liquid-Crystal Display (LCD) television screens (Shaikh *et al.,* 2020). According to D'Adamo *et al*. (2019), the economic analysis states that the recycling of LCDs has proven to be very profitable in many countries where some have even earned €134 000. However, the value of LCDs is determined by both the covering material and the printed circuit boards, and profit is seen as feasible, usually only with the presence of a recycling fee for small deposits of the LCD e-waste (D'Adamo *et al.,* 2019).

**2.4.3 Lighting equipment and batteries**

Lighting equipment as an e-waste stream includes light bulbs. According to Recyclebank (2015), the status of light bulbs as an e-waste stream is arguable; however, it does filter into different hazardous and non-hazardous disposal. Incandescent light bulbs are traditional bulbs before more energy-efficient options were readily available (Reuter *et al*., 2015). Halogen bulbs function as electricity passes through halogen gas; however, this is non-toxic (Vats & Singh, 2014). Jensen *et al.,* (2021) therefore promote that since these two bulbs do not consist of hazardous material, they can be disposed of through general waste as long as they are placed in a way that will not shatter the glass. In contrast, compact fluorescent bulbs are said to be more efficient in terms of energy; however, electricity is transported through a gas such as mercury which is hazardous and therefore must be disposed of correctly to e-recycling companies (Zeng & Li, 2014). Light-emitting diode (LED) lamps have become very common in households because they are seen as the most efficient light source and while not hazardous, should be delivered to e-waste recyclers (Reuter *et al*., 2015).

There are various types of batteries in the e-waste stream. However, the most popular e-waste batteries sourced from households are rechargeable batteries such as lithium-ion (for its high energy), nickel-metal hydride, nickel cadmium (for its strong performance at low temperatures) and lead-acid for its low cost yet large power supply (SRS Media, 2019). Non-rechargeable batteries such as alkaline, zinc carbon, and lithium metal are standard in households (Kpormon & Douglas, 2018). According to Ansari *et al.* (2010), these batteries are most often found in cell phones, laptops, and other consumer devices.

Mulckhusye *et al.* (2021) sustain that South African residents hold several small household WEEE consisting of small information technology devices. Ultimately the more households possess of a specific electronic stream, the more e-waste of that stream will be generated (Shaikh *et al.,* 2021). This section has discussed the different types of devices that give rise to the various streams of e-waste present in the industry, namely, consumer devices, ICT, small and large household appliances, lighting, and batteries. The next section of this chapter focuses on the various e-waste collection methods tasked to collect WEEE from the different waste streams discussed such as consumer, household, lighting and battery devices.

## 2.5 E-waste collection methods

Rathore (2020) argues that the centre of an effective closed-loop supply chain model rests in the consistent flow of e-waste being collected at the end of their life so that the reverse phase of the model can be implemented. While there is still a definite shortage of e-waste recycling sources, the number of companies providing location-specific collection, dissembling, and recovery of e-waste has grown in the last five years globally and specifically in Africa as a new approach to e-waste has been introduced (Abafe & Martincigh, 2015). There are three forms of role players present in formal e-waste collection in South Africa. First, there are large integrated waste management companies such as PETCO with a range of clients and advanced resources for the waste system (Godfrey *et al.,* 2019). Secondly, there are smaller operators that collect, refurbish and process WEEE collected directly from consumers and consist of private companies such as EZ Computer Recycling (Modise *et al.,* 2017). Last, there are municipal collectors such as Pikitup (Modise *et al.,* 2017).

According to Wang *et al*. (2012), there are three main categories of e-waste collection, delivery, household collection, and courier of the items. Ichikowitz and Hattingh (2020:48) provide four preferred incentives from their research results, such as "incentivized retail trade in" which could apply to both online and physical stores, along with "a deposit/refund system" where consumers are refunded their initial deposits, and "automated collection schemes" as it makes the e-recycling process more convenient to the strife of urban living. Ultimately, collection through formal government-recognized e-recycling companies is the most secure option (Gollakota *et al.*, 2020).

### 2.5.1 Delivery and deposits

Delivery and deposits of WEEE require the consumer to deliver their items to an appropriate collector, drop-off bins, or e-waste recycling organisation. This category also comprises trade ins and incentivised deposit systems whereby consumers trade their old appliance in for a newer model (Saldaña-Durán. & Messina-Fernández, 2021). Additionally, this involves returning end-of-life devices to their producers for their initial deposit as part of an advanced recycling fee initiative to be refunded (Shan *et al.*, 2021). ATMs (automated teller machines) are also a form of deposit systems where individuals can deposit their e-waste into a machine that will assess the value of the waste and provide the consumer with payment (Syahputra *et al*., 2020). A local example of this is a Samsung collaboration with selected Makro stores in South Africa (Figure 2.4). Another option would be consumers being able to return the devices to producers' stores for batch delivery to WEEE recycling companies, which is more convenient to consumers (Nowakowski *et al*., 2020).


Figure 2.4.: Samsung and Makro e-waste deposit containers (Samsung Newsroom, 2014).

### 2.5.2. Household collection

Household collection of e-waste occurs when an e-recycling company offers a mobile service to collect WEEE from households directly (Favot & Grassetti, 2017). Households often favour this as it minimizes the time and transportation resources of their e-waste (Nduneseokwu *et al.*, 2017). Household collection can occur in numerous ways. The single-day collection is one of the most feasible methods as South African e-recycling companies do not have the resources and infrastructure to collect e-waste from consumer's households each day (Bimir, 2020). Instead, consumers can organize their e-waste at home and prepare for it to be collected once a week, fortnightly, or even monthly (Shevchenko *et al*., 2019).

As per Shi *et al.* (2020), the mobile collection of WEEE is a particularly favoured and successful collection stream as it is convenient for households and companies. Due to the innovation present in the Fourth Industrial era, there are new opportunities to utilize for mobile e-waste collection, such as mobile and web-based applications that help plan and manage optimal collection routes for e-waste recycling companies (Shi *et al*., 2020). Batoo *et al.* (2021) argue that search algorithm can be applied to identify such routes for maximum waste collection. Based on the algorithm used, an e-waste company can increase the efficiency of their collection points between 1.2% and 6.6% (Nowakowski *et al.*, 2020: 13). Additionally, a profit increase from 5.1% to 13.2% is possible from using an algorithm to manage mobile collection routes (Nowakowski *et al.,* 2020:13).

### 2.5.3 Courier

The courier method of e-waste collection is one of the least popular (Bimir, 2020). While it may be convenient for a household to use a tertiary stakeholder to transport the e-waste from their homes to the appropriate e-waste company, this is one of the most expensive options for households (Shevchenko *et al*., 2019). Therefore, this collection stream is only applicable to the households willing to pay this cost and only accessible to households from higher-earning households and suburbs within the courier company's vicinity. Furthermore, this method is only acceptable for smaller electronic waste and limits the amount of e-waste to be deposited at an e-waste company (Dijk, 2016).

While there are numerous e-waste collection categories and options available to households practicing e-waste recycling, many choose other options rather than recycling. According to Mulckhusye *et al.* (2021:23), "the majority of respondents gave away their previous large electronic equipment to someone they know, cell phones were also given away frequently," and 15% stored their waste at home. During Mulckhusye *et al.'s* (2021) study, it was found that 47.1% of respondents acknowledge that they were aware of recycling facilities and drop-off points in their vicinity that accept e-waste, while 11.8% were unsure and 41.2% were unaware of drop-off points and recycling facilities. Ultimately, the proper collection of e-waste helps lower the effects of hazardous substances on the environment and human health which calls for increased e-waste recycling opportunities (Ogunseitan, 2013).

Thus, there are different categories of e-waste based on the stream of e-waste and its collections method. Deposits and delivery of WEEE by consumers is the most common but household collection is the preferred method for consumers (Shi *et al*., 2020). However, this is only feasible when there is a weekly or monthly collection date. It is important to make collection streams more effective to motivate consumers to participate in the collection phase to ultimately increase collection rates. The following section will focus on the environmental and human health impact of incorrect and illegal disposal and processing of WEEE which occurs when the implementation of separate waste streams and effective collection methods are not practiced.

## 2.6 Impact of incorrect and illegal disposal of e-waste

There is an exposure risk of pollutants to both waste industry workers and communities residing in nearby locations, rendering pollutants a health hazard (Li & Achal 2020). As Gangwar *et al*. (2019) argued, the incorrect and illegal disposal and processing of e-waste generates large amounts of pollution and adds numerous organic and non-organic pollutants such as heavy metals, acids, and greenhouse gases to the atmosphere which affect both the ecosystem and human health. However, the toxins released into the ecosystem are dependent on the e-waste stream and other additives used for the processing of waste (Orisakwe *et al.,* 2019). This section of this chapter will identify the various effects of illegal and informal WEEE disposal on the environment and humans exposed to e-waste pollutants.

### 2.6.1 Environmental degradation

Due to the toxic nature of e-waste components, when e-waste is not disposed of according to the correct procedure and delivered to appropriate recycling companies, it negatively impacts the environment. Firstly, when e-waste incorrectly enters a landfill, heavy metal toxins contaminate the soil that it penetrates, which then enters the soil pathway. This further impacts aquatic biodiversity, and human health comes into contact with the contaminated path (Ackah, 2017). Therefore, recycling e-waste helps mitigate climate change by decreasing fossil fuels and virgin resource extraction entering the electronic industry (Debnath *et al.,* 2018). It is vital to remember that sustainability should be the goal for waste management, keeping in mind that modern technology is said to owe nature an apology (McAllister *et al*., 2014). Due to the inherent threat of illegal and informal e-waste disposal, e-waste has received a lot of attention from the Department of Environmental Affairs, who see this industry as both a threat and an opportunity (Bob *et al*., 2017).

Cai *et al*. (2021) emphasize that there are many toxic materials introduced to the environment through e-waste. Saidan *et al*. (2012) also share that these toxic materials include heavy metals, and persistent organic pollutants, including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), brominated flame retardants (BFRs), perfluoroalkyl and polyfluoroalkyl substances (PFASs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Acids such as hydrochloric acid, sulfuric acid, nitric acid, and perchloric acid are used during informal processing of e-waste and then released into the environment adding to air pollution (Sunder & Singh, 2021). Furthermore, a variety of metals and organic elements are added to e-waste in trace amounts for different reasons during processing, and this may be done to strengthen or enhance the electrical and thermal conduction of the material before it is reused (Robinson, 2009). Ahirwar and Tripathi (2021) sustain that these additives are not usually hazardous until released into the atmosphere. This informal processing of e-waste can be destructive and increases the risk of contamination to the environment and individuals located in the area (Figure 2.5).

Figure 2.5: Informal burning of e-waste in Ghana (Earth Touch News, 2014).

### 2.6.2 Impact on human health

Electronic devices are usually manufactured with toxic components such as mercury, arsenic, lead, and cadmium (Robinson, 2009). When disposed of incorrectly or informally, e-waste items release chemicals and gases into the atmosphere, which have been proven to cause pulmonary, cardiovascular, and respiratory illnesses (Ádám *et al*., 2021). This is problematic as the informal burning of waste is a general practice in South Africa, particularly in areas where the correct e-waste management services are not provided or easily accessible (Bimir, 2020).

E-waste toxins entering the ecosystem have been reported to contaminate drains and surface soils from discarded acid wastes, including antimony, copper, and lead; additionally, indoor dust and vegetation have been found contaminated with e-waste toxins (Ádám *et al*., 2021). Robinson (2009) describes exposure to e-waste toxins via inhalation, ingestion, or dermal contact at either a workplace or through contaminated water, air, soil, and food. The population groups more affected and prone to health concerns of such contamination are the elderly, children, and pregnant women (in utero exposure can cause many complications) living in close proximity to e-waste recycling plants (Xu *et al.*, 2021). Health assessments have been conducted to study the impact of e-waste on human health by analysing levels of e-waste pollutants and their derivatives in serum, blood, cord blood, and the placenta (Dórea, 2021). It has been established that such exposure to contaminants may "affect thyroid function, cause genotoxicity [DNA damage], alter the cellular expression, physical growth, cognitive functions, lower living capacity, and present behavioural, neurological changes" (Ahirwar & Tripathi, 2021:7). The damage of deoxyribonucleic acid at the cell level by pollutants is of major concern due to its potential to increase risk of long-term health challenges (Figure 2.6).

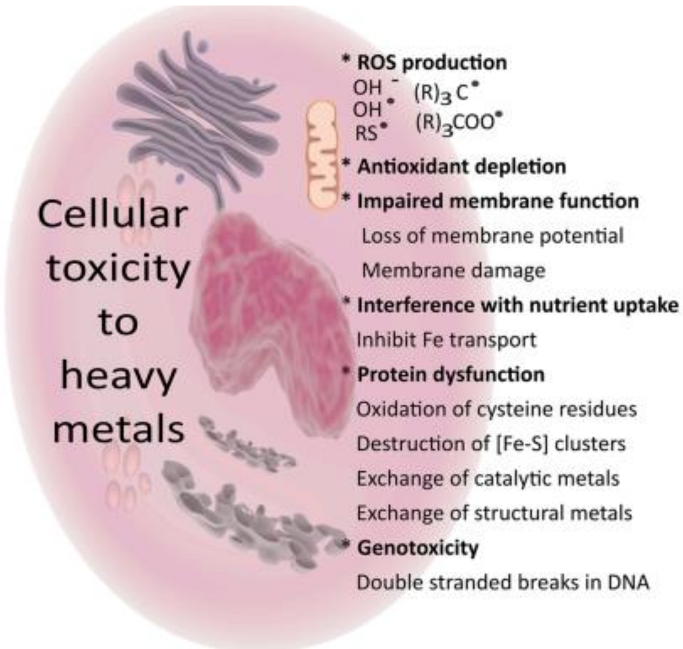


Figure 2.6: Toxicological mechanisms of heavy metals in humans (Ahirwar & Tripathi, 2021:7).

Thus, an ineffective e-waste system ignores the potential value of the industry and leads to negative impacts on human health and the natural environment. These impacts need to be acknowledged to prioritize development in the e-waste industry. These impacts can manifest through soil degradation, increased greenhouse gas emissions in the atmosphere from informal burning, and cardiovascular and respiratory illnesses in the exposed populations. The following section of this chapter will discuss the different financial opportunities of e-waste when the industry's potential value is recognized and developed.

## 2.7 Financial opportunities of WEEE

The process of producing a single computer with its monitor utilizes a minimum of 1.5 tonnes of water, 21.7 kg of chemicals, and 240.4 kg of fossil fuels (Leblanc, 2020). As supported by Rathore (2020), to benefit from the financial development of our country through the e-waste industry, the system has to be well organized and implemented. As supported by Lydall *et al.* (2017:i), the e-waste system can support the advancement of a “local, regional and secondary resources economy that provides a maximum local social and economic benefit,” emphasizing the opportunity possessed by this industry. The process of dissembling WEEE into secondary resource technologies induces the country to address the environmental concerns of e-waste. It prompts economic revitalization as the process creates socio-economic growth as waste is turned into a resource (Cucchiella *et al.*, 2015). According to Ravindra and Mor (2019) the different government sectors expect certain stakeholders to be responsible for e-waste management as the financial aspect of WEEE becomes prioritized. This highlights the importance of collaboration between all stakeholders in the e-waste recycling system. Thus, this section will discuss an effective e-waste industry's economic viability and the opportunities it can create for a city.

### 2.7.1 Cost and value of WEEE components

According to Ilankoon *et al.* (2018), e-waste is seen as valuable due to the value of raw materials used in individual components such as the presence of multiple precious metals (e.g., gold, platinum, palladium, ruthenium, rhodium, iridium, copper, and silver) along with other valuable materials such as iron, aluminium, cobalt, indium, germanium, bismuth, and antimony. The value of waste electrical and electronic equipment ranges widely in their value. Mostafa and Sarhan (2018) promote that the average grade of metal in different electronics possess a higher quality of metal than that excavated from current mines. Furthermore, it is essential to note that sometimes a charge is required when recycling complex e-waste, particularly when data destruction has to be practiced. According to Labuschagne (2020), for the destruction of hard drives, one can expect to pay R20 per unit, and secure destruction of other devices is charged at R10 per kilogram (kg). Desco, a well-established and resourced e-waste recycling company, rewards consumers who deliver e-waste to their stores with a minimal fee of R1 per kg of e-waste (Labuschagne, 2020). Since ICT is regarded as one of the more valuable e-waste streams, consumers can expect to receive compensation from a range of R1 to R8 per kg of e-waste (Labuschagne, 2020). However, valuable and voluminous components such as Random-Access Memory (RAM) items, Central Processing Units (CPU), and Personal Computers boards can earn consumers a reward of R30 to R2 000 per kg (Labuschagne, 2020).

Another vital consideration is the value and opportunity of functioning WEEE. Ishak *et al.* (2018) emphasise a significant social opportunity of WEEE as it has the potential to provide second-hand devices to less-advantaged communities (Lau *et al.*, 2013). For example, many low-resourced schools and university students could benefit from these used devices that they would not necessarily afford, particularly when bursaries do not provide funding for devices. This lack of devices and its effect in lower socio-economic communities has become prevalent during the COVID-19 pandemic as learning gravitated to an online space. Mulckhusye *et al.* (2021) support that there are numerous economic opportunities in South Africa. It is estimated that the country's e-waste industry's potential market value is "around R280 million, of which currently only R38 million is realized" (Mulckhusye *et al.*, 2021:16). Rathore (2020) also emphasizes that a large amount of the potential value is lost during incorrect processing of WEEE which emphasizes the importance of formal training of e-waste workers and recycling to maximize the value of e-waste.

### 2.7.2 Job opportunities

The e-waste industry is not currently a noteworthy supplier of employment. In 2015, WEEE recycling provided jobs to approximately 677 people across 18 firms in 2015 (Lydall *et al*., 2017). In contrast, the e-waste industry has the potential to be a significant employer as 25 jobs can be created for every 1 000 tonnes of e-waste managed, which has the potential to increase if maximizing the collection phase of the value chain is achieved (Lydall *et al*., 2017). Safdar (2020) supports that the e-waste industry's role in providing job and occupational opportunities is important, particularly in developing countries and countries with a reasonable informal recycling sector driven by waste pickers. The e-waste industry, with its occupational hazards and high-value potential, emphasizes a need for skilled workers working in formal e-recycling companies, which can help countries decrease unemployment challenges (Goel, 2019). Thus, the presence of job creation and skills training is vital to unlocking the potential economic benefits held by the e-waste industry (Figure 2.7).

Figure 2.7: E-waste recycling employment (EcoMENA, 2020).

### 2.7.3 Circular economy

A circular economy plays an important role in streamlining sustainability aimed by an effective e-waste industry. When an e-waste industry is effective, it uses the refurbished materials which were an output of the production process and transfers it back into the input process of production, thereby using waste as a resource (Forti *et al.*, 2020). In other words, sustainability is promoted as the end products of manufacturing are returned to the start of production which increases profits as less new materials are used while decreasing waste that enters landfills. As defined by Shevchenko *et al.* (2019:1), a circular economy is "a tool for the operationalization of the concept of sustainable development as it deals with entire life cycles and covers production, consumption, secondary raw materials, and waste management." D'Adamo *et al.* (2019) also maintain that a circular economy can be seen as a framework to achieve sustainability, emphasizing the social, economic, and environmental sectors of the country. Additionally, Velenturf and Purnell (2021) share that a reverse supply chain of e-waste aligns with the needs of the characteristics of a circular economy. This is because a circular economy assumes the maximum use of raw materials in a closed-loop economy and limits the final amount of waste to enter landfills as a last resort (Awasthi *et al.*, 2019). Second-hand and refurbished goods also play an important part in diverting EEE from entering the waste stream and landfills when directing back into use can decrease pressure on the waste stream (Lepawsky, 2018).

Thus, the potential value and economic opportunities for the e-waste industry play an important role in prioritizing the development of the e-waste system. Economic revitalization can be streamlined by redirecting waste into a resource while it creates jobs and training opportunities. The next section of this chapter will focus on the various consumer challenges currently preventing more positive e-recycling behaviour. Consumers play a vital role in an effective e-waste system as they provide the volume to re-enter manufacturing processes (Forti *et al.*, 2020). Therefore, it is essential to understand what is preventing them from contributing to the e-waste industry.

## 2.8 Consumer challenges limiting e-recycling.

Aboelmaged (2021) argues that consumers remain the weakest factor in developing South Africa's e-waste sector, which is mainly attributed to their lack of consumer knowledge regarding recycling, more specifically, e-recycling. Bob *et al.* (2017) argue that consumers and the collection process remain an immense challenge to the South African e-waste industry while they are, in fact, essential stakeholders in the e-recycling system. Manhart *et al.* (2011) also support that inconsistent and inadequate e-waste volumes are among the most prominent problems impacting the sourcing and recovery of these technologies. To increase consumer participation in e-waste collection methods, the factors that influence household e-recycling behaviour need to be identified. Therefore, this section will focus on the four main categories of barriers to collection that challenge households to recycle their e-waste which include location, time, behaviour, attitude, and lack of knowledge on e-waste.

### 2.8.1 Location and time

Location and time as a challenge to positive e-recycling behaviour focuses on the situation and context of e-recycling collection sources. Many households are discouraged from participating in e-waste recycling due to their complicated and busy urban lives that they are unable to allocate time to sort their waste, identify potential collection streams and companies that are suitable for them (Van Yken *et al.*, 2021). Furthermore, taking the journey to deliver their e-waste is also thought to be time exhaustive (Chen & Gao, 2021). Thus, convenience is a vital determinant of e-recycling in households.

### 2.8.2 Behaviour

Behavioural challenges to e-recycling in households primarily centre around household disorganization. Consumers fail to organize both their physical electronic items and time demarcated to sorting and depositing their e-waste at the appropriate place (Mahmod *et al.*, 2021). Ananno *et al*. (2021) argue that there are demographic factors that directly influence the e-recycling behaviour of households. While e-recycling practices differ in households across different geographic locations, it is essential to note that education, gender, and age have been identified in influencing e-recycling behaviour (Chen & Gao, 2021). A paradigm shift known as the 'new environmental paradigm' has become a trend supporting that youth and individuals with higher educational levels, such as tertiary qualifications, are more willing to participate in various waste recycling and responsible consumerism projects (Islam *et al*., 2021). Simaro *et al.* (2021) and Dhir *et al.* (2021) support that a specific demographic target is more accessible to practice consistent e-waste recycling, which consists of individuals with a living standard score of 8 to 10, come from a middle- to high-income group, and reside within an urban population.

In contrast, Kumar (2019) has used an Extended Theory of Planned Behaviour model to study young adult's interaction with e-recycling. The attitude and control of individual responsibility, as well as the subjective norms associated with culture such as an overall concern for the environment, was concluded to have a substantial effect on positive e-recycling behaviour (Kumar, 2019). This is supported by Delcea *et al.* (2020) who also emphasizes the relationship between positive e-recycling practices and planned behaviour in consumers. In contrast to the other studies completed such as Chen and Gao's (2021) research on e-recycling practices, awareness constructs, and the convenience of e-recycling did not act as barriers to positive e-recycling behaviour. However, this study was conducted with young adults in China; while it may provide background on the e-recycling consumer behaviour in China, it does not provide background in the context of South Africa. Ultimately, consumer behaviour is vital to the circular economy and the e-waste recycling system. The demand for products and services, and in extension, the return of end-of-life products to the value chain, is determined by consumers who play a vital role in the success of sustainable e-waste management (Shevchenko, 2019).

### 2.8.3 Attitude

According to Aboelmaged (2020), attitude as a challenge to e-recycling exists in response to consumers' opinions and perceptions. For example, environmental indifference where an apathetic approach is taken in response to the practice of e-recycling is a common observation (Agyei-Mensah & Oteng-Ababio, 2012). It needs to be acknowledged that consumers are not obliged always to be ideal consumers and that most of their behaviour is conducted from the individual's attitude towards the collection process of e-recycling (Aboelmaged, 2021). Dhir *et al.* (2021) therefore argue that understanding the internal and external motivations individuals have for e-waste collection is vital in improving consumer participation. Sari *et al*. (2021) also hypothesize that the higher the ease of recycling e-waste coupled with the awareness and importance of e-recycling and incentives to encourage the consistent collection, the maximum their participation levels will be in the WEEE system. Previous studies that have been completed in developed and developing countries revealed that households in developing countries hold an accumulation attitude towards wealth collection and therefore prefer to keep WEEE whether it is functional or non-functional (Attia *et al.*, 2021). This phenomenon has been termed "moral obsolescence" (Shevchenko *et al*., 2019:11).

Another study by Dhir *et al*. (2021:1) examined Behavioural Reasoning Theory (BRT) and identified the relationship between "reasons for" and "reasons against" in influencing the attitude and behaviour of households. The results from this study revealed that "reasons for" are linked to positive e-waste recycling behaviour and attitudes, whereas "reasons against" are linked to negative e-waste recycling behaviour and attitudes (Dhir *et al.*, 2021:11). Kirby (2021) emphasizes the role of effective and well-executed policies on e-waste recycling, service providers, and the government, which influences the comfort consumers have with the WEEE industry. Smith (2020) conducted similar research in the context of Nelson Mandela Bay. This research concluded that most households have either a neutral or apathetic attitude towards recycling general and electronic waste. The study results also concluded that the main factors influencing positive e-recycling behaviour within households are the cost-effectiveness and time-consumption of recycling (Smith, 2020). Therefore, accessible recycling sites that do not charge for recycling promote a more positive attitude on consumers (Kirby, 2021).

### 2.8.4 Lack of Knowledge

One of the most critical challenges facing households in practicing e-recycling is the lack of knowledge on waste and the correct recycling procedure. Individuals are often said to neglect recycling of their WEEE because they are unaware of the consequences of informal and illegal disposal (Kirby, 2021). Shevchenko *et al.* (2019:7) argue that one of the main challenges towards e-waste recycling participation is the "knowledge-to-action gap," whereby most households fail to practice general e-recycling purely because they lack the knowledge of its importance and the actual process of separation and disposal of waste.

This section has focused on identifying and describing the different challenges that consumers experience, preventing them from practicing more responsible e-recycling behaviour. Time and convenience mostly limit consumers from recycling their e-waste as they feel it does not fit into their busy suburban lifestyles. Behaviour and attitude are also significant challenges that hinder consumers from recycling e-waste, and different theories and factors explaining behaviour have been discussed. Many consumers also lack the knowledge of the importance of e-recycling and the procedure involved in doing it correctly. To promote households recycling e-waste, these challenges need to be addressed. The following section of this chapter will address the utilization of incentives to encourage recycling e-waste in households. These incentives are an important opportunity to motivate consumers to recycle their e-waste and become active participants in the e-waste system.

## 2.9 The use of incentives to promote e-waste recycling in households

There are numerous incentives that can be implemented to increase e-recycling participation and promote positive attitudes and discussion. Some WEEE initiatives include increasing the number and locations of drop-off points for e-waste to be deposited (Jaunich *et al*., 2020). Another initiative to promote this participation is the collaboration between producers and e-recycling companies to facilitate local and global enterprises in adopting waste responsibility (Bhaskar & Turaga, 2018). One community initiative streamlined is organizing events to help spread awareness and information to empower households to practice e-recycling (Davis & Garb, 2020). Supplementary to this idea, information on recycling e-waste can also be streamlined on social media to inform residents on the importance and procedure for recycling their end-of-life devices (Petridis *et al.*, 2020). Thus, this section will identify and describe how the three main incentive categories, namely, financial, community, and environmental, can encourage consumers to practice recycling their e-waste.

### 2.9.1 Financial incentives

Extended-producer and consumer responsibility may allow for e-recycling to become more accessible. This can be done by producers offering consumers the opportunity to pay an advanced recycling fee which is based on the polluter-pays and pay-as-you-throw principle and will contribute to the e-waste recycling fee of the item when returned to the store (Schmidtchen *et al*., 2021). From previous studies, this initiative has not been successful as consumers prefer financial incentives.

In contrast, Ben Yahya *et al*. (2021) suggest that providing consumers with a valuable incentive is vital to promote successful participation in e-recycling collection programmes. Nguyen *et al.* (2021) share that an old-for-new trade program has been very successful in countries such as China, where consumers could deliver their old devices to the producers and get the new model free or at a significantly discounted rate. Apple is an example of a company that is practicing a similar program where new-for-old trade ins are accepted in exchange for discounts on new devices purchased (Figure 2.8). Alternatives to such a program consist of cashback initiatives and discount coupons for one's next purchase at the producer's store (Wang *et al*., 2021).


Figure 2. 8: Apple i-phone trade in program (Apple Insider, 2020).

Shevchenko *et al*. (2019:12) propose a more experimental economic incentive known as an EBS, an "Electronic bonus card system" whereby consumers are credited with electronic points on their account when they purchase, return and recycle their electronic products. When consumers have accumulated enough points, they can use them to buy new products at a discounted rate (Shevchenko *et al*., 2019). However, this system carries inherent challenges. First, finding the potential investors for this system is seen as a dominant challenge (Wang *et al.,* 2020). Second, its ability to be shared through different enterprises may be questioned which would make the system more accessible and user-friendly as points would be earned at a more manageable rate (Kang *et al.,* 2020). This potential incentive does align with the overall financial incentive idea to motivate consumers to recycle their e-waste (Schmidtchen *et al*., 2021).

**2.9.2 Community incentives**

Community incentives focus on the producers of electronics contributing to the local community on behalf of the consumer when WEEE is returned and recycled (Peng & Wei, 2018). This is usually in the form of a donation towards a non-profit or non-governmental organization for societal change and development (Mohamed & Rasnan, 2021). Institutions such as schools often use community incentives where students are educated about the importance and process of e-waste recycling, and often students are rewarded by companies through school donations (Zhou *et al*., 2021). A good example of this is the Asus programme that collaborated with schools (Figure 2.9).


Figure 2.9: Asus school e-waste recycling target program (Netans, 2017).

### 2.9.3 Environmental incentives

Environmental incentives concentrate on the producers or any other relevant organization offering to contribute to environmental sustainability and conservation in return for the recycling of e-waste by consumers (Dhir *et al.,* 2021). For example, after a household has recycled their e-waste and received a certificate for it from the e-recycling company, they can present this certificate to an environmental organization that will plant a tree on their behalf.

This section of the chapter has focused on identifying and describing how the three main categories of incentives can increase households' willingness towards e-waste recycling. Financial incentives that directly benefit the consumer are said to be preferred and motivate consumers the most. Community and environmental incentives may also be used to help non-profit and non-government organizations with their causes. The following section will provide a conclusion on this chapter which has discussed the global and local background of e-waste to understand the opportunities and consumer challenges facing the e-waste industry.

## 2.10 Conclusion

It is important to note that it is not necessarily the growth of the technology industry that dictates the future and dynamic development of the e-waste industry but rather the availability and input of consistent volumes of e-waste into the local e-recycling system (Garg, 2021). Therefore, there must be a collaboration between the major stakeholders involved in the South African WEEE industry. Consumers, who are the main generators of such waste, producers who create the original devices, and local recycling firms share the responsibility in contributing to the management of correct disposal and recycling of their waste electrical and electronic equipment (Lydall *et al*., 2017). To increase consumer e-waste recycling, the aim of other stakeholders such as producers and recycling companies should be to create a convenient infrastructure to make e-recycling more accessible to households (Arain *et al.,* 2020). An essential advantage of having a favoured collection method is acquiring high-quality recycling equipment (Fernandes *et al.,* 2021). The e-waste recycling industry allows a region to reduce its greenhouse emissions and carbon footprint while providing energy saving on virgin extraction of resources (Rao *et al*., 2021). This chapter has outlined the global and local status of e-waste, notably lacking in effective legislation and governance. The various waste streams, including consumer and ICT, small and large household appliances, lighting, and batteries, have been discussed. The different e-waste collection methods of deposit and delivery, household collection, and courier have been distinguished.

Additionally, both the environmental and human health impact of incorrect and informal WEEE processing has been argued. The financial opportunities of WEEE leading to waste as a resource, employment, and training opportunities, and the goal of a circular economy has been outlined. In conclusion, consumer challenges of location and time, behaviour, attitude and lack of knowledge have been identified Financial, community, and environmental incentives have been discussed as techniques to promote positive e-recycling behaviour of CoJ households. The following chapter will focus on the methodology section of this research project.

# Chapter 3: Methodology

## 3.1 Introduction

This study aimed to investigate e-waste streams and the e-waste recycling behaviour of households in the City of Johannesburg (CoJ), South Africa. The study used the Theory of Planned Behaviour (TPB) as a theoretical framework to identify factors contributing to household recycling, such as knowledge levels, practices, opinions, and attitudes. TPB is commonly used in studies of research behaviour (Aboelmaged, 2021; Tonglet *et al*., 2004).

This primary data phase of the study was conducted in four stages to answer the research aim and objectives posed in Chapter 1. In the first stage of the study, a survey approach was adopted, and an online questionnaire was developed to collect primary data about recycling behaviour and volumes of e-waste in households. The second stage of the study involved a pilot study with a limited group of participants to complete the online questionnaire in their own time to identify how it may be improved by identifying and addressing any problems of the questionnaire. In the third stage of the study, the survey method was used to collect data from a larger sample of residents of the CoJ. Data collection was done by obtaining permission from residential associations across the CoJ to share the link to the questionnaire on various social media platforms. The fourth stage of the study focused on selecting data analysis techniques and then analysing the results of the data collected and discussing these results, which will be the focus of Chapter 4.

A mixed-methods approach was used through the different survey sections by blending open and fixed-response questioning, which streamlined quantitative and qualitative research. This provided qualitative and quantitative answers and reflections on the e-waste streams and the e-waste recycling behaviour of residents in the CoJ. The following section is tasked with discussing the study area of this research project, namely, the City of Johannesburg.

## 3.2 Study Area

This research on e-waste recycling behaviour was set in the City of Johannesburg (CoJ) to determine household behaviour and consumer willingness in e-recycling. The CoJ has been selected as the study area as it is the economic hub of South Africa and the largest producer of waste and e-waste. As supported by the second draft of the South African State of Waste Report (DEA, 2018), Gauteng is currently the core of both economics and waste electronic and electrical equipment (WEEE) collection and processing as it works with almost 55% of South Africa's e-waste. However, only an estimated 9.7% of collected e-waste is said to be recycled and recovered (DEA, 2018). In addition, WEEE has been identified as both a threat due to its costs and toxicity and an opportunity through its valuable components and job creation in the CoJ (Ichikowitz and Hattingh, 2020). The CoJ was studied specifically as there are trends in more electronic equipment and waste being present in more urbanized areas, particularly during this age of the Fourth Industrial Revolution (Lydall *et al*., 2017). The CoJ has a diverse population in terms of age (albeit it has a youthful population due to migration for education and employment opportunities), race, socio-economic background, and education levels which provides a versatile background to investigate the effect of demographic variables on e-waste recycling behaviour on a representative population (Statistics South Africa, 2011). The CoJ is found in the Gauteng province in the interior of South Africa (Figure 3.1).

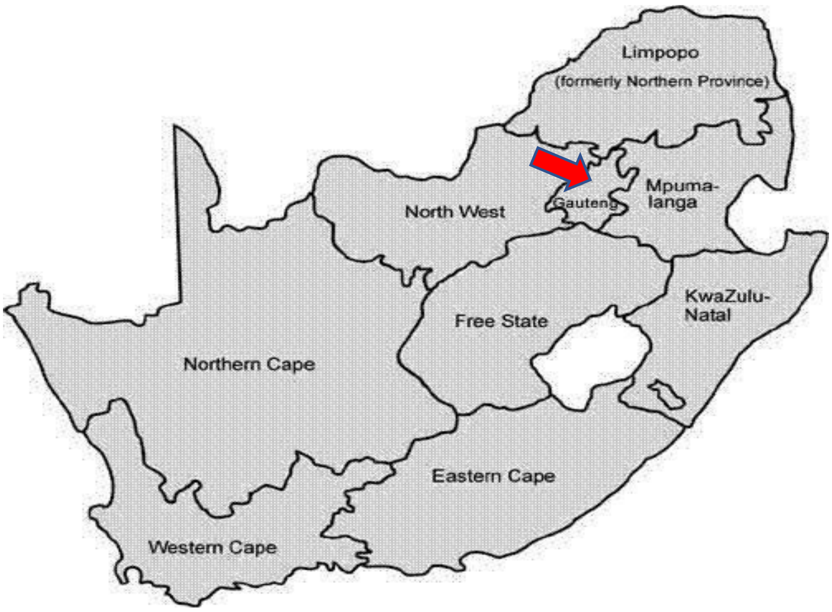


Figure 3.1: Map of South Africa showing Gauteng in relation to the other eight provinces (Adapted from: Cawthorn & Witthuhn, 2011).

This metropolitan municipality covers an area of more than 1 645 $km^2$ composed of seven diverse administrative regions (Statistics South Africa, 2018). The CoJ is home to an estimated 5.5 million residents within 1.85 million households making it the largest metropolitan municipality (Statistics South Africa, 2020). Thus, the study area comprises different suburbs in the CoJ (Figure 3.2).

| | |
|---|---|
| Region A | Diepsloot, Kya Sands, Dainfern, Midrand, Lanseria, Fourways |
| Region B | Randburg, Rosebank, Emmarentia, Greenside, Melville, Mayfair, Northcliff, Rosebank, Parktown, Parktown North |
| Region C | Roodepoort, Constantia Kloof, Northgate, Florida, Bram Fischerville |
| Region D | Doornkop, Soweto, Dobsonville, Protea Glen |
| Region E | Alexandra, Wynberg, Sandton, Orange Grove, Houghton |
| Region F | Inner City, Johannesburg South |
| Region G | Orange Farm, Weilers Farm, Ennerdale, Lenasia, Eldorado Park, Protea South |


Figure 3.2: Map of Johannesburg showing the seven regions of the city (Pikitup, 2015a).

## 3.3 Sampling

As per Veholar *et al.* (2016), a sample refers to a portion of the population a researcher wishes to engage with to learn about the whole population. A non-probability-based sample technique, specifically convenience sampling, has been used for data collection using the questionnaires, however this technique is flawed because the sample representativeness of the population will be unknown (Etikan *et al*., 2016; Lavrakas, 2008). Convenience sampling is a standard method of non-probability sampling whereby individuals are available and have access to participate in the research (Etikan *et al*., 2016; Baxter *et al*., 2015). Veholar *et al.* (2016) add that convenience sampling aligns with unrestricted and availability sampling as an unlimited population of available participants are invited to complete the survey questionnaire. The boundary of sampling was CoJ which is the study area of this research project. As specific answers on behaviour and attitudes needed to be answered, non-probability-based sampling allowed a larger population to participate in this research as any interested individual participated in the research by completing the online questionnaire (O'Cathain & Thomas, 2004).

This sampling technique was also selected due to the current limitations of COVID-19. With its need for social distancing, the current pandemic limits in-person communication, which called for online communication with the target population (Vindrola-Padros *et al*., 2020). The target population composed of individuals aged 18 to 75 (to uphold the ethics of more vulnerable ages) and living in the CoJ. The participants approached to engage in this research were invited as members of a specific residential association such as a residential estate in the study area, through contact with their estate manager, chairperson, or another appropriate member of the residential estate's body corporate. The following section of this chapter will discuss the pilot study of this research project.

## 3.4 Pilot

A pilot run of the questionnaire was administered online to identify any errors or ambiguities that may affect the questionnaire results' reliability and validity. This pilot study took place between 15 and 16 July 2021. Participants of the pilot study consisted of five academic peers. The feedback provided was positive, with participants concluding that the survey questionnaire was simple albeit longer than the average questionnaires they have completed. All the pilot participants shared that the introductory notes on WEEE before the questionnaire began clarified the content they were being questioned about, and the questionnaire in its entirety made them think about e-waste and emphasized the absence of hearing about it before. There was only one comment regarding the classification of smartphones. Still, its classification as a communication device, as opposed to a small appliance, is preferred by the researcher and team who consulted on the design of the questionnaire and is used in other studies such as Lydall *et al*. (2017). Therefore, no changes were required to improve the survey questionnaire. The following section will discuss the methods adopted for data collection in this study and the rationale for using a survey questionnaire.

## 3.5 Methods of data collection

This study used a survey approach to collect both quantitative and qualitative data. According to Dalati and Gomez (2018), a survey questionnaire is a classical approach to collecting primary data for studies. A questionnaire refers to a research tool used to collect data to answer the objectives of a study (Jafari *et al*., 2017). This research was conducted by blending qualitative and quantitative approaches as specific recycling qualities, and numerical data were collected. Data collection occurred through the administration of questionnaires that included both open-ended questions such as additional experiences or challenges the respondents wish to share and closed-ended questions such as preferred e-waste stream collection options and preferred incentives. A total of 286 participants submitted completed questionnaires for analysis. A mixed-method approach is favourable when researching recycling behaviour. Additionally, the integration of the approaches provides more confidence in the findings that are collected and interpreted and provides a more varied collection of data to be analysed (Lavrakas, 2008).

The online questionnaire was employed and completed through self-administered surveying by participants. A self-administered online questionnaire was selected for various reasons. First, it abides by COVID-19 protocols of social distancing and the use of online platforms for safe communication (Vindrola-Padros *et al*., 2020). Second, it appeals to participants more as they can participate in the research in their own time and the setting of their choice (Dalati and Gomez, 2018). Regmi *et al*. (2016) argue that in a world embracing the Fourth Industrial Revolution, digital surveying has been welcomed as a large portion of households, even in developing countries, have access to at least one mobile device with internet access which provides an accessible platform for participants to engage in research. As this research project is focused on e-waste recycling and consumer behaviour, an online survey completed by a target audience of electronic device consumers aligns well with digital surveying (Glazier and Topping, 2021). However, there are disadvantages associated with online questionnaires. First, the researcher is absent in the completion of the questionnaire and cannot provide clarity on questions participants may have, and as a result, responses may be less reliable (Lavrakas, 2008). In addition, participants also leave some questions unanswered, which results in a non-response error and can potentially decrease the quality of the data (Dalati and Gomez, 2018). While using the digital space for research engagement in the Fourth Industrial Revolution can be advantageous, it does have a potential for exclusion and a lack of representation in participants who do not have mobile devices or online access (Regmi *et al*., 2016). Following this method, an online questionnaire was designed and validated in a team effort by those participating in the larger e-waste recycling project; this is discussed in more detail in the following sub-section.

## 3.6 Online survey questionnaire

The online survey questionnaire used for the data collection in this study was designed to extract specific answers to the research objectives of this research project (Addendum A). The design of the survey questionnaire used as the data collection tool for the study made use of the e-waste categories of the EMPA questionnaire. EMPA is an interdisciplinary research institute part of the Swiss Federal Laboratories for Materials Science and Technology who are researching and innovating new concepts of nanostructured materials, sustainable building and technologies for the environment and medicine (EMPA, 2021). The EMPA questionnaire was used for their e-Waste Assessment Methodology Training and Reference Manual and was developed to foster knowledge partnerships in e-waste recycling within developing countries (Schluep *et al*., 2012). The questionnaire has been designed with statements to determine household recycling behaviour concerning the different e-waste streams. These statements used are similar to statements used in other recycling research, such as the statements used to assess recycling behaviour of solid household waste (Schoeman & Rampedi, 2021) and (Kumar, 2019) but have been adapted for e-waste recycling and behaviour in the CoJ. A study by Tonglet *et al*. (2004) also used similar statements to test personal recycling behaviour and recycling attitudes by looking at whether people believe that recycling is responsible, good for the environment, and rewarding.

Additionally, the questionnaire includes statements that test for potential incentives and attitudes that may be used to encourage increased participation in e-waste recycling. Examples of similar statements include agreement levels for “Recycling can provide job opportunities” and “It is important to recycle household waste,” as per Schoeman & Rampedi (2021:152). Other similar statements testing situational factors as challenges to recycling have been used, such as “Recycling takes up too much time” and “Recycling is too complicated” (Tonglet *et al*., 2004:203).

Dr. Thea Schoeman, who supervised this research project, is a part of a South African e-waste research group that consists of academics from the University of Johannesburg, the University of Cape Town, and the University of the Western Cape. The questionnaire was shared with this group of academics for input and feedback. There were a few changes to the baseline questionnaire that were suggested. First, the type of appliances, for example, the EMPA categories, referred to heat exchange equipment (Schluep *et al*., 2012). Heat exchange equipment is not a familiar term to South Africans. Therefore, it was suggested that this term be replaced with an air conditioner and electric heater for participants to understand what is being discussed in the questionnaire. This e-waste research group also suggested that batteries and light bulbs should be removed from the questionnaire as most respondents would be unable to accurately indicate the number and type of lightbulbs such as halogen and compact fluorescent lightbulbs (Vats & Singh, 2014; Xeng & Li, 2014) and batteries such as rechargeable and non-rechargeable (SRS Media, 2019; Xeng & Li, 2014) in their household. These suggestions were incorporated into the questionnaire, which helped streamline an effective survey questionnaire for primary data collection.

The online questionnaire was generated using Question Pro which is professional software for web-based research. The collection of primary data which made use of the online questionnaire ran for a period of four weeks, from 19 July to 14 August 2021. The questionnaire began with a message inviting respondents to complete the questionnaire and provided background on the study with a short description of the e-waste stream in South Africa to introduce respondents to the concept of e-waste to better understand the questions asked in the following sections. Contact details of my supervisor were also provided for communication purposes. Section A of the questionnaire collected data on demographics of respondents such as the province, city, and suburb to ensure that they are within the study area. The participants’ gender, employment status, highest education level, monthly income, residence type, and household size were asked to provide the data required to analyse the relationship between demographic variables and e-waste recycling behaviour. The demographic variables of household income and age were analysed to draw conclusions on participants’ e-waste recycling behaviour.

Thereafter, Section B focused on the various WEEE found in households through selecting the appropriate response from a table, and for disposal methods, multiple appropriate responses were ticked on the response tables. Sub-section 1 collected data on large appliances in the household such as fridges, freezers, dishwashers, washing machines, etcetera, based on the number of large appliances in use, not working, not needed/used. The type of disposal method used for each large appliance such as selling to a second-hand shop, handing over to a recycling company, selling to someone or donating, etcetera. was also asked. Sub-section 2 collected data on small appliances in households such as irons, microwaves, blenders, etcetera, asking how many are in use, not working, not needed/used, and their preferred disposal method for small appliances. Sub-section 3 collected data on the ICT equipment in households such as PCs, laptops, mobile phones, LCD monitors, etcetera., regarding how many of these devices are in use, not working, not needed/used, and preferred disposal methods. Sub-section 4 collected data on consumer electronics in households such as cameras, game consoles, e-smoking devices, etcetera, in the different categories of their state and preferred disposal methods. Sub-section 5 collected data on any other household devices that were not mentioned in the previous sections and then expanded on the number of these devices in their varying use states and disposal methods.

Section C focused on knowledge, intention, and attitude towards e-waste recycling and started with statements such as ‘Do you know or have you heard of any e-waste project in your city or town?’ with levels of agreement of ‘Yes’ and ‘No.’ Following this, was a table to test respondent’s knowledge and note their opinions on e-waste by indicating their levels of agreement to statements such as ‘I know how to recycle my e-waste’ through a five-point Likert scale composed of options for ‘strongly disagree,’ ‘disagree,’ ‘neutral,’ ‘agree,’ and ‘strongly agree.’ This was chosen as it is user-friendly, and most respondents have used something similar in other consumer surveys (Tastle & Wierman, 2007).

The last section, Section D, focused on other data and recommendations for recycling e-waste, such as witnessing unsound e-waste recycling practices, attitudes towards using refurbished electronic equipment, and opinions on how to encourage recycling of e-waste. The end of the survey provided a separate response page for those who wish to receive a short report on key findings of the study to ensure that responses to the survey questions remain anonymous. The following section is tasked to discuss the data collection and handling process of the study.

### 3.7 Data analysis methodology

Once the data was collected, quantitative and qualitative analysis of the results was conducted. The responses from the completed questionnaires were exported into SPSS. This statistical analysis has been carried out using SPSS as it provides a range of analysis functions that need to be applied to the data collected (Valeri & VanderWeede, 2013). Statistical analysis was selected for both descriptive and inferential statistics. For the questions using a Likert scale of agreement, answering the first two objectives (determining household recycling behaviour concerning the ICT e-waste stream and identifying challenges and incentives influencing household e-waste recycling behaviour), descriptive statistics have been used to analyse these results to determine an average response. For open-ended question results yielding qualitative data, content analysis, more specifically, thematic analysis, was used to identify the frequency of common keywords and themes present in the data collected. For example, opinions on how to motivate e-waste recycling.

For the third objective of investigating the relationship between e-waste recycling behaviour and the demographic variables of income level and age, a chi-square test for independence was conducted to identify if there was a significant relationship between demographic variables and prior e-waste recycling behaviour. As per Neuman (2013), a chi-square analysis tells us the depth of correlation between two variables and their association. Questions that yield descriptive statistics have been analysed and presented using various graphs and tables (Chapter 4), such as the different levels of awareness and willingness to participate in e-recycling programs to provide visualization on these e-recycling factors researched as stated by Rowley (2014). The following section of this chapter will discuss the quality of data aimed for in this study.

### 3.8 Data quality

The quality of data collected is discussed in this section. If time and other contextual issues were absent, such as COVID-19 restrictions, an additional data collection method such as interviewing could have been done. As per Mackey and Bryfonski (2018), an additional method could further increase data quality by supporting and clarifying results from the questionnaire and could have focused on specific participants to increase the representation of the sample of the study. Content validity is vital in research and refers to the extent to which the research tool covers the content that is being studied (Brod *et al.*, 2009). Thus, the questionnaire has been designed with specific questions to illicit the answers to the study's objectives. Smith (2005) argues that construct validity is vital in research and refers to whether inferences can be drawn from the questionnaire statements. The questionnaire set statements on a Likert scale to provide for inferences on knowledge levels on e-waste recycling. Lastly, reliability refers to the accuracy of the research tool used and the degree to which an instrument can consistently reproduce similar results (Mohamad *et al*., 2015). Reliability has been aimed for in this study through the pilot study to identify mistakes, having a consultation team to aid the questionnaire design, and providing instructions and information to respondents to clarify questions along with protecting their identity to help them feel comfortable enough to answer the questionnaire honestly. The next section of this chapter will discuss the ethics streamlined throughout the study.

## 3.9 Ethics

Throughout this study, the privacy and voluntary participation of participants were upheld. Ethical clearance from the University of Johannesburg was obtained before commencing the study (Addendum B). While this research project did not require ethical clearance at an honours research project level, it has been granted for the larger study of which this project is a component. Two specific measures, namely voluntary participation and privacy and confidentiality were put into place to protect the rights of participants. All participants were invited to participate in the study, and thus participation was voluntary and at the participant’s leisure. In addition, all communication with residential associations via emails, calls, and messages were handled confidentially and not made available to anyone external of the research team involved in the study. As a matter of privacy, all links for data collection were forwarded to figures of authority, ensuring there was no direct contact with residents to uphold the rights streamlined in the updated POPI Act. The following section of the chapter will discuss the problems and limitations experienced in the study.

## 3.10 Problems and limitations

One of the main challenges experienced during this study on e-waste recycling in the City of Johannesburg was the challenge of time faced in conducting the data collection and analysis techniques. This time challenge was due to this study being one component of a larger project taking place, and as a result, the questionnaire tool to be used for data collection took longer than expected to be generated. Fortunately, an extension of time was provided for collection and analysis of the responses. Due to this time challenge, the pilot study had to be limited.

Another limitation in this study was the use of only an online survey questionnaire method for data collection as it excluded parts of the population who do not have mobile devices or online access to complete the questionnaire. This problem could have been remediated through face-to-face surveying and circulation of hard copy questionnaires. However, this was not possible during the time of this study which corresponded to the third wave of the Coronavirus in South Africa and peak infection rates in the Gauteng province (National Institute for Communicable Diseases, 2021). During this collection phase, there was also a period of looting and unrest in Johannesburg (Seleka, 2021).

The strict privacy policies of private estates and security estates acted as a challenge through coverage error as many of these estates shared that they do not participate in studies like this due to the privacy protection of their residents. This decreased the potential sample population of the study and consequently reduced the representation of participants and data quality.

Research on e-waste recycling streams and e-waste recycling consumer behaviour has been scarce in South Africa, particularly in the CoJ, where the majority of WEEE is disposed of. A detailed survey questionnaire was therefore required to collect adequate and quality data for the study. However, the length of the survey may have resulted in questionnaire fatigue. As per Lavrakas (2008), questionnaire fatigue leads to a higher non-response and non-completion rate by participants who may have started the survey and were discouraged from completing it due to its length.

A common trend and challenge that has been identified in data collection using survey questionnaires in studies on recycling are that consumers who do already engage in recycling and possess an awareness of its process and hold pro-environmental attitudes are more likely to participate in recycling studies while those without a recycling background tend to not participate, potentially from fear of judgement (Kumar, 2019). The following chapter is tasked with the analysis and interpretation of the responses received by participants in the data collection phase of the study.

# Chapter Four: Data analysis and interpretation

## 4.1 Introduction

Chapter 3 described the methodology of this research project on e-waste recycling behaviour, including the data collection procedure and data analysis techniques. This chapter reports on the key findings of data collected through the survey questionnaire research tool. The analysis of the questionnaire responses provides the information required to investigate e-waste streams and the e-waste recycling behaviour of households in the City of Johannesburg. Due to the limited focus of an honours research project, not all data collected in the questionnaire will be analysed and reported on. The analysis will begin with a focus on household attitude and behaviour. Thereafter, the information and communication technology (ICT) device e-waste stream will be analysed in the context of device usage in the CoJ. Furthermore, challenges restricting household e-waste recycling and suggestions provided by participants to increase the presence of e-waste recycling will be analysed. Lastly, the relationship between e-waste recycling behaviour and the demographic variables of income level and age will be analysed. The study's main findings will be discussed, followed by data quality and final thoughts on this chapter.

As the survey questionnaire tool was developed as part of a larger research project, it was created to collect a depth of material on e-waste recycling behaviour. For this research project, specific questions from the questionnaire and their responses will be analysed to answer the research objectives and to identify current e-waste recycling attitudes and behaviour held by CoJ residents in comparison to the statistics provided in previous literature as discussed in Chapter 2. The following section will discuss the demographics of the research participants.

## 4.2 Demographics

A total of 286 participants completed the survey. Participants reside in a range of suburbs located in the CoJ with a high proportion of 40 individuals from Modderfontein, 26 from Lonehill, 24 from Boskruin, 17 from Greenside and the remainder of participants were from other suburbs. In terms of the gender demographics, 69.4% of respondents identified as female, 29.9% identified as male and 0.7% identified as LGBTQ+ which overall shows a higher participation from females. The most common participant age was 51 years of age while the average mean participant age was 50 years. Demographics on education showed that 1.8% of respondents had some high school education, 13.7% have their National Senior Certificate, 23.2% have a post-matric diploma or certificate, 20% have a bachelor’s degree, and 41.4% have a post-graduate degree (Honours, Master’s or Doctorate) which reflected a high proportion of participants possessing a tertiary level of education.

In terms of household monthly income of participants, 0.7% stated that their household income was less than R3 500 per month while 38.1% stated it was more than R75 000 per month (Figure 4.1). The following section will discuss e-waste recycling knowledge and participation of households in the CoJ.

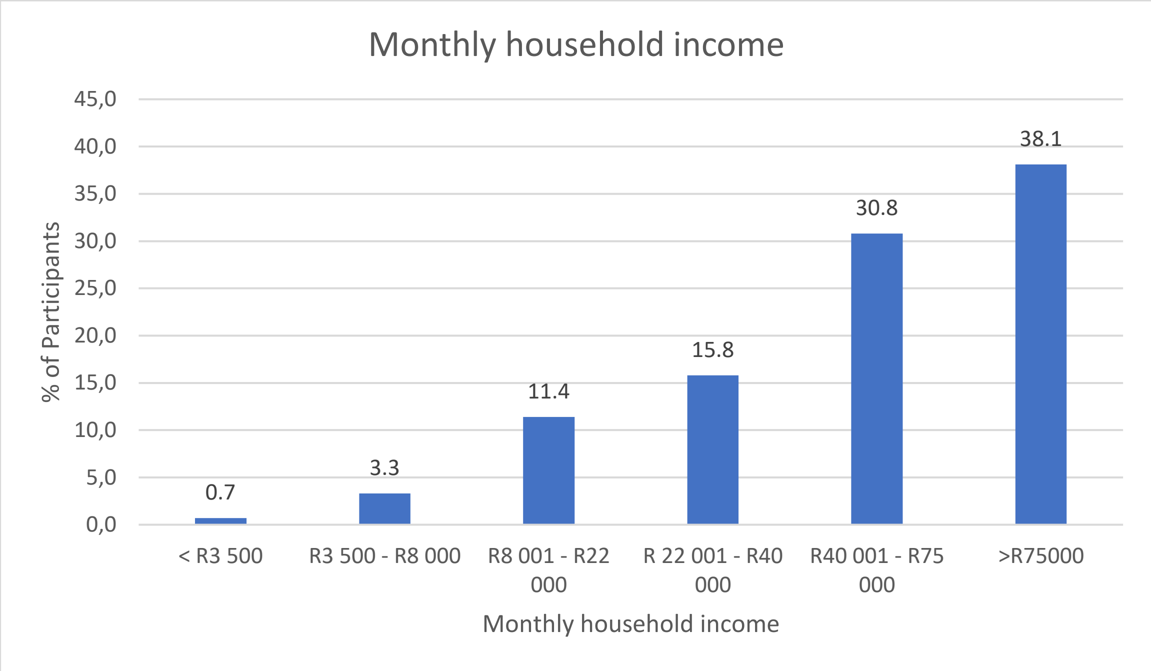


Figure 4.1: Monthly household income of participants

### 4.3 E-waste recycling knowledge and participation

The e-waste recycling knowledge and participation of CoJ residents were established by analysing the average agreement levels towards specific statements provided in the questionnaire. Analysis started with the first two questions under Section C of the survey questionnaire based on knowledge, intention and attitude towards e-waste recycling. Only 54.4% of participants shared that they know of or have heard of e-waste recycling projects in their suburb or area in the CoJ while 45.6% said they have not. Second, in terms of prior recycling participation 57.7% shared that they have recycled their e-waste in the past while 42.3% stated that they have not previously recycled their e-waste. In answering an important question of whether respondents recycle their e-waste or not, it can be said that just over half of the sampled population do recycle their e-waste looking at their previous recycling activity but there is still room for a lot more residents to participate in the recycling of their e-waste. The potential of e-recycling behaviour increased to 82.2% when asked if they plan to recycle their e-waste in the future. This shows an increase in a more pro-environmental attitude and increased willingness to start recycling their e-waste. Perceived control according to three statements on e-waste recycling will be discussed next.

### 4.4 Perceived control

Perceived control is the belief of a person of their control over their behaviour and activities in recycling (Tonglet *et al.*, 2014). Three statements investigated respondents perceived control in e-waste recycling (Figure 4.2). Overall, respondents indicated that they do not have much control in e-waste recycling activities. The most positive response was on the statement 'I know how to recycle my e-waste' where 43.5% of respondents agreed or strongly agreed with this statement. However, almost the same number (40.0%) disagreed or strongly disagreed with the statement. The second statement for perceived control was 'E-waste recycling is easy' where 25.4% of respondents agreed or strongly agreed with the statement, 45.2% disagreed or strongly disagreed with the statement. Thus, the majority of respondents did not find recycling of their e-waste easy. The third statement was 'I have plenty of opportunities to recycle my e-waste' where only 18.7% shared that they agreed or strongly agreed with this statement. In contrast, 55.7 % disagreed or strongly disagreed with this statement. These responses emphasize the significant gap in the provision of e-waste recycling opportunities to make e-recycling more accessible for households in the CoJ. Perceived control has been witnessed to be much higher for solid waste as seen in solid-waste research than it is for e-waste. In comparison, a recent study shared the following perceived control for solid waste (Schoeman, 2021). First, 63% of respondents indicated that they know how to recycle their waste (Schoeman, 2021). Second, 55.1% agreed or strongly agreed that recycling is easy while 26% disagreed or strongly disagreed with it being easy (Schoeman, 2021). Last, 61.4% agreed or strongly agreed that they have plenty of recycling activities, while 20.8% disagreed (Schoeman, 2021). This shows that there is an overall more perceived control in solid waste activities than there is in e-waste recycling activities.

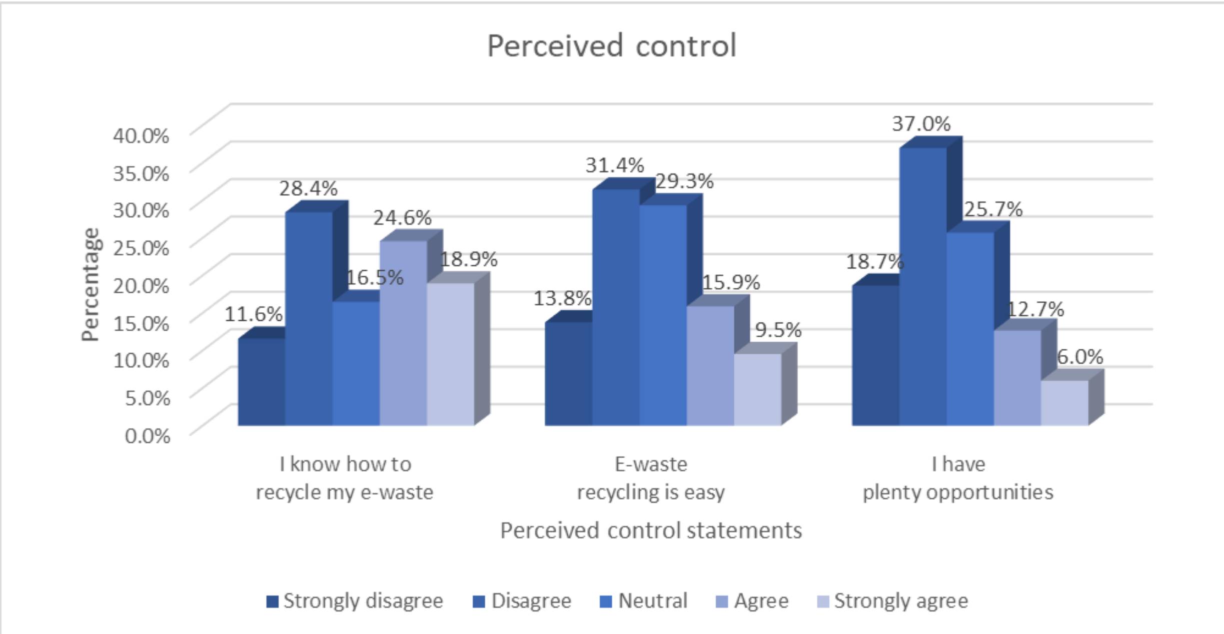


Figure 4.2: Perceived control regarding e-waste recycling

## 4.5 Willingness to pay

Three statements investigated respondent's willingness to pay for e-waste recycling services. Overall, respondents shared an unwillingness to pay for e-waste recycling such as advanced fees. The most positive response received was for the first statement, 'I would be willing to pay a deposit when purchasing an EEE item that would be refunded to me when I return the item at its end of life' where 45.8% said they agreed or strongly agreed with this statement (Figure 4.3). However, 26.2% disagreed or strongly disagreed and 28% had a neutral stance. The second statement was 'I would be willing to pay a recycling fee when purchasing an EEE product to assist the producer in correctly recycling the item', where 36% agreed or strongly agreed, 36% disagreed or strongly disagreed and 26.2% had a neutral stance. The last statement was 'I would be willing to pay an additional fee to my municipality for separate collection of e-waste on set dates', where 29.1% agreed or strongly agreed. In comparison, 49.5% of respondents disagreed or strongly disagreed with this statement while 21.4% held a neutral stance. This ultimately shows that respondents are not willing to pay upfront recycling fees to producers or municipalities.

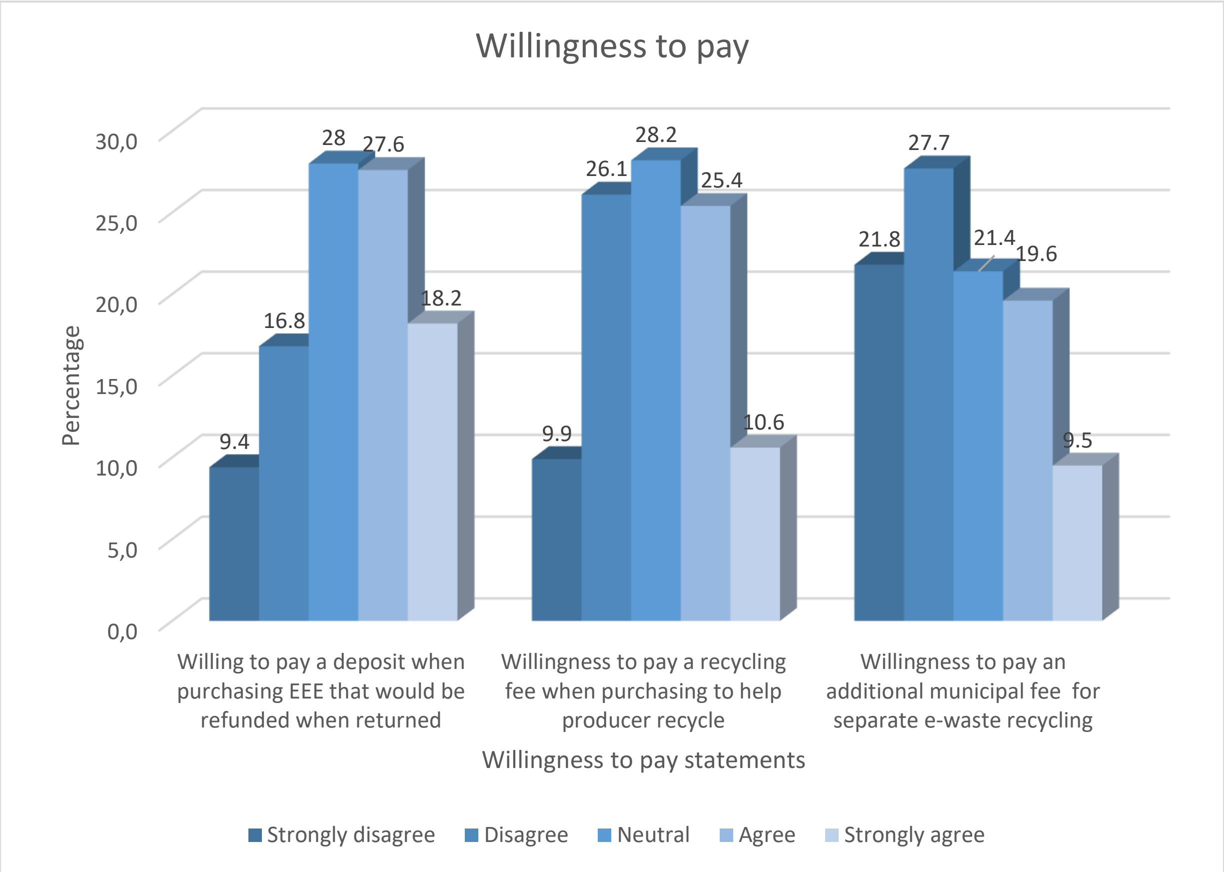


Figure 4.3: Willingness to pay for e-waste recycling services

## 4.6 Economic value and environmental concern

Overall perceptions from the responses from participants show acknowledgement of the economic value associated with e-waste recycling. In response to the statement ‘E-waste items include valuable materials’, 87.7% respondents agreed or strongly agreed whereas 1.1% disagreed or strongly disagreed and 11.3% had a neutral stance (Figure 4.4). This was also supported by the accompanying statement, ‘Recycling my e-waste creates jobs’, to which 82.8% agreed or strongly agreed to this benefit of e-waste recycling. In contrast, 0.7% of respondents disagreed and 16.5% were neutral to this statement. Thus, it can be said that CoJ households acknowledge the economic importance of developing the e-waste industry.

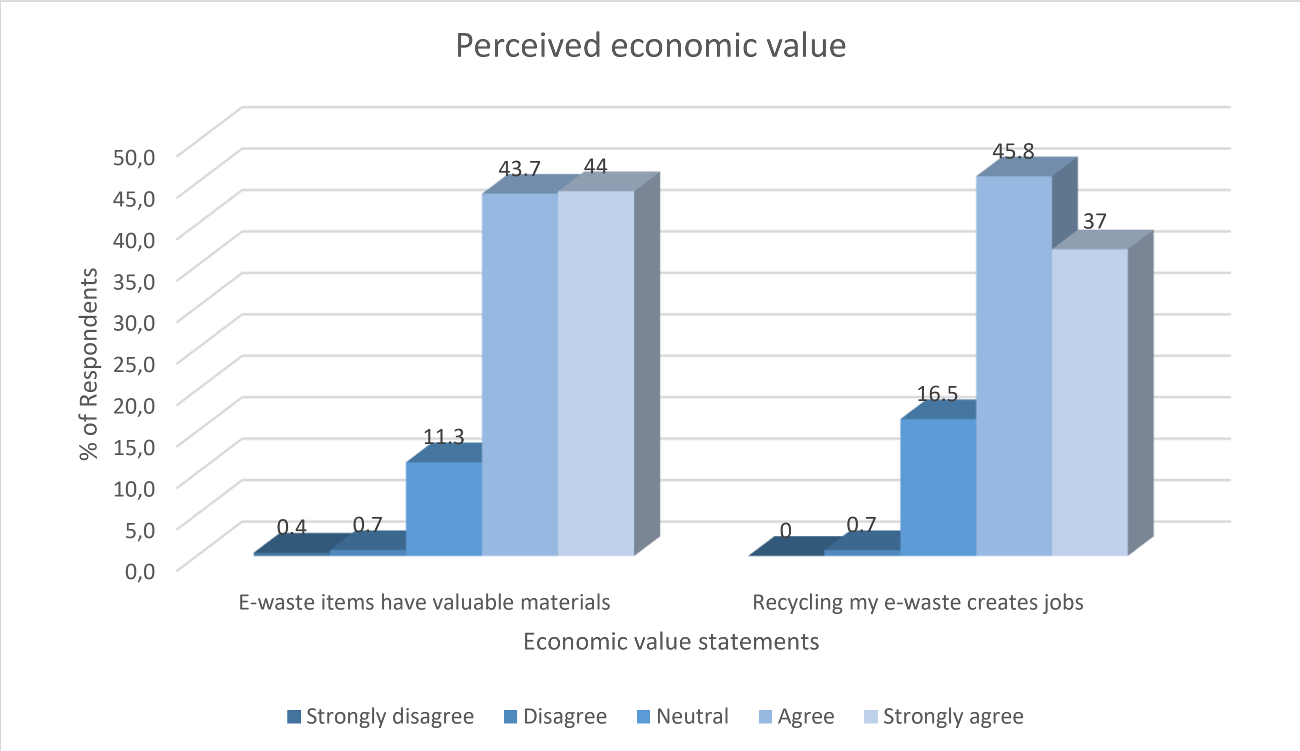


Figure 4.4: Perceived economic value of e-waste recycling

In terms of the environmental value of e-waste recycling, there was an overwhelming acknowledgment of the role of e-waste recycling in reducing damage to the environment. In response to the statement, ‘E-waste recycling reduces damage to the environment’, 90.6% agreed or strongly agreed whereas 3.9% disagreed or strongly disagreed and 5.6% were neutral (Figure 4.5). For the statement ‘It would be wrong of me to not recycle my e-waste’, 87% agreed or strongly agreed while 3.5% disagreed or strongly agreed and 9.5% were neutral. In response to the statement ‘E-waste recycling is the responsible thing to do’, 96.1% of participants agreed or strongly agreed while 1.1% disagreed or strongly disagreed and 2.8% held a neutral stance. These statistics reflect an overall positive attitude held by these consumers towards e-waste recycling as they acknowledge the importance that e-waste has in preventing environmental destruction, and that partial responsibility of correctly recycling e-waste falls to residents. While consumers' attitude is essential to understand the state of e-waste recycling in the CoJ, it is vital to also look at the actual e-waste recycling practices.

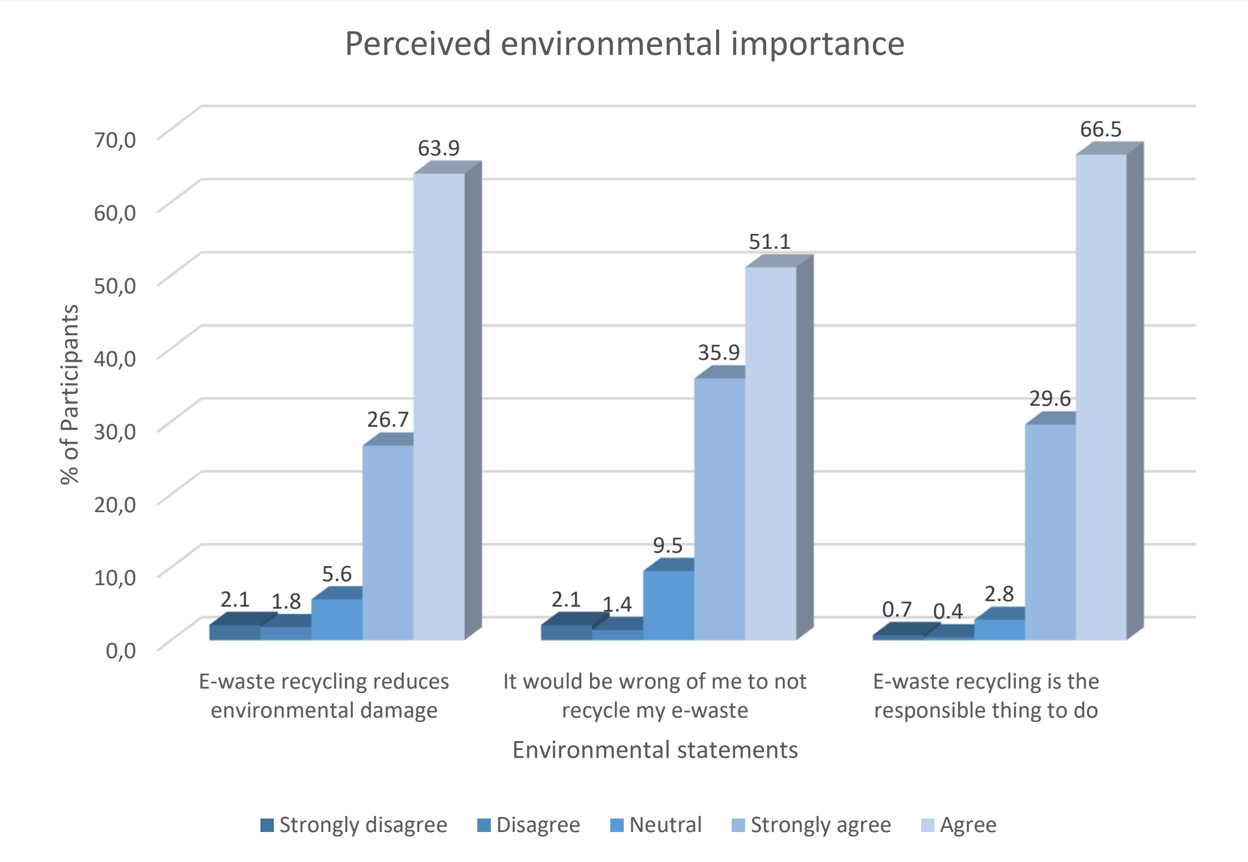


Figure 4.5: Perceived environmental importance of e-waste recycling

## 4.7 ICT e-waste stream

The Information and Communication Technology stream was focused on in this study as ICT devices are often the devices that are hibernated for long periods of time (Gilal *et al.*, 2019). As per the questionnaire responses, 47% of participants shared that they prefer to give a laptop to someone else, and 21% stated that they prefer selling the laptop to someone else. In comparison, 30% of the cases shared that they would hand the laptops over to a recycling company. With response to hibernated laptops, 12.9% shared that they have one device, not in use or needed, while 3.9% of respondents have two devices, not in use or needed.

In terms of mobile phones, 55% said that they would rather give it to someone, 18.8% said that they would sell it to someone, while 21% said that they would hand it to a recycling company. The breakdown of preferred disposal methods of mobile phones is presented in Table 4.1. These percentages of preferred disposal methods were not restricted to one disposal method for a respondent, but they could select multiple preferred methods. Out of this sample of cases, 14.1% declared that they had one mobile phone that was not needed or in use, while 5.9% stated that they had three or more mobile phones not required or used. This highlights that most residents do not see handing in their devices to recycling companies as a primary method to dispose of their e-waste. Instead, the multiple devices that are not in use or needed reflect the accumulation attitude discussed in other studies and highlight that their potential value is considered even when devices are not used (Shevchenko *et al*., 2019, Gilal *et al*., 2019). Shaikh *et al*.'s (2020) assumption that consumers usually practice alternatives to recycling was confirmed in this study. Most households shared that they would usually give their unused or non-functional devices to someone else or sell functional devices to someone else or a second-hand store. Additionally, Leblanc (2020) argues that a major cause for increased ICT device consumption is obsolescence, as each upgraded software and hardware edition of EEE replaces its former version. Fortunately, consumers in the study shared increased enthusiasm towards recycling their e-waste by the end of the questionnaire. There was an increase of 32% compared to past recyclers, who shared that they are now interested in recycling their e-waste in the future.

Table 4.1: Preferred method of ICT-mobile phone and laptop e-waste disposal by questionnaire respondents.

| Disposal method for mobile phones | Percentage of respondents who favoured this disposal method for laptops | Percentage of respondents who favoured this disposal method for mobile phones |
|---|---|---|
| Sell to a second-hand shop or scrap dealer | 12.2 % | 16.9% |
| Give to informal waste collector | 4.1% | 4.4% |
| Dispose with household waste | 0.9% | 5.1% |
| Hand over to recycling company | 18.1% | 21.7% |
| Give to someone | 28.3% | 55.1% |
| Sell to someone | 12.7% | 18.8% |
| Donate | 18.6% | 26.1% |
| Other | 4.8% | 7.0% |

## 4.8 Consumer’s attitude towards second hand and refurbished devices

Refurbishment of electronic devices is encouraged in the e-waste sector to decrease the number of end-of-life devices that enter the waste stream (Ichikowitz & Hattingh, 2020). However, the responses provided by the sample reflect apprehension towards the use of refurbished devices. Respondents shared that 74.1% of them have not purchased or used second-hand or refurbished electrical and electronic equipment (EEE), while 25.9% said they have. The Department of Environmental Affairs (2018:vi) estimated that of the 11% of e-waste collected, only 9.7% is recycled or refurbished. The results from this study show that more people have used second hand and refurbished electrical equipment, but this difference could be influenced by the area of the CoJ itself where electronic device consumption has grown in such an urbanised and metropolitan environment where many cannot afford to purchase new EEE (Modise *et al.*, 2017). However, the responses changed when asked if residents would buy repaired/refurbished EEE in the future as 44.7% said they would purchase repaired/refurbished while 26.6% said no and 28.7% said they were unsure. This difference in responses shows a potential change in attitude towards refurbished EEE and indicates a maintained concern over such devices that makes consumers doubt the effectiveness of refurbished electrical and electronic equipment.

The primary rationale provided by respondents for the apprehension towards refurbished EEE was centred on the concern for warranty, guaranty, and the safety of the device which highlights the need for more effectively managed and certified refurbished devices (Lepawsky, 2018). A few participants stated that while they would purchase home appliances second-hand, they would not do so for ICT devices. The respondents who would not purchase refurbished EEE shared that they felt uncomfortable with the concept because they would not know the device's history and have confidence in the person or company who provided the repairs and that they believed the device would not work effectively for long. These respondents who do not support refurbishment also stated that purchasing new is not a problem if they can afford new technology. Another important reason for this response was that consumers want updated technology with the most recent versions available. Some of the statements providing reasons for these views on refurbished devices (Table 4.2). This attitude supports Shevchenko *et al*. (2019) concept of moral obsolescence as EEE consumers prefer the latest technology and follow the newest device trends set, contributing to more EEE entering the waste stream.

Table 4.2: Comments provided by respondents to explain why they would not purchase, or use repaired or refurbished EEE.

| Some comments provided by respondents as to why they would not purchase, or use repaired or refurbished EEE |
| --- |
| “Appliances Ok, but concern about electronic goods (phones, laptops, etc.) being up to date.” |
| “Concerned that it wouldn’t last. I don’t replace things until they break, so it makes sense to buy new.” |
| “Depends on quality, price and guarantees.” |
| “I don’t have confidence in the honesty of the refurbishment, it could be dangerous if not correctly done.” |
| “If you have the financial means then I think you are more inclined to buy new electronic and electrical equipment. Especially with the advances in technology, most people prefer to have the newest items.” |
| “Needs to be accredited. Refurbished iPhones are an example of something I’d buy knowing it’s done reputably.” |

### 4.9 E-waste recycling application

Another interesting component of current literature on e-waste recycling is the development and implementation of mobile applications that have been recommended. These applications are suggested to make e-waste recycling more accessible to residents who can plan for weekly or monthly collections and provides a more convenient pick-up option of e-waste, so residents do not have to spend time or effort on transportation for drop-off of e-waste (Nowakowski *et al.*, 2020). However, these applications are dominantly being developed and implemented in cities of developed countries. It can be argued whether its implementation would be effective in Johannesburg and South Africa in a larger context. Such technology may not be effective where many individuals see e-waste as a source of extra income and prefer to sell the device to someone else or even sell non-functioning devices to informal recyclers for the worth of individual components. However, most participants support the idea of an e-waste application, with 46.9% of respondents saying they would use such an application to arrange for the collection of e-waste from their residence, 44.4% of respondents said they would likely support this application while only 4.2% said it was unlikely they would use this application (Figure 4.6). The argument against such an application is supported by some respondents sharing that they would not make use of such an application because they do not have money for extra data costs or time for administrative efforts to use the application. Some participants said that they do not have mobile phones that accommodate such applications, or that they prefer giving their old devices to family, friends or someone who can repair it. Other concerns centred around privacy and security of their residence, along with the fact that the application would probably only be used occasionally. Some respondents shared that they have found a reliable recycling company and have no desire to change their current disposal method. The challenges limiting e-waste recycling in CoJ households will be discussed in the following section.

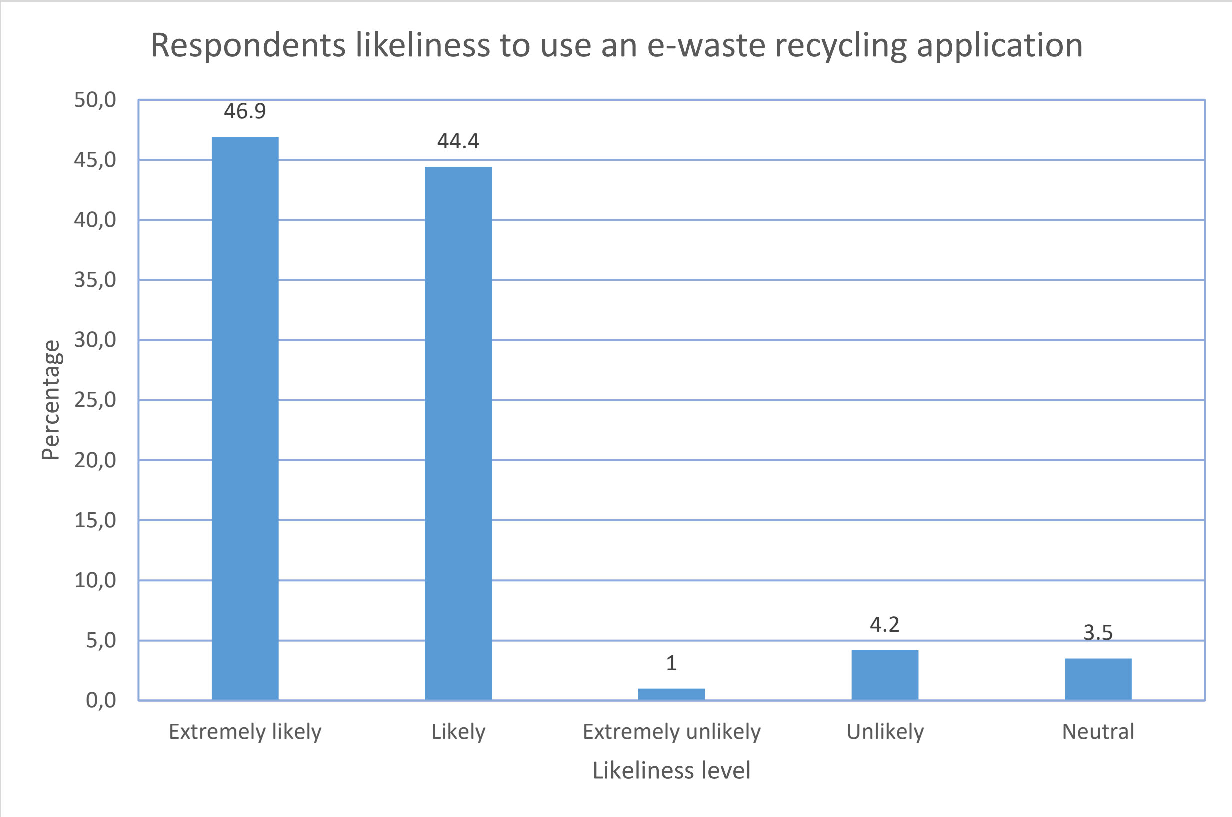


Figure 4.6: Respondents' likeliness to use an e-waste recycling application

## 4.10 Challenges limiting current e-waste recycling

The second objective was focused on identifying factors influencing household e-waste recycling behaviour. This objective was answered in two ways to analyse the challenges influencing household e-waste recycling behaviour. First, through the Likert scale, agreement levels in response to statements posed. Second, the last open-ended question in the questionnaire allowed for keywords to identify these challenges. These two methods supported each other as numerical and thematic data was used to analyse challenges households face regarding recycling their e-waste.

A general challenge shared by respondents was a lack of education and accessibility as information needs to be shared on what e-waste recycling is, how and why it should be done, and where it can be done. These comments were further supported by 12.1% of respondents who strongly agreed, and 21.6% who agreed that recycling e-waste is too complicated (Figure 4.7). This general lack of knowledge and accessibility only furthers consumers' apprehension towards e-waste recycling. Many resources exist online to help consumers recycle their waste electrical or electronic equipment (WEEE) correctly; however, more visible marketing is required to make these resources known. As previously discussed in Section 4.4, this lack of accessibility is supported as a challenge as 18.7% of participants strongly disagreed, and 37% disagreed that there are plenty of opportunities to recycle their e-waste. This highlights the need to increase the number of accessible drop-off zones for e-waste and community e-waste recycling initiatives to assist and encourage households. A few participants in the study stated that while they used to drop off their e-waste at a drop-off centre in the past, those locations have since closed, and most website information on recycling centres that accept WEEE are outdated. This calls for the need to update traditional marketing, websites, and other online advertisements that share information on where consumers can recycle. Time was expected to be significant as it was seen as a barrier in other studies such as Chen and Gao (2021) and Mahmod *et al.* (2021). Only 2.1% of respondents strongly agreed, and 19.1% agreed that recycling e-waste is time exhaustive, decreasing their likeliness to recycle their household WEEE. However, it still reflects a need to make e-waste recycling less time-consuming for those who find time a challenge to their recycling practices.

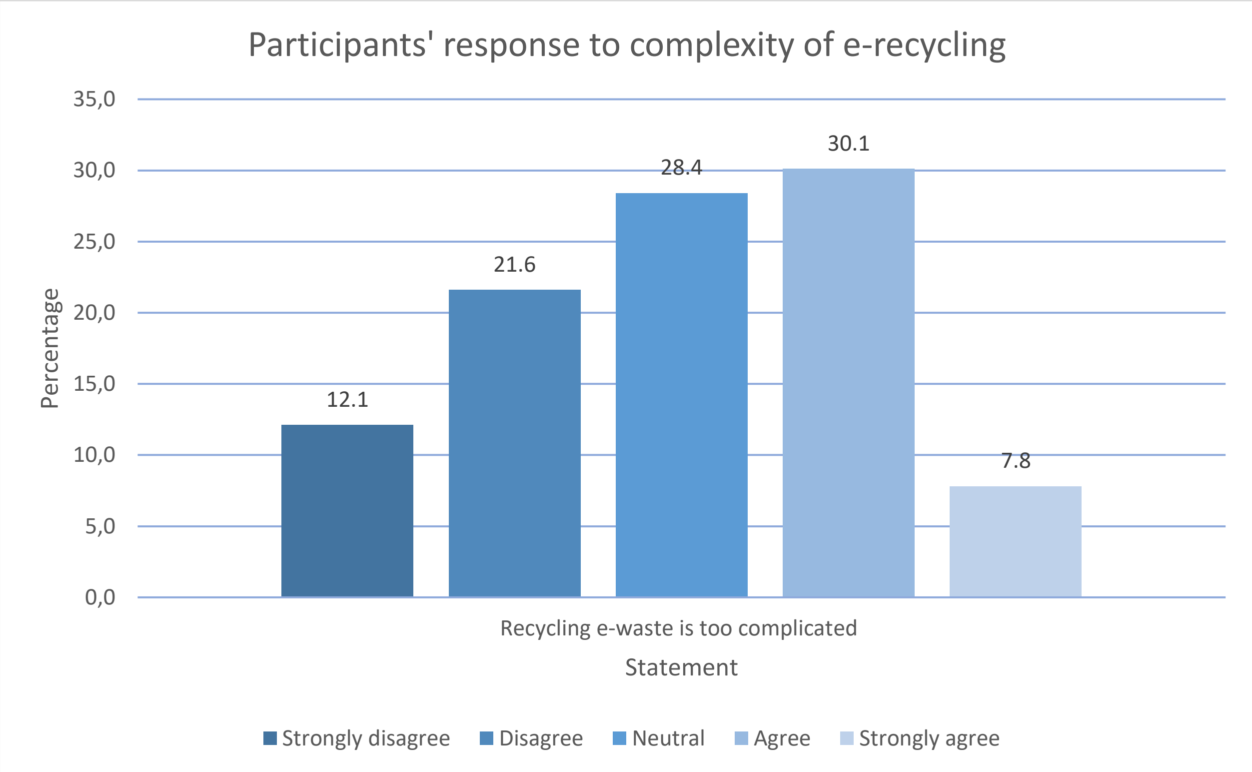


Figure 4.7: Participants' response to complexity of e-recycling

One of the challenges discussed by the participants was a concern on the erasure of data from their WEEE on both functioning and non-functioning devices. Such data could include passwords and automated logins for social media, bank, and business accounts which makes consumers feel apprehensive towards handing in their devices; however, most registered e-waste recycling companies provide data erasure services and certification on request (Labuschagne, 2020). The recycling of heavy and large e-waste items was also a challenge by some consumers who stated that more collectors of e-waste need to be engaged to help consumers make it more convenient to recycle consumer goods like refrigerators. Participants shared that there is a lack of available information accessible to CoJ residents to guide them to different e-waste recycling drop-off centres and pick-up services. The quote from a respondent below shares this sentiment:

> *"Need information available online in an SA context. I tried to recycle a vacuum cleaner some years ago. Took it back to Samsung at Cresta, but it had closed. None of the other stores would accept it for recycling. I left it on the street in the end, and waste pickers collected it. I put small items (broken GPS and hand blenders) in recycling bags and always hope it's okay that I do so. I do drop items off at a recycling facility in Parkhurst, but I sometimes don't know if I am putting things in the right place".*

This is coupled with limited knowledge on the process of recycling e-waste, limiting consumers' behaviour even when their best interests are inclined towards recycling their WEEE. These challenges help identify accompanying solutions to motivate residents to increase their e-waste recycling practices. Suggestions on how these challenges can be addressed are discussed in the following section.

## 4.11 Suggestions to increase the recycling of e-waste

The last open-ended question of the questionnaire asked participants to share what they believe can be done to increase the recycling of e-waste. In response to this question, the common keywords that arose were 'accessibility,' 'organization,' 'education' and 'awareness,' 'incentives,' 'training,' and 'drop-off sites' (Table 4.3). Most of the responses to this question suggested that more education, at both a community level and in the South African schooling system, is necessary to understand what WEEE is composed of, why it should be correctly disposed of, and how it should be disposed of. This can be done through schools and leading technology manufacturers such as Asus, who have already implemented WEEE recycling into selected school programs (Zhou *et al*., 2021; Netans, 2017). Another essential aspect of knowledge to address is educating and training e-waste recycling stream personnel to ensure that they are equipped and certified with the necessary skills for safe and secure dismantling and refurbishment of EEE. This provides a host of benefits, including improving the safety conditions of workers, providing training and formal job opportunities for previously informal waste collectors, increased trust in refurbished goods by consumers and more valuable e-waste components that have been dismantled correctly (Ahirwar & Tripathi, 2021; Mulckhusye *et al.*, 2021).

The content analysis identified that keywords such as 'accessibility,' 'drop-off points,' and 'convenient locations' were mentioned by 29% of respondents. Additionally, keywords of 'information,' 'education,' and 'awareness' were mentioned. More specifically, 29% of respondents shared that accessibility in terms of convenient drop-off points needs to be prioritized. Safety and security of old data was also a concern for some respondents, which emphasizes the need for e-waste recycling companies to improve awareness and implementation of data erasure certificates as certificates are usually only provided on request to promote the Protection of Personal Information Act as discussed by Labuschagne (2020). Respondents stated that drop-off zones within popular shopping centres would help increase the ease of recycling their e-waste for smaller and medium sized items while collection is needed for larger items that are difficult to transport.

Table 4.3: Suggestions submitted for increasing the rate of e-waste recycling in the CoJ.

| Some suggestions provided by respondents to increase the recycling of e-waste |
|---|
| "They could educate people on the issues because some of us don't know the dangers nor are aware e-waste could be recycled." |
| "More education (to households directly? Flyers etc?) More convenient locations, or just knowing what locations there are. Knowing what items could be refurbished, and how it can benefit those doing the refurbishing (jobs, income etc)." |
| "Incentify recycling in general." |
| "Include an end life rebate on next purchase." |
| "YOU HAVE FORGOTTEN THE MOST IMPORTANT ITEM – BATTERIES." |
| "Incentives, behavioural change campaigns, social media challenges, education." |
| "Create a private non-governmental company to manage it responsibly with passionate environmental conscious ppl in charge that will make it easy to recycle - drop off & collection options available- free of charge but then the valuable ingredients can be harvested and sold for profits." |
| "Marketing, just tell me where and I will make it happen." |

Incentives were mentioned often to motivate consumers to recycle their e-waste. Positive reinforcement includes rebates on purchased EEE and discounts on devices when returned for recycling. This positive reinforcement aligns with the incentives promoted in other studies (Mohamed & Rasnan, 2020; Wang *et al.*, 2021; Shevchenko *et al*., 2019). Schmidtchen *et al*. (2021) share that financial incentives are most preferred by consumers. This corresponds to respondents who stated that receiving discounts when purchasing new items and being compensated for the time and effort they put into e-recycling would motivate them to e-recycle. However, the findings from this study reveal that direct financial incentives are not the most preferred incentives but rather donations in their name towards environmental and community causes were favoured more, with 81.1% and 81.7% respectively strongly agreeing and agreeing that this would motivate them to recycle their e-waste in comparison to 67.5% collectively agreeing that financial incentives would encourage them. Furthermore, the reward points system was also emphasized as 33.9% of respondents agreed that a bonus reward card system would encourage them to recycle their e-waste, which supports the electronic bonus card system as discussed by Shevchenko *et al*. (2019). However, the financial sources to fund such an initiative are a challenge to implement, particularly in the socio-economic climate of Johannesburg where other priorities exist. In contrast, there were negative reinforcement suggestions by two participants who stated that more intense legislation, penalties such as fines, and government monitoring need to be adopted to prompt CoJ residents to take more responsibility for their WEEE and general waste. Such strengthening of recycling legislation is supported by other recycling studies (Shittu *et al*., 2021; Patil & Ramakrishna, 2020). Objective three which focused on the relationship between the demographic variables of household income and age and e-waste recycling behaviour will be discussed in the following section.

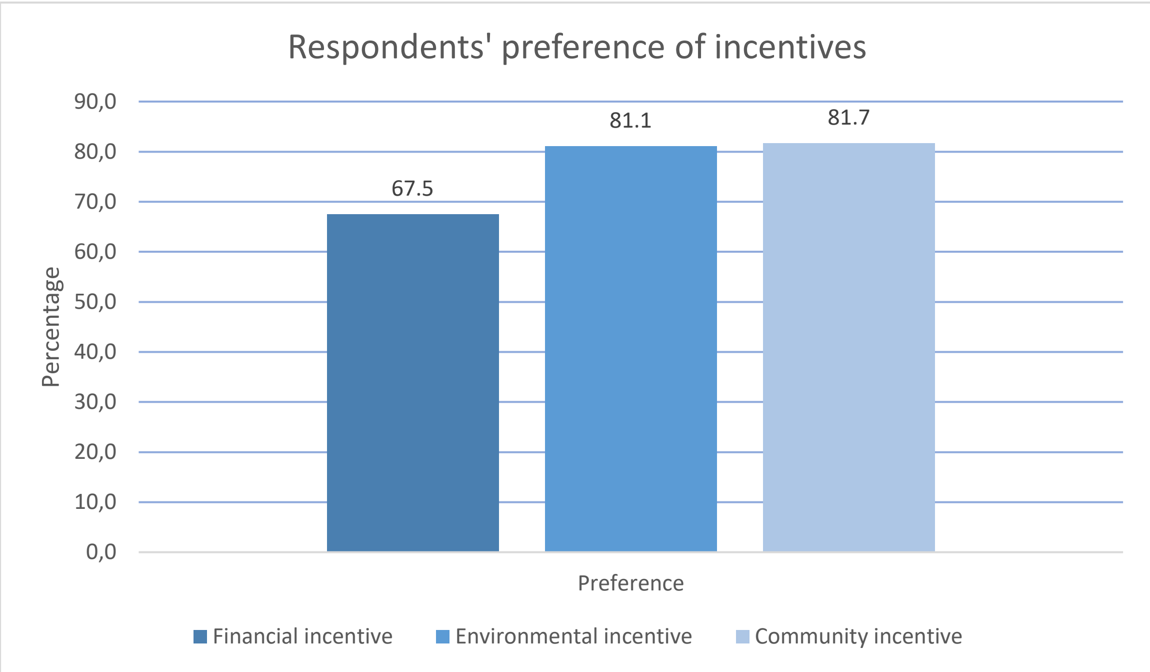


Figure 4.8: Respondents’ preference of incentives to motivate e-waste recycling

### 4.12 The relationship between demographic variables and e-waste recycling behaviour

The third objective of this study focused on investigating the relationship between e-waste recycling behaviour and demographic variables. The analysis will only focus on two demographic variables- namely, age and income level of respondents, which were tested with statements for recycling attitude to identify if a relationship of independence existed. For the demographic variable of income level, the null hypothesis selected was ‘E-waste recycling behaviour does not depend on the income level of consumers.’ For the demographic variable of age, the null hypothesis selected was ‘E-waste recycling behaviour does not depend on the age of consumers.’ Behaviour was determined using the questionnaire statement on whether respondents had recycled their e-waste in the past. This objective of identifying the relationship between demographics and e-waste recycling behaviour was analysed using Chi-Square analysis to test for independence in this relationship.

### 4.12.1 The relationship between income level and e-waste recycling behaviour

As stated above, the null hypothesis set for the Chi-Square analysis to test the significance between income level and e-waste recycling behaviour was, 'E-waste recycling behaviour does not depend on the income level of consumers.' After cross-tabulation of income level and whether respondents had recycled e-waste previously, using Chi-Square analysis, the *p*-value was compared with the α value as suggested by Neuman (2013). It should be noted that zero cells had an expected count of less than five, so the Chi-Square assumption of independence was not violated and, therefore, is considered valid. This allowed for testing of the significance present between income level and e-waste recycling behaviour. The test result of the Pearson Chi-Square *p*-value of 0.221 is larger than the α-value of 0.05, which results in the upholding of the null hypothesis (Table 4.4). Ultimately, the results suggest that income is not a significant demographic variable that influences households recycling their e-waste. In contrast, some studies have identified a correlation between household income and e-waste recycling behaviour with the rationale that higher-income households ought to find recycling more accessible as they can afford to travel to recycling drop-off centres or afford to pay courier fees (Jafari *et al*., 2017). This study shows that while higher-income receiving consumers can afford more expensive EEE such as Google Home Systems and more luxury devices like air purifiers and coffee machines, it does not influence their e-waste recycling behaviour any more than the recycling behaviour of other income-earning households.

Table 4.4: Chi-Square analysis output for cross-tabulation between household income and previous e-waste recycling practices.

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 4.404[a] | 3 | 0,221 |
| Likelihood Ratio | 4,387 | 3 | 0,223 |
| Linear-by-Linear Association | 4,327 | 1 | 0,038 |
| N of Valid Cases | 273 | | |

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 17.85.

**Symmetric Measures**

| | | Value | Approximate Significance |
|---|---|---|---|
| Nominal by Nominal | Phi | 0,127 | 0,221 |
| | Cramer's V | 0,127 | 0,221 |
| N of Valid Cases | | 273 | |

### 4.12.2 The relationship between age and e-waste recycling behaviour

To test the relationship between age and e-waste recycling behaviour, the following null hypothesis was set, 'E-waste recycling behaviour does not depend on the age of consumers.' After cross-tabulation of the demographic variables of age and past e-waste recycling behaviour, using Chi-Square analysis, the α-value and *p*-value were compared to determine if there was a significant relationship or not. The Chi-Square assumption of independence was valid during this test as zero cells had an expected count less than five. The *p*-value was 0.002 and therefore smaller than the α-value of 0.05. Thus, the null hypothesis was rejected and can be reformulated to state that 'E-waste recycling behaviour is dependent on the age of consumers' (Table 4.5). Thus, the results reveal that age is a significant demographic variable for influencing recycling behaviour as a higher proportion of middle-aged participants have previously recycled their e-waste. In contrast, there were lower proportions of younger and older aged participants having previously recycled WEEE as discussed in other studies (Kumar, 2019; Mahmod *et al*., 2021). The results of this study on e-waste recycling behaviour in the CoJ better align with a study conducted on household recycling and millennials also based in the CoJ (Schoeman & Rampedi, 2021). In contrast to popular beliefs, Johannesburg millennials are not as knowledgeable about recycling as previously expected, which has been accompanied by diminished marketing programmes to raise awareness of the importance of recycling and the necessary resources provided to residents (Schoeman & Rampedi, 2021).

Table 4.5: Chi-Square analysis output for cross-tabulation between age and previous e-waste recycling practices.

**Chi-Square Tests**

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 19.040[a] | 5 | 0,002 |
| Likelihood Ratio | 19,247 | 5 | 0,002 |
| Linear-by-Linear Association | 6,676 | 1 | 0,010 |
| N of Valid Cases | 281 | | |

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.89.

**Symmetric Measures**

| | | Value | Approximate Significance |
|---|---|---|---|
| Nominal by Nominal | Phi | 0,260 | 0,002 |
| | Cramer's V | 0,260 | 0,002 |
| N of Valid Cases | | 281 | |

Thus, the relationships between the two demographic variables of income level and age have been determined. While there is no significant relationship between household income and e-waste recycling behaviour, there is a significant relationship between age and e-waste recycling behaviour. Chi-Square analysis proved to be effective in determining the relationship between these demographic variables and helped construct a further understanding of recycling behaviour as analysed in other studies (Schoeman & Rampedi, 2021; Schoeman, 2021; Lydall et al., 2017; Ichikowitz & Hattingh, 2020). The following section will conclude the analysis and findings of this study on e-waste recycling behaviour in CoJ households.

### 4.13 Data quality

The results of this study can be said to be reliable. A sampling size of 385 respondents for a 95% confidence level and a 5% margin of error is said to provide quality data (Mohamad *et al*., 2015). However, 286 completed questionnaires were used for analysis, decreasing the confidence level to a 90% confidence level with a 5% margin of error. Brod *et al.* (2009) share the importance of complete data not contaminated by incomplete responses for quality data. There were incomplete questionnaire submissions but only completed questionnaires were used for analysis to uphold data quality. Thus, the data was considered valid, and the percentages of responses to questions aligned with the questions and general trends identified in previous research. One limitation of the research sample was the lack of adequate representation as 86.5% of respondents were White South Africans. This is not a rare challenge in South African research, where often White South Africans have been recorded to participate more in mainstream and online research engagement (Strydom, 2018). Therefore, alternative data collection methods should be used to make research participation more accessible to all South Africans who do not have access to online research participation. Furthermore, every participant’s responses remained confidential, and all participation was voluntary to uphold the ethics of the study. The following section will conclude this chapter on analysis and discussion of this study.

### 4.14 Conclusion

This chapter has discussed the analysis and main findings from the primary data collected through the methodology outlined in Chapter 3. These findings have answered the three objectives that were set for this research project. The first objective focused on determining household recycling knowledge and behaviour with a focus on the ICT e-waste stream. Overall, it was established that knowledge and e-waste recycling practices and opportunities are limited in the sample population along with skepticism towards the introduction of an e-waste application and refurbished EEE. The second objective focused on identifying challenges restricting positive household e-waste recycling behavior which were identified as lack of awareness, accessibility, outdated information, safety and privacy concerns. The second objective also identified suggestions to encourage households to recycle their e-waste in the future which included increased recycling drop-off zones, incentivizing e-recycling through positive and negative reinforcement and education and training programmes. The third objective focused on investigating the relationship between e-waste recycling behaviour and the demographic variables of household income level and age. While there was no significant relationship between household income and prior e-recycling practices, there was a significant relationship between age and prior e-recycling practices with middle-aged respondents having engaged more in e-recycling. The following chapter will provide a conclusion to this study on household e-waste recycling in the CoJ, along with recommendations for future research.

# Chapter Five: Conclusion

## 5.1 Conclusion

Electronic consumption is being further pressured by the Fourth Industrial Revolution, which calls for increased use of the Internet of Things and technology to replace traditional means of doing things which results in growing e-waste (Brem *et al.,* 2021; Bimir, 2020). The e-Waste Association of South Africa (e-WASA) estimates that 25% of the total volume of WEEE is being recycled in the country, and these low recycling rates have been confirmed in this research project as hibernation of WEEE is still practiced more than delivering e-waste to the appropriate e-recycling companies (Lydall *et al*., 2017:12). Therefore, this study has aimed to investigate e-waste streams and the e-waste recycling behaviour of households in the City of Johannesburg. This has been achieved through three objectives: determining household recycling behaviour concerning the ICT e-waste stream, identifying challenges and incentives influencing household e-waste recycling behaviour, and investigating the relationship between e-waste recycling behaviour and demographic variables of income level and age.

In terms of the e-recycling behaviour of the different e-waste streams, ICT has been identified as an e-waste stream of interest. The ICT e-waste stream is continuously growing, and a considerable challenge is that providing WEEE to recycling companies is not the primary disposal method. Instead, selling or giving WEEE to someone else is practiced more often. Additionally, hibernation, accumulation, and obsolescence of devices further pressure the e-waste industry by challenging its progress towards a circular economy (Lydall *et al*., 2017; Forti *et al*., 2020). Unfortunately, while the obsolescence of devices cannot be avoided in the 21st Century with new versions of the devices being released, the correct disposal methods through recycling need to be promoted (Lydall *et al*., 2017; Shevchenko *et al*., 2019). Such promotion of e-waste recycling suggested by respondents is online and traditional advertising and more interesting promotion through social media or school challenges based on e-recycling. The findings from this research project show that respondents have an overall positive recycling attitude and acknowledge both the environmental and economic value inherent in recycling e-waste. This was supported by a majority of respondents who agreed or strongly agreed that WEEE contains valuable materials and creates job opportunities. Furthermore, the majority of respondents also agreed that recycling their WEEE would be the responsible thing to do and reduces environmental damage.

While refurbished EEE is hoped to alleviate the industry by diverting functional devices away from landfills, it is challenged by the negative perceptions held by consumers who are not confident in the functionality and safety of such devices, which calls for effective data destruction, warranties on refurbished goods and trained e-waste workers. The potential creation of an application to increase accessibility to recycling opportunities may be an option to improve recycling practices but holds limitations primarily based on funding and the fact that not all CoJ residents will have access to the resources needed for the application.

Suggestions of using positive and negative reinforcement have been identified to encourage the adoption of e-waste recycling practices. Positive reinforcements have included tax rebates, discounts on new devices, and earning reward points. In contrast, negative reinforcements have included fines and stricter recycling legislation to make e-waste recycling mandatory. While most consumers have shared that they are willing to recycle their e-waste in the future if it is under convenient conditions, they also argue that they were less likely to pay extra to municipalities for collection of e-waste or pay producers a fee to recycle their EEE.

The study found that 43.5% of respondents know how to recycle their e-waste correctly, while 40% do not feel confident in their e-recycling knowledge. Furthermore, only 18.7% of respondents have heard about e-waste recycling opportunities which shows a considerable lack of knowledge and recycling options. Thus, the main challenges identified were a lack of knowledge, lack of time, accessibility issues, and outdated e-waste recycling information. This has resulted in the need to update information resources, provide awareness and education programmes on how, why, and where to recycling e-waste. This education factor includes the training of waste workers to streamline job opportunities and maximize the value of WEEE for economic growth. The use of various financial, environmental and community incentives that consumers have supported will encourage more active e-recycling. Lastly, it has been determined that age is a significant demographic factor as the middle-aged population has been engaged the most in e-waste recycling, while household income does not influence e-waste recycling behaviour based on previous e-recycling practices.

Overall, it can be concluded that despite the increasing production of e-waste in South Africa that is estimated per annum to be 7.1 kg generated per person, recycling of e-waste is still not taking place at the rate that is aimed to streamline a more sustainable state of waste (Mulckhusye *et al.,* 2021). Changes need to be made to the e-waste industry, and programmes to engage CoJ residents and encourage more positive e-waste recycling behaviour must be established. This needs to include education and awareness programmes (Zhou *et al*., 2021, Netans, 2017), updated e-waste recycling resource information, training, and certification within EEE refurbishment practices (Ahirwar & Tripathi, 2021; Rathore, 2020), and the introduction of positive and negative reinforcement to encourage e-recycling by households (Dhir *et al.,* 2021; Shevchenko *et al*., 2019; Kirby, 2021). The following section concludes this research project by providing recommendations for future research on e-waste recycling behaviour.

## 5.2 Recommendations

While this research project has contributed to the discussion of e-waste recycling behaviour in the CoJ, a significant gap in the research space still exists. Therefore, this section will discuss recommendations for future research in this e-waste discussion. In terms of methodology, more mixed approaches that use both questionnaires and other methods with sampling techniques to improve the representation of the population are essential. Of particular interest, there need to be more collection methodologies that provide access to participation to those who do not have access to complete online questionnaires because of Wi-Fi access and incompatible devices that may not be suitable for the extensive surveys required. This could help decrease representation problems, such as in this research project where the respondents were predominantly White South Africans. Planning a schedule for communicating with different stakeholders such as recycling companies, residential associations, second-hand dealers is recommended as the communication between these parties can be rather prolonged in terms of waiting for responses, permission from boards of directors, and sharing of survey links can take place over several months which in turn prolongs the data collection phase.

Future research on e-waste recycling should attempt to investigate deeper into the other stakeholders that have been discussed in this research project, such as the government, e-waste recycling companies, and dealers of refurbished EEE. Understanding the role of government and policies that govern the state of waste would provide important insight to understand how these policies have been envisioned and the gaps in their implementation, which may pose challenges to e-waste recycling practices by residents, businesses, and any other institutions. Engagement with e-waste recycling companies could provide important insight into the current volumes of e-waste entering the e-waste recycling streams and their resources to encourage and engage with residents and businesses. This could help identify if the resources being offered between recycling companies and EEE consumers are relevant, updated, and informative to help consumers understand the importance, risks, and economic value involved in the correct recycling of their e-waste. It is also recommended that future research investigates the processes involved in the selling and buying of refurbished EEE from secondhand dealers to investigate the data destruction/removal processes, warranty, and the effectiveness of repairs to assist in creating a more positive perception of refurbished devices to decrease the volume of end-of-life WEEE entering the waste stream. Education and awareness have been identified as vital components in improving current e-waste recycling practices. Thus, an investigation into any current awareness programmes or the introduction of new awareness programmes could be studied to determine their success in streamlining more positive e-waste recycling practices. Previous literature has shown that some EEE producers, such as Asus, have developed e-waste recycling programmes in schools (Netans, 2017). Identifying the success of these initiatives in developing pro-recycling behaviour and the e-waste streams could be investigated. Ultimately, the growing e-waste industry presents both challenges and opportunities in the state of waste management, but further research is required to understand its presence and management.

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# E-WASTE SURVEY

Dear Respondent

You are invited to participate in our e-waste survey. E-waste is electronic and electrical equipment that is discarded, not working or no longer in use. Globally and in South Africa it is the fastest-growing waste stream and only 11% of e-waste is annually recycled in South Africa. E-waste contains harmful substances that can cause damage to the environment and human health if not disposed in a safe manner. E-waste also contains valuable materials that can be used as a secondary source of raw materials and therefore can contribute to job creation and the circular economy in South Africa.

The aim of this study is to determine the volume of e-waste in South African households and the e-waste recycling behaviour of residents. There is no information available on these two aspects of e-waste so by completing this survey you will make a valuable contribution to the body of knowledge regarding e-waste. Participation is voluntary and anonymous and should take 10 to 15 minutes of your time.

If you are interested in the results of the study, please provide an email address on the new link provided after submission of your responses. Use of a new link will protect your anonymity as it will not be possible to link your responses to questions in this survey to your email address on the new link. If you have any questions about this study, you are welcome to contact me on the email address below.

Thank you in advance for your time and participation.

Dr Thea Schoeman
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## SECTION A: DEMOGRAPHICS

1a. In which province do you live?

- ◯ Eastern Cape
- ◯ Free State
- ◯ Gauteng
- ◯ KwaZulu-Natal
- ◯ Limpopo
- ◯ Mpumalanga
- ◯ Northern Cape
- ◯ North West
- ◯ Western Cape

1b. In which city/town do you live?

City/town (e.g. Randburg):

Suburb (e.g. Randpark Ridge):

2. What is your gender?

- Female
- Male
- LGBTQ+

3. What is your age (in years)?

4. What is your ethnic group?

- Black
- Coloured
- White
- Asian/Indian

5. What is your employment status?

- Employed
- Part-time employed
- Unemployed
- Homemaker
- employed
- Pensioner
- Student

6. What is the highest education level you have achieved to date?

- ◯ Some primary school
- ◯ Completed primary school
- ◯ Some high school
- ◯ Completed high school (Matric)
- ◯ Post-matric diploma/certificate
- ◯ Bachelor's degree
- ◯ Post-graduate degree (Honours, Master's, Doctorate)

7. What is the monthly income of the household in which you live?

- ◯ Less than R3 500 per month
- ◯ R3 500 to R8 000 per month
- ◯ R8 001 to R22 000 per month
- ◯ R22 001 to R40 000 per month
- ◯ R40 001 to R75 000 per month
- ◯ More than R75 000 per month

8. Do you live in a:

- ◯ Private house
- ◯ Townhouse
- ◯ Flat (apartment)
- ◯ Estate
- ◯ Commune
- ◯ Student residence or student accommodation
- ◯ Retirement village/old age home
- ◯ RDP house
- ◯ Informal dwelling (shack)
- ◯ Other, please specify:

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9. What is the total number of family members/people living in your household?

______________________________

## SECTION B: ELECTRONIC AND ELECTRICAL EQUIPMENT (EEE) IN YOUR HOUSEHOLD

Electronic and electrical equipment (EEE) is equipment that is dependent on electric currents or electromagnetic fields in order to work properly.

This section determines the number of appliances and devices in your household. There are different categories and for each you will be required to indicate the number of appliances/devices:

1. That are working and **IN USE** in your household;
2. That are **NOT WORKING** and are to be disposed of at a later stage; and
3. That are either **NOT NEEDED/NOT USED**. This could include an obsolete appliance that is to be disposed of at a later stage or a spare appliance which you keep in case the one in use no longer works.

The numbers from 1, 2 and 3 above should give the total number of the specific appliance/device in your household. For example, you may have 2 kettles in your household where 1 kettle is **in use**, you have 0 kettles **not working**, and you have 1 kettle **not used** (spare in case the kettle in use stops working). In this example you would enter 1 kettle under the IN USE section, 0 kettles under the NOT WORKING section, and 1 kettle under the NOT NEEDED/NOT USED section.

1. Which of these listed large appliances do you have in your household?

- [ ] Fridge
- [ ] Air conditioner
- [ ] Washing machine
- [ ] Freezer
- [ ] Tumble dryer
- [ ] Electric heater
- [ ] Dishwasher
- [ ] Electric griller
- [ ] Electric/gas stove
- [ ] Electric/gas oven
- [ ] Steam oven

1a How many of each large appliance are **IN USE** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Fridge | ○ | ○ | ○ | ○ | ○ |
| Air conditioner | ○ | ○ | ○ | ○ | ○ |
| Washing machine | ○ | ○ | ○ | ○ | ○ |
| Freezer | ○ | ○ | ○ | ○ | ○ |
| Tumble dryer | ○ | ○ | ○ | ○ | ○ |
| Electric heater | ○ | ○ | ○ | ○ | ○ |
| Dishwasher | ○ | ○ | ○ | ○ | ○ |
| Electric griller | ○ | ○ | ○ | ○ | ○ |
| Electric/gas stove | ○ | ○ | ○ | ○ | ○ |
| Electric/gas oven | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Steam oven | ○ | ○ | ○ | ○ | ○ |

1b How many of each of the large appliances listed are **NOT WORKING** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Fridge | ◯ | ◯ | ◯ | ◯ | ◯ |
| Air conditioner | ◯ | ◯ | ◯ | ◯ | ◯ |
| Washing machine | ◯ | ◯ | ◯ | ◯ | ◯ |
| Freezer | ◯ | ◯ | ◯ | ◯ | ◯ |
| Tumble dryer | ◯ | ◯ | ◯ | ◯ | ◯ |
| Electric heater | ◯ | ◯ | ◯ | ◯ | ◯ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Dishwasher | ◯ | ◯ | ◯ | ◯ | ◯ |
| Electric griller | ◯ | ◯ | ◯ | ◯ | ◯ |
| Electric/gas stove | ◯ | ◯ | ◯ | ◯ | ◯ |
| Electric/gas oven | ◯ | ◯ | ◯ | ◯ | ◯ |
| Steam oven | ◯ | ◯ | ◯ | ◯ | ◯ |

1c How many of each of the large appliances listed are **NOT NEEDED/NOT USED** in your household**?**

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Fridge | ○ | ○ | ○ | ○ | ○ |
| Air conditioner | ○ | ○ | ○ | ○ | ○ |
| Washing machine | ○ | ○ | ○ | ○ | ○ |
| Freezer | ○ | ○ | ○ | ○ | ○ |
| Tumble dryer | ○ | ○ | ○ | ○ | ○ |
| Electric heater | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Dishwasher | ○ | ○ | ○ | ○ | ○ |
| Electric griller | ○ | ○ | ○ | ○ | ○ |
| Electric/gas stove | ○ | ○ | ○ | ○ | ○ |
| Electric/gas oven | ○ | ○ | ○ | ○ | ○ |
| Steam oven | ○ | ○ | ○ | ○ | ○ |

1d What method of disposal would be used for each of the large appliances? (choose all applicable methods of disposal)

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| Fridge | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Air conditioner | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Washing machine | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Freezer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Tumble dryer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Electric heater | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| Dishwasher | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Electric griller | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Electric/gas stove | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Electric/gas oven | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Steam oven | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

2. Which of these listed small appliances do you have in your household?

- [ ] Iron
- [ ] Kettle
- [ ] Blender
- [ ] Microwave
- [ ] Hair dryer
- [ ] Mixer
- [ ] Fan
- [ ] Vacuum cleaner
- [ ] Toaster
- [ ] Slow cooker
- [ ] Fryer (e.g. air fryer)
- [ ] Electric toothbrush
- [ ] Extension cable
- [ ] Power tools (e.g. drill, angle grinder)
- [ ] Electric lawnmower
- [ ] Alarm clock
- [ ] Electric hot plate

2a How many of each small appliances listed are **IN USE** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Iron | ○ | ○ | ○ | ○ | ○ |
| Kettle | ○ | ○ | ○ | ○ | ○ |
| Blender | ○ | ○ | ○ | ○ | ○ |
| Microwave | ○ | ○ | ○ | ○ | ○ |
| Hair dryer | ○ | ○ | ○ | ○ | ○ |
| Mixer | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Fan | ○ | ○ | ○ | ○ | ○ |
| Vacuum cleaner | ○ | ○ | ○ | ○ | ○ |
| Toaster | ○ | ○ | ○ | ○ | ○ |
| Slow cooker | ○ | ○ | ○ | ○ | ○ |
| Fryer (e.g. air fryer) | ○ | ○ | ○ | ○ | ○ |
| Electric toothbrush | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Extension cable | ○ | ○ | ○ | ○ | ○ |
| Power tools (e.g. drill, angle grinder) | ○ | ○ | ○ | ○ | ○ |
| Electric lawnmower | ○ | ○ | ○ | ○ | ○ |
| Alarm clock | ○ | ○ | ○ | ○ | ○ |
| Electric hot plate | ○ | ○ | ○ | ○ | ○ |

2b How many of each of the small appliances listed are **NOT WORKING** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Iron | ○ | ○ | ○ | ○ | ○ |
| Kettle | ○ | ○ | ○ | ○ | ○ |
| Blender | ○ | ○ | ○ | ○ | ○ |
| Microwave | ○ | ○ | ○ | ○ | ○ |
| Hair dryer | ○ | ○ | ○ | ○ | ○ |
| Mixer | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Fan | ○ | ○ | ○ | ○ | ○ |
| Vacuum cleaner | ○ | ○ | ○ | ○ | ○ |
| Toaster | ○ | ○ | ○ | ○ | ○ |
| Slow cooker | ○ | ○ | ○ | ○ | ○ |
| Fryer (e.g. air fryer) | ○ | ○ | ○ | ○ | ○ |
| Electric toothbrush | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Extension cable | ○ | ○ | ○ | ○ | ○ |
| Power tools (e.g. drill, angle grinder) | ○ | ○ | ○ | ○ | ○ |
| Electric lawnmower | ○ | ○ | ○ | ○ | ○ |
| Alarm clock | ○ | ○ | ○ | ○ | ○ |
| Electric hot plate | ○ | ○ | ○ | ○ | ○ |

2c How many of each of the small appliances listed are **NOT NEEDED/ NOT USED** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Iron | ◯ | ◯ | ◯ | ◯ | ◯ |
| Kettle | ◯ | ◯ | ◯ | ◯ | ◯ |
| Blender | ◯ | ◯ | ◯ | ◯ | ◯ |
| Microwave | ◯ | ◯ | ◯ | ◯ | ◯ |
| Hair dryer | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mixer | ◯ | ◯ | ◯ | ◯ | ◯ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Fan | ◯ | ◯ | ◯ | ◯ | ◯ |
| Vacuum cleaner | ◯ | ◯ | ◯ | ◯ | ◯ |
| Toaster | ◯ | ◯ | ◯ | ◯ | ◯ |
| Slow cooker | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fryer (e.g. air fryer) | ◯ | ◯ | ◯ | ◯ | ◯ |
| Electric toothbrush | ◯ | ◯ | ◯ | ◯ | ◯ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Extension cable | ◯ | ◯ | ◯ | ◯ | ◯ |
| Power tools (e.g. drill, angle grinder) | ◯ | ◯ | ◯ | ◯ | ◯ |
| Electric lawnmower | ◯ | ◯ | ◯ | ◯ | ◯ |
| Alarm clock | ◯ | ◯ | ◯ | ◯ | ◯ |
| Electric hot plate | ◯ | ◯ | ◯ | ◯ | ◯ |

2d What method of disposal would be used for each of the small appliances? (choose all applicable methods of disposal)

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| Iron | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Kettle | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Blender | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Microwave | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Hair dryer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Mixer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Fan | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Vacuum cleaner | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Toaster | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Slow cooker | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| Fryer (e.g. air fryer) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Electric toothbrush | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Extension cable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Power tools (e.g. drill, angle grinder) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Electric lawnmower | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Alarm clock | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Electric hot plate | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

3. Which of the listed Information and Communication Technology (ICT) equipment do you have in your household?

- ☐ PC
- ☐ Laptop
- ☐ Tablet
- ☐ Notebook
- ☐ CRT monitor
- ☐ LCD monitor
- ☐ Mobile phone
- ☐ Phone (dial)
- ☐ Printer
- ☐ Copy machine
- ☐ Scanner
- ☐ Fax machine
- ☐ Router
- ☐ Modem
- ☐ Cable
- ☐ UPS

3a How many of each ICT device listed are **IN USE** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| PC | ◯ | ◯ | ◯ | ◯ | ◯ |
| Laptop | ◯ | ◯ | ◯ | ◯ | ◯ |
| Tablet | ◯ | ◯ | ◯ | ◯ | ◯ |
| Notebook | ◯ | ◯ | ◯ | ◯ | ◯ |
| CRT monitor | ◯ | ◯ | ◯ | ◯ | ◯ |
| LCD monitor | ◯ | ◯ | ◯ | ◯ | ◯ |
| Mobile phone | ◯ | ◯ | ◯ | ◯ | ◯ |
| Phone (dial) | ◯ | ◯ | ◯ | ◯ | ◯ |
| Printer | ◯ | ◯ | ◯ | ◯ | ◯ |
| Copy machine | ◯ | ◯ | ◯ | ◯ | ◯ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Scanner | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fax machine | ◯ | ◯ | ◯ | ◯ | ◯ |
| Router | ◯ | ◯ | ◯ | ◯ | ◯ |
| Modem | ◯ | ◯ | ◯ | ◯ | ◯ |
| Cable | ◯ | ◯ | ◯ | ◯ | ◯ |
| UPS | ◯ | ◯ | ◯ | ◯ | ◯ |

3b How many of each ICT device listed are **NOT WORKING** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| PC | ○ | ○ | ○ | ○ | ○ |
| Laptop | ○ | ○ | ○ | ○ | ○ |
| Tablet | ○ | ○ | ○ | ○ | ○ |
| Notebook | ○ | ○ | ○ | ○ | ○ |
| CRT monitor | ○ | ○ | ○ | ○ | ○ |
| LCD monitor | ○ | ○ | ○ | ○ | ○ |
| Mobile phone | ○ | ○ | ○ | ○ | ○ |
| Phone (dial) | ○ | ○ | ○ | ○ | ○ |
| Printer | ○ | ○ | ○ | ○ | ○ |
| Copy machine | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Scanner | ○ | ○ | ○ | ○ | ○ |
| Fax machine | ○ | ○ | ○ | ○ | ○ |
| Router | ○ | ○ | ○ | ○ | ○ |
| Modem | ○ | ○ | ○ | ○ | ○ |
| Cable | ○ | ○ | ○ | ○ | ○ |
| UPS | ○ | ○ | ○ | ○ | ○ |

3c How many of each ICT device listed are **NOT NEEDED/ NOT USED** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| PC | ○ | ○ | ○ | ○ | ○ |
| Laptop | ○ | ○ | ○ | ○ | ○ |
| Tablet | ○ | ○ | ○ | ○ | ○ |
| Notebook | ○ | ○ | ○ | ○ | ○ |
| CRT monitor | ○ | ○ | ○ | ○ | ○ |
| LCD monitor | ○ | ○ | ○ | ○ | ○ |
| Mobile phone | ○ | ○ | ○ | ○ | ○ |
| Phone (dial) | ○ | ○ | ○ | ○ | ○ |
| Printer | ○ | ○ | ○ | ○ | ○ |
| Copy machine | ○ | ○ | ○ | ○ | ○ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| Scanner | ○ | ○ | ○ | ○ | ○ |
| Fax machine | ○ | ○ | ○ | ○ | ○ |
| Router | ○ | ○ | ○ | ○ | ○ |
| Modem | ○ | ○ | ○ | ○ | ○ |
| Cable | ○ | ○ | ○ | ○ | ○ |
| UPS | ○ | ○ | ○ | ○ | ○ |

3d What method of disposal would be used for each of the ICT devices? (choose all applicable methods of disposal)

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| PC | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Laptop | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Tablet | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Notebook | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| CRT monitor | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| LCD monitor | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| Mobile phone | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Phone (dial) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Printer | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Copy machine | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Scanner | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Fax machine | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| Router | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Modem | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cable | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| UPS | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

4. Which of these listed consumer electronics do you have in your household?

- ☐ TV (CRT)
- ☐ TV (flat panel)
- ☐ Radio
- ☐ Stereo
- ☐ DVD player
- ☐ VCR player
- ☐ MP3 player
- ☐ Camera
- ☐ Game console
- ☐ GPS
- ☐ Calculator
- ☐ E-smoking device

4a How many of each consumer electronic device listed are **IN USE** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| TV (CRT) | ◯ | ◯ | ◯ | ◯ | ◯ |
| TV (flat panel) | ◯ | ◯ | ◯ | ◯ | ◯ |
| Radio | ◯ | ◯ | ◯ | ◯ | ◯ |
| Stereo | ◯ | ◯ | ◯ | ◯ | ◯ |
| DVD player | ◯ | ◯ | ◯ | ◯ | ◯ |
| VCR player | ◯ | ◯ | ◯ | ◯ | ◯ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| MP3 player | ◯ | ◯ | ◯ | ◯ | ◯ |
| Camera | ◯ | ◯ | ◯ | ◯ | ◯ |
| Game console | ◯ | ◯ | ◯ | ◯ | ◯ |
| GPS | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculator | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-smoking device | ◯ | ◯ | ◯ | ◯ | ◯ |

4b How many of each consumer electronic device listed are **NOT WORKING** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| TV (CRT) | ◯ | ◯ | ◯ | ◯ | ◯ |
| TV (flat panel) | ◯ | ◯ | ◯ | ◯ | ◯ |
| Radio | ◯ | ◯ | ◯ | ◯ | ◯ |
| Stereo | ◯ | ◯ | ◯ | ◯ | ◯ |
| DVD player | ◯ | ◯ | ◯ | ◯ | ◯ |
| VCR player | ◯ | ◯ | ◯ | ◯ | ◯ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| MP3 player | ◯ | ◯ | ◯ | ◯ | ◯ |
| Camera | ◯ | ◯ | ◯ | ◯ | ◯ |
| Game console | ◯ | ◯ | ◯ | ◯ | ◯ |
| GPS | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculator | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-smoking device | ◯ | ◯ | ◯ | ◯ | ◯ |

4c How many of each consumer electronic device listed are **NOT NEEDED/ NOT USED** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| TV (CRT) | ◯ | ◯ | ◯ | ◯ | ◯ |
| TV (flat panel) | ◯ | ◯ | ◯ | ◯ | ◯ |
| Radio | ◯ | ◯ | ◯ | ◯ | ◯ |
| Stereo | ◯ | ◯ | ◯ | ◯ | ◯ |
| DVD player | ◯ | ◯ | ◯ | ◯ | ◯ |
| VCR player | ◯ | ◯ | ◯ | ◯ | ◯ |
| | None (0) | 1 | 2 | 3 | More than 3 |
| MP3 player | ◯ | ◯ | ◯ | ◯ | ◯ |
| Camera | ◯ | ◯ | ◯ | ◯ | ◯ |
| Game console | ◯ | ◯ | ◯ | ◯ | ◯ |
| GPS | ◯ | ◯ | ◯ | ◯ | ◯ |
| Calculator | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-smoking device | ◯ | ◯ | ◯ | ◯ | ◯ |

4d What method of disposal would be used for each of the consumer electronic devices listed? (choose all applicable methods of disposal)

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| TV (CRT) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| TV (flat panel) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Radio | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Stereo | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| DVD player | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| VCR player | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| MP3 player | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Camera | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Game console | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| GPS | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Calculator | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| E-smoking device | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

5. Do you have any other device/(s) in your household?

- ◯ Yes
- ◯ No

5 Please list the other device(s) you have in your household:

- [ ] Device Item 1:
- [ ] Device Item 2
- [ ] Device Item 3
- [ ] Device Item 4
- [ ] Device Item 5

Please specify the name of other device 1:

Please specify the name of other device 2:

Please specify the name of other device 3:

Please specify the name of other device 4:

Please specify the name of other device 5:

5a How many of each other device are **IN USE** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Device 1 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 2 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 3 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 4 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 5 | ◯ | ◯ | ◯ | ◯ | ◯ |

5b How many of each other device are **NOT WORKING** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Device 1 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 2 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 3 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 4 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 5 | ◯ | ◯ | ◯ | ◯ | ◯ |

5c How many of each other device are **NOT NEEDED/ NOT USED** in your household?

| | None (0) | 1 | 2 | 3 | More than 3 |
|---|---|---|---|---|---|
| Device 1 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 2 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 3 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 4 | ◯ | ◯ | ◯ | ◯ | ◯ |
| Device 5 | ◯ | ◯ | ◯ | ◯ | ◯ |

5d What method of disposal would be used for each of the other devices?

| | Sell to second hand shop or scrap dealer | Give to informal waste collector | Dispose with household waste | Hand over to recycling company | Put on street | Give to someone | Sell to someone | Donate | Other |
|---|---|---|---|---|---|---|---|---|---|
| Device 1 | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Device 2 | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Device 3 | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Device 4 | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| Device 5 | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

## SECTION C: KNOWLEDGE, INTENTION AND ATTITUDE TOWARDS E-WASTE RECYCLING

Electrical and electronic equipment becomes e-waste once it has been discarded or indefinitely stored by its owner without the intent of reuse.

1. Do you know, or have you heard of any e-waste recycling project in your city or town?

○ Yes

○ No

2. Did you recycle any e-waste in the past?

○ Yes

○ No

3. Do you plan to recycle your e-waste in the future?

- ◯ Yes
- ◯ No
- ◯ Not sure

4. Based on your knowledge and opinion about e-waste please indicate your level of agreement with each of the following statements.

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| E-waste recycling is good | ◯ | ◯ | ◯ | ◯ | ◯ |
| Recycling e-waste is too complicated | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-waste recycling reduces health hazards | ◯ | ◯ | ◯ | ◯ | ◯ |
| I know how to recycle my e-waste | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-waste recycling reduces damage to the environment | ◯ | ◯ | ◯ | ◯ | ◯ |
| E- waste recycling is easy | ◯ | ◯ | ◯ | ◯ | ◯ |
| I have plenty of opportunities to recycle my e-waste | ◯ | ◯ | ◯ | ◯ | ◯ |
| Recycling e-waste takes up too much time | ◯ | ◯ | ◯ | ◯ | ◯ |
| It would be wrong of me not to recycle my e-waste | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-waste recycling is beneficial to the environment | ◯ | ◯ | ◯ | ◯ | ◯ |
| Recycling e-waste takes up too much space | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-waste recycling is the responsible thing to do | ◯ | ◯ | ◯ | ◯ | ◯ |
| Recycling my e-waste creates jobs | ◯ | ◯ | ◯ | ◯ | ◯ |
| E-waste items include valuable materials | ◯ | ◯ | ◯ | ◯ | ◯ |
| There are very toxic materials in e-waste that can harm people and the environment | ◯ | ◯ | ◯ | ◯ | ◯ |

5. Please indicate your level of agreement with each of the following statements.

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| I would recycle my e waste if I get cashback and/or discount coupons on new items when returning old items | ○ | ○ | ○ | ○ | ○ |
| I would recycle my e waste if a donation is made on my behalf to an environmental cause (e.g. planting a tree) | ○ | ○ | ○ | ○ | ○ |
| I would recycle my e waste if a donation is made on my behalf to a community charity (e.g. Meals on Wheels) | ○ | ○ | ○ | ○ | ○ |
| I would recycle my e waste if there is a bonus card system where recycled e-waste earn me points to use for shopping discounts | ○ | ○ | ○ | ○ | ○ |
| I would recycle my e waste if I am able to trade old-for-new electronic items as discounted prices | ○ | ○ | ○ | ○ | ○ |
| I would be willing to pay a deposit when purchasing an EEE item that would be refunded to me when I return the item at its end of life | ○ | ○ | ○ | ○ | ○ |
| I would be willing to pay a recycling fee when purchasing an EEE product to assist the producer in correctly recycling the item | ○ | ○ | ○ | ○ | ○ |
| I would be willing to pay an additional fee to my municipality for separate collection of e-waste on set dates | ○ | ○ | ○ | ○ | ○ |
| I would be willing to drop off my e-waste at a recycling facility | ○ | ○ | ○ | ○ | ○ |
| I would be willing to drop off my e-waste at a convenient location such as a shopping centre | ○ | ○ | ○ | ○ | ○ |
| I would hand over my e-waste to a private recycling company that collects from my residence | ○ | ○ | ○ | ○ | ○ |
| Concerns about access of stored data (e.g. contact details, photos, etc.) on old devices hinders me to hand over such devices for recycling | ○ | ○ | ○ | ○ | ○ |
| I would hand over my e-waste to NGOs and institutions to train the unemployed or e-waste entrepreneurs on how to repair and dismantle e-waste properly | ○ | ○ | ○ | ○ | ○ |

6. An organisation is developing a cellphone app where residents can arrange for the collection of e-waste from their residence. Would you make use of such app if it becomes available?

- Extremely unlikely
- Unlikely
- Neutral
- Likely
- Extremely likely

7. If you are 'extremely unlikely' or 'unlikely' to use an app to arrange for the collection of e-waste from your residence, please provide reason(s) in the space below.

## SECTION D: OTHER AND RECOMMENDATIONS FOR RECYCLING OF E-WASTE

1. Have you ever seen environmental unsound recycling of electrical or electronic products such as open burning of cables, smashing of screens or drainage of batteries acid into the environment?

- Yes
- No

2. Have you bought or received second-hand/refurbished EEE that you used or are using?

- Yes
- No

3. Would you buy repaired/refurbished electronic and electrical equipment?

- ◯ Yes
- ◯ No
- ◯ Not sure

3.1 If you answered 'No' or 'Don't know' to buying repaired/refurbished electronic and electrical equipment, please provide reason(s) in the space below.

4. In your opinion, what can be done to increase the recycling of e-waste? (E.g. more education, etc.)

You have reached the end of the survey. To submit your response please click 'Done'.

When you click 'Done' you will be redirected to a new link. If you would like to receive a short report summarizing key findings from the survey please provide your email address on this new link. The new link is used in order to ensure your responses to the survey questions remain anonymous.

UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

FACULTY ETHICS COMMITTEE

**Ethics Reference Number: 2021-04-01/ Schoeman**

**Researcher: Mrs T Schoeman**
**Department: GEMES**
**Title:** Determining households' e-waste streams and willingness to participate in e-waste management services sector

07 April 2021

Dear Mrs T Schoeman

**Re: Feedback on your application for ethical clearance**

**Status – Approved**

With reference to your application for ethical clearance to use humans for testing/ research purposes that served on 01 April 2021, the Ethics Committee of the Faculty of Science, University of Johannesburg, reviewed and approved the application.

**Note:** Commencement/execution of this project is dependent on the following:

1. Adherence to all Government and UJ regulations related to the COVID-19 pandemic.

Sincerely yours

Prof Cobus Van Dyk
Chair: Faculty of Science Ethics Committee
University of Johannesburg