AN ASSESSMENT OF ELECTRONIC WASTE MANAGEMENT PRACTICES IN COLLINS CHABANE LOCAL MUNICIPALITY, LIMPOPO PROVINCE, SOUTH AFRICA

by

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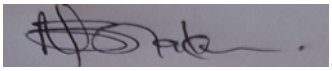
DECLARATION

I, the undersigned **Makamu Nkhensani Nancy**, student number **50704494**, hereby declare that this thesis is my own original work in design and execution, except for quotations and references, which are attributed to their sources. Furthermore, this thesis has not been submitted for a similar degree or any other degree at this or any other university.

Signature……  ……

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PREFACE AND ACKNOWLEDGMENTS

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ABSTRACT

Electronic waste (e-waste) is a millennium challenge due to the rapid growth of the usage of electronic devices and appliances, the gradual improvement of living standards, and the life of technology we are living in. Recently, COVID-19 has added to the pressure on the usage of information and communications technology (ICT), leading to a super-growth of e-waste. The world has entered the 4th industrial revolution, and voluminous amounts of e-waste have been generated. Less developed regions are already facing greater challenges due to their failure to address the challenges presented by e-waste appropriately. Numerous studies on e-waste management in South Africa have been conducted, but most scholars have focused on the larger metropolitan areas of the nation, overlooking the local municipalities. Thus, this study was conducted with the aim of assessing e-waste management practices, including collection, transportation, and disposal, at Collins Chabane Local Municipality.

Primary data was collected through checklist observations, closed-ended questionnaires, and semi-structured interviews. Secondary data was collected from different sources such as the internet, government publications (the Gazette), journals, and audit reports from Collins Chabane Local Municipality. Data was analysed using Statistical Package for Social Science (SPSS) version 27, Microsoft Excel, and the logit statistical model. The logit regression model was employed to determine the factors influencing the community's awareness of electronic waste in Collins Chabane Local Municipality.

This study found that Collins Chabane Local Municipality does not have any policy in place to manage or regulate e-waste management. Furthermore, e-waste is treated the same as other streams of waste. Communities were found to lack or have less knowledge of e-waste. It was found to have no single company dealing with e-waste recycling and related matters within the study area, leading to incorrect handling of e-waste by most community members, who ended up keeping obsolete e-waste in their storerooms. This study established further that lack of regulation of the e-waste stream has led to failure to know the specific amount of e-waste generated at Collins Chabane Local Municipality in terms of tons; however, the study managed to establish the types of e-waste generated the most. Moreover, the role of waste pickers in the reduction of

e-waste that is supposed to reach landfill sites is not recognised by relevant bodies dealing with waste.

Keywords: e-waste, waste pickers, waste management, recycling, community awareness

NKOMISO

Thyaka ra xielekitironiki i ntlhontlho wa malembexidzana hikwalaho ka ku kula ko hatlisa ka ku tirhisiwa ka switirhisiwa swa xielekitironiki, antswiso wo nonoka wa mipimo ya ku hanya, na vutomi bya thekinoloji lebyi hi hanyaka eka byona. Sweswinyana, COVID-19 yi engeterile ntshikelelo ehenhla ka ku tirhisiwa ka thekinoloji ya vuxokoxoko na vuhlanganisi (ICT), leswi vangaka ku kula ko tlula mpimo ka thyaka ra xielekitironiki. Misava yi nghenile eka ncinco wa indasitiri ya vu4, naswona mipimo leyikulu ya thyaka ra xielekitironiki yi endliwile. Swifundza leswi hluvukisiweke switsongo se swi langutana na mitlhontlho leyikulu hikwalaho ka nhluleko wa swona wa ku tirhana hi ndlela leyi faneleke na mitlhontlho leyi tisiwaka hi thyaka ra e. Milavisiso yo hlayanyana hi mayelana na malawulelo ya thyaka ra e eAfrika-Dzonga yi endliwile, kambe valavisisi vo tala va kongomisile eka tindhawu madorobakulu ya tiko, va tsan'wa timasipala ta miganga. Hikwalaho, ndzavisiso lowu wu endliwile hi xikongomelo xa ku kambela maendlelo ya malawulelo ya thyaka ra e ku katsa na nhlengeleto, vutleketli na heriso, eka Masipala wa Miganga wa Collins Chabane.

Switiviwakulu swi hlengeletiwile hi ku tirhisa mixiyaxiyo ya nxaxamelo wo kambela, tikhwexinere ta makumu yo pfaleka, tiinthavhiyu leti nga na xivumbeko xa hafu. Switiviwatsongo swi hlengeletiwile kusuka eka swihlovo swo tanihi inthanete, mikandziyiso ya mfumo (Gazete), tijenali, na swiviko swa oditi kusuka eka Masipala wa Miganga wa Collins Chabane. Switiviwa swi xopaxopiwile hi ku tirhisa vhexini ya 27, Phakeji ya Tinhlayonhlayo ya Sayense ya Vanhu, Microsoft Excel, na modlolo wa tinhlayonhlayo wa *logit*. Modlolo wo tlhelela endzhaku wa *logit* wu tirhisiwile ku kumisisa swiphemu leswi hlohlotelaka vulemuki bya vaakandhawu bya thyaka ra xielekitironiki eka Masipala wa Miganga wa Collins Chabane.

Ndzavisiso lowu wu kume leswaku Masipala wa Miganga wa Collins Chabane wu hava pholisi yihi kumbe yihi leyi tirhisiwaka ku lawula malawulelo ya thyaka ra e. Ku yisa emahlweni, thyaka ra e ri khomiwa kufana tanihi mixaka yin'wana ya thyaka. Vaakandhawu va kumekile va ri karhi va pfumala vutivi kumbe va ri na vutivi byitsongo bya thyaka ra xielekitironiki. Ku kumekile leswaku ku hava na khamphani na yin'we leyi tirhanaka na mbuyeleriso wa thyaka ra xielekitironiki na timhaka leti fambelanaka endhawini ya ndzavisiso, leswi vangeke makhomelo mo ka ma nga lulamangi ma

thyaka ra xielekitironiki hi vaakandhawu vo tala, lava heteleleke va hlayisile thyaka ra xielekitironiki ra khale swinene etikamareni ta vona ta vuhlayiselo. Ndzavisiso lowu wu tumbuluxile ku yisa emahlweni leswaku mpfumaleko wa vulawuri bya muxaka wa thyaka ra xielekitironiki wu vangile nhluleko wa ku tiva mpimo wo kongoma wa thyaka ra xielekitironiki leri endliwaka eka Masipala wa Miganga wa Collins Chabane hi ku ya hi tithani; hambiswiritano, ndzavisiso lowu wu kotile ku tumbuluxa mixaka ya thyaka ra xielekitironiki leri endliwaka hi vunyingi. Kuhundza kwalaho, xiave xa varhwalathyaka eka ku hungutiwa ka thyaka ra xielekitironiki leri ri faneleke ku fikelela tindhawu ta matala a xi tekeriwi enhlokweni hi tihuvo leti faneleke leti tirhanaka na thyaka.

Maritokulu: thyaka ra xielekitironiki, varhwalathyaka, malawulelo ya thyaka, mbuyeleriso, vulemuki bya vaakandhawu

KAKARETŠO

Ditlakala tša ilektroniki (i-weiste) ke tlhohlo ya ngwagakete ka lebaka la kgolo ye e kitimago ka lebelo ya tšhomišo ya ditibaese le diapholayentshe tša ilektroniki, kaonafatšo ya maemo a bophelo ganyane-ganyane, le bophelo bja theknolotši yeo re phelago go yona. Malobanyana, COVID-19 e okeditše kgatelelo godimo ga tšhomišo ya theknolotši ya tshedimošo le dikgokagano (ICT), yeo e dirago gore go be le koketšego ye kgolo ya ditlakala tša ilekroniki. Lefase le tsene go phetogo ya bo-4 ya diintaseteri, gomme go tšweleditšwe palo e kgolo ya ditlakala tša ilektroniki. Mafelo ao a sa hlwago a hlabologa ka botlalo a šetše a lebane le ditlhohlo tše kgolo ka lebaka la go palelwa ga tšona go rarolla ditlhohlo tšeo di tšweletšwago ka tshwanelo ke ditlakala tša ilektroniki. Dinyakišišo tše ntši ka ga taolo ya ditlakala tša ilektroniki di dirilwe ka Afrika Borwa, eupša bontši bja banyakišiši ba lebišitše šedi go mebasepala ye megologolo, ba tlogela go šetša mebasepala ya selegae. Ka go realo, nyakišišo ye e dirilwe ka nepo ya go sekaseka mekgwa ya taolo ya ditlakala tša ilektroniki, go akaretšwa kgoboketšo, dinamelwa tša go rwala ditlakala, le go lahla ditlakala, ka Mmasepaleng wa Selegae wa Collins Chabane.

Datha ya mathomo e kgobokeditšwe ka go lebelela ditšhekeliste, mananeopotšišo a dipotšišo tše di tswaletšwego (closed-ended), le dipoledišano tše di rulagantšwego seripa (semi-structured). Datha ya sekontari e kgobokeditšwe go tšwa methopong ye e fapanego go swana le inthanete, dikgatišo tša mmušo (Kuranta ya mmušo), dijenale, le dipego tša tekolo ya dipuku go tšwa go Mmasepala wa Selegae wa Collins Chabane. Datha e sekasekilwe ka go šomiša tlhagišo ya 27 ya *Statistical Package for Social Science* (SPSS) 27, Microsoft Excel, le mmotlolo wa dipalopalo wa *logit*. Mmotlolo wa *logit regression* o šomišitšwe go laetša mabaka ao a huetšago temošo ya setšhaba ka ga ditlakala tša ilektroniki ka Mmasepaleng wa Selegae wa Collins Chabane.

Nyakišišo ye e hweditše gore Mmasepala wa Selegae wa Collins Chabane ga o na pholisi ya go laola goba go sepetša semolao taolo ya ditlakala tša ilektroniki. Go feta fao, ditlakala tša ilektroniki di swarwa go swana le ditshepedišo tše dingwe tša ditlakala. Ditšhaba di hweditšwe gore di hloka goba di na le tsebo ye nnyane ya ditlakala tša ilektroniki. Go hweditšwe gore ga go na khamphani e tee yeo e šomago ka go risaekela ditlakala tša ilektroniki le tše dingwe tša go amana natšo ka lekaleng

la nyakišišo, e lego se se lebišago go tshwaro ye e fošagetšego ya ditlakala tša ilektroniki ka bontši bja maloko a setšhaba, ao a feleletšago a boloka ditlakala tša ilekroniki tšeo di fetilwego ke nako ka mabolokelong a bona. Nyakišišo ye e laeditše gape gore go hloka taolo ya tshepedišo ya ditlakala tša ilektroniki go lebišitše mo go palelweng ke go tseba palo ye itšego ya ditlakala tša ilektroniki tšeo di tšweleditšwego ka Mmasepaleng wa Selegae wa Collins Chabane go ya ka ditone; le ge go le bjalo, nyakišišo e kgonne go laetša mehuta ya ditlakala tša ilektroniki tšeo di tšweleditšwego kudu. Go feta fao, karolo ye e bapalwago ke batopi ba ditlakala mo phokotšong ya ditlakala tša ilektroniki tšeo di swanetšego go fihla bolahlelwaditlakala ga e amogelwe ke mekgatlo ya maleba yeo e šomago ka ditlakala.

Mantšu a bohlokwa: ditlakala tša ilektroniki (i-weiste), batopi ba ditlakala, taolo ya ditlakala, go risaekela, temošo ya setšhaba

DEFINITIONS

The definitions provided below are specified with precise reference to and perspectives on this study and do not automatically declare the same (international) terminologies given in the literature review:

e-Waste as defined by Barapatre and Rastogi (2021), refers to any household appliance that consumes electricity and has reached the end of its life cycle.

Waste pickers are informal collectors who recover waste in its different forms from different sources and sell it to recyclers in order to earn a living while protecting the environment (Ghulam & Abushammala, 2022).

Waste management refers to the means by which waste of any form is handled such that at the end it does not contaminate or negatively impact the environment, and that includes collection, transporting, processing, recycling, and disposing of waste materials (Chatira-Muchopa & Tarisayi, 2019).

Recycling is the process of converting waste materials into new materials and objects with the aim of saving raw materials and energy (Saif, Salem & Allam, 2023).

Awareness is the knowledge of knowing something about certain circumstances (Mouton, 2020).

Community awareness then refers to the knowledge the community has about e-waste (Masoabi, 2022).

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LIST OF ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
CCLM	Collins Chabane Local Municipality
CPU	Central Processing Unit
CRT	Cathode Ray Tubes
DEA	Department of Environmental Affairs
DET	Department of energy and Trade union
EoL	End of Life
EEE	Electrical and Electronic Equipment
FET	Further Education and Training
EIP	Electronic Information Products
EPA	Environmental Protection Agency
EPR	Extended producer responsibility
EPWP	Extended Public Works Programme
EU	European Union
EWASA	Electronic Waste Association of South Africa
e-Waste	Electronic Waste
FEPA	Federal Environmental Protection Agency
HEI	Higher educational institutions
ICT	Information and Communication Technology
IDP	Integrated Development Plan
IT	Information Technology
LCD	Liquid Crystal Display
LED	Light Emitting Diode
Mt	Metric tonne
NEMA	National Environment Management Act
NESREA	National Environmental Standards and Regulations Enforcement Agency
NGO	Non-Government Organisation
PCB	Printed Circuit Boards
PPE	Personal Protection Equipment
PV	Photovoltaic
PWMA	Public Waste Management Authority

RoHs	Reduction of Hazardous Substances
SAWIC	South African Waste Information Centre
STATSSA	Statistics South Africa
SPSS	Statistical Package for Social Sciences
UK	United Kingdom
URC	Universal Recycling Company
USA	United State of America

CHAPTER 1: INTRODUCTION

1.1 Introduction

This chapter explains the nature of e-waste and how it is managed. The chapter elaborates further on the background information about the challenges that come with the mismanagement of e-waste globally and the impact e-waste has on the environment. It presents the problem statement and what motivated the study to be conducted, and it concludes with a summary of each subsequent chapter.

1.2 Background information

Recent outbreaks of the corona virus in 2019 (COVID-19) have accelerated and shown how the 4th industrial revolution must apply in many sectors, and consumer electronics are becoming a major part of our daily lives (Barapatre & Rastogi, 2021). In the modern era, people have had to adapt to a new way of doing things such as attending meetings, classes and even events virtually using various virtual platforms. This change leads to increased usage and production of electronic and electrical equipment (EEE), which are already growing exceptionally in real terms of capacity and sales, thereby reducing their life expectancy (Maphosa & Maphosa, 2020). As soon as the EEE reaches the end of its life span, it becomes waste which is known as electronic waste (e-waste). The term e-waste is defined in this study as obsolete electronics that have reached the end of their lives and can no longer be cared for as they used to (Baldé, Forti, Gray, Kuehr & Stegmann, 2017). In contrast, Barapatre and Rastogi (2021) defined e-waste as any obsolete, broken, or non-functional electronic device, such as an old television, a computer, a monitor, a laptop, a printer, a scanner, even an electric kettle.

The new Information Technology (IT) devices are being produced at a faster rate since smartphones, laptops, and powerful televisions are being produced more frequently (Nivedha & Sutha, 2020). Although improved technology always brings its benefits, e-waste generation accelerates, burdening the natural environment (Olubanjo, Osibanjo & Nnorom, 2015; Simiari, Shojaee & Oladghaffari, 2018). Several concerns have been expressed about e-waste since most of its constituents are lethal and non-biodegradable (Chinyere & Afeez, 2019). As for electronic and electric household appliances, many of them are hazardous and should be handled with caution when it

comes to their treatment; therefore, they should not be disposed of in landfills (Maphosa & Maphosa, 2020).

Internationally, e-waste is the burning issue and it is considered the highest distress for justifiable consumption and manufacturing since it involves various sectors that are necessary for the global economy to grow (Ghulam & Abushammala, 2023). This includes technology, communications and economy which are the key factors for the increase of e-waste. e-Waste is a multidisciplinary encounter that is emerging swiftly. Since 2019, and measured in Metric tonne (Mt), countries such as Europe (12 Mt), USA (13.1 Mt), Indonesia (1.62 Mt), Japan (2.57 Mt), India (3.23 Mt), and China (10.1 Mt) have produced about 70% of e-waste globally. The study revealed further that only 17.4% of that e-waste generated internationally was recycled and the other percentage were shipped to regions like Africa as second-hand goods donated to the country (Ghulam & Abushammala, 2023). Thus, resulting to environmental challenges and need to be given special attention to be resolved.

Among the e-waste produced in Africa, the majority is generated by imported EEE at about 50–85% (Rahul, Kuldip, Sarbjit, Atul & Manjeet, 2021); the least is generated locally (Africa), while the rest is generated by illegal transboundary imports from America and Europe, posing serious challenges for e-waste management (Ghulam & Abushammala, 2023). Although Africans are aware of the dangers of e-waste, most have not approved the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, also known as the Basel Convention, which states that the country that produces hazardous waste such as e-waste needs to minimise the quantities of waste that are transported. Moreover, the e-waste, or rather, the hazardous waste produced in that country, needs to be treated and disposed of closer to the place where it was produced (Andeobu, Wibowo & Grandhi, 2022). This means the Basel Convection needed each region to manage its own hazardous waste, but when waste such as e-waste is no longer disposed of in the country of origin but is transported to other regions, making management difficult (Masoabi, 2020), However, South Africa has been able to regulate e-waste imports and exports as a priority (Uhunamure, Nethengwe, Shale, Mudau & Mokgoebo, 2021). Worryingly, in some municipalities in South Africa, e-waste is still collected with solid waste from households, whereas the majority is stored in homes and offices. Although households

and local municipalities may use improper methods to manage waste, some companies in South Africa are opting to use best practises by sending their e-waste to recycling service providers (Sadan, 2019).

Generally, the local governments that are reluctant to enforce the regulations face challenges regarding e-waste management. Furthermore, an inadequate technological infrastructure results in poor e-waste management. e-Waste is typically managed by recycling, untrained recycling, landfilling followed by burning, or disposing in open areas (Mmereki, Baldwin, Hong & Li, 2016; Jayaraman, Vejayon, Raman & Mostafiz, 2018). Thus, developed countries such as the United States of America (USA), Switzerland, North America, and European countries throughout the world use the best technological infrastructure for treating and disposing of e-waste, combined with sound environmental policy and legislation that is applied effectively (Govender, 2016; Azodo, Ogban & Okpor, 2017; Nivedha & Sutha, 2020).

Moreover, the lack of education on the effects of e-waste on consumers, health hazards, improper e-waste disposal practices, lack of environmental policies addressing e-waste, and failure to enforce the e-waste policies also contribute to improper e-waste management (Kumar, Holuszko & Espinosa, 2017; Barapatre & Rastogi, 2021). Therefore, raising awareness of the said challenges could play a key role in curbing the effects of e-waste on human health and the environment (Masoabi, 2020).

1.3 Problem statement

In the 4th industrial revolution, there is high demand for ICT devices, which in turn leads to the concentration of EEE that originates from households with complex structures (Börner & Hegger, 2018). The amount of EEE generated by South African households is increasing rapidly and needs to be managed effectively. Therefore, special directives should be given for collection, sorting, transporting, and disposing of e-waste (Ledwaba & Sosibo, 2017). Particularly in South Africa, environmental policy and legislation allow municipalities to oversee waste treatment, and outlined by-laws serve as guidelines. Even so, some local municipalities do not treat e-waste as hazardous waste and do not enforce waste by-laws, while others treat solid waste

streams in the same way as e-waste (Ledwaba & Sosibo, 2017; Sadan, 2019; Ichikowitz & Hattingh, 2020).

Based on some of the challenges outlined prior, it is evident that e-waste management practises need to be given serious attention through different methods such as research studies and communication media such as conferences and the presentation of public lectures on e-waste-related issues until better solutions can be found (Sakr, Saafan & Saraya, 2021). Additionally, there have been various studies on waste management conducted in different South African local municipalities. However, e-waste has not been investigated at Collins Chabane Local Municipality. Collins Chabane Local Municipality residents live during the Fourth Industrial Revolution; therefore, they are more likely to generate electronic waste. Mobile phones, laptops, hairdryers, irons, kettles, tablets, and many more may be at the top of the list of electronic gadgets that are upgraded more frequently by the residents in the study area (Ledwaba & Sosibo, 2017; Uhunamure *et al*., 2021). The repair of EEE is more expensive, so most of the electronic equipment is discarded or disposed of in the open field and replaced with new ones. Personal computers, fax machines, photocopiers, scanners, printers, and cartridges are among the common types of e-waste disposed of in large numbers due to failure to repair them instead of replacing them (Needhidasan, Samuel & Chidambaram, 2014; Nuwematsiko, Oporia, Nabirye, Halage, Musoke & Buregyeya, 2021).

Collins Chabane Local Municipality is a newly formed municipality with a legal dumpsite. However, the landfill lacks a weighing bridge, which makes it unsuitable as a legal landfill site. Additionally, municipal solid waste is dumped at the landfill too close to the villagers in the area. Municipal solid waste is not separated, and all solid waste streams (solid waste, garden waste, and e-waste) are disposed of in the landfill (Mabadahanye, 2017; Mathako, 2019).

According to Mabadahanye (2017) and Mathako (2019), there is possible mismanagement of waste streams at large as a result of policy misunderstanding. Accordingly, it is imperative to perform more studies on e-waste considering this emerging concern to gain a deeper understanding of this issue. In addition, it is necessary to consider the challenges that arise from the management of e-waste and its surroundings (Sadan, 2019). Ultimately, it is necessary to conduct this research in

order to gain a better understanding of how the residents of a Collins Chabane local municipality handle e-waste and, furthermore, to equip them with the necessary knowledge on how to handle e-waste and to be aware of the numerous health challenges that are related to e-waste.

1.4 Motivation of the study

There is a relatively low amount of research conducted on e-waste in South Africa, particularly in the Limpopo Province. Ichikowitz and Hattingh (2020) suggested that more researchers should pay attention to the challenges arising from e-waste and its surroundings to come up with different and better ideas about how to manage e-waste. Even though there are some studies done on e-waste, including the following: “the policy terrain and the transition toward a formal system of electronic waste management (Lawhon, 2012; Lawhon, 2013), possibilities for developing a green channel (Anahide, 2007), green economy possibilities for the informal economy (Smith & Musango, 2015), and the potential for applying technological solutions to valuable electronic waste fractions (Ledwaba & Sosibo, 2017; Richards, 2019),” yet more studies need to be done in order to understand and address the challenges brought about by e-waste (Ichikowitz & Hattingh, 2020).

Few studies have been conducted on e-waste practises in Limpopo Province and other rural provinces of South Africa. In 2014, Tshimbana conducted a study on the management of e-waste in Ba-Phalaborwa Local Municipality. The results of Tshimbana (2014) revealed that residents at Ba-Phalaborwa Local Municipality owned and discarded a lot of large households' e-waste. A low level of e-waste management was discovered to be a challenge, while the municipality did not have any policy or e-waste regulation put in place to regulate e-waste management. The results of the study motivated the current study to be conducted with the motive of finding out if the challenges experienced by the Ba-Phalaborwa Local Municipality were an isolated case or if many other local municipalities are experiencing the same challenges in terms of e-waste management.

A study by Ledwaba and Sosibo (2017) revealed that South Africa is faced with many challenges, most of which are related to consumer awareness, collection, recycling processes, and e-waste disposal, amongst others. The study acknowledged that the

recognition of e-waste as a priority waste stream is a step in the right direction and that the government and associated institutions are working towards establishing an e-waste management system. The outcome indicated further that the government has vowed to divert about 50% of e-waste from reaching landfills by 2024. In order for the government of South Africa to reach its goal, more studies on e-waste management across all municipalities need to be conducted with the purpose of understanding the role played by local municipalities, including metropolitan municipalities, in preventing e-waste from reaching landfill sites.

Another study by Snyman, Vosterer and Jacobs (2017) indicated that South African legislation should address e-waste as a separate waste stream and that the e-waste disposal industry should be developed to a level where employment and e-waste volumes are increased through increased awareness of e-waste disposal.

Mouton (2020) revealed that from a study of the framework for the re-use, recycling, and disposal of e-waste, consumers indicated a positive attitude towards e-waste recycling. Furthermore, environmental awareness was one of the biggest contributors to recycling e-waste. The study also revealed that e-waste recycling is one of the biggest drivers for success in proper e-waste management, but this is not supported. Moreover, the study recommended that the South African Government introduce dedicated e-waste legislation that can be monitored, where the management of the system is done by a Producer Responsibility Organisation (PRO) that involves different stakeholders who are going to avoid corruption at all costs for the effectiveness of the smooth running of such programmes.

Ichikowitz and Hattingh (2020) did a study on consumer e-waste recycling in South Africa, and it was found that there is a general lack of consumer awareness about e-waste recycling and limited pro-recycling behaviours, influenced by underdeveloped technologically advanced collection mechanisms and infrastructure.

Mkhwanazi (2021) also did a study on an assessment of electronic waste (e-waste) management in eThekwini municipality, KwaZulu-Natal province. The research's outcome indicated that communities in the eThekwini municipality failed to comply with waste regulations and standards due to the mismanagement of e-waste. Furthermore, the eThekwini Municipality's representatives dealing with waste management

acknowledged that e-waste as a hazardous substance was not part of the service they were giving to their communities due to a lack of relevant infrastructure needed to treat e-waste, thus leading to the degradation of the environment associated with the release of toxic emissions during the uncontrolled burning of waste and soil contamination from poorly managed informal facilities.

While Viljoen, Schenck, Volschenk, Blaauw and Grobler (2021) focused on household waste management practises and challenges in a rural, remote town in the Hantam Municipality in the Northern Cape, South Africa, the outcome of the study revealed that the rural municipality of Hantam in the Northern Cape had a challenge managing waste in general, including e-waste. e-Waste was found disposed of in an illegal dumping area mixed with solid waste. The main challenges that led to the illegal dumping of e-waste among them were financial constraints, a lack of proper equipment, infrastructure, and treatment centres. However, the community expressed their willingness to participate in a separation-at-source program as a better way to manage waste in an environmentally friendly manner.

In addition to the mentioned studies, other studies were conducted in South Africa about e-waste management, and yet more studies need to be conducted to fill the gap left by previous studies, in particular the gap of research done in remote rural areas of South Africa. Some of these studies include the study by Sadan (2019) on exploring the potential for local end-processing of e-waste in South Africa. Viljoen *et al*. (2021) point out that local municipalities need to conduct research on e-waste management to better understand the waste management practises in remote rural areas and the methods used to effectively manage e-waste. The findings of Tshimbana (2014), Viljoen *et al*. (2021), and Mkhwanazi (2021) were the key articles that motivated the current study to be undertaken.

1.5 Research aim and objectives

1.5.1 Research aim

The aim of the study was to assess e-waste management practises in Collins Chabane Local Municipality, Limpopo Province, South Africa.

1.5.2 Research objectives

To address the aim of this study, the following objectives were pursued:

- To identify the types of e-waste generated in Collins Chabane Municipality.
- To assess e-waste management practises such as collection, transportation, and disposal by Collins Chabane Local Municipality.
- To evaluate the level of community awareness of e-waste in Collins Chabane Local Municipality.
- To assess e-waste reclamation in Collins Chabane Local Municipality.

1.6 Research questions

- What are the types of e-waste generated at Collins Chabane Local Municipality, and who are the major generators between the community and the municipal office?
- What are the best methods used at Collins Chabane Local Municipality to manage e-waste?
- What is the level of community awareness of e-waste in Collins Chabane Local Municipality?
- What is the status of e-waste reclamation at Collins Chabane Local Municipality?

1.7 Structure of the dissertation

Chapter 1

The chapter outlines the background of global e-waste management practices, the research problem, the motivation of the study, the aim, the research questions, and the objectives of the study.

Chapter 2

This chapter examines the literature on global e-waste management practices as well as national, provincial, and local practises in the study area. Various types of e-waste generated, community awareness levels, the effects of e-waste on the environment and health of individuals, and challenges in managing e-waste are discussed.

Furthermore, the chapter examines the status of e-waste reclamation globally, nationally, and locally.

Chapter 3

This chapter presents detailed information about the study area, methods used for data collection, ethical considerations, and limiting factors of the study.

Chapter 4

The chapter presents the findings of the research in detail using data coding, discussions, and analysis of results in depth.

Chapter 5

This chapter provides an in-depth review of what the researcher learned through the research questions, the challenges encountered during the study, and how this can contribute to improving waste management practices. Furthermore, the main findings, recommendations, and conclusion are presented.

1.8 Conclusion

This chapter provided information about the challenges that led to the study's conduct. The motives from previous studies related to the recent study The objectives and the research questions were also briefly discussed. The structure of the dissertations is elaborated on in this chapter.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the nature of e-waste and how it is generated. It elaborates further on the challenges e-waste brings in terms of proper management. The policies that were put in place globally as guidelines to manage e-waste correctly were discussed in this chapter. The countries that are applying the policies correctly to manage e-waste and are efficacious were discussed. Furthermore, challenges faced by regions that are struggling to implement e-waste policies are discussed in detail.

2.2 Contextual information on e-waste

The effects of the COVID-19 pandemic globally had forced many people to rely mainly on the use of digital communications like never before (Murthy & Ramakrishna, 2022). Different levels of education departments at schools, tertiary institutions, private sectors, and some government departments had to work from home and study online, and all these online platforms had increased the usage of electronic telecommunications (Maphosa & Maphosa, 2020). To date, there are still higher institutions of learning, the private sectors, and other government departments that are encouraging people to study and work from home to curb the increase in contamination and spread of the COVID-19 pandemic (Maphosa, 2021). In so doing, there will be an increase in the production of e-waste that needs to be managed correctly so that the environment is conserved and human life is protected from any harm or damage these constituents of e-waste may cause (Maphosa, 2021). Murthy and Ramakrishna (2022) stated further that “the combined effects of the pandemic and the drastic shift towards the prolonged use of artificial intelligence (AI) resulted in privacy infringements, a lack of physical activity, health concerns, and a lack of social interactions, while adding to an already existing challenge of an increase in e-waste." Except for the effects of the COVID-19 pandemic on e-waste, population growth and industrialisation have also increased the usage of technology, which has led to a rapid increase in e-waste (Babayemi, Jha, Ogundele & Ogundiran, 2020; Nuwematsiko *et al.*, 2021).

Globally, the rate of e-waste has escalated twice as fast as it did a decade ago (Barapatre & Rastogi, 2021). e-Waste is a global problem that needs to be

aggressively addressed and needs a global solution. Unlike municipal solid wastes, electronic products such as computers, fluorescent lights, TVs, and mobile phones contain toxic substances, and it is therefore very important to manage e-waste effectively and correctly to avoid environmental pollution (Aparcana, 2017; Chinyere & Afeez, 2019). Nyeko *et al.* (2023) indicated that developed Western European countries such as the United States of America and Australia are the regions internationally that generate the most e-waste. Furthermore, the said countries generate almost 80% of e-waste annually, and 50% of the estimated e-waste ends up reaching less developed countries and African soil the most. Zero point six million metric tonnes of e-waste in the European countries were disposed of into the normal municipal waste bins since separation was seen as a challenge (Forti, Baldé, Kuehr & Bel, 2020), thus resulting in mismanagement of e-waste. According to Ghulam and Abushammala (2023), e-waste generated in Western regions and the USA finds its way to less developed regions because recycling e-waste is more expensive than purchasing new products. Hence, some regions, such as Japan and China, send their e-waste to African soil as a gift or sell it at the most affordable price (Saif *et al*., 2023).

In sub-Saharan countries such as Ghana and Nigeria, e-waste production is increasing tremendously since these countries sell goods that are purchased as second-hand merchandise at lower prices; hence, their lifespan has been reduced from about 4 to 2 years (Olubanjo *et al*., 2015; Ferronato & Torreta, 2019; Richards, 2019). The higher usage of technological equipment globally contributes to a high increase in e-waste generation, and this is becoming the most dangerous threat to the environment and organisms within it (Almeer, 2014; Adanu, Gbedemah & Attah, 2020; Babayemi *et al*., 2020).

Viljoen *et al*. (2012) argued that though e-waste management is a challenge posing a negative environmental impact on livelihoods, if managed effectively, it would not have any negative impact. According to Bhutta, Omar and Yang (2011), many countries in Africa, including Ghana, Kenya, Botswana, and Burundi are struggling to manage e-waste because they do not have legislative mechanisms to address the challenge of e-waste, and have not yet acknowledged it as a hazardous waste stream. That argument was supported by several other studies (Asiimwe, 2013; Azodo *et al*., 2017; Daum, Stoler & Grant, 2017). In addition, e-waste generation is accumulative since

users choose to substitute their damaged devices rather than repair them (Needhidasan *et al*., 2014; Chinyere & Afeez, 2019).

In South Africa, e-waste is growing at a faster rate as compared to other usual municipal solid waste (Richards, 2019). This is because South Africa has been growing in the use of technology for the last few decades (Tshimbana, 2014; Govender, 2016; Ledwaba & Sosibo, 2017; Sadan, 2019). The escalation in the usage and ownership of electronic goods, including tablets, by some public-school pupils in the regions of South Africa is evidence of higher usage of technology, thereby leading to more generation of e-waste (Govender, 2016). These result in more tonnes of e-waste being generated, putting additional pressure on municipal solid waste management, which needs to be practised effectively for the benefit of the environment and the health of the public (Singh, Saxena, Bharti & Singh, 2018).

2.3 Definition of e-waste

There are various definitions used to define waste electronic, electric equipment (WEEE), or e-waste, but Barapatre and Rastogi (2021) defined e-waste as “any household appliance that consumes electricity and has reached the end of its life cycle.” While Chowdhury and Patel (2020) defined e-waste as worn-out electronic and workplace equipment that uses electric current to power household electrical appliances that is destined for re-use, Miner *et al.* (2020) state that WEEE are electrical devices that have ceased to be used and are no longer useful to their owners. On the other hand, Babayemi *et al.* (2020) and Needhidasan *et al.* (2014) defined e-waste as a rapidly growing electronic gadget varying from household devices to personal devices such as TV sets, computers, home theatre systems, cell phones, and refrigerators that are no longer useful to their owners and have been discarded. Furthermore, Bhutta *et al.* (2011) also described e-waste as any white goods, consumer and business electronics, and information technology hardware that have lost their value to their owners. Regardless of the scholars' differing points of view, they are all in agreement that once electronics reach their life span, owners are unable to care for them as before and therefore they become e-waste.

2.4 e-Waste legislation

e-Waste legislation refers to the legal structure that gives guidelines dealing with acceptable ways in which e-waste can be managed consciously (Mouton, 2020).

2.4.1 International policies and conventions on e-waste

International policies, conventions, and agreements to this point are the main driving forces that promote the development of a national framework that deals with hazardous waste, including waste produced from electronic and electrical equipment (Roldan & Gibby, 2018; Murthy & Ramakrishna, 2022). These conventions are used at the international and national levels as a point of reference regarding issues relevant to e-waste and any other hazardous waste (EPA, 2016). Baldé *et al*. (2017) argued that these agreements are used to provide a common platform in most countries for such countries to regulate their own policies that best suit their needs. Thus, considering the social and economic status of their countries, there may be challenges posed to the environment by e-waste. There are various e-waste legislations that are put in place internationally and that, thus far, have played a vivacious role in regulating and governing neither private stakeholders nor the government sector dealing with e-waste directly or indirectly (Murthy & Ramakrishna, 2022). In the year 1992, The Basel Convention was held; thereafter, most developed regions started to act on regulating their e-waste policies; to date, about 71% of regions around the globe have integrated national environmental laws with the Basel Convention motion (Salhofer, 2017).

2.4.2 Basel Convention

The main objective of the Basel Convention was to provide nations with various definitions of waste, protect human health, and protect the environment from the negative effects of hazardous waste (Roldan & Gibby, 2018; Rajput & Nigam, 2021). Moreover, this convection had given the directive that nations should decrease the production of perilous waste while prioritising proper and effective waste management at large. Movements of hazardous waste between countries, in particular countries from the East and South, were encouraged and should be minimised at all costs (Olubanjo *et al.,* 2015; Singh *et al*., 2018).

It was indicated in the convection that transboundary movement of e-waste must be legalised to such an extent that “the government of the exporter (which may in turn require the producer or exporter) must obtain written consent from the competent authority of the government of import before any exporting may take place” (Roldan & Gibby, 2018). One of the agreements that the nations were obliged to consider in their policy of managing e-waste was to implement a policy that can monitor transportation, treatment, and disposal of e-waste. This led most countries to ratify policies to deal with e-waste as hazardous waste in the long run, hence the extended producer responsibility (EPR) policy to help deal with proper management of e-waste by producers (Bimir, 2020).

2.4.3 Bamako Convention

The Bamako Convention occurred in Africa as an agreement adopted from the Basel Convention with the aim of lessening the import of e-waste by African countries from developed countries (Kitila, 2018). The Bamako Convention allows the movement of hazardous waste from one region to another only if the producer of hazardous waste is not capable of disposing of such waste in an effective manner that does not impact the environment or human life negatively (Kitila, 2018; Roldan & Gibby, 2018). African countries such as Malawi did not ratify the Bamako convention faster, for according to Roldan and Gibby (2018), Malawi was still in the process of developing policies for e-waste. The treaty was amended in order to cover the grey area that was not covered in the Basel Convention, and it was therefore able to address all types of hazardous waste and prohibit its transboundary (Richards, 2019). Even though African regions that are part of African Unity are part of the Bamako Treaty, they are still struggling to manage e-waste correctly, especially in terms of recycling (Uhunamure *et al*., 2021).

2.4.4 e-Waste legislation in European countries

According to Singh *et al*. (2018), the European Union (EU) is a governmental and economic community established in 1993 made up of 28 countries. Thus far, the EU has had a great influence globally in terms of environmental policy, including hazardous e-waste, which is the umbrella of e-waste (Roldan & Gibby, 2018; Mkhwanazi, 2021; Rajput & Nigam, 2021). Furthermore, the EU passed an ordinance intending to promote the three R's: reduce, re-use, recycle, and other forms of retrieval

(Mkhwanazi, 2021) in order to improve the environmental performance of commercial operators involved in the treatment of WEEE (Singh *et al.*, 2018). In addition, the directive sets criteria for the collection, treatment, and recovery of WEEE (Rajput & Nigam, 2021), which was amended in 2012 in order to widen its scope to include photovoltaic (PV) panels. The directives were stretched further and entrenched into the principle of extended producer responsibility (EPR), with the determination to provide detailed information to the producers of e-waste on how to reduce lethal constituents in the products and have a proper way of managing e-waste (Bimir, 2020). To date, most developing countries are studying the EU environmental legislation and policies and then using them as a mirror to ratify the environmental policies in their own countries regarding e-waste and any other related hazardous waste (Forti *et al.*, 2020; Mkhwanazi, 2021). Most developing countries are using the EU policies than Switzerland, since the objectives outlined in the directives of Switzerland required that solid waste be separated from e-waste and that the e-waste be converted to energy production at landfill sites (Islam, Dias & Huda, 2018).

2.4.5 e-Waste legislation in China

China is one of the Asian countries with the highest amount of e-waste generated since its economy is escalating much faster than it was a decade ago (Salhofer, 2017; Forti *et al.*, 2020). After the Basel Convention, China's government acknowledged that e-waste is a type of hazardous waste that needs to be treated with consciousness, so they developed an environmental law to regulate the proper management of e-waste (Maphosa & Maphosa, 2020). China regulated the first environmental law dealing with e-waste in 2003, "Circular on Strengthening Environmental Management of Waste Electrical and Electronic Equipment." The law aimed to help different stakeholders, mainly creators of e-waste (manufactures and consumers), manage e-waste effectively (Baldé *et al.*, 2017). The law regulated the generation, transportation, and disposal of e-waste by stakeholders and reporting to environmental protection departments.

In 2004, the policy for the prevention of pollution from electrical and electronic products was established for the purpose of decreasing large quantities of e-waste while accumulating a high number of recyclable products that cannot pose any negative impact to the environment (Needhidasan *et al.*, 2014; Daum *et al.*, 2017; Singh *et al.*,

2018). Other policies, such as the General Environmental Law, the Solid Waste Pollution Control Law, and the Clean Production Promotion Law, were established later. These environmental laws were put in place to help the departmental government dealing with the environment enforce the law on e-waste producers (Forti *et al.*, 2020; Rajput & Nigam, 2021). Furthermore, China developed a policy on e-waste regulations on the administration of the recovery and disposal of waste electrical and electronic products, which it adopted from well-known European countries.

The policy assisted the government to manage e-waste generated by manufacturers of WEEE and was embedded in the principle of EPR. The systems were meant to communicate a detailed instrument for formal e-waste treatment through market-oriented means such as direct fund subsidies and others (Daum *et al.*, 2017; Sadan, 2019; Masoabi, 2020). In 2011, another law, "Regulation on Management of Waste Electrical and Electronic Equipment's Recycling and Disposal," was passed to give correct directives to the formal recycling channel. While "Ordinance on Management of Prevention and Control of Pollution from Electronic Information Products (EIPs)" was passed with the aim of curbing higher usage of elements containing lethal constituents from electronic and electrical equipment (Salhofer, 2017; Murthy & Ramakrishna, 2022).

2.4.6 e-Waste legislation in India

Baldé *et al.* (2017) indicated that India is one of the BRICS countries with a significant growth in its economy, generating enormous amounts of e-waste that impact the environment of the nation due to an inadequate manner of handling e-waste. Much research has been done in relation to e-waste management and related issues of policy and legislation governance, which has resulted in more ratification of some policies in order to come up with the relevant ones to address the specific challenge of e-waste management (Rajput & Nigam, 2021; Murthy & Ramakrishna, 2022). Since Basel Convection, the Indian government has implemented several policies to address e-waste challenges; nevertheless, a lack of specific infrastructure to address the problem and less enforcement of the policy played a role in the failure to manage e-waste adequately (Salhofer, 2017; Mouton, 2020; Bimir, 2020). In the year 2008, an e-waste policy titled "Guidelines for Environmentally Sound Management of e-Waste" was made known by different government bodies that are dealing with waste directly

and indirectly (Rajput & Nigam, 2021). Furthermore, in 2011, e-waste (Management and Handling Rules) was introduced as the first legislative rule to manage e-waste, and by then, e-waste had been added to the waste stream of the country (Duan, Singh &Tang, 2017).

Rajput and Nigam (2021) emphasised that the “e-waste management and handling rule” was ratified to be in line with the EU's WEEE and Reduction of Hazardous Substances (RoHs) directives and principles, thus contributing to implementing the policy of EPR. India, like many other developing countries, has formulated an e-waste policy under the guidance of well-developed policies in European regions (Salhofer, 2017; Boardman, Geng & Lam, 2019; Adanu *et al.*, 2020). According to Rajput and Nigam (2021), the introduction of EPR policy in 2018 was for the purpose of “encouraging recycling of usable e-waste products, thus minimising hazardous wastes destined for landfills and ensuring that all forms of e-waste are handled in an environmentally sound manner,” and he further outlined a new amendment to the e-waste management and handling rule as follows: e-waste collection by producers should be done formally and be collected separately. Consequently, according to the RoHS provisions, “the cost for sampling and testing shall be borne by the government to execute the RoHS test” and “If the test results do not validate the specification of RoHS, the manufacturer shall bear the cost of the test” (Rajput & Nigam, 2021).

2.4.7 e-Waste legislation in African regions

Malawi is one of the less developed countries in Africa; by 2017, the country did not have a policy in place to manage e-waste, despite knowledgeable information about the convections and the growing tonnage of e-waste produced in the country (Kitila, 2017). However, the region started to outline the legislation and framework to be passed as environmental law to deal with e-waste in 2018 (Roldan & Gibby, 2018). The study indicated further that e-waste is growing in the country, though there is no policy whatsoever to give directives on the best method to manage e-waste properly to the point of conserving the environment. On the contrary, Ghana passed in 2012 a bill known as the Hazardous and Electronic Waste Control and Management Bill, intended to propose the payment of tax on any e-waste goods entering the country (Daum *et al.*, 2017).

There have been numerous regulations and guidelines in Ghana formulated to deal with environmental issues way before the rise of e-waste as a serious problem (Attia, Soori & Ghaith, 2021). In the year 1994, the Environmental Protection Agency Act was developed, which was followed by various environmental laws, such as the Environmental Sanitation Policy of Ghana (1999); Environmental Assessment Regulations (1999); Guidelines for the Development and Management of Landfills in Ghana; and Guidelines for Bio-medical Waste in the year 2000 (Bimir, 2020). In 2016, Ghana legislated the Hazardous and Electronic Waste Control and Management Act (Daum *et al.*, 2017), with the purpose of "providing for the control, management, and disposal of hazardous waste, electrical waste, and electronic waste" (Babayemi *et al.*, 2020).

The bill was passed as part of the Basel Convection and was aligned with Ghana's "future ability to fulfil international obligations and mitigation" plan to reduce the high amount of e-waste that is seen piled up on and in the ground of Ghana (Daum *et al.*, 2017). Ghana ratified the Basel and Bamako Conventions in 2012, hoping to control the flow of e-waste entering the country while imposing fines on non-compliant stakeholders (Daum *et al.*, 2017); however, Ghana is still facing more challenges regarding e-waste since the country seems to be the destiny of e-waste from developing countries (Mmereki, Li & Li'ao, 2015; Attia *et al.*, 2021; Maphosa & Maphosa, 2020).

Botswana is one of the southern African countries, and the amount of e-waste produced is escalating faster than a decade ago (Mmereki *et al.*, 2016). Nevertheless, the country has thus far not implemented the EPR programme to direct the ICT companies dealing with e-waste directly or indirectly on the proper manner to handle e-waste. Thus, this resulted in these companies' failure to apply the take-back methods to the products that had reached their life span (Masoabi, 2020).

Egypt has witnessed a drastic increase in information and communication technology (ICT) since a decade ago (Almeer, 2014). Ninety-eight million personal cell phones were subscribed to in 2016; hence, the penetration of other electric and electrical equipment has increased. Egyptians are the local producers of air conditioners; on the other hand, more electrical appliances are entering the country, thus leading to a high surge of e-waste. Egypt has had various regulations to manage waste, like the

“Environmental Law of 1994, the Telecommunication Law of 2003, and the Import-Export Trade Law of 2007” (Sakr *et al.*, 2021).

The Ministry of Environmental Affairs of Egypt acknowledges the challenge of e-waste the country is facing and has signed the Bamako and Basel Conventions to ratify the ban amendment bill as well as restrict the inflow of hazardous waste. However, there is no policy to address the challenge that comes with managing e-waste (Baldé *et al.*, 2017; Sakr *et al.*, 2021). Conversely, the Department of Environment in Egypt is working on establishing legislation for e-waste management. The policy aimed to encourage the private sector to deal with e-waste directly and indirectly to promote an environmentally friendly way to manage and dispose of e-waste (Sakr *et al.*, 2021). Private sectors dealing with e-waste, such as the International Technology Group and Eco Integrated Industrial Systems, are emerging actors in recycling (Almeer, 2014; Bimir, 2020).

Nigeria’s national environment ministry had developed the National Federal Environmental Protection Agency (FEPA) around the late 1980s to act as the directive for national waste management (Bimir, 2020). In 2007, the National Environmental Standards and Regulations Enforcement Agency (NESREA) was established to manage e-waste and other environmental-related matters. Regardless of NESREA regulations, e-waste remained the leading waste without a specific policy to address the impact that e-waste had on the environment (Olubanjo *et al.*, 2015). In 2011, Nigeria’s government amended the waste policy and passed the National Environmental (Electrical/Electronic Sector) Regulations S.I. No. 23 of 2011 to address the challenges of e-waste, in particular the informal recycling of e-waste (Almeer, 2014; Olubanjo *et al.*, 2015; Bimir, 2020).

2.4.8 e-Waste legislation in South Africa

Like the rest of the world, the effects of the COVID-19 pandemic have affected the growth of the South African economy and development, thus forcing the economy to adapt to the usage of electrical and electronic equipment (Maphosa & Maphosa, 2020). Consequentially, e-waste is expected to escalate extremely quickly. South Africa had been experiencing inadequate e-waste management practices; therefore, the existing environmental legislation will need to be enforced in order to curb the

hazardous disaster from heading to our environment and human health (Masoabi, 2020; Uhunamure *et al.*, 2021). South Africa has already ratified the Basel Convention and has been busy working with the partnership of stakeholders such as the Electronic Waste Association of South Africa (e-WASA) to formalise e-waste policy to work as a guideline on effective management of e-waste from producers to consumers (Ledwaba & Sosibo, 2017; Sadan, 2019; Masoabi, 2020). Apart from the guideline on e-waste, South Africa has other sets of laws, such as the National Environmental Management Waste Act 59 of 2008, the National Environmental Management Waste Amendment Act 26 of 2014, and the National Environmental Management Act 107 of 1998, aimed at providing guidance on enacting solid waste and covering hazardous substances produced and how they are treated and disposed of (Tshimbana, 2014; Machete, 2017; Mathako, 2019).

In the long run, it was observed by non-government organisations (NGO's) like e-WASA that there is a lack of law enforcement emphasis on environmental law, and where enforcement was taking place, there was no monitoring taking place, thus resulting in improper management of waste by producers (Baldé *et al.*, 2017; Mathako, 2019). These resulted in the formation of other legal frameworks to address challenges related to inadequate management of e-waste; thus, the following framework was established: The National Waste Management Strategy, Hazardous Substances Act, Environmental Conservation Act, National Water Act, Atmospheric Pollution Prevention Act, and Occupational Health and Safety Act" (Mathako, 2019). However, relaxation in exercising the enforcement of these laws and monitoring will result in failure to conserve our environment (Bimir, 2020). Lately, the South African government adopted the policy and the principle of extended producer responsibility (EPR) to address the formal recycling of e-waste processes by the producers (Sadan, 2019), which was influenced by the European Union's Waste Electronic and Electrical Equipment and RoHS Directive and supported by e-WASA (Mkhwanazi, 2021). Thus far, the e-waste sector in South Africa has been progressing over phases from landfilling (the dominant solution) "to regulating certain types of waste and the emerging recycling operations" (Almeer, 2014; Bimir, 2020).

2.5 Sources of e-waste

e-Waste is generated from numerous sources, which include industries (producers of electrical and electronic equipment), institutions, and households (Salhofer, 2017; Miner *et al.*, 2020). Most electronic devices, those in households, have very short life spans and are changed frequently; as a result, the rate of e-waste generation escalates (Maphosa & Maphosa, 2020). Electrical gadgets like cell phones are improved habitually, hence their life span is reduced (Sadan, 2019), while they are in high demand in the market (Adanu *et al.*, 2020). Most government institutions and private sectors are leaders in the use of electronic products, and e-waste has emanated as a result.

Mmereki *et al.* (2015) revealed that other sources of e-waste in Africa, particularly Ghana and Nigeria, are the result of illegal transboundary movement of e-waste, and South Africa is no exception. Higher educational institutions (HEIs) are among the other institutions that have become sources of e-waste. Since the outbreak of COVID-19, the education system around the globe has had to introduce online teaching and learning using information and communication technology (ICT) devices (Maphosa, 2021). Thus, leading to higher usage of ICT devices that can process enormous volumes of information quickly (Salhofer, 2017). Hence, the lifespan of most ICT devices has been reduced; therefore, consumers are forced to change and upgrade their electronic and electrical equipment (EEE) faster between the periods of two and three years (Adanu *et al.*, 2020). Table 2.1 indicates the types of EEE, their estimated mass, and their life span.

Table 2.1: Source of e-waste, their estimated mass and life span Source: Govender (2016).

Type of electronic item	**Mass (Kg)**	**Estimated life (years)**
Air conditioner	55	12
Cellular phone	0.1	2
Dish washer	50	10
Electric cooker	60	10
Electronic game consoles	3	5
Facsimile machine	3	5

Food mixer	1	5
Freezer	35	10
Hair dryer	1	10
High-fi system	10	10
Iron	1	10
Kettle	1	3
Microwave	15	7
Personal computer	25	3
Radio	2	10
Photocopier	60	8
Refrigerator	35	10
Television	30	5
Telephone	1	5
Toaster	1	5
Tumble dryer	35	10
Vacuum cleaner	10	10
Video recorder/DVD player	5	5
Washing machine	65	8

EEE such as cell phones, personal computers (PC), kettles, and photocopiers are the most used EEE and are likely to reach their life span way earlier than the estimated period. Moreover, these items and many other EEE not listed on the table become e-waste when reaching end of life (EoL) and would need to be managed accordingly (Maphosa & Maphosa, 2020). In the current study area, sources of e-waste are likely to be the household's appliances, where the likes of cell phones, kettles, irons, hot plates, and hair dryers might top the list (Uhunamure *et al.*, 2021). According to Uhunamure *et al.* (2021), e-waste in South Africa is classified according to Table 2.2.

Table 2.2: South Africa e-waste categories and the examples Source: Uhunamure *et al.* (2021)

Classification of e-waste	**Examples**
Large household appliances	Refrigerator
Small household appliances	Coffee maker
ICT and telecommunications equipment	Computers, laptops, and cell phones
Consumer equipment and photovoltaic panels	Solar panels
Lighting equipment	Ceiling or wall mounted lights, chandelier
Electrical and electronic tools (except for large-scale stationary industrial tools)	Diagnostic scan tool
Toys, leisure, and sports equipment	Electric scooter, electric guitar
Medical devices (except for all implanted and infected products)	Scales, blood pressure monitor, spectrophotometer
Monitoring and control instruments	Image sensor
Automated dispensers	Automated soap dispenser, automated hand sanitizer, automated pill dispenser

From the list of e-waste classified in South Africa, toys, lightning equipment, small household appliances, and electrical and electronic tools were the most common e-waste sources found in most households, as revealed by Uhunamure *et al.* (2021). Though the sources of e-waste were smaller electrical appliances the most, Limpopo is likely to generate more e-waste from bigger households and ICT since it consists of some districts that are developing faster, with many government departments utilising ICT equipment daily (Uhunamure *et al.*, 2021).

2.6 e-Waste generation across the globe

According to Boardman *et al.* (2019), e-waste generation is increasing faster across the world. The study revealed further that in 2009, e-waste was estimated to be about 40 million metric tonnes globally, while in 2016, it was estimated to be 45 million metric tonnes. Mmereki *et al.* (2015) estimated the increase in e-waste to be 52 million metric tonnes globally in 2021. Waste generation differs according to the percentage of

income countries have. Higher-earning regions produce a high number of electronic devices, unlike regions with low and poor incomes (Needhidasan *et al.*, 2014). However, low-income countries are experiencing an increase in terms of e-waste generation due to the high demand for electronic devices. One other reason that increases the speed of e-waste generation in lower-income regions is the decrease in prices of electronic devices (Nagajothi & Kala, 2015; Adanu *et al.*, 2020; Ichikowitz & Hattingh, 2020), since they are second-hand imports from richer countries (Maphosa, 2021).

In African countries like Nigeria, Kenya, and Ghana in particular, including parts of Asian regions, e-waste generation keeps on rising since developed regions export e-waste to those countries (Almeer, 2014; Forti *et al.*, 2020). Generated e-waste from around the world contains hazardous waste, even though some can be recycled and recovered to make new products (Singh *et al.* 2018). e-Waste can be classified either as domestic, commercial, or industrial (Uhunamure *et al.*, 2021), and all need to be managed in such a way that they do not pose a threat to humans since they contain hazardous substances such as mercury, lead, gallium, selenium, arsenic, zinc, cobalt, tin, palladium, and aluminium that can be more dangerous than normal municipal solid waste (Miner *et al.*, 2020). The classification of e-waste is extremely assorted according to the constituents they carry and how perilous such constituents are to the environment (Hossain, Al-Hamadani & Rahman, 2015; Sadan, 2019). Generally, domestic electronic devices produce a high percentage of e-waste as compared to information and communications technology equipment and consumer electronics (Almeer, 2014).

Electronic devices and products contain heavy metals such as mercury, lead, gallium, selenium, arsenic, zinc, cobalt, tin, palladium, and aluminium. These elements can be found in most domestic electronics and electric devices and therefore demand special treatment when managed as waste (Singh *et al.*, 2018; Chinyere & Afeez, 2019).

2.7 e-Waste generation in South Africa

According to Mhlanga (2018) South Africa contributes about 8% of e-waste to global e-waste, and the speed in which the ICT usage is increasing due to various reason, e-waste stream is expected to propagate in high percentage that is twice than what

was revealed in the reviewed articles in coming years. Therefore, Department of Environmental Affairs gave a second report in 2018, indicating that South Africa had produces 66,9 million tonnes of hazardous waste, of which 6% was a recycled hazardous e-waste recovered from produced waste (DEA, 2018). COVID-19 on the other hand had enforced communities to adapt to the new ways of official communication through Microsoft Teams for instance, whereby others were able to work from home having all necessary ICT devices, thus leading to higher usage of ICT devices, which in the long run will cause the e-waste stream to increase (Maphosa, 2021). e-Waste had been growing in a lower rate in South Africa as way back as from five decades ago, but to date the speed in which e-waste is growing is alarming and need to be addressed accordingly (Uhunamure *et al*., 2021). Maphosa and Maphosa (2020) indicated the advancement of technology as one of the main reasons of e-waste elevation even in African countries, and so is South Africa. The growth of ownership of cell phones has increased drastically since in the early introduction of the 4th industrialisation (Maphosa, 2021), thus leading to mountain tonnes of cell phone e-waste.

Department of Environmental Affairs (DEA, 2018), indicated about 44 tonnes of waste in general was produced in the country and the amount of 360 000 tonnes of e-waste was generated. Yet in 2019, South Africa had generated more tonnes of e-waste at the amount of 461 000 tonnes (Mkhwanazi, 2021), while recovering lower percentage of recyclable material of about 10%. However, according to Uhunamure *et al*. (2021) it is not easy to get to know the actual amount of e-waste tonnes generated in South Africa annually, since some rural areas of the country, are not knowledgeable on how to manage e-waste in an environmental sound manner and therefore, waste generated in those areas are unknown. Ledwaba and Sosibo (2017) revealed that further research in waste management especially in rural areas, need to be conducted in order to get a better understanding of the level of e-waste status in the country. Furthermore, documented e-waste will help the policy makers and many other stakeholders involved to be able to device the better and practical method to manage e-waste effectively according to the availability of infrastructures (Machete, 2017; Sadan, 2019; Maphosa, 2021).

Collins Chabane Local Municipality as a study area is one of the municipalities under Vhembe District in Limpopo Province and is likely to experience challenges of e-waste as a result of population growth. According to report of Integrated Development Plan (IDP, 2019), Collins Chabane Local Municipality, has a waste management system that collects waste mainly in informal settlements focusing on municipal solid waste. The report revealed further that the Municipality collect 576 tons of waste generally per month in town (Malamulele) and 170 villages around the whole municipality. The collection of waste is done daily in town and once per week in the villages Collins Chabane Local Municipality (IDP, 2019). This statement is a clear indication that in this area there is production of waste and e-waste is no exception. However, the challenge exposed by the report is that all sorts of waste are collected the same, meaning e-waste is likely to reach the dumping site irrespective of its hazardous constituents. It was indicated by the report (IDP, 2019) that about 92.7% of households in the study area receive the service of waste collection at least once in a while, and 87.3% are using their homemade dump, then 3.7% of refuse is removed at least once a week. The indication of percentage is worrying concerned and drastic changes need to be taken in order to ensure that waste, in particular e-waste is managed soundly in order to protect the environment and the health of human life (IDP, 2019).

2.8 Waste management practices

Waste management practices, as defined by Chatira-Muchopa and Tarisayi (2019), refer to the way waste of any form is handled such that at the end it does not contaminate or impact the environment in a negative way, and that includes collection, transporting, processing, recycling, and disposing of waste materials. The best management practises for e-waste dictate that the waste is treated in the most environmentally anticipated manner, thus protecting the environment (Kitila, 2018; Forti *et al.*, 2020). If e-waste is not addressed prominently, toxic constituents found in it can pose health problems to animals and impact the environment in a negative manner (Hossain *et al.*, 2015; Ledwaba & Sosibo, 2017).

2.8.1 e-Waste management globally

Waste management practises differ for developed and developing areas, rural and urban areas, residential and business sectors, and health and industrial sectors

(Cohen, Martinez & Schroder, 2015; Daum *et al.*, 2017; Nuwematsiko *et al.*, 2021). Many developed countries have established policies to guide them on how to reduce the amount of waste generated (Khalima, 2016; Diaz, 2017). The best methods to manage waste, including e-waste, are through waste minimisation (Mihai, Gnoni, Meidiana, Ezeah & Elia, 2019). Waste minimisation, as defined by Mihai *et al.* (2019), refers to the reduction of waste from the source by means of sorting the recyclables accordingly, reusing them, and then disposing of those that cannot be used again. Waste separated from the source can be diverted from reaching the landfill and directed to other places where it can be used to produce energy, compost, or another material of the same value as the original (Nagajothi & Kala, 2015). According to Liu, Li, Ren, Duan and Zheng (2012), e-waste can be managed by neither minimising nor controlling the volume of unwanted electronic devices. Furthermore, e-waste can be minimised if designers ensure that the products are manufactured for re-use, repair, and upgradeability. Olubanjo *et al.* (2015) and Miner *et al.* (2020) suggested that manufacturers of electronic devices should use materials that contain fewer lethal constituents, materials that are recyclable, easy to recover, and can be taken back for re-use, and materials that are easy to disassemble where practical.

European countries manage e-waste by following their policy that focuses on recycling WEEE (Kanwar, Nischal, Singh & Sharma, 2021). The policies used in these European countries require manufacturers to reduce the production of e-waste and have a plan in place to recycle. In the United States, “there is no national policy for WEEE recycling, but at least half of the states in the United States have their own range of laws for recycling of e-waste” (Barapatre & Rastogi, 2021). In Latin America, including countries such as Colombia, Mexico, Costa Rica, Peru, and Brazil, e-waste policies are enforced strictly in order to manage e-waste properly (Attia *et al.*, 2021).

In Sweden, a small amount of e-waste is found within the municipal solid waste since they have proper legislation in place to manage e-waste (Hossain *et al.*, 2015; Mihai *et al.*, 2019). The country emphasised that all stakeholders, together with distributors, users, and recyclers, have a precise and judicious responsibility to work on, and it is a clear system with very few administrative expenses that is used to manage e-waste precisely (Liu *et al.*, 2012; Nagajothi & Kala, 2015; Doan, Ameer & Lee, 2019). In Malaysia, a lot of companies producing electronics, like Dell and Nokia, implemented

take-back programmes to comply with corporate environmental regulations. These companies also started an online recycling website to receive all brands of castoff computers for free recycling, as they offer an incentive fee for consumers who recycle discarded Dell products. The process helps to manage e-waste rather than send it to landfill sites (Doan *et al.*, 2019; Jayaraman *et al.*, 2018).

Many Asian countries like China, Korea, Vietnam, and Japan, including many U.S. states and regions, have established e-waste regulations, and most companies in those countries use them effectively in terms of e-waste management (Almeer, 2014; Baldé *et al.*, 2017; Mihai *et al.*, 2019). Also, Doan *et al.* (2019) indicated that Australia passed a regulation of e-waste in 2011 for the purpose of improving the rate of e-waste recycling. United Nations countries, conversely, are working together as a union to combat further growth in e-waste by maximising the adherence to e-waste regulations standards for all stakeholder groups from their national, regional, and local municipalities (Attia *et al.*, 2021; Kanwar *et al.*, 2021). This is achieved by using conscious recycling mechanisms and the correct recycling infrastructure. India, Japan, and Korea are using collection, recycling, recovery, and disposal methods to minimise and manage e-waste much better by following the life cycle evaluation of WEEE products (Kanwar *et al.*, 2021).

2.8.2 e-Waste management in Africa

“Africa is not a major contributor to the generation of e-waste globally; however, the continent is a major receptacle, with Ghana and Nigeria being the main recipients” (Daum *et al.*, 2017). Most African countries are struggling to manage e-waste not because they are receptors of e-waste (Akon-Yamga, Daniels, Quaye, Ting & Asante, 2021), but because they do not have proper legal regulations in place to guide them on how to manage it properly, or rather, existing regulations are not fully implemented (Ledwaba & Sosibo, 2017). Nevertheless, the e-waste management modus operandi in many African countries is still in the developing stage (Maphosa & Maphosa, 2020). Although many regions in European and South American countries have developed policies to guide them on how to manage the amount of e-waste generated, African countries are still not able to manage it effectively (Khalima, 2016; Diaz, 2017). This is because policy and legislation developed to guide e-waste management practises in these countries like Egypt, Nigeria, Ghana, and Zimbabwe did not include legislation

on e-waste, meaning these countries do not have specific guidelines to deal with e-waste so far (Ledwaba & Sosibo, 2017).

A country like Ghana relies mainly on the informal sector, which resorts to recycling e-waste in order to manage it (Akon-Yamga *et al.*, 2021). Egypt lacks a suitable management system and the technological infrastructure to bring about a proper way to deal with e-waste (Barapatre & Rastogi, 2021; Sakr *et al*., 2021), irrespective of the fact that it is the highest producer of e-waste among African countries. Furthermore, Egypt focuses on regulating e-waste to send abroad, while other e-waste is managed informally. It was argued that e-waste is managed successfully through market-driven and self-organized processes, while the rest is disposed of together with either municipal solid waste or in any other unhealthy way (Sakr *et al.*, 2021).

In Southern African regions like Botswana, Lesotho, and South Africa, waste collection and transportation are the responsibility of the municipality; this includes domestic and commercial waste (Tshimbana, 2014; Mmereki *et al.*, 2015; Khalima, 2016; Ledwaba & Sosibo, 2017). Domestic e-waste consisting of smaller electronic devices such as irons, electric kettles, fans, and heaters is likely to reach landfills if informal waste pickers fail to get hold of those devices before waste removal (Azodo *et al.*, 2017). Mmereki *et al.* (2015) revealed that Botswana had an e-waste law on paper, but enforcing the practise is a challenge. As a result, municipal solid waste collected from both rural and urban areas is found to have some e-waste. As cited by most researched articles, African countries are struggling to implement legislation on e-waste (Azodo *et al.*, 2017; Ledwaba & Sosibo, 2017; Maphosa & Maphosa, 2020). Basically, e-waste in Botswana is generally done unscientifically by consumers and local authorities' solid waste workers. Companies were said to have failed to implement the EPR due to a lack of proper regulation of e-waste put in place (Mmereki *et al.*, 2015).

2.8.3 e-Waste management in South Africa

South Africa has not passed an e-waste legislation yet, but the process is in the pipeline, and there is a progressive structure in place that recognises the principle of the Environmental Waste Management Act (Uhunamure *et al.*, 2021). The study revealed further that South Africa, for instance, had no specific legislation to deal with

e-waste; however, there is a progressive framework functioning that recognises the principle of the Environmental Waste Management Act. Moreover, the government of South Africa has regulated the EPR rule that is in the developmental stage to guide the companies that work with EEE on how to manage waste effectively and in an environmentally friendly manner (Sadan, 2019; Mouton, 2020). Thus far, some companies, such as Interwaste and Cape e-waste, are able to collect and recycle e-waste in different ways.

This is achieved by collecting e-waste from companies and government departments and by paying individuals, such as waste pickers, incentives when they sell them this recyclable e-waste (Sadan, 2019). The study revealed further that households that are not sending the obsolesce to be recycled store it at home rather than discard it with normal solid waste or burn it. Their arguments are based on a lack of knowledge concerning the impact of e-waste and a lack of proper facilities in their areas where they can take their e-waste to be processed, or rather, recycled. This is the same case discovered by both Tshimbana (2014) at Ba-Phalaborwa municipality and Mmereki *et al.* (2015) in Botswana. Lack of community awareness on the best methods to manage e-waste needs to be considered in order to curb the rising challenge of e-waste in South Africa.

2.9 e-Waste collection globally

e-Waste collection, treatment, and disposal are part of waste management (Kitila, 2018). Municipalities in established countries such as Switzerland and Sweden collect e-waste and operate treatment systems in collaboration with electronic waste generators (Salhofer, 2017; Sadan, 2019). In less developed regions of Asia, e-waste collection remains the duty of informal sectors (Chinyere & Afeez, 2019; Mmereki *et al.*, 2015). Kitila (2018) revealed that the collection of e-waste in China and India, respectively, is done by the informal sectors, where a high amount of second-hand electronics is found (Liu *et al.*, 2012; Salhofer, 2017). While the study done by Olubanjo *et al.* (2015) designated that regions that neglect to enforce environmental health standards open an opportunity for informal collectors (recyclers) and the black market, it also leads to an increase in improper management of e-waste. This is so because there is a lack of proper legislation guiding the collection of e-waste.

According to Mouton (2020), Western regions like Germany collect e-waste through buy-back methods. The study detailed that e-waste is collected according to its classes, and specific companies such as the Public Waste Management Authority (PWMA) are responsible for e-waste collection. Whereas in Japan, more than two decades ago, e-waste used to be collected by a group of companies dealing with EEE directly or indirectly, which included Panasonic, Toshiba, Mitsubishi, and Hitachi. The method, though, focused more on recyclable materials than treatment (Mouton, 2020). Almeer (2014) indicated that the Taiwan government collects e-waste through a system of municipal collection sites or private collection sites. Like other continents where e-waste collection is done by informal recyclers, Taiwan also has informal recyclers to recycle e-waste that has not reached the municipal collection sites.

2.9.1 e-Waste collection in Africa

Collection of e-waste in African countries like Nigeria in Miner and Niger states is done informally by scavengers or waste pickers who collect it from around Metropolis (Bimir, 2020), whereas the uncollected e-waste happens to reach landfills due to the lack of facilities necessary to address the challenge of e-waste collection. Godfrey and Oelofse (2017) revealed that e-waste in Ghana is collected by informal collectors from households, business sectors, and government institutions. This statement is evident because the waste collectors are everywhere on the street picking up the e-waste without much control from the government, thus resulting in e-waste reaching the landfill along with municipal solid waste (Ogbenna & Raymond, 2018; Bimir, 2020).

According to Roldan and Gibby (2018), in Kenya e-waste collection is done formally and informally, mainly by waste pickers. The report further detailed that waste pickers collect e-waste from various places, including school premises, shops, and other government buildings. However, private sectors like ICT firms that deal with EEE and are knowledgeable about EPR planned to collect e-waste from their shops, thus encouraging consumers to use those collection points as a drop-off point for EEE materials that had reached their end of life, in particular cell phones (Almeer, 2014; Kitila, 2018).

In Algeria, for instance, e-waste is collected with normal solid household waste where separation is not taking place due to the lack of an e-waste policy put in place to

regulate waste management (Daum *et al.*, 2017). In Egypt, e-waste collection is done informally (Almeer, 2014), where valuable materials from e-waste are removed while the remains are burned down or sent to landfill sites. Sakr *et al.* (2021) supported the point by illustrating that the private sector has formed partnerships with waste pickers and recycling enterprises, among others, to network the collection of e-waste until it is disposed of formally.

2.9.2 e-Waste collection in South Africa

According to Lawhon (2013), in South Africa, e-waste is collected by private companies dealing with EEE from electronic repair shops. Mhlanga (2018) affirmed that the likes of Desco and Samsung do collect e-waste from collection points that are placed at Makro, Hi-Fi Corporation, and Incredible Connection. Nevertheless, informal collection of e-waste takes place in the black market, where waste pickers take their recyclable waste and sell it to relevant stakeholders (Mouton, 2020). In a study done in Botswana, Mmereki *et al.* (2015) revealed that lack of knowledge about where to take electrical equipment that has reached its life span caused people to store their goods indoors. Sadan (2019) revealed that the shortage of recycling companies that deal with e-waste might be the reason why people store their obsolete e-waste in their houses. Companies like Samsung are doing e-waste collection in line with EPR policy (Mhlanga, 2018); however, more companies dealing with e-waste directly or indirectly are needed to come on board and be part of recycling to reduce the e-waste that is likely to reach the black market or landfill sites. Way back in 2012, South African metropolitan municipalities initiated a drop-off zone for e-waste; however, due to a lack of monitoring, the idea did not materialise (Mouton, 2020).

2.9.3 Treatment of e-waste globally

Treatment of e-waste is different in developed (Australia) and less-developed (India) countries, and it is determined by the availability of facilities suitable to treat e-waste (Sadan, 2019). Repair, reuse, and refurbishment are forms of e-waste treatment that need to be done effectively to prevent constituents of e-waste from reaching the environment (Nagajothi & Kala, 2015). According to Azodo *et al.* (2017), India, Pakistan, and Ghana depend on the manual disassembling and mechanical handling of e-waste for the recovery of crude materials as a form of e-waste treatment.

Moreover, recycling using the black market is employed with the purpose of reducing the amount of e-waste (Boardman *et al.* 2019). South Africa is using similar methods of treating e-waste as India; however, the country has fewer unskilled recyclers, and they have companies such as Desco that collect e-waste from distinctive companies and recycle it in exchange for incentives (Anderson, 2018; Mhlanga, 2018; Sadan, 2019). Contrary to this, developed regions like the USA and other European countries employ metallurgical procedures to recover metals (Almeer, 2014; Kitila, 2018; Mihai *et al.*, 2019).

Mmereki *et al.* (2015) indicate that the best practise of e-waste treatment should include recycling, even though the cost of recycling e-waste is more expensive than replacing electronic devices with brand-new devices. Due to the high cost of recycling e-waste in regions with poor e-waste management legislation, their waste ends up reaching landfills despite that it contains toxic substances (Viraja & Yogesh, 2014; Singh *et al.*, 2018; Boardman *et al.*, 2019). Lack of proper technological infrastructure for e-waste is another reason why e-waste in places like Nigeria and Ghana ends up in landfills (Olubanjo *et al.*, 2015; Amechi & Oni, 2019). Additionally, the lack of a well-established e-waste system makes it difficult to follow the proper methods of treating waste generated from electronic devices (Mmereki *et al.*, 2015). In continents where environmental policies for regulating electronic devices are established, it is easier to follow the system of separation, sorting, storage, collection, transportation, and disposal when managing e-waste (Nuwematsiko *et al.*, 2021).

2.9.4 Treatment of e-waste in Africa

Proper treatment of e-waste must include disassembling and processing the useful material found in electronic appliances that have reached their life span (Salhofer, 2017; Forti *et al.*, 2020). Disassembling EEE is done to remove or take out perilous constituents, and it must be done using the correct infrastructure to avoid endangering the health of human life (Alabansa, Mahrad, Icely & Newton, 2021). The process of e-waste treatment can be done properly through formal recycling channels (Attia *et al.*, 2021). Most African regions are struggling to treat waste properly since there is a lack of correct treatment infrastructure to perform the work (Mmereki *et al.*, 2015; Kitila, 2018; Maphosa, 2021). It has been discovered that in Africa, informal treatment of waste emanates as a result of a lack of legislation and unregistered black markets that

target the recovery of gold, copper, and many other valuable materials for end-of-life electric appliances (Olubanjo *et al.*, 2015). It was argued further by Ogbenna and Raymond (2018) that unskilled waste pickers risk their health by dismantling e-waste manually and selling it to people doing refurbishment.

The worst scenario is when burning takes place as a solution to treat e-waste. Alabansa *et al.* (2021) argued critically that educating consumers about the composition of EEE products could help to avoid and reduce e-waste while being able to estimate the life span of such products. Furthermore, the products of EEE could be re-directed for formal recycling before becoming waste. Nevertheless, African regions to this point are dominated by the black-market practise of e-waste recycling or treating e-waste by using landfills (Mouton, 2020). Hence, Olubanjo *et al.* (2015) revealed that the driving force of informal recycling in most African regions is the lack of the correct infrastructure needed to treat e-waste in an environmentally sound way. Maphosa and Maphosa (2020) argued that for African regions to be able to minimise the e-waste black market, they need to solemnise the sector with small enterprises such that the sector receives funding for training and the purchase of recycling technologies. On the other hand, Mouton (2021) revealed that the supply chain of EEE needs to be monitored effectively in order to support the implementation of EPR, which seems to be working effectively in developed regions.

According to Alabansa *et al.* (2021), a lack of control and enforcement of the law in terms of transboundary and inflow WEEE results in endangering the environment and human health and putting more pressure on the environmental management sector. The researcher argues further that the use of less developed techniques to manage e-waste and the disposal protocols used are other reasons e-waste surges in a swift manner in African countries. Sadan (2019) and Mouton (2020) argued that even though most African countries are struggling to treat e-waste properly due to financial constraints and other political reasons, South Africa and Egypt are the most progressive countries with at least prescribed facilities for recycling e-waste; nevertheless, they still experience the challenge of informal recycling. Alabansa *et al.* (2021) support the statement of Sadan (2019) and Mouton (2020) that formal recycling of WEEE in Africa lacks ultramodern facilities to abstract salvageable supplies safely since they are expensive to install.

2.9.5 Treatment of e-waste in South Africa

Alabansa *et al.* (2021) indicated that recycling e-waste is being seen as one of the ecological resolutions for dealing with the increased heaviness of e-waste in the environment, both in established and still-establishing countries. Recycling of e-waste usually starts with the pre-processing procedure, where valuable metals like gold, copper, and silver are hauled out (Mouton, 2020). In South Africa, e-waste is treated through the process of recycling (Mhlanga, 2018; Sadan, 2019). Mouton (2020) indicated that recycling companies like Universal Recycling Company (URC), one of the biggest recycling companies recycling ferrous and non-ferrous metals, recycle using the methods of shredding, extracting, shears, and balers, among others, to treat waste. Hence, Desco Recycling deals with dismantling and hand sorting to treat e-waste.

The process used by Desco helped to restore valuable materials that can be re-used for other WEEE gadgets and prevent the use of virgin materials (Mouton, 2020). The study indicated further that almost 90% of recovered printed boards by Desco are taken abroad for further processing since South Africa does not have the correct technological devices to do the processing. Oricol is the company that recycles e-waste, in particular fluorescent lamps, and other e-waste like ferrous. Fluorescent lamps contain toxic metals like mercury and should be managed correctly to avoid the contamination of the ground with mercury (Sadan, 2019). Nevertheless, the country still experiences a high amount of informal recycling of e-waste, as other African regions do (Alabansa *et al.*, 2021).

2.9.6 e-Waste disposal

Disposal of e-waste differs from country to country depending on the environmental facilities available for such countries to dispose of waste more effectively (Hussein & Mona, 2018). The availability of proper technological waste facilities determines the methods by which e-waste can be treated and disposed of (Cohen *et al.*, 2015). Azodo *et al.* (2017) and Kitila (2018) indicate that in countries like South Africa, Botswana, and Nigeria, the final solution to disposing of e-waste is through landfill sites. Many of the developing regions in Africa, including South Africa and Kenya, are still seeking some environmentally friendly methods to dispose of e-waste, which will further lead

to sustaining and protecting our environment instead of disposing of it in landfills (Hussein & Mona, 2018).

Besides landfilling, Olubanjo *et al.* (2015) revealed that members of the community in Nigeria burned e-waste as a form of managing it. Moreover, they disposed of it in open dumps or at water bodies to get rid of it. Ogbenna and Raymond (2018) affirmed in their study that in some states of Nigeria, like Niger, e-waste reached the landfill side together with other types of waste, including waste from the business sector and residential areas. Unlike in Botswana, Mihai *et al.* (2019) and Mmereki *et al.* (2015) pointed out that communities keep their electronic products that have reached their end-of-life. Owners believed that the likes of PCs, mobile phones, and tablets still possess important information and therefore should be kept in a safe place, while others donated to non-governmental organisations (NGO). Lack of correct technological infrastructure to dispose of e-waste is the most dangerous and thus leads to environmental challenges (Nuwematsiko *et al.*, 2021).

2.9.7 e-Waste disposal in South Africa

Godfrey and Oelofse (2017) indicated that South Africa's waste management model is based on a method of using and disposing of waste, of which landfills happen to be the destiny. The study revealed further that about 90% of South African municipal waste ends up in landfills, and some of this landfill is about to reach its life span. Mouton (2020) argued that South African waste is discarded in landfills because there are no other affordable or reliable methods to replace landfilling. This includes e-waste since some households discard their e-waste together with garbage waste (Ichikowitz & Hattingh, 2020). Hence, the Department of Environmental Affairs (2013) introduced waste norms and standards for waste disposal at landfills while dictating the necessities to prevent waste from reaching landfills but being taken to different recycling companies. The norms and standards were regulated by the National Environment Management Act (NEMA Act, 107 of 1998), which is constructed on the polluter pays principle and provides for sufficient administration of waste through recycling, treatment reduction, and disposal (Mkhwanazi, 2021). The purpose of introducing the "polluter pays" principle was to encourage communities to reduce waste by reusing or recycling recyclable materials (DET, 2013). However, a lack of information about the places doing recycling for e-waste (Ichikowitz & Hattingh, 2020),

low educational awareness on e-waste, better methods of storing what needs to be recycled, and low landfilling costs made waste generators decide to continue using landfill sites to dispose of all types of waste rather than environmentally friendly methods to treat waste (Godfrey & Oelofse, 2017).

To date, more than 10,000 metric tonnes of municipal waste, including e-waste, according to Mouton (2020), is landfilled, thus leading to a negative environmental impact on human health and animals. Alabansa *et al.* (2021) suggested that the waste tariffs need to be reviewed to attract business in the recycling sector, while correct technological infrastructures to treat e-waste are considered. On the other hand, Ichikowitz and Hattingh (2020) suggested that waste stakeholders and policymakers should design and improve the existing collection schemes for e-waste. Thus, leading to more e-waste being sent for formal recycling through collection schemes.

2.9.8 e-Waste reclamation

Waste reclaimers are informally collecting and recovering waste in its different forms from different sources and selling it to recyclers in order to earn a living while protecting the environment (Tran & Salhofer, 2018). e-Waste reclaimers or waste pickers are making valuable contributions to municipalities in urban areas by converting unusable e-waste into a productive resource as well as by cleaning those areas where they have picked unusable waste (Mothiba, 2016; Ohajinwa *et al.*, 2018). Aparcana (2017) agrees that informal waste reclaimers contribute a lot to waste management in most cities of developing countries by reducing the volume of waste that was supposed to be transported to the landfill site and, at the same time, reducing the formation of air and land pollution. Waste reclaimers and pickers have made a well-deserved reputation for assisting families with income through the recycling of e-waste as they protect the environment from the harm of electronic waste (Sadan, 2019).

Researchers such as Aparcana (2017), Snyman *et al.* (2017), Viljoen *et al.* (2021), Ntusi, Baloyi and Tshimbana (2022), and Shoroma, Baloyi and Tshimbana (2022) have acknowledged and recognised the valuable role informal waste pickers and reclaimers have played through collecting recyclable materials and selling them to recycling companies. In Vietnam, e-waste reclamation takes place through the role of different companies that run legal e-waste recycling, where informal waste reclaimers

are potential suppliers supplying recyclable materials to these companies (Ahmed, 2017). In South Africa, 11% of e-waste is said to have been recycled in 2016 with the help of waste reclaimers (Ichikowitz & Hattingh, 2020). The study revealed further that 55% of respondents agreed that waste reclaimers are playing a vital role in protecting the environment. Nevertheless, 20% of the 55% were unable to participate in e-waste recycling. India and China are among the Asian countries where informal e-waste is practised a lot, and waste reclaimers are found in high numbers collecting e-waste together with solid waste that contains hazardous constituents (Nagajothi & Kala, 2015; Azodo *et al.*, 2017; Mihai *et al.*, 2019).

Sekati *et al.* (2014) indicated that China has a high number of recyclers that assist in the reduction of e-waste that is supposed to reach landfills. Moreover, waste reclaimers provide secondary raw materials to recycling companies at low prices, which reduces air, water, and land pollution (Sekati *et al.*, 2014). Many researchers agreed that the more waste is managed effectively through the role of waste reclaimers, the more materials are re-used, resold, and/or recycled, leading to a reduction of greenhouse gases, which contributes to minimising global warming (Mothiba, 2016).

2.9.9 Level of community awareness regarding e-waste

All regions of the globe are generating e-waste as a result of high usage of technology (Diaz, 2017; Anderson, 2018; Jayaraman, 2018). Regardless of the recent growth in e-waste, communities in Sub-Saharan Africa are ignorant of the toxicity or hazardous nature of e-waste on the health of people and the environment due to a lack of knowledge (Uhunamure *et al.*, 2021). The study revealed further that 35% of respondents in a study by Uhunamure *et al.* (2021) were not aware of anything related to e-waste. Communities can acquire knowledge about the constituents found in e-waste when they are educated about them (Govender, 2016). Therefore, the government and private sectors dealing with EEE directly or indirectly need to devise a strategy for educating communities about the importance of proper management of e-waste (Mmereki *et al.*, 2015). Azodo *et al.* (2017) reported that communities in Nigeria and Uganda are not knowledgeable of the potential hazards electronic waste possesses. Nuwematsiko *et al.* (2021) attested to the findings of Azodo *et al.* (2017), thus endangering the health of humans and negatively impacting the environment.

This is due to a lack of public awareness regarding electronic waste management (Attia *et al.*, 2021). Singh *et al.* (2018), Hossain *et al.* (2015), and Almeer (2014) attested that a lack of environmental education on electronic waste management contributes to the mismanagement of e-waste treatment. Those working in the dangerous crude recycling activities are also ignorant of the dangers of e-waste due to a lack of knowledge. Ichikowitz and Hattingh (2020) noticed that some communities are aware of the negative impact of e-waste on the environment and the livelihood of humans. However, lack of effectiveness in monitoring the dropping point of e-waste and low observed awareness might be the reasons for the lack of commitment to recycle e-waste or send it to the dropping point (Ichikowitz & Hattingh, 2020).

Nagajothi and Kala (2015) and Murthy and Ramakrishna (2022) confirmed that communities in India did not show any sign of knowledge on how to treat e-waste, regardless of spending most of the time dismantling electronic devices that have reached the end of their useful lives. Doan *et al.* (2019) argued that developing countries are still in the beginner phase regarding the essential treatment of e-waste, coupled with a lack of relevant legislation to give directives on e-waste treatment. Hence, there is little or no awareness of electronic management aimed at addressing consumers (Bimir, 2020). The study further indicated the need for public awareness of environmental education to help educate and inform communities about effective methods to manage e-waste. Salhofer (2017), supported by Mihai *et al.* (2019), indicated that Arabian regions had a similar challenge as most African developing countries: a lack of public awareness regarding e-waste. The study pointed out that public awareness can benefit different sectors if it is done frequently to educate people on best practises for managing e-waste. Moreover, increased knowledge among the public will help to decrease the disposal of e-waste with normal municipal solid waste while improving the quality of the product (Viraja & Yogesh, 2014; Singh *et al.*, 2018).

Attia *et al.* (2021) pointed out that educating consumers about e-waste can also increase recycling rates. Lack of knowledge about the place to take e-waste to be recycled could be the reason most African consumers lack interest in recycling EEE (Nuwematsiko *et al.*, 2021). Lack of public awareness goes hand in hand with a lack of a proper e-waste management policy (Lopes dos Santos, 2020). Attia *et al.* (2021) found that Japan had educated the consumers of laptops and cell phones on the

importance of proper management of these goods, thus leading to a high recycling rate.

2.10 Summary of the literature

According to Murthy and Ramakrishna (2022), the escalating growth of e-waste is a global concern. However, differences lie in the actions taken by the national departments of environmental sectors and how they devise a plan to mitigate the challenges. Mouton (2020) revealed that different measures are applied when it comes to the management of e-waste, the legislation used to manage e-waste, and the level of environmental education applied to educate consumers. When comparing global legislation to South African legislation, there is a gap. South African legislation in terms of e-waste collection is limited to rural areas, yet European countries and many other developed countries have proper collection points for e-waste that are well documented and cover all sectors in the country (Ledwaba & Sosibo, 2017). The study indicated further that municipalities with existing drop-off points for e-waste are not controlled when waste is disposed of by consumers.

The level of formal e-waste recycling in South Africa is still in its development stage, though the country is the leader as compared to other African regions in terms of EPR and other related e-waste legislation (Masoabi, 2020). On the contrary, South Africa is still lagging when compared to countries like Sweden, Switzerland, and China (Bimir, 2020). There is a lack of efficient enforcement of e-waste legislation dealing with the import of second-hand devices, thus leading to an unnecessary escalation of e-waste in the country (Grant, 2019). Again, South African e-waste legislation does not regulate the management of e-waste transboundary as compared to well-developed nations, and this is the same challenge experienced in less developed countries (Bimir, 2020; Maphosa, 2021).

There is a lack of environmental education for consumer awareness purposes in particular communities. Therefore, there is a need to create a high level of awareness about the environmental effects of ineffective e-waste management (Nuwematsiko *et al.*, 2021). Japan used educational awareness on the importance of recycling e-waste to educate the communities, resulting in a higher amount of cell phones being recycled (Attia *et al.*, 2021).

The EPR regulations have been ratified in 2020; their implementation will gradually take place, and this will cause the e-waste model in South Africa to swing progressively in the direction of a circular economy. Nevertheless, western regions began implementing the EPR a decade ago (Mkhwanazi, 2021). In Japan, they have used EPR regulations to manage e-waste, and it is effective since the enforcement of the regulations is monitored (Masoabi, 2020).

The study at Collins Chabane Local Municipality revealed that most households store or dispose of their e-waste incorrectly due to a lack of knowledge. On the contrary, established countries like Europe and Switzerland have devised ways where e-waste from households is collected in an environmentally friendly manner to avoid negative impacts on the environment (Salhofer, 2017).

The last aspect reviewed is the role of e-waste reclamation, and studies by researchers such as Olubanjo *et al.* (2017), Mouton (2020), and Ntusi *et al.* (2022) attest that reclamation of e-waste in a formal way in developed countries being regulated by e-waste policy has reduced e-waste and led to correct management of e-waste. On the contrary, e-waste reclamation flow in South Africa is not effective; there are a lot of grey areas that need to be considered, including the enforcement of all legislation related to e-waste. However, willingness to take part in reclaiming e-waste is influenced by incentives and determined by the proximity of the recycling infrastructure (Mkhwanazi, 2021).

2.11 Conclusion

This chapter reviewed various sources such as thesis from different university portals, newspapers articles and scholarly articles that are related to e-waste management internationally and nationally. From the reviewed articles, it was discovered that e-waste is a global problem because of its nature and how complicated it is to manage it effectively without the correct infrastructure in place. The chapter discovered that developed countries with correct facilities that implement e-waste regulations correctly can minimise the risks e-waste has on the environment. Moreover, they are using EPR for waste management strategies and can avoid negative impacts that are supposed to affect the health of humans and the environment. Except for the challenges e-waste presents globally, e-waste is also one of the aspects that is increasing swiftly globally

and is a great threat to our environment. It is also another aspect that contributes to global warming. In developed regions that are finding it difficult to manage e-waste effectively, they dispose of their e-waste in less developed countries as a form of donation.

Reviewed articles in this chapter shows that, nationally, South Africa is behind in implementing e-waste legislation; however, the country is taking the lead as compared to other African countries. To date, South Africa has used the EPR policy to make the producers take accountability for managing the end-of-life of electrical appliances. The introduction of EPR in South Africa in the future can lead to proper recycling of e-waste, thus leading to economic growth since more employment can be created. Another review of the literature indicated a need to integrate informal recycling of e-waste with formal recovery of e-waste, which can work towards a circular economy and protect human health and the environment.

From the review of the relevant sources, the researcher found that there is one aspect that is analogous in different states across the globe. That is the severe increase in rate of e-waste generation. Conversely, there are disposal practices and legislation that are put in place by various state to the next to address the challenge of e-waste (Murthy and Ramakrishna, 2022). European countries and Sweden are using the EPR policy to manage e-waste and it is working effectively even in policing the methods of disposing off e-waste. South African government also regulated the policy of EPR as a way of addressing the challenge of e-waste. The researcher believed that the EPR policy be implemented by all municipalities including local municipality such as Collins Chabane local municipality. The use of the EPR policy will direct waste producers from the Local municipality to take accountability for management of e-waste at end-of-life span, thus leading to high awareness level done to the consumers. In turn, e-waste will not be disposed of together with normal solid municipal waste. Thus, leading to more e-waste being recovered (Masoabi, 2020). The methods had been practiced in Japan, and had shown a fruitful result (Attia *et al*., 2021).

CHAPTER 3: MATERIALS AND METHODS

3.1 Introduction

Research methodology is the most critical part of the research since it provides detailed information on data collection and analysis. Initially, the research focuses on finding out the best methods to manage e-waste effectively. The chapter discussed in detail the use of mixed methods (quantitative and qualitative) in this study, with the aim of assessing the type of e-waste generated the most at Collins Chabane Local Municipality and understanding the practical methods used in the municipality to manage e-waste.

3.2 Study area

The research was conducted at Collins Chabane Local Municipality in Limpopo Province, South Africa. The municipality was part of Thulamela Local Municipality in Vhembe District before the re-demarcation of municipalities to become a stand-alone since August 2016. Collins Chabane Local Municipality shares its borders with Mopani District and Thulamela Municipalities. The municipality is situated in the eastern part of Vhembe district, and its borders extend to the borders of Kruger National Park (Punda-Maria Gate), as shown in Figure 3.1. Collins Chabane Local Municipality covers about 5,467.216 km2 of land with a population of approximately 372,728 people, which has increased from 646 to 17,136 as revealed by the census conducted in 2022 (STATSSA, 2022).

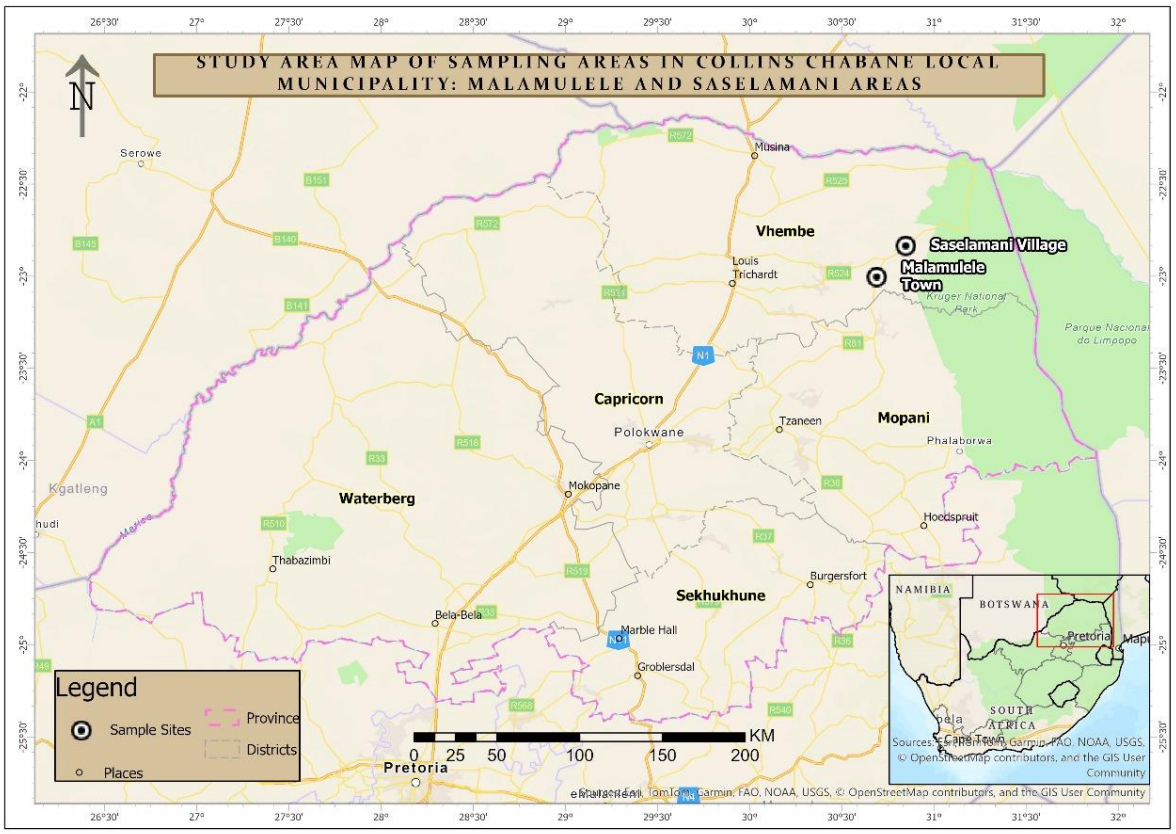

Figure 3.1: Map indicating Limpopo and sampling area at Collins Chabane Local Municipality

Collins Chabane Local Municipality is made up of 174 villages, three informal settlements, and 36 wards. The municipality is situated 191 km away from Polokwane, with Malamulele being its headquarters. There are other vital offices of the municipality situated in developing areas of the municipality, such as the office in Vuwani (Statssa, 2022). Collins Chabane Local Municipality is a savannah biome municipality and receives less rain during the summer, and the winter season is warm (Rutherford & Mucina, 2006).

Collins Chabane Local Municipality has an estimated population of 91,936 households (IDP, 2019). Malamulele, which is a township, and Saselamani, a village that is developing faster to be more like a township (IDP, 2019), were identified for study purposes since they receive waste removal services from the municipality. Out of the 36 wards in Collins Chabane Local Municipality, only four wards, Malamulele and Saselamani, receive waste removal services constantly. The estimated households of this study area, forming part of four wards, are 9,900 households (IDP, 2019). Ward 1 has an estimated population of 2,460 households, ward 2 has 2,455, ward 3 has 2,285,

and ward 4 has 2,700 households (IDP, 2019). The study concentrated more attention on Malamulele and Saselamani as study areas of choice. Figure 3.1 indicates the map of Limpopo province, and Collins Chabane Local Municipality is of the local municipality in the province. The study focused on two different study area, Saselamani Village and Malamulele Township, and on the map the sampling places are indicated by yellow colour in Figure 3.1.

3.3 Research design

The research design can be defined as the researcher's overall strategy to obtain answers to the research questions leading to the study (McMillan & Schumacher, 2010). Leedy and Ormrod (2014) defined research design as a complete, leading plan or line of attack for finding a solution to the research problem. Hence, Mouton (2020) defined research design as a plan or blueprint of how a researcher intends to conduct research.

The study has used a mixed method (quantitative and qualitative) approach in order to reach the objectives and aim of the study and be able to answer the research phenomena in question (McMillan & Schumacher, 2010). The inspiration to use diverse research methods (quantitative and qualitative) was to allow the study to provide multidimensional perceptions about the research phenomena in question (Daniel, 2016). Furthermore, the use of the mixed methods approach to this research helped to draw out the strengths while minimising the disadvantages of the quantitative and qualitative research approaches. Therefore, the two methods were used to complement each other. Qualitative and quantitative research vary in their definitive approaches with respect to their ways of knowing and examination of the nature of reality, what is to be known, and assumptions about the nature of reality (Leedy & Ormrod 2014).

3.3.1 Qualitative approach

A qualitative research approach refers to a description of things and uses instruments such as personal observation, open-ended questions, in-depth interviews (audio), and field notes to collect data from participants in their natural settings (O'Connor & Gibson, 2017). A qualitative approach in the form of a semi-structured interview was used to interview municipal personnel under the Waste Management Directorate in

order to get detailed information about e-waste management practises at Collins Chabane Local Municipality, challenges related to e-waste management, and the level of knowledge the offices dealing with waste had in terms of e-waste management. This provided the researcher with a chance to work directly with the participants and be able to ask follow-up questions where clarity was needed (Saunders, Lewis & Thornhill, 2012).

Semi-structured interviews were used to collect data from e-waste reclaimers; the guideline questions (Appendix 5) were administered to them. The qualitative approach allows the researcher to collect non-numerical data through observations and the taking of important information by means of scribbling notes and taking pictures (Leedy & Ormrod, 2014). Creswell (2014) indicates that the use of qualitative research requires the researcher to be the main active participant to have control over the questions given to the participant.

3.3.2 Quantitative approach

Quantitative design was also employed in this research study since it involves various methods to collect data, such as closed-ended questionnaires and checklist observations (Mouton, 2020). The quantitative method is straight-forward, focused, and yields statistical data (Mouton, 2020). A quantitative method is defined as a research method that is used to measure the problem by producing mathematical data or data that can be transformed into functional statistics (Saunders *et al.*, 2012). The study employed a quantitative approach by enquiring about the types of e-waste generated by households, how it is managed (including how e-waste is stored by households before collection by the relevant designated stakeholders, and how knowledgeable they are in terms of handling e-waste).

An observation tool was also used to find out how the municipality's personnel collect e-waste, when it is collected, and what type of transportation is used. Furthermore, an observation tool was used to collect data during a site visit at the landfill site to see how the waste is disposed of. The purpose was to see whether waste is weighed before being disposed of and to check if sorting of waste occurs before it is disposed of. Moreover, the availability of waste reclaimers at landfill sites was observed using a checklist tool, which forms part of quantitative methods.

3.4 Sampling

3.4.1 Sampling technique

Sampling is a specific principle used for selecting population members to be included in research (Saunders *et al.*, 2012). This research study used stratified random sampling, which leads to simple random sampling. A stratified random sampling was used for households. Stratified random sampling, according to Saunders *et al.* (2012), refers to possible methods of sampling in which the residents are scattered into two or more groups according to one or more common attributes. Stratified sampling is a type of probability sampling technique that can work better if the population numbers are high (Robson, 2011). Stratified sampling can be divided into two groups: proportionate and disproportionate. The use of proportionate stratified random sampling techniques involves determining sample size in each branch in a comparable manner to the entire population; hence, in disproportionate stratified random sampling, the numbers of subjects recruited from each stratum do not have to be proportionate to the total size of the population (Saunders *et al.*, 2012).

This study employed proportionate stratified sampling because it generates more accurate primary data as compared to disproportionate sampling (Saunders *et al.*, 2012). Collins Chabane Local Municipality has an estimated population of 91,936 households (IDP, 2019). Malamulele and Saselamani were identified for study purposes since they receive waste removal services from the municipality. Out of 36 wards in Collins Chabane Local Municipality, only four wards in Malamulele and Saselamani receive waste removal services. The estimated number of households in this study area, which forms part of four wards, is 9,900 (IDP, 2019). Ward 1 has an estimated population of 2,460 households, ward 2 has 2,455, ward 3 has 2,285, and ward 4 has 2,700 households (IDP, 2019). Stratified random sampling was employed since the households were from different wards. The total population of the study area was stratified into four strata: wards 1, 2, 3, and 4.

In this approach, each stratum sample size is directly proportional to the population size of the entire population of strata; therefore, each stratum sample has the same sampling fraction. Wards 1 and 2 were stratified as rural areas of Saselamani, while wards 3 and 4 were stratified as township areas in Malamulele. Within each section or

ward area, the final sampling size of each stratum was further sampled using simple random sampling. A proportionate stratified random sampling technique was employed to ensure a legitimately equal representation of the variables for the study (Robson, 2011).

Table 3.1 indicates how the entire population of the study area was stratified using proportionate stratified sampling. The formula for Proportionate Stratified Random Sampling: $n_h = (Nh / N) * n$----------(1)

Where:

$\mathbf{n_h}$= Sample size for h^{th} stratum

$\mathbf{N_h}$= Population size for h^{th} stratum

N = Size of entire population

n = Size of entire sample

Table 3.1: Stratification table

Stratum	Ward 1	Ward 2	Ward 3	Ward 4
Population size (households)	2 460	2454	2286	2700
Sampling fractions	½	½	½	½
Final sampling size results	**1230**	**1227**	**1143**	**1350**

A simple random sampling method was then used to select households from the final sampling size. Simple random sampling is defined as a sampling technique where every item in the population has an even chance and likelihood of being selected in the sample (Creswell, 2014). Here the selection of items entirely depends on luck or probability, and therefore this sampling technique is also sometimes known as a method of chance. Simple random sampling is a fundamental sampling method and can easily be a component of a more complex sampling method. The main attribute of this sampling method is that every sample has the same probability of being chosen.

The study had adopted the method for determining sample size to use simple random sampling proposed by Krejcie and Morgan (1970). The formula was constructed as follows:

$$s=X^2 NP(1-P) \div d^2 (N-1) + X^2 P(1-P) \quad (2)$$

Where s - is the required sample size

X^2 - the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N - Represents the population size

P - Is the population proportion (assumed to be 0,50 since this would provide the maximum sample size)

d - Denoted the degree of accuracy expressed as a proportion (0,05)

According to Krejcie and Morgan (1970) table for determining sample size, by choosing 4,950 as the population size, the sample size of 357 was obtained.

The sample size calculator was also used to sample confidently, which resulted in a high probability that shows that the survey is statistically accurate.

Population size = 4,950 (total number of final sampling size in stratified method)

Confidence level = 95%,

Margin of error (confidence interval) = 5%

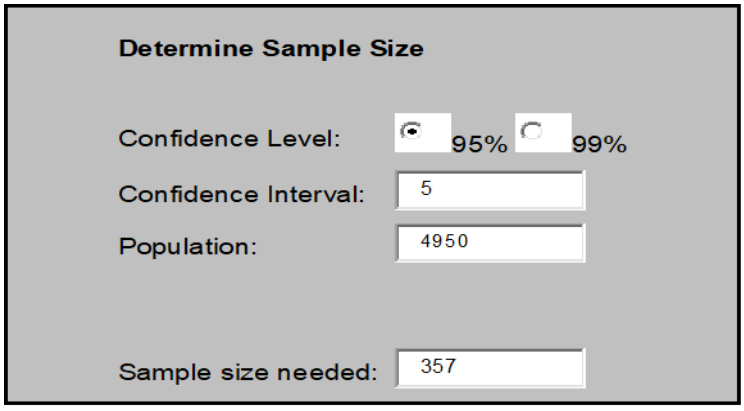

Figure 3.2: Example of sample size calculator Source: Krejcie and Morgan (1970).

3.4.1.1 Snowball sampling method

The snowball sampling technique is non-probability sampling and uses small populations that are difficult to access in order to interview as many respondents as possible (Taherdoost, 2016).

3.5 Primary data collection method

The study's primary data was collected by checklist observations, closed-ended questionnaires, and semi-structured interviews.

3.5.1 Interviews

An interview is a confrontational or telephonic verbal interchange in which an interviewer tries to pull out ideas, information, beliefs, or views from another individual (Mothiba, 2016). An interview can be done using Skype, Zoom, or Ms. Teams, or the interviewer may respond to all the questions using non-confrontational methods such as email addresses to avoid unnecessary movement due to the recent outbreak of the Corona virus (Mathako, 2019). Personnel from the Waste Management Directorate of Collins Chabane Local Municipality and waste pickers were interviewed. Waste pickers were interviewed face-to-face, while environmental officers dealing with waste at Collins Chabane Local Municipality were not interviewed face-to-face.

3.5.1.1 Municipal waste management directorate interviews

According to IDP (2019), Collins Chabane Local Municipality has five official personnel who are working at the Waste Management Directorate; however, two personnel were interviewed. Waste managers and environment officials were initially supposed to be interviewed, such that no specific sampling was used to select the interviewee, but the whole population of municipal officials working as environmental waste officers was interviewed.

Nevertheless, only two representatives were interviewed since others are working with waste under EPWP, the programme that does not deal with all sorts of waste but only solid waste. Even though a state of disaster was lifted, the interview was done online because of the busy schedule of municipal personnel. The interview questions were delivered to the office in hardcopy and given to the relevant officers who agreed to do

the interview. The officers went through the questions and were able to complete the questionnaires in the absence of the researcher, then emailed their responses back to the researcher. The questions were sent in advance to allow the officers to familiarise themselves with the questions and prepare in advance.

3.5.1.2 Waste pickers interviews

At Collins Chabane Local Municipality, the number of waste pickers that were part of the study was not known before data collection; hence, the municipality's estimation of the number of waste pickers was 30 (Mathako, 2019). Hence, the researcher used the snowball sampling technique, which is a non-probability sampling technique that uses small populations that are difficult to access in order to interview as many waste pickers as possible (Taherdoost, 2016). With the guidance of the snowball sampling technique, all waste pickers estimated to be existing were interviewed, and a total of 16 waste pickers were interviewed, while others were not known in the area. Unfortunately, the researcher could not get hold of other waste pickers mentioned by their co-workers. Waste pickers were interviewed face-to-face in a controlled environment. Waste pickers were provided with a new surgical face mask to wear before conducting the interview. Closed-ended questions were given to them; some were not writing on their own; they asked for assistance from ward committee members who accompanied the researcher during that time of data collection.

The provision of face masks was done in accordance with the new regulations, preventing the spread of COVID-19 while ensuring the safety of both the researcher and the participants. Social distancing was observed during the interview, which was conducted using Xitsonga and Tshivenda, languages spoken by the interviewee. The interview for waste pickers was done in the presence of the ward committee for safety purposes and to assist in ensuring that social distancing is followed from the time the interviews started until the end (Pholose, 2019).

3.5.2 Questionnaires

A questionnaire, as defined by Saunders *et al*. (2012), is an instrument consisting of a sequence of questions that are put together with the intention and determination of collecting data from the respondents. In most cases, questionnaires provide closed-ended questions that are easy to answer and are straight-forward. The researcher can

gather a lot of information by using a larger number of samples, and for this study, three hundred and fifty-seven (357) households were the sample size and were administered questionnaires during data collection for the results of the study to be reliable and fair. Saselamani (wards 1 and 2) and Malamulele (wards 3 and 4) were administered 89 questionnaires in each ward.

A questionnaire was given to one member of the household who is over 18 years of age. For those who cannot read and write English, the researcher was reading and interpreting for them in Xitsonga or Tshivenda to be able to understand and answer the questions effectively. The researcher and the field assistants were accompanied by ward committee members for safety purposes in some areas of the study. The field assistants had signed the consent form of confidentiality, binding them to keep the data confidential. Social distancing during the administration of questionnaires to participants was observed. Waste reclaimers were also given questionnaires, even though their questionnaires were very brief as compared to the questionnaire given to household personnel.

3.5.3 Observations

An observation is an orderly, decisive, and selective way of seeing and listening to an interaction or phenomenon as it occurs (Kumar *et al*., 2017). The researcher used an inductive approach that starts with an observation rather than a pre-established truth or assumption (Leedy & Ormrod, 2014). During observations, notes were taken of every important piece of information on the field about all the activities that were taking place during waste collection, transportation, and disposal at the landfill sites (Mathako, 2019). Observations were used to collect primary data to identify waste management practises implemented at Collins Chabane Local Municipality.

Data was collected from the landfill site and from households on different days when the waste was collected by the municipality. During the observation, a checklist was used, and the workers were not disrupted or interfered with during waste collection from households and many other areas where waste was collected. A camera was used to take photographs during observations. However, neither waste pickers nor municipal officials were photographed during the observation. A note book was used to comprehend the checklist and scribe more information. Permission to do the

observations and interviews was obtained from the office of Collins Chabane Local Municipality's manager.

3.5.4 Secondary data collection method

Secondary data is the data that already exists, is about a certain phenomenon studied before, and can be reused in order to answer similar questions in a new research study (Martins, da Cunha & Serra, 2018). Secondary data can be further defined as data that was once collected as primary data by certain researchers who archived it and made it available as articles, books, report papers, or newspaper articles (Johnston, 2014). Secondary data can therefore be used as a referral if it is relevant to the topic the new researcher or reporter is dealing with. Secondary data were collected from different sources, such as the internet, government publications (the Gazette), past journals, waste, and audit reports from Collins Chabane Local Municipality. The secondary data was used as comparative information. Secondary data was compared with primary data to see if there were any similarities in terms of waste management practises at Collins Chabane Local Municipality with the practises used nationally according to the waste policy and regulations (Mothiba, 2016).

3.6 Data analysis

To analyse the data, descriptive statistics and a logit statistical model were employed. while others were analysed using comparative and content analyses.

The descriptive statistics, such as frequencies, mean, standard deviations, percentages, and standard errors, were presented in the form of tables, charts, and other plots interpreting the outcome of the collected data. The logit regression model was employed to determine the factors influencing the community's awareness of electronic waste in Collins Chabane Local Municipality.

The respective study objectives were analysed as follows:

Objective 1: To identify the types of electronic waste generated in Collins Chabane Local Municipality.

Descriptive statistics such as frequencies, mean, standard deviations, percentages, and standard errors of types of e-waste were presented in the form of tables,

histograms, and pie charts. e-Waste was then classified into ten categories accordingly: large household appliances, IT and telecommunications equipment, small household appliances, consumer equipment, lighting equipment, electrical and electronic tools, medical devices, toys, leisure and sports equipment, monitoring and control instruments, and automatic dispensers, and then presented in graph form.

Objective 2: To evaluate the factors influencing the community awareness of e-waste.

A logit regression model was used to establish the relationship between dependent and independent variables for the above objective. The dependent variable is awareness, and the independent variables are demographic and socio-economic aspects such as age, gender, marital status, family size, level of education, and place of residence. A logit model was employed to determine the factors that influence the level of community awareness of electronic waste in Collins Chabane Local Municipality. The logit model was appropriate to be used to model the dichotomous outcome of variables, meaning that the dependent variable took a value of 1 if the respondent is aware and 0 if the respondent is not aware of the electronic waste in the community. In the logit model, the log odds of the outcome are modelled as a linear combination of the predictor variables. The logit function was specified as the inverse of the sigmoidal function used in mathematics, particularly in statistics.

When the function's parameter represents a probability *p*, the logit function gives the log-odds, or the logarithm of the odds *p*/(1 − *p*).

The logit of a number *p* between 0 and 1 is given by the formula

$$\operatorname{logit}(p) = \log\left(\frac{p}{1-p}\right) = \log(p) - \log(1-p) = -\log\left(\frac{1}{p} - 1\right). \quad (3.1)$$

The "logistic" function of any number α is given by the inverse-logit:

$$\operatorname{logit}^{-1}(\alpha) = \frac{1}{1+\exp(-\alpha)} = \frac{\exp(\alpha)}{\exp(\alpha)+1} \quad (3.2)$$

If *p* is a probability, then *p*/(1 − *p*) is the corresponding odds; the logit of the probability is the logarithm of the odds. Similarly, the difference between the logit of two

probabilities is the logarithm of the odds ratio (*R*), thus providing shorthand for the correct combination of odds ratios simply by adding and subtracting:

$$\log(R) = \log\left(\frac{p_1/(1-p_1)}{p_2/(1-p_2)}\right) = \log\left(\frac{p_1}{1-p_1}\right) - \log\left(\frac{p_2}{1-p_2}\right) = \text{logit}(p_1) - \text{logit}(p_2). \quad (3.3)$$

So, putting all this together, the key equation (usually termed the "multivariate logistic regression equation" or "multivariate logistic regression model") to which one fits the data is:

$$\log\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} \quad (3.4)$$

where Pi is the probability and that Y_i is 1.

P_i/ (1-P_i) are called the "odds". In the analysis, the function is estimated with the maximum likelihood method and Y = 1 when the community members are aware of the electronic waste in the area; and Y = 0, when community members are not aware of the electronic waste in the area. The independent variables considered in this study are presented in Table 3.2. The parameters estimated in the analysis include logit coefficient estimates, standard deviation, standard error, Z values and significance, confidence intervals at 95%, the Chi-Square tests and the Pearson Goodness-of-fit test.

Table 3.2: Variable labels and their expected effects

Independent variables	Variable label	Expected effect
X_1	Number of household dependents (number)	Positive
X_2	Age (number)	Positive
X_3	Gender (Male or Female)	Positive
X_4	Are you married (yes= 1 and no =1)	Positive
X_5	Level of education (continuous)	Positive

X_6	Years of experience on waste collection (continuous)	Positive
X_7	Do you own electrical and electronic equipment? (yes = 1, no = 0)	Positive/Negative
X_8	Do you reside in Malamulele (yes = 1, no = 0)	Positive/Negative
X_9	Do you reside in Saselamani? (yes = 1, no = 0)	Positive/Negative

Objective 3: To assess the electronic waste management practices such as collection, transportation, and disposal by Collins Chabane Local Municipality.

Data was collected through interviews, and the outcome was grouped according to themes and then classified according to similarities to help the researcher discover challenges encountered by Collins Chabane Local Municipality concerning waste management practises such as collection, transportation, and disposal of electronic waste. Furthermore, the data was grouped together according to similar patterns and trends. The researcher was able to interpret the meaning of the information that showed similar patterns by using comparative analysis. Comparative analysis is the process of comparing similar or related information from different sources to a standard way of doing something (Leedy & Ormrod, 2014).

Data collected on waste management practises was compared with the national waste management practises regulations and the observation tool used in the field to see if there were similarities or differences. The researcher had used the comparative analysis to argue if there is support between the findings of the study and the arguments constructed from reviewed articles (Saunders *et al*., 2012).

Objective 4: To assess electronic waste reclamation in Collins Chabane Local Municipality.

The data obtained from the waste pickers was analysed using content analysis. The same themes and patterns were grouped together, and the researcher used the patterns to construct or support the arguments about the value of e-waste reclaimers in the study area. The outcome of the results was used to determine whether e-waste reclaimers play a vital role in conserving the environment or not. Data and evidence obtained from the field (waste reclaimers) and the reviewed literature were analysed using comparative analysis (Saunders *et al*., 2012).

3.7 Data validation and reliability

The validity of data in a research study refers to the truthfulness of the findings and conclusions (Mouton, 2020). In this study, research methods to collect data were considered in order to get trustworthy information. Personal observation by the researcher was done too. All this covered the use of quantitative research in order to get valid data that helped the researcher conclude the study based on the findings obtained. Different methods were used for data collection to get the same information from different perspectives in order to get a valid outcome.

Reliability is the research instrument's ability to produce the same results that are consistent when consistent measurements are applied repeatedly (Mothiba, 2016). To get reliable data, the researcher asked similar questions to the participants to ensure the reliability of the interview guide. A pilot interview was conducted before to test the interview guidelines. The researcher had used different aspects of data collection to ensure the reliability of the outcome, which included a questionnaire, observation, and photographs. The researcher visited the study area on various occasions for the purpose of observing the collection and transportation of electronic waste to get a reliable outcome.

3.8 Ethical considerations

Polit and Beck (2017) described ethical consideration as the organisation of moral values influencing human behaviour, which compels a researcher to act in a professional manner and respect the socio-economic status of all the participants. The researcher had applied and obtained ethical clearance from the Unisa ethical committee (2021/CAES-HREC/096), Appendix 4. During the collection of data from the research site, ethical issues were observed until the conclusion of the study (Sadan, 2019).

3.8.1 Permission to conduct the study

The researcher had asked permission from the Waste Management Directorate of Collins Chabane Local Municipality to use their municipality as the study area to conduct the research as guided by the College of Environmental Science at Unisa (Appendix 2). Permission to do the research was granted by the manager of Collins

Chabane Local Municipality (Appendix 3). Ethical clearance from the Unisa-CAES Health Research Ethics Committee (reference number 2021/CAES-HREC/096) was granted to the researcher in order to start collecting data from the study area (Appendix 4). The confidentiality of the participants was protected and honoured; the names of the participants were protected, and not a single name was mentioned during the result discussion. The questionnaires administered to the participants were kept secret; only the researcher and authorised personnel had access to the questions. Collected data was used for the purpose of this study only, and any electronic gadget used to store information had a strong password that was accessed only by the researcher and sanctioned personnel. The confidential binding form was signed and attached to the dissertation as evidence showing how the researcher conducted himself or herself during data collection (Polit and Beck, 2017).

3.8.2 Informed consent

The researcher provided consent forms to the participant, stating clearly that at any given chance, if they felt like withdrawing from participating, they could do so without paying any penalty fee, provided they did not start answering the questionnaires (Appendix 5). The researcher had administered a questionnaire to personnel without mental challenges who are mentally stable, mature youth, and adults. The researcher had politely indicated that participation is on a voluntary basis, and there was no amount of money or gifts offered in exchange for the precious time they had offered to provide data.

3.9 Limitations of the study

Limitations of the study refer to any aspects that can hinder the researcher from obtaining the expected outcome according to how the chosen methodology has been stipulated (Mouton, 2020). One of the limitations of this study was the unwillingness of the community members to participate due to fear of contracting the COVID-19 virus, while others were afraid to disclose their names on the consent forms. It took a long time to collect data because some community members were not willing to participate since there were no gifts offered to them as a token of appreciation in exchange for the information. Time management became a limiting factor in the sense that the allocated time frame for data collection was not met. Not all members of the waste directorate

were interviewed as proposed; only two members were interviewed, and that became a limiting factor. Members of the community were interviewed as anticipated; however, it took longer than predicted.

3.10 Conclusion

Initially, the research used a mixed method (quantitative and qualitative) approach in order to reach the objectives and aim of the study and be able to answer the research phenomena in question, which focused on finding out the best methods to manage e-waste effectively. Questionnaires were outlined to be used during the interviews as methods to collect primary data, and observations were also done for the collection of primary data. Literature was reviewed to analyse the collected data. Limitations were taken into consideration in order to avoid any situation that could have prevented the data from being collected. Lastly, ethical consideration was taken into consideration as well, since it was a requirement to take all logistics into account with respect to all the people who form part of the study. Their rights and their dignity were considered; hence, ethical considerations were considered.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter discusses in detail the research findings on e-waste management practises at Collins Chabane Local Municipality. The results are presented in the form of tables, graphs, and pie charts and discussed using descriptive statistical analysis. The results were classified, structured, and arranged as sub-topics.

4.2 Demographic and communal profile of the households in Collins Chabane Local Municipality

4.2.1 Gender distribution and residence area of the respondents

The respondents who participated in this research were of different genders: Malamulele and Saselamani. Gender distributions revealed a higher percentage of females than males and those who preferred not to expose their gender. Figure 4.1 represents the distribution of gender that is characterised by females (51.5%), males (44.7%), and 3.8% of participants who prefer their gender not to be known. Mathako (2019) also reported the dominance of females (53%) over males (47%) from a municipal solid waste management study in Vhembe District Municipality, Limpopo Province, and this could be attributed to the higher female populations than males in the province (STATSSA, 2018). This high percentage of female respondents is also similar to an e-waste management practises study in Masoabi (2020) in Maseru, Lesotho, where female respondents constituted 65.3% more than male respondents. In terms of residence, Malamulele is a township and the headquarters of Collins Chabane Local Municipality, and many people reside in a township for the perceived better municipal services than in the rural villages (Mathako, 2019).

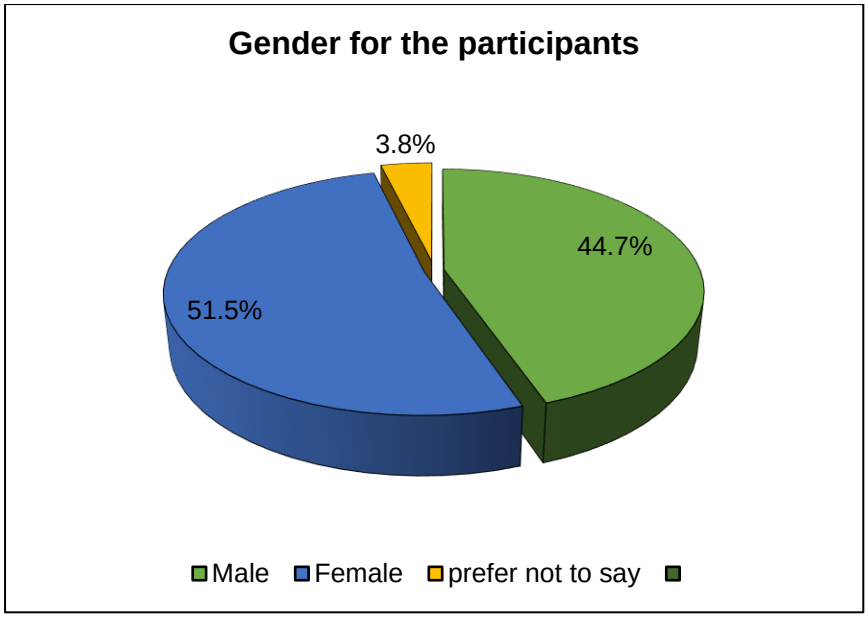

Figure 4.1: Gender of community participants

4.2.2 Age of the respondents

The respondents in this study were represented by all genders, including transgender people, between the ages of 18 and 60. Respondents were of the age groups indicated in Figure 4.2, excluding the waste pickers. Respondents in the age group 18 – 35 (31.8%) are regarded as youth and had the highest percentage of any other age group. Age groups 60 and above (11.2%) had the lowest percentage, with age groups 56 – 59 (14.1%), 46 – 55 (22.6%), and 36 – 45 (20,3%) moderately represented. IDP (2022) affirmed that Collins Chabane Local Municipality's population consists mainly of youth as compared to elderly people. However, people in the age group 46 – 55 (22.64%) had a higher percentage than people aged 36 – 45 (20.29%).

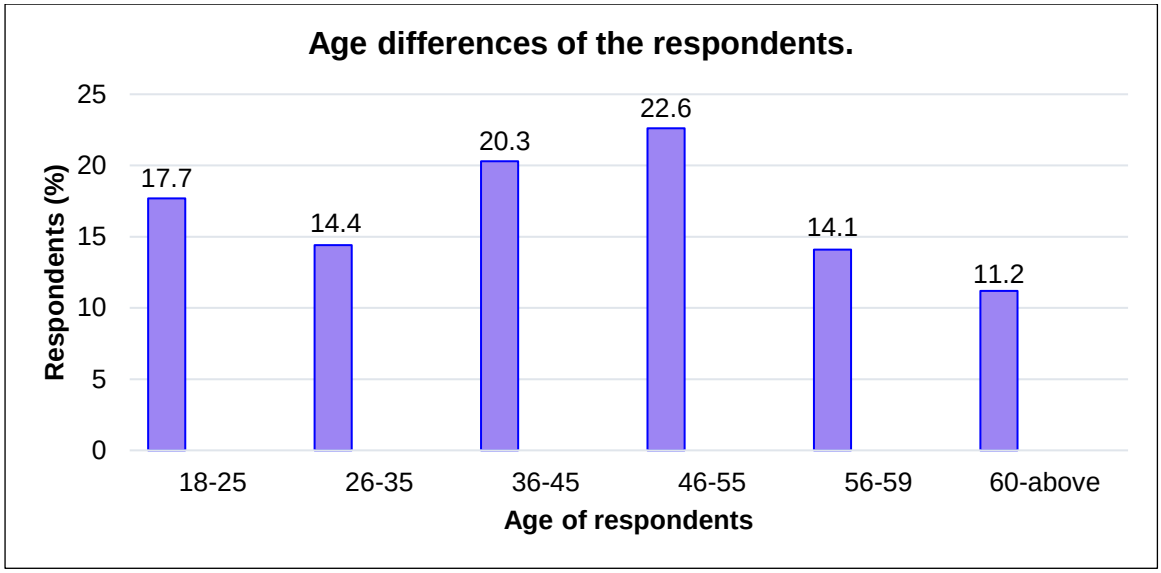

Figure 4.2: Different age groups of the respondents

4.2.3 Educational background of the respondents

Figure 4.3 represents the educational background of the households' respondents. The respondents with secondary or high school qualifications (47.1%) are more represented than other educational levels, followed by tertiary level (36.5%). Primary level and no formal education were least represented at 7.6 and 8.8%, respectively. The respondents with tertiary and secondary qualifications (80%) likely understood the questions and be able to understand the impact e-waste has on the environment.

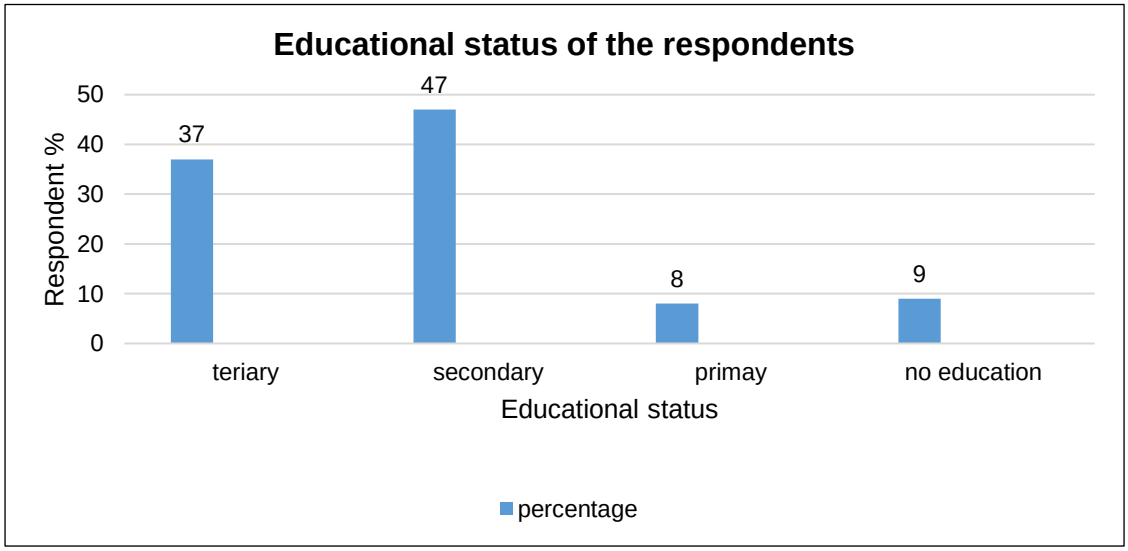

Figure 4.3: Education background of the respondents in Collins Chabane Local Municipality

However, Kitila (2018) showed that communities with higher educational qualifications in Kampala had a negative impact on e-waste management and disposal methods. Those findings are like those of Mkhwanazi (2021), where communities with higher education levels in eThekwini Municipality in KwaZulu-Natal Province, South Africa, were not able to separate their waste. Thus, this suggests that the management of e-waste is not influenced by the level of education but rather by ignorance. On the contrary, household respondents in the toxicity evaluation of e-waste study in China showed an inversely positive attitude toward waste separation (Duan *et al*., 2020).

4.2.4 Employment status of the respondents at Collins Chabane Local Municipality

Figure 4.4 provides an overview of the employment status of the respondents at Collins Chabane Local Municipality.

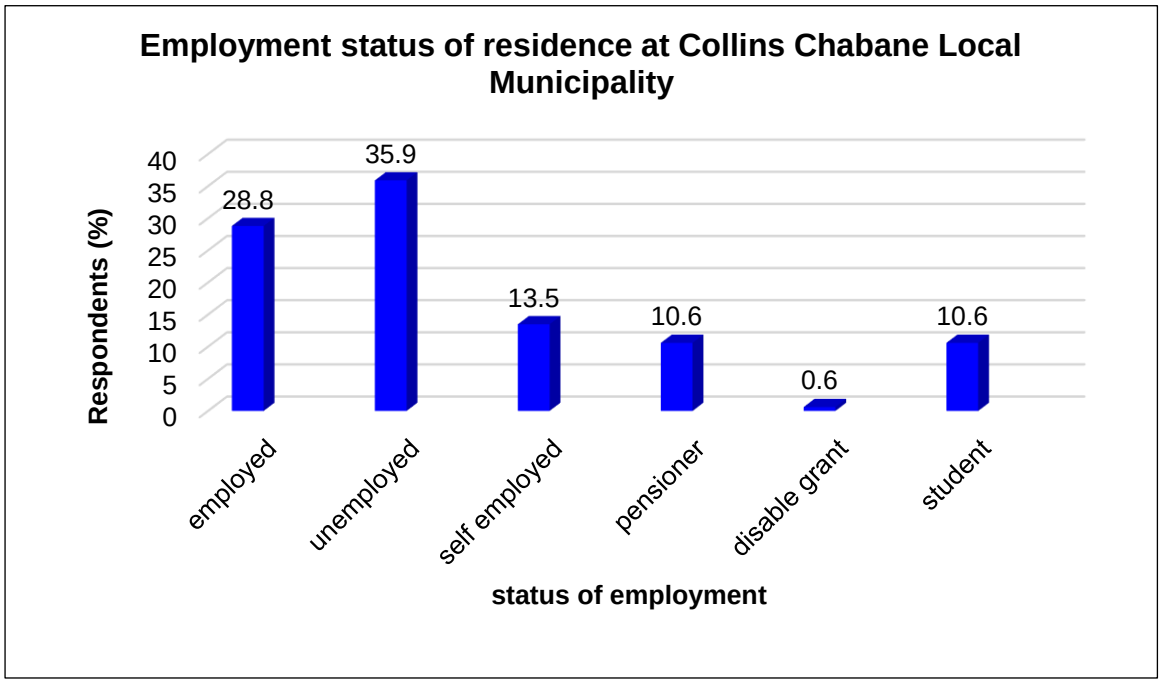

Figure 4.4: Employment status of the respondents at Collins Chabane Local Municipality

As shown in Figure 4.4, a total of 35.9% of the respondents in Collins Chabane Local Municipality were unemployed. Students (high school and/or tertiary) and pensioner groups participated, comprising 10.6% each. Adults depending on disability grants were least represented at 0.6%. Self-employed respondents comprised 13.5%, and

the group of employed participants was at 28.8%. Geographically, Collins Chabane Local Municipality is situated next to the abundance of wildlife in the Kruger National Park, Punda Maria Gate, which presents an opportunity for tourism; however, the employment rate presented by tourism is still low (IDP, 2022). The employment rate in South Africa is not growing according to population (Statssa, 2022), and young graduates are the most disadvantaged group as compared to other age groups. Figure 4.4 shows that the working class at Collins Chabane Local Municipality comprises people at the age of 36 and above rather than youth, yet the highest population of residence at the municipality is young people (IDP, 2022).

The findings of the Statistics South Africa report no. P0318 of 2022 revealed that the graduate unemployment rate remains comparatively low as compared to those of other educational levels. However, unemployment among the youth continues to be a burden, regardless of educational achievement, and the youth at Collins Chabane Local Municipality are no exception (IDP, 2022; STATSSA, 2022). The employment status of the respondents was not classified; therefore, the study did not disclose or estimate the income of the employed dependents. However, other studies revealed that level of income had an influence on the socio-economic status of respondents, and that can also have an influence on the amount of e-waste a household can generate (Uhunamure *et al*., 2021). A study by Viljoen *et al.* (2021) affirmed that socio-economic status can influence how e-waste is generated within the community. The findings in the current study at Collins Chabane Local Municipality reveal that 50% of respondents are employed when putting together the self-employed and the employed; therefore, the outcome of waste generation is likely to be influenced by the socio-economic status in a study area.

The findings of the current study revealed that most of the families have 5–6 members (49.1%) per family, on average, followed by 3–4 members (28.5%), while families with at least 7 and more members were at 22.4%, as indicated in Figure 4.5.

The average household size is 33.3%, which is equivalent to a mean size of 3.3 members per household. This is an indication that most households in the study area have a medium family size, which might have an influence on the volume of e-waste generated (Kitila, 2018). These findings are similar to those of Almulhim (2022), where

it was found that the size of the family determines the amount of waste families can generate.

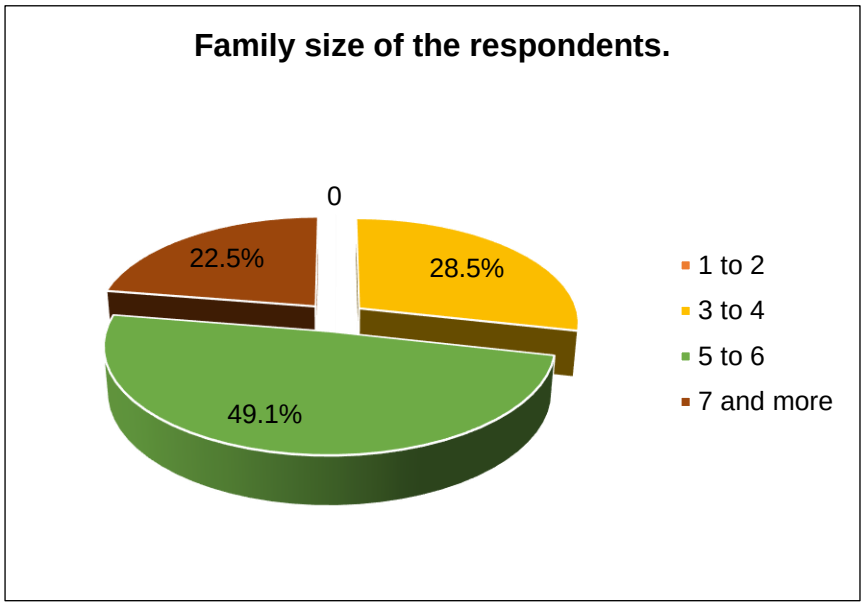

Figure 4.5: Family size of the respondents at Collins Chabane Local Municipality

4.3 Generation, causes of e-waste and types of ICT owned by different households of Collins Chabane Local Municipality

Data on e-waste generation, causes, and ICT owned in different households of Collins Chabane Local Municipality were collected through questionnaires over a period of 3 months (July to October 2022). e-Waste generated in the study area was categorised as ICT, garden appliances, smaller household appliances, or bigger household appliances (Ledwaba & Sosibo, 2017). The percentage of e-waste generation causes and ICT present at different households are provided in Figure 4.6.

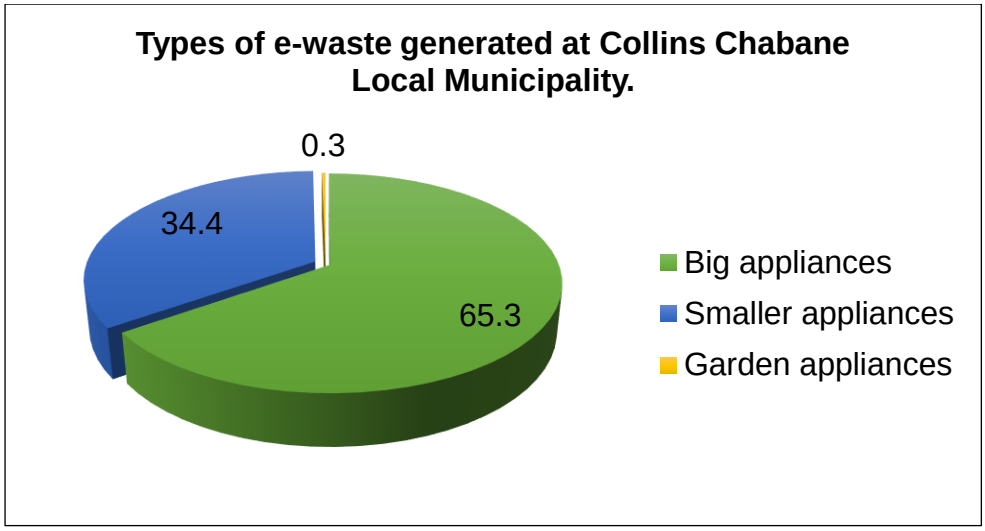

Figure 4.6: Types of e-waste generated at Collins Chabane Local Municipality

Figure 4.6 shows that bigger household appliances such as refrigerators, TVs, freezers, electric stoves and washing machines constitutes higher percentage (65.3%), whereas smaller household appliances such as Kettles, Irons, Fans, hair dryers, toasters, grillers, lights, and microwave ovens constitutes 34.4% with garden appliances consisting of 0.3%. Additionally, Figure 4.7 indicates the breakage (79.4%) of electrical appliances as the key factor for e-waste while 5.6% and 14.4% of the e-waste was due to the appliances being outdated and reached its life span respectively.

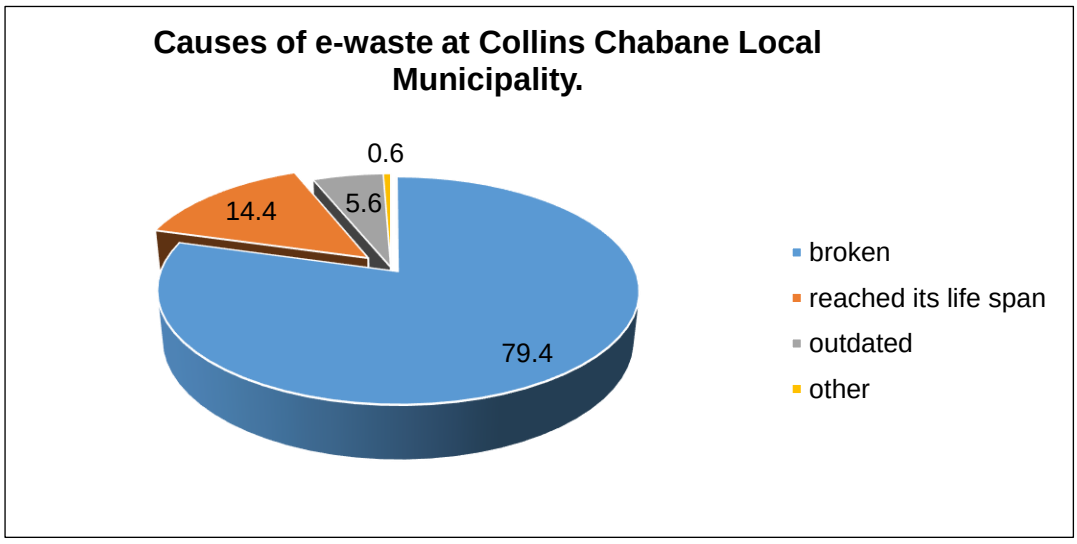

Figure 4.7: Causes of e-waste generation at Collins Chabane Local Municipality

The cause of 0.6% of the e-waste generated was not specified. The current study concurs with findings from previous studies where it was found that the major cause

of e-waste generation in Polokwane, Limpopo Province, was the breakage of household waste EEE (Uhunamure *et al*., 2021) and that malfunctioning of household appliances led to the generation of e-waste in higher volumes in Maseru, Lesotho (Masoabi, 2020).

Figure 4.8 shows that 93% of respondents per household owned more than one telecommunications appliance. Similar results were reported by Almulhim (2022) in Saudi Arabia, where most of the electrical devices generated by the community in Dammam were cell phones and TVs. Almulhim (2022) indicated further that the kind of ICT owned the most was cell phones, followed by laptops, desktops, and tablets. Hence, Maphosa (2021) found that the use of cell phones, in particular smart phones, has become one of the needs of communication since the outbreak of the pandemic COVID-19, which was supported by Almulhim (2022), who found that the lifespan of cell phones has been reduced, thus making the production of other smart phones in high demand. Moreover, people are embracing the use of online shopping, which requires one to have an ICT gadget with relevant features to meet the requirements of shopping online, online schooling, and online meetings; hence, the practise increases e-waste generation (Bimir, 2020; Maphosa, 2021).

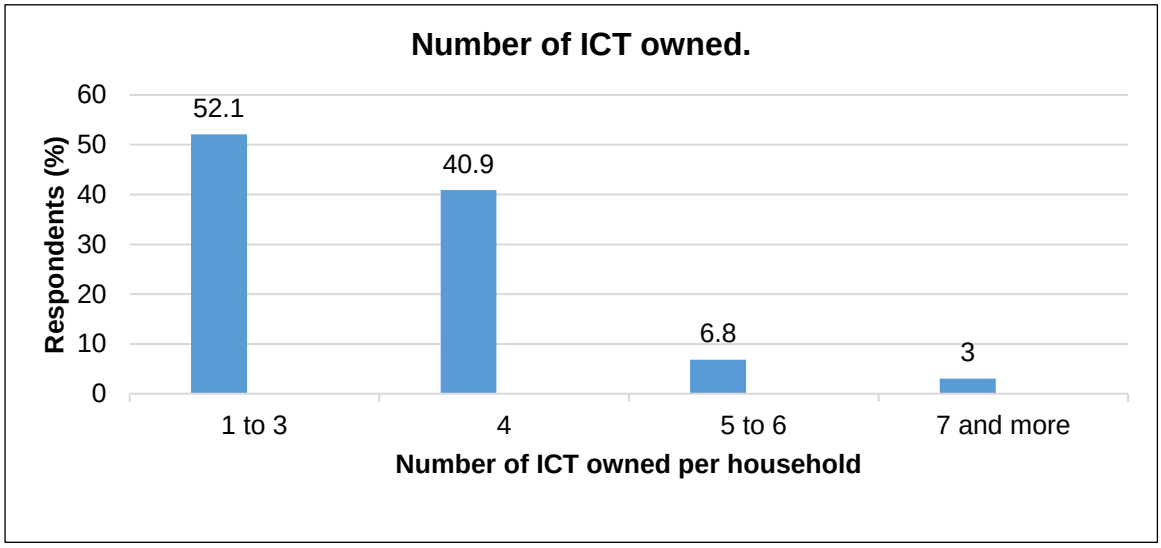

Figure 4.8: Types of ICT owned in different households of Collins Chabane Local Municipality

Figure 4.9 shows that 76% of the respondents in both Saselamani and Malamulele replace their ICT when there is a need to do so, while 19% change their ICT every two

years, 3% change their ICT annually, and 1% do not indicate a specific time they change their ICT. Similarly, Attia *et al*. (2021) revealed that 29% of respondents were found to be changing their cell phones after a three-year cycle, while 22.8% were changing their cell phones after a two-year cycle. Furthermore, changing mobile phones on a two- or three-year cycle can be influenced by the reduced life span of some mobile phones, which has been reduced from four years to three or two years (Awasthi, Zeng & Li, 2015). Other studies indicated that repairing electrical devices such as laptops, desktops, and cell phones is generally more expensive than purchasing a new one with better features; hence, they change these gadgets in a two- or three-year cycle (Bimir, 2020; Attia *et al*., 2021; Rahul *et al*., 2021).

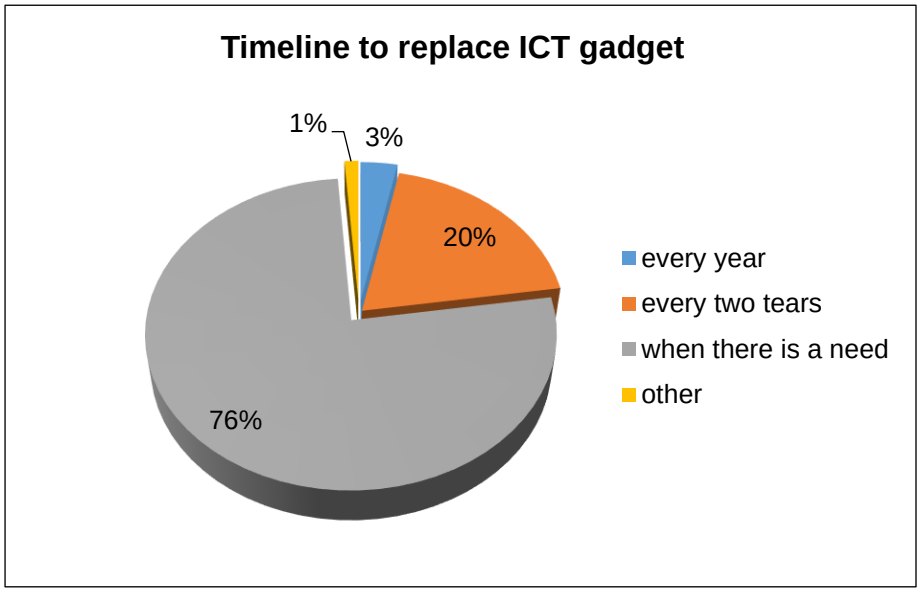

Figure 4.9: Timeline for ICT gadget replacement (cell phones)

4.4 Management of e-waste in Collins Chabane Local Municipality

4.4.1 e-Waste management methods used in Collins Chabane Local Municipality

Proper management of e-waste is integrated into knowledge, perception, and thorough e-waste education, which is neglected and overlooked in developing regions of the African continent (Uhunamure *et al*., 2021). To date, South African local municipalities have not yet implemented the collection of e-waste in the same way as the collection of municipal solid waste (Ledwaba & Sosibo, 2017), due to insufficient instruments relevant to managing e-waste, and Collins Chabane Local Municipality is no exception. Most people are keeping various e-waste in their storage rooms

because they do not consider it appropriate to throw it in the garbage (municipal solid waste). Figure 4.10 illustrates the management of e-waste at Collins Chabane Local Municipality and points out that 47% of residents keep e-waste in their houses, while 22.9% prefer to sell it. Some prefer to keep their e-waste (likely to be smaller electrical appliances classified under ICT, such as cell phones, tablets, and chargers) either in the store room or chest drawers (16.8%), which is like Botswana residents (Mmereki *et al.*, 2015).

Furthermore, 21.8% of the respondents in Collins Chabane Local Municipality were unable to manage e-waste properly since they did not know the best methods to dispose of it. Additionally, 20.6% just keep their e-waste because they do not know what to do with it. Besides, 17% of the respondents indicated that they manage e-waste by repairing it, with only 6% wishing to recycle their e-waste.

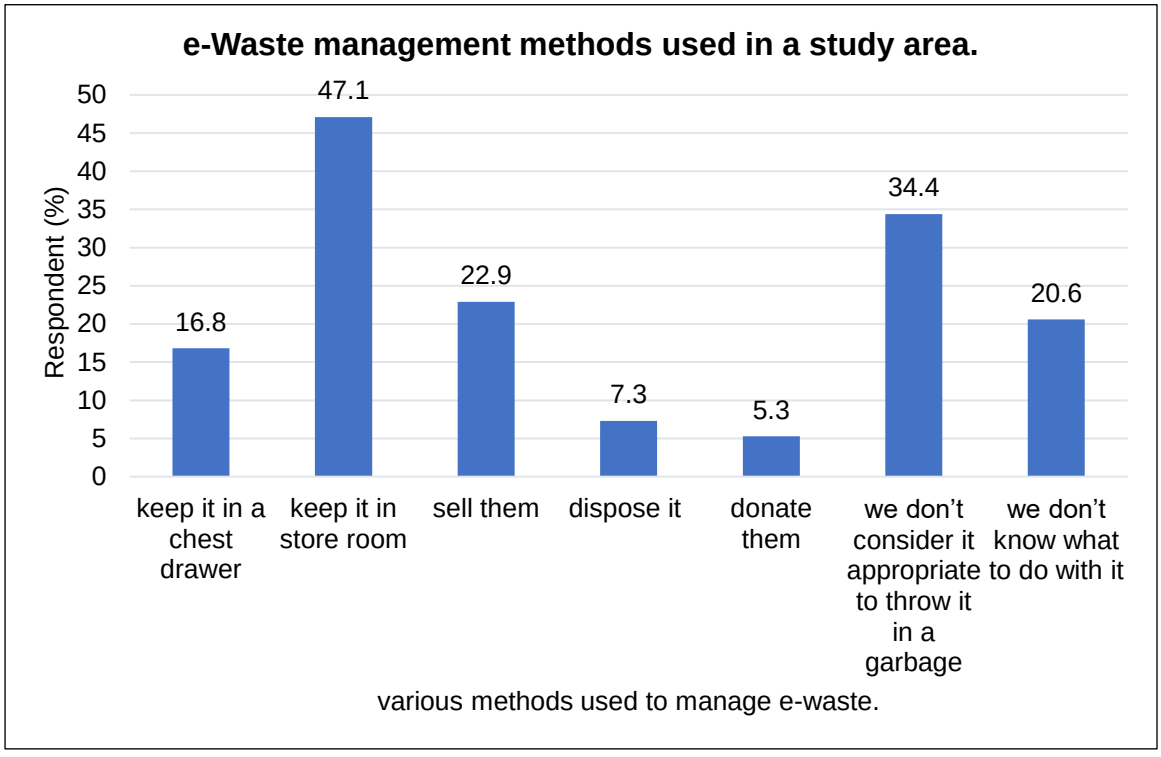

Figure 4.10: Various methods used to manage e-waste in a study area

The findings of the current study are like those of Ichikowitz and Hattingh (2020), where it was revealed that lack of knowledge on how to manage e-waste properly was the reason respondents kept their unused electrical devices in storerooms. Attia *et al.* (2021) and Amechi and Oni (2019) confirmed that communities keep dysfunctional

mobile phones in their houses as a matter of keeping them safe. On the contrary, Sakr *et al.* (2021) indicated that some households manage e-waste by burning it with the aim of recovering precious elements such as copper. The findings in the current study reflect a clear lack of knowledge and understanding about e-waste management. Besides not having some knowledge about e-waste management, the respondents were not able to store e-waste safely. Interestingly, all these findings are indicative of the improper ways in which various communities from different regions manage e-waste (Sakr *et al.*, 2022).

To understand the management practises further, respondents were asked what they exactly do with their e-waste. The results indicated a level of misunderstanding among the respondents. As shown in Figure 4.10, 80% of the respondents collectively stored their e-waste because either they did not know what to do with it or they did not consider it appropriate to throw it in the bin. Hence, Figure 4.11 indicates that 35.6% store their e-waste, 38.2% sell it to scrap dealers, 24.1% give it back to the company for services, and 2.1% sell it to e-waste business dealers. Yet in figure 4.12, 53% of respondents indicated that in their area there is no company recycling e-waste. meaning that those who indicated to be selling their e-waste to scrap dealers (24.1% dealing with e-waste) or to e-waste business dealers (2.1%) were confused, and that tells us they really do not understand e-waste management. Nevertheless, respondents who are storing their e-waste (35.6%) do not contradict the results presented in Figures 4.11 and 4.12. The kinds of responses indicated by respondents in Figure 4.11 reflect a lack of knowledge and understanding about e-waste management.

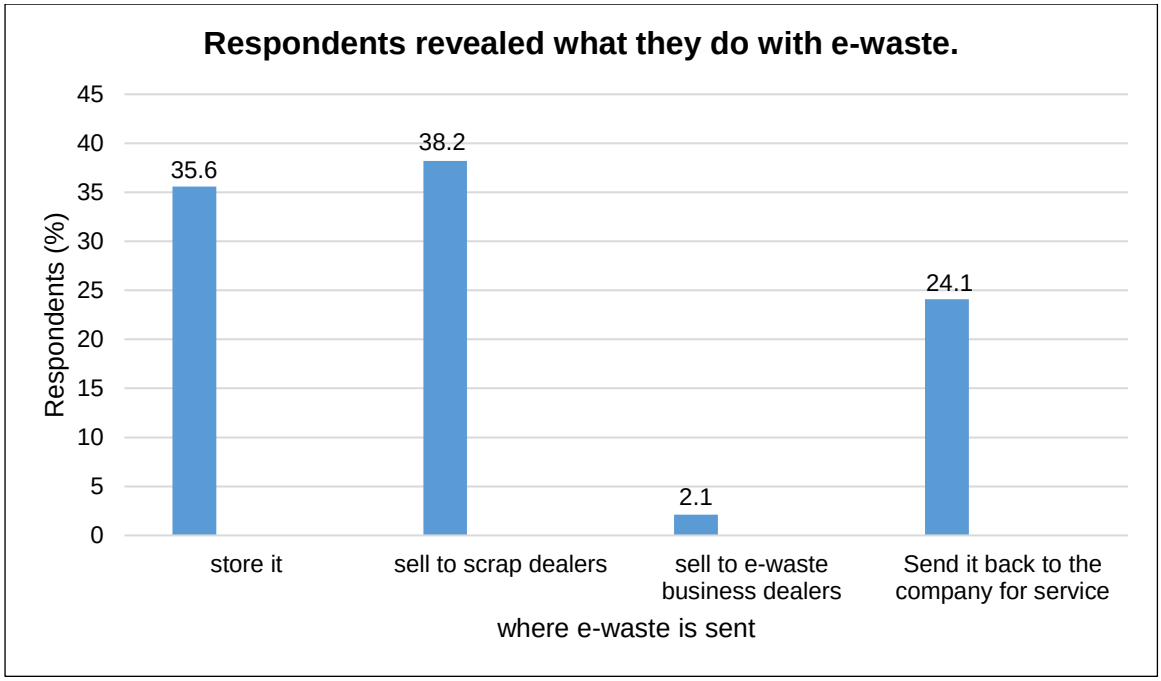

Figure 4.11: Showing what respondents do with their e-waste

4.4.2 Knowledge and the desire to recycle e-waste by communities of Collins Chabane Local Municipality

Most of the respondents (73%) indicated that they do not store their e-waste according to categories, while 27% categorically store their e-waste. Collins Chabane Local Municipality is still in its developing stage, and it is rare to have the availability of feasible recycling companies dealing with e-waste. Figure 4.12 illustrates that 53% of independent variables from Saselamani and Malamulele were not aware of (dependent variable) of any e-waste recycling companies closer to their area. Although some respondents (28%) were aware that e-waste recycling companies do exist, while 15% were knowledgeable that their areas did not have any existing companies dealing with e-waste, only 4% agreed that they had a recycling company in their area. Similarly, Dzah, Agyapong, Apprey, Agbevana and Kagbetor (2020) reported that 53% of Ho Municipality in Ghana did not have an e-waste recycling company.

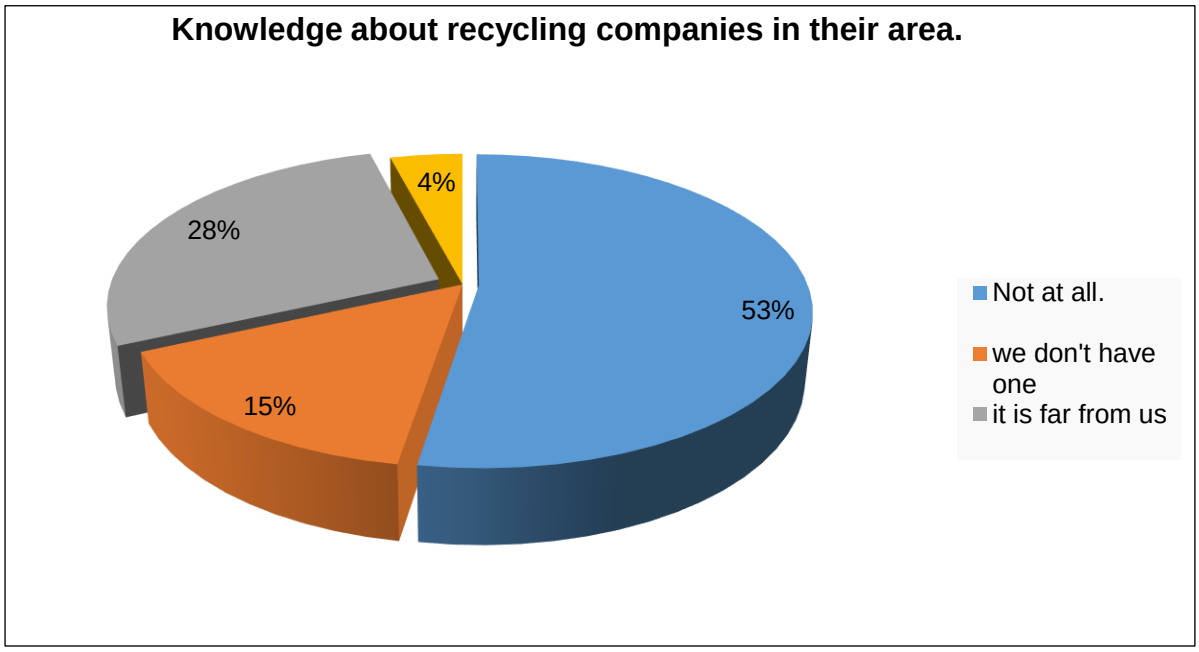

Figure 4.12: Showing the knowledge about recycling companies in their area

The findings in this study are like those of Masoabi (2020), where communities in Namibia were keeping their old and broken electrical devices in their houses. Similarly, Uhunamure *et al.* (2021) confirmed that Limpopo Province residents were keeping their broken electrical devices, hoping to get them fixed, and were donating their old phones to NGO's or less fortunate people. However, Mmereki *et al.* (2015) suggested that one of the reasons respondents manage e-waste by keeping it rather than contributing to reducing e-waste through recycling is a lack of knowledge.

According to second objectives to evaluate the factors influencing the community awareness on e-waste, figure 4.12 shows that independent variables with higher percentage were not knowledgeable of the dependent variable. This was the same case across the other variables, the dependent variables had lower percentage (ratio) with negative effect of 0 as compared to independent variables. The independent variables influenced the dependent variable negatively. Demographic area had equal number of respondents, but their family size and socio-economic aspects such as employment and education had a negative influence towards the dependent variable. Most independent variables from Saselamani had higher number of families, unemployment rate and average level of education, hence it played a role indicating a lack of knowledge in terms of e-waste management practices. The ratio of the outcome

was (0;1), since the dependent variable took a value of 0 because the respondent (independent) was not aware of any e-waste management practices in the community.

Figure 4.13 shows that respondents (60%) showed their interest in recycling electrical devices, provided there is a recycling company they can send their devices to, but 6.8% did not show any interest in recycling their devices, while 33.3% were undecided about recycling e-waste.

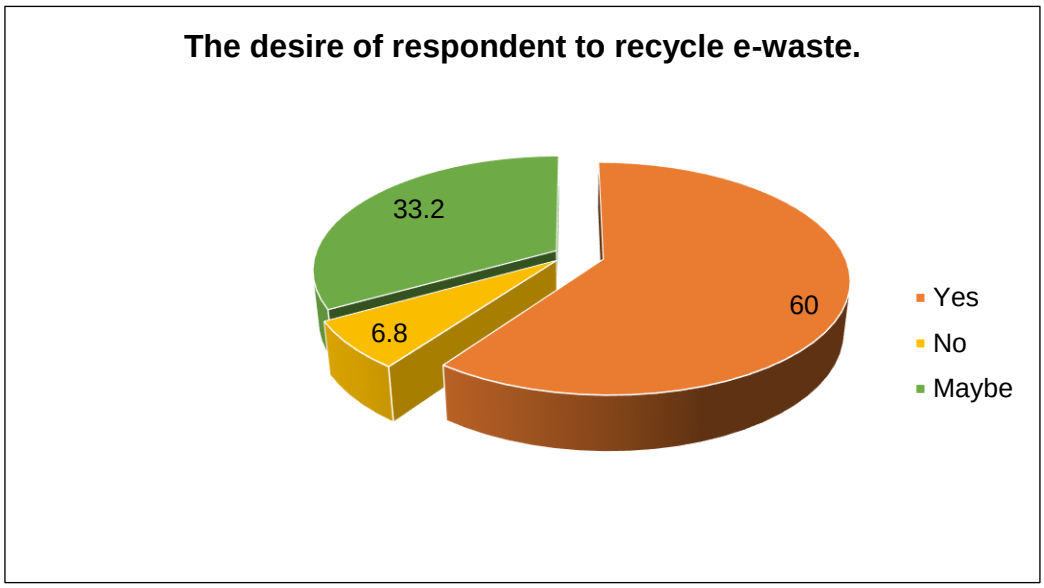

Figure 4.13: Chart showing the desire to recycle e-waste

However, a study by Ichikowitz and Hattingh (2020) revealed that residents of Mangaung were concerned about recycling e-waste, for they believed devices like cell phones carried personal information, and therefore, they would rather keep it safe than recycle. Additionally, Mkhwanazi (2021) confirmed that 7% of households were sending their e-waste for recycling; hence, the current study concurs that the highest number would prefer to recycle their e-waste. Moreover, 60% of the respondents showed their willingness to recycle their e-waste. This is like the outcome by Attia *et al*. (2021), where almost 80% of the respondents were willing to participate in e-waste recycling. The findings of this study are like those of Dzah *et al.* (2022), who indicated that Ho Municipality in Ghana did not have a recycling company; therefore, communities were unable to send their e-waste for formal recycling.

Should the response from Collins Chabane Local Municipality be given the platform to send obsolete appliances to a recycling company, they can recover a lot of valuable

materials that can be used to make other electrical appliances. However, recovering e-waste can be fruitful only if the correct procedure to recycle is known (Dzah *et al.*, 2022).

Additionally, Alabansa *et al.* (2021) show that e-waste generated from ICT and laptops has greater potential to be recycled. Furthermore, Ichikowitz and Hattingh (2020) attested that precious metals like gold, silver, and copper can be recovered from mobile phones, laptops, TVs, LCDs, and desktops. Moreover, both Attia *et al.* (2021) and Rahul *et al.* (2021) also attested that recycled e-waste has the highest potential for recovering valuable materials that can be reused.

These include valuable materials such as e-plastic, glass, iron, aluminium, copper, and precious metals such as silver, gold, and others that can be recovered from e-waste. Recovering such materials can save on the production of virgin materials while saving electricity and the environment at the same time (Dias *et al.*, 2019). It is unfortunate that most developing countries are still experiencing challenges where e-waste is either stored in households or informal recycling of e-waste occurs due to a lack of proper legislation put in place and poor enforcement of policy (Ohajinwa *et al.*, 2018).

4.5 Collections, transportation, and disposal of e-waste

Collection, transportation, and disposal of e-waste need to be done effectively to avoid negative impacts from hazardous elements found in them (Uhunamure *et al.*, 2020). Rahul *et al.* (2021) indicated that certain perilous quantities of e-waste need exceptional treatment and, therefore, need to be disposed of safely. According to the environmental officer of Collins Chabane Local Municipality, to this date, the municipality has not collected e-waste; however, municipal solid waste is being collected at Malamulele and sometimes at Saselamani. IDP (2019) also revealed the areas that are getting solid waste removal within the wards of Collins Chabane Local Municipality, but e-waste is not classified anywhere in their collection roster, though e-waste is classified as hazardous substances (Ohajinwa *et al.*, 2018).

The respondents indicated different collection methods for e-waste in their areas. As illustrated in Figure 4.14, 38.2% indicated that waste is collected from their households by Extended Public Work Programme (EPWP) workers twice per week at 29.7%.

Municipal waste collections take place once per week at 33.8%; hence, the percentage representing municipal collection is 37.3%. Those who are doing self-disposal of waste are at 24.4%, and they dispose of it once a month at 35.9%.

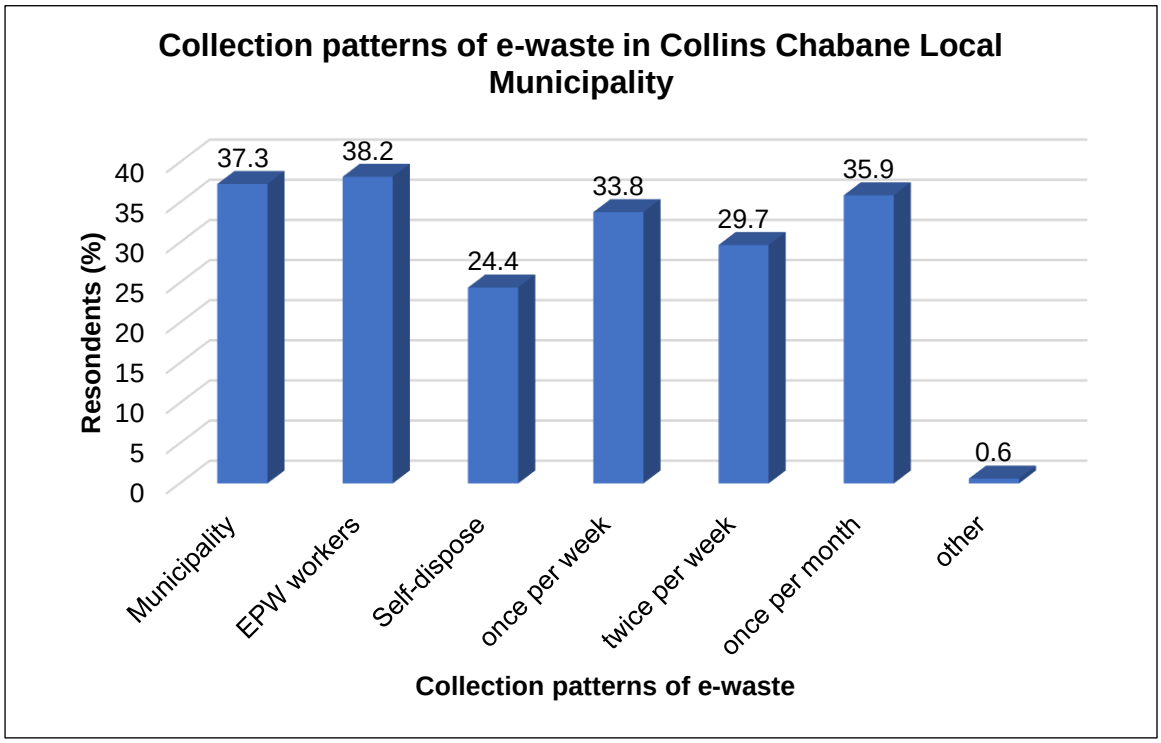

Figure 4.14: Collection patterns of e-waste in Collins Chabane Local Municipality

All respondents agreed that though the municipality or EPWP workers are collecting waste, e-waste is not part of the waste collected, and their statements support the statement given by the environmental officer interviewed. Others (24.4%) use other methods not mentioned in the questionnaire, but in most cases, they choose to burn or bury their waste at the back of their houses. According to the environmental officer dealing with waste at Collins Chabane local municipality, Malamulele is the township that is fast developing (IDP, 2019). Waste is collected daily according to different sections since they have fewer resources to collect waste; hence, the highest percentage (70%) represents the area where waste is collected either by EPWP workers or the municipality.

The findings of the current study are similar to those of Viljoen *et al.* (2021), where some communities in Hantam Municipality were burying their waste in the backyards of their houses. On the contrary, the findings from Mkhwanazi (2021) show that municipal trucks at eThekwini Municipality collected all types of waste and transported

it to the landfill sites. Due to a lack of knowledge of proper management of e-waste, 41% of the respondents in eThekwini Municipality were disposing of their e-waste together with municipal solid waste, which ended up in landfill sites; hence, 20% were sending their e-waste for recycling, and 2% were disposing of e-waste illegally. Logically, 63% of respondents in eThekwini continued to dispose of e-waste in a manner that was affecting the environment (Mkhwanazi, 2021). On the contrary, respondents from the rural township of Malamulele and the rural village of Saselamani did not receive any collection of e-waste from their municipality since their by-laws did not regulate the management of e-waste.

Respondents from Malamulele and Saselamani were aware that 37.3% of e-waste collection is handled by the municipality. Unlike the respondents from Mangaung Metropolitan Municipality in a study by Ichikowitz and Hattingh (2020), respondents at 75% were not observant of how e-waste collectors handle it. Lack of educational awareness on e-waste matters by relevant stakeholders, including the leading government in its municipalities, might be the reason why respondents at Mangaung were not aware of how e-waste is being handled by collectors in their areas (Viljoen *et al.*, 2021). The e-waste management methods practised by respondents in Saselamani and Malamulele are attributed to a lack of awareness concerning e-waste. As far as the collection of e-waste is concerned, as indicated in Figure 4.14, there is no transportation of e-waste since there is no collection of e-waste. However, municipal solid waste collected is transported by the municipal truck and disposed of at the landfill site (IDP, 2021).

According to the information illustrated in Figure 4.14, collection patterns reflect that waste is collected either by the municipality or EPWP; nevertheless, communities indicated that there was no consistency in terms of days of waste collection. These results are similar to the outcome of a study by Viljoen *et al.* (2021). A study by Rahul *et al.* (2021) suggested that inconsistency in the collection of e-waste or solid waste promotes burning or burying of waste. Conversely, Attia *et al.* (2021) established that collection of e-waste that is not consistent may lead to a high surge in illegal dumping. Collins Chabane, the environmental officer interviewed, confirmed that the challenge they faced as the municipality was illegal dumping. Although respondents are keeping most of their e-waste in their houses, without some knowledge on how to manage it

safely, that waste stands a chance to be burned or buried along with other types of waste.

Since other respondents from Saselamani are likely to bury yard waste, burn it, or dump it into their nearby streams, they are likely to dispose of e-waste the same way they do with other types of municipal solid waste. This finding matches the results of Mihai *et al.* (2019), affirming that uncollected household waste ends up being burned and/or dumped as an alternative to managing waste. Similar results were reviewed in a study by Ogbenna and Raymond (2018), which found that e-waste was found disposed of in the mix with other solid waste on the streets of Minna State in Niger. This kind of practise is encouraged by the fact that most developing countries do not have incineration infrastructure for e-waste, and Collins Chabane Local Municipality and other municipalities like metropolitan municipalities in South Africa are not exceptional (Viljoen *et al.*, 2021).

4.5.1 Observation checklist of waste collection and disposal at Saselamani

The results indicated in Figure 4.14 contradict the observation checklist used by the researcher to monitor the collection and disposal of waste in a study area. During the observation that occurred for three weeks from the last week of June 2022 until the 14th of July, no municipal truck was seen collecting waste from the village, except from the business site picking up the skip filled up with solid waste and e-waste. Some burned waste was observed lying at the corners of their yards, especially at those stands on the outskirts of the village.

Figure 4.15 was captured at the corner of the fence in one of the families at Saselamani. The family had already burned solid waste but could not burn e-waste, and it seems as if it was not long before the obsolete e-waste was disposed of in that place.

Figure 4.15: Burned solid waste mixed with of old electric kettle and extension cable, at the back yard of the house in Saselamani village. Source: Makamu

Figure 4.16 was captured at the outskirts of the village (Saselamani); these cables were burned together with papers, an old electric kettle, and other solid waste, but the cables were not burned up completely.

Figure 4.16: Burned e-waste mixed with a bit of solid waste at the outskirt of Saselamani village. Source: Makamu

The researcher observed that most of the respondents at Saselamani practise on-site waste management more than off-site management. The findings from the current study support the outcome of the report by Forti *et al.* (2020) on the global state of e-waste, which indicated that regions like Ghana, India, and Nigeria practise managing e-waste through burning or dumping on open land due to poor enforcement of regulations related to e-waste management. Furthermore, the non-availability of

formal recycling companies, a lack of collection sites, and a lack of educational awareness contribute to the illegal dumping or burning of waste (Mihai *et al.*, 2019; Forti *et al.*, 2020).

The findings from the study indicate that, according to the interviewed municipal officers from the waste directorate at Collins Chabane Local Municipality, when the skip of waste from the business area of Saselamani is full, the waste collectors transport it to a landfill site to dispose of it. However, that waste is not separated from the point of collection or even from the landfill site. Similar findings were reported at Hantam Municipality in the Northern Cape (Viljoen *et al.*, 2021).

Additionally, a lack of enough funds allocated to the waste directorate and limited infrastructure in local municipalities in remote rural areas for waste collection could be factors in the irregular collection of waste, which results in increased chances of burning or illegally disposing of waste in general. Furthermore, Mmereki *et al.* (2015) suggested that limited funds, at times political activities, a lack of clear regulations on e-waste management, limited infrastructure, and weak enforcement of policies dealing with e-waste management in developing countries play a major role in improper management of e-waste, as Alabansa *et al.* (2021) attested in their study.

4.5.2 Observation checklist of waste collection and disposal at Malamulele

The researcher observed that most of the respondents at Malamulele Township used off-site waste management methods. Viljoen *et al.* (2021) defined off-site waste management as the management of waste where the municipality provides bins to the communities and does collection, transport, and disposal of waste. According to the observation made by the researcher in this study, most of the households at Malamulele had container bins at their gates on the day the municipal truck was collecting waste. The observation confirmed the information presented in Figure 4.14. However, some new sections (new section B and new section D, known as the Mavandla area) did not have bins. New Section D of Malamulele did not receive a service of waste collection at all, and they form part of the 38.2% who are getting service from EPWP workers, as illustrated in Figure 4.14. Open fields in Section D, next to the streams, were used as dumping areas while others burned their waste. Nevertheless, other sections, like sections A, B, and C of Malamulele Township,

received waste collection services on different days. Though in all collections there was no special collection of e-waste, this is because the by-laws did not regulate the collection of e-waste to this extent, even though it is regarded as hazardous waste.

During waste collection, there was no separation of waste, which suggests even e-waste can somehow be mixed with other types of waste and end up reaching landfill sites (IDP, 2019). A man was observed pushing a wheel barrow filled with old goods, including a broken microwave, a broken electric sewing machine, and corrugated iron, which were supposed to reach the landfill site. The researcher observed that both Malamulele and Saselamani residents were unable to separate their waste; nevertheless, some broken goods that were too big to fit into the container bins were placed next to the bin rather than forced into the bin.

4.6 Community awareness of e-waste, impact of e-waste on the environment and human health

4.6.1 Community awareness on e-waste

Respondents were asked if they had ever heard of the word or term "e-waste." About 56.8% of respondents had no perception of the concept; nonetheless, 42.6% were aware of the concept of e-waste. The concept of "e-waste" was defined, and the respondents were asked if the definition given was correct. This was done to get a deep insight into the knowledge of e-waste awareness from the respondents. As illustrated in Table 4.1, about 50% were uncertain if the concept was correct or not; hence, 33.8% agreed that the concept was correct, and only 16.2% said the concept was incorrect. The concept given about e-waste was correct; however, 66% of respondents could not give an accurate answer because they were not knowledgeable about e-waste. Considering the results obtained, it is a clear indication that educational awareness needs to be given to these communities on e-waste management matters. These results are similar to the outcomes attained by Attia *et al.* (2021) and Borthakur (2022), where about 73% of respondents were not aware of or understood what e-waste is or the complications it can cause to the environment or human health.

Table 4.1: Indicating different awareness on e-waste

Characteristics on e-waste awareness	Frequency	Percentage
Have you ever heard of the word e-waste?		
Yes	145	42.6
No	2	0.6
Not sure	193	56.8
Is the statement below, correct?		
e-Waste refers to any electrical appliances that has reached its lifespan.		
True	**115**	**33.8**
False	**55**	**16.2**
Not sure	**170**	**50.0**
Are you aware of electrical appliances containing hazardous elements		
Yes	143	42.1
No	197	57.9
Are you aware of e-waste in your house that need to be dispose in a special way?		
Yes	166	48.8
No	174	51.2
Do you think electronic devices like TV contains hazardous substances?		
Yes	265	77.9
No	75	22.1

Kitila (2018) indicated that 60% of respondents were aware of the concept of e-waste, which was the lowest percentage as compared to the percentage of respondents at Collins Chabane Local Municipal. The study indicated further that the results were influenced by the level of education and awareness respondents acquired. Simiari *et al.* (2018) affirmed that a lack of essential educational awareness towards e-waste contributes to the way e-waste is managed in developing countries. In a study conducted in Lesotho, it was revealed that a lack of public awareness and information concerning e-waste is the factor that results in improper management of e-waste

(Masoabi, 2020). One other explanation given in a study of Masoabi is that the waste management directorate of the municipality should run an awareness programme on waste-related matters to educate the communities, such as the “cleanest town or village” campaign. Mkhwanazi (2021) affirms that clean-up campaigns and environmental education can be used by local municipalities as a tool to empower their communities with correct information on how to handle e-waste management properly, and that was also attested to by Almulhim (2022).

Knowledge is precious, and therefore any human being empowered by correct knowledge on e-waste management will be of great relief to most municipalities. Viljoen *et al.* (2021) suggested that communities from remote rural areas deserve to be educated on matters related to waste management, including e-waste, for them to act accordingly. Viljoen *et al.* believe that empowering people in rural and remote areas with enough information on waste management can change their perception of how to handle all types of waste. Local municipalities, such as Dr JS Moroka, integrated with the Department of Agriculture, Rural Development, Land, and Environmental Affairs (Dardlea) within the municipality to run clean-up campaigns, cleanest town competitions, global warming competitions, and green school competitions to reach their communities and educate them about waste management (IDP, 2019). Viljoen *et al.* (2021) mentioned that the local municipality at Hantam Municipality had already employed an environmental education coordinator to assist in bringing awareness to the communities about the issues related to waste management, including e-waste.

According to the Vhembe District integrated development plan (2022–2023), Collins Chabane Local Municipality contracted two young people (youth) to facilitate environmental education and awareness that also includes waste clean-up campaigns. Should the programme run smoothly, Collins Chabane Local Municipality communities are likely to be educated and empowered about environmental issues, including the management of waste, in particular e-waste.

4.6.2 Community awareness on the impact of e-waste on the environment and human health

Table 4.2: Indicating community awareness on the impact of e-waste.

Are you aware of the impact of e-waste on the environment?	**Frequency**	**Percentage**
Yes	119	35.0
No	221	65.0
Are you aware of the impact of e-waste on human health?		
Yes	129	37.9
No	211	62.1

Respondents were asked to fill out another questionnaire to determine if they were aware of the negative impact e-waste can pose to the environment. Most of the respondents (65.0%) indicated that they were not aware of any danger e-waste can cause to the environment. Moreover, they were not aware of how this e-waste can pose a danger to the environment. However, 34.7% knew that e-waste can affect the environment negatively. In terms of human health, about 37.9% were conscious of the negative impact e-waste has on human health, but 62.1% were not aware of such a problem. This result concurs with findings from Rahul *et al.* (2020), where respondents were not aware of the effects e-waste had on human health and the environment. Similarly, Mkhwanazi (2021) affirmed that 63.1% of respondents lacked knowledge in terms of the dangers that e-waste can cause to the environment and/or human health. Hence, 33% of the respondents were sensible about the risks e-waste poses to the environment. One explanation for the perception of respondents in eThekwini and the lack of knowledge of the respondents in Collins Chabane Local Municipality could be the lack of policy enforcement and the implementation of regulations about e-waste.

In South Africa to date, e-waste has already received enough attention (Grant, 2019), but it seems as if there are network gaps in terms of the flow of information from national government institutions to local institutions regarding e-waste policies. This is being witnessed through the findings of Uhunamure *et al.* (2021), Mkhwanazi (2021), Viljoen *et al.* (2021), and the results of the current study. It is high time that local

municipalities start to amend their by-laws about municipal solid waste to cater for e-waste and educate their communities about the accountable management of e-waste that is environmentally friendly and can lead to preserving the environment and protecting the health of individuals.

The knowledge and awareness communities have towards e-waste can influence the way they handle e-waste (Duan *et al.*, 2020). On the contrary, reviewed studies such as Kitila (2018) clearly show that the respondents (45%) were aware that substances from e-waste are perilous and can damage the environment, with only 19% clueless about the danger that e-waste is having on both the environment and the health of human beings. Nevertheless, the respondents continued to manage e-waste incorrectly, irrespective of the level of knowledge they possessed concerning the management of e-waste.

4.6.3 Awareness on electrical appliances containing hazardous elements

Table 4.3: Indicating electrical containing hazardous elements

Are you aware of electrical appliances containing hazardous elements	**Frequency**	**Percentage**
Yes	143	42.1
No	197	57.9
Are you aware of e-waste in your house that need to be dispose in a special way?		
Yes	166	48.8
No	174	51.2
Do you think electronic devices like TV contains hazardous substances?		
Yes	265	77.9
No	75	22.1

It was necessary to find out what respondents knew regarding the types of electrical appliances in their households that contained perilous substances. Knowing the kinds of hazards and substances in the kinds of appliances used can help in knowing how to handle such appliances. In light of that, respondents were asked if they were aware

of any electrical appliances in their households containing hazardous substances. In response to the question, 57.9% were not knowledgeable of any household appliances containing hazardous elements, and only 42.1% were aware of appliances containing perilous elements. A follow-up question was posed to respondents in order to find out the type of hazard found in electrical appliances such as TVs. The results revealed that 48.8% agreed that a TV contains elements that are dangerous to human health, and 52.1% did not agree.

According to Attia *et al.* (2021), 67.5% of respondents in their study area were aware of the hazards found in electrical appliances but were not aware of the negative impact such hazards had on human health. TV has been found to contain lead and organohalogen flame retardants (OFR) that are hazardous when exposed to the environment (Bimir, 2020). Flame retardants can diffuse slowly from the TV and other electronics, such as batteries in electric toys, and therefore they need to be managed correctly to avoid human health impacts and damaging the environment in the long run (Duan *et al.*, 2020).

4.6.4 Awareness on institution communicating with the community about e-waste

In order to find out if respondents are aware of any institutions in their area dealing with e-waste, an inquiry was posed to them in the form of a questionnaire. The results illustrated in Figure 4.17 indicate that 91.2% of respondents revealed that there is no institution (government or private sector) running any awareness programmes related to e-waste. However, only 8.9% were aware of institutions dealing with e-waste in their area.

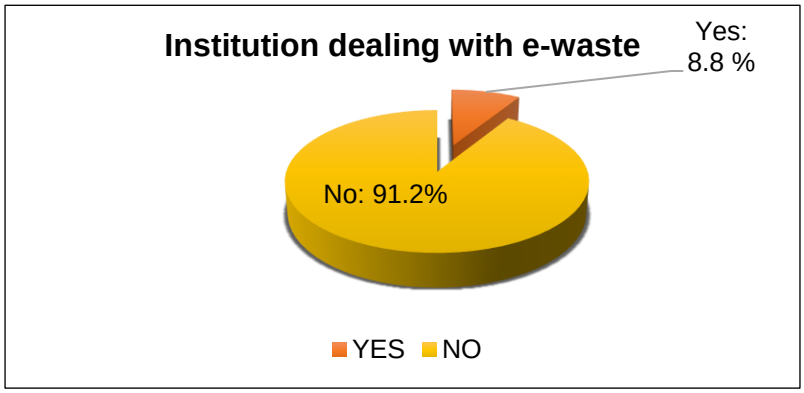

Figure 4:17: Availability of an institution dealing with e-waste at Collins Chabane Municipality

Another question was posed to check if a community meeting was held (imbizo) to do clean-up campaigns or to educate communities about the management of e-waste. Indicated on Figure 4.18, the highest percentage, 89.4%, agreed to have never heard of a clean-up or imbizo meetings concerning e-waste. On the other hand, the lowest percentage, 11.3%, claims to have heard about the meetings in their area.

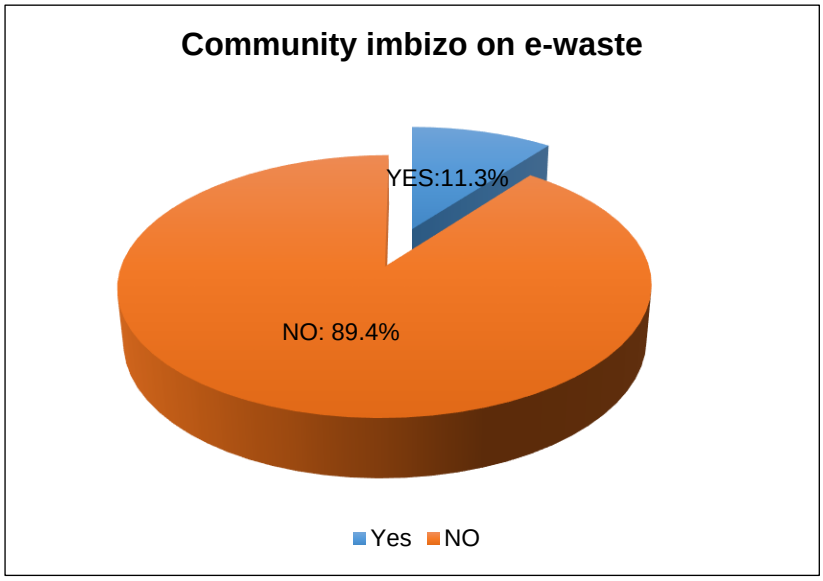

Figure 4.18: Community meetings on e-waste

Almost 90% of respondents indicated the same point that in their area there is no institution and that there were never any meetings arranged to inform or educate them about the proper way of managing waste, in particular e-waste. Through an observation checklist, it was noted that some parts of the study area, especially the remote rural area of Saselamani, did not have bins, suggesting that waste management practices, including e-waste, are not managed according to international regulations (Duan *et al.*, 2020).

To conclude the questionnaire, respondents were asked if they anticipated attending the meetings should any educational or awareness meetings be held. About 70% were looking forward to attending, while 30.3% were not looking forward to attending at the time of data collection, as shown in table 4.4. Technically, 70% of respondents agreed to attend meetings of awareness should the municipality and stakeholders dealing with waste management arrange such meetings.

Table 4.4: The desire of the communities to attend community meetings on e-waste related matters

Do you desire to attend community(imbizo) meetings on e-waste?	Frequency	Percentage
Yes	102	30
No	238	70

Table 4.4 shows that communities in rural areas need information so they can be educated and act accordingly in terms of managing e-waste. In the study of Dzah *et al.* (2022), it was believed that educating the general public through professionals on the repercussions of bad management practises of e-waste will go a long way in improving these management practises in the city and the country at large in the fight for ecologically and humanely friendly approaches. On the other hand, Bimir (2020) and Maphosa (2021) suggested that state-supported educational sentience on e-waste regulations is necessary to be done in order to detect bad habits of e-waste management by decreasing the e-waste through proper management and encouraging e-waste recycling. While Mihai *et al.* (2019), supported by Ameresh, Thammaiah, Guptha and Nagarathna (2020), indicated that the use of giant media such as TV can benefit large numbers of community members if used as a platform to educate communities about e-waste.

4.7 Role played by waste reclaimers in the study area to minimize e-waste

4.7.1 Gender profile

In this research, one of the objectives was to assess the role waste reclaimers play in reducing e-waste. For the said objectives to be reached, closed-ended questionnaires were designed and given to the waste pickers in the study area. Waste pickers who participated were of different genders, but the highest percentage (62.75%) were females, 31.25% were males, and 6.25% did not disclose their gender. Below is a graph indicating the gender profile of waste pickers in a study area.

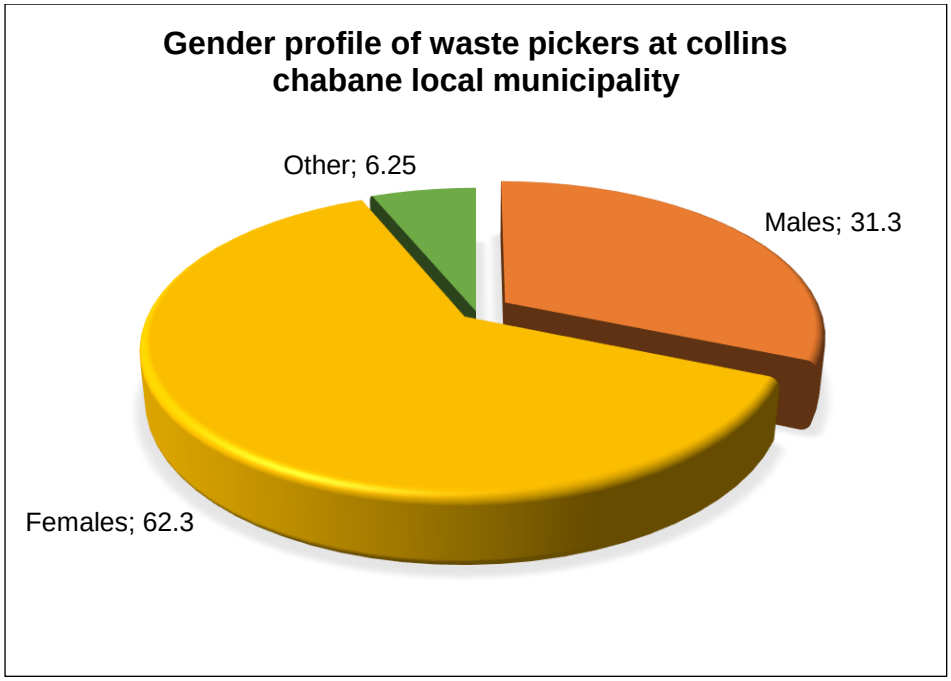

Figure 4.19: Gender profile of waste pickers

Salhofer (2017) indicated that females seen doing waste picking and those found in landfill sites are in high numbers as compared to the opposite gender. This finding is supported by Mathako (2019) and Shoroma *et al.* (2022), where females were in high numbers at Makhado landfill and Tzaneen landfill sites in Limpopo Province, and Ntusi *et al.* (2022) at Ehlanzeni District Municipality in Mpumalanga Province, all in South Africa.

4.7.2 Age profile

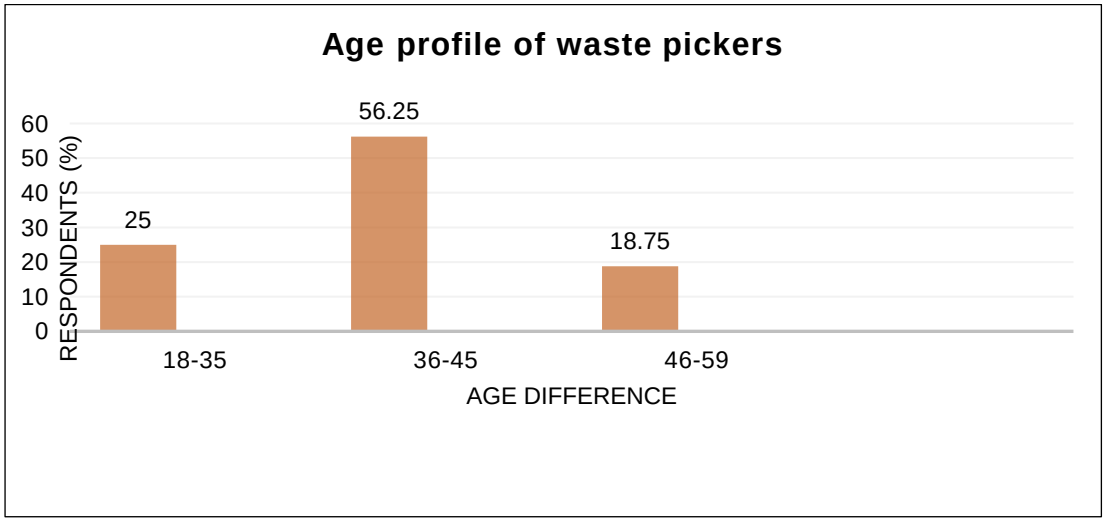

Figure 4.20: A profile age of reclaimers at Collins Chabane Municipality

The study interviewed respondents from the ages of 18 to 59. The outcome disclosed that respondents aged 36–45 have a higher percentage (56.25%) than any other age group. Collectively, young people aged 18–35 have a lower percentage (25%) as compared to 75% of adults who are over 35 years old. This outcome is similar to the results of Shoroma *et al.* (2022), where waste pickers aged 34 and above were at 63% as compared to youth.

4.7.3 Education profile

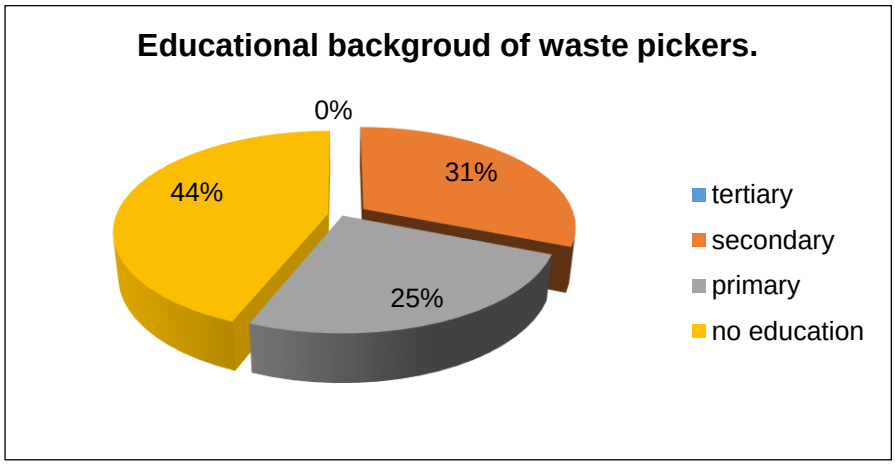

Figure 4.21: Educational profiles of waste pickers at Collins Chabane Local Municipality

The educational background of the waste reclaimers at Collins Chabane Local Municipality is illustrated in Figure 4.21. Most of the waste reclaimers did not have any formal education (44%); those who obtained high school education were at 31.1%; and those with primary education were at 25%. The results of this study are similar to those obtained by Snyman *et al.* (2017), where they realised that waste pickers at the streets and landfill sites of Pretoria North had low educational standards. Similarly, landfill sites in most municipalities in India have a high number of children working alongside their mothers doing waste separation without education or, rather, with low education (Salhofer, 2017). Ntusi *et al.* (2022) attested that waste pickers at Ehlanzeni District Municipality did not obtain any tertiary qualifications, and this is the same situation for waste pickers at Collins Chabane Local Municipality.

4.7.4 Most dominant waste collected by waste pickers at Collins Chabane Local Municipality

Illustrated in Figure 4.22, the results showed that waste pickers collect a higher percentage of papers, cardboard boxes, cans, and bottles than e-waste. Typically, waste pickers collect an average of 81,1% of aluminium cans; 56,1% of papers and card boxes; and 94% of bottles.

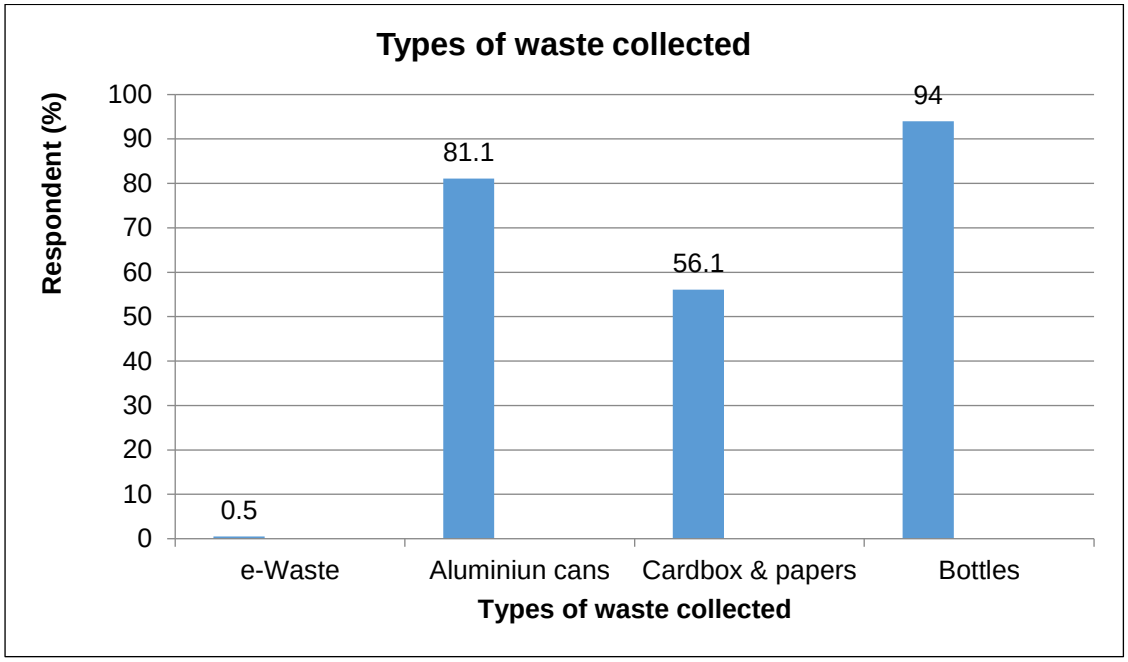

Figure 4.22: Types of waste collected by waste pickers

Almost 88% of waste is collected either along the streets, where there are parties, or from illegal dumping hotpots, as indicated on Figure 4.22. While 56.1% of waste is collected from business areas and 44% of waste is collected from households (door-to-door collection) on the day the municipal waste truck is collecting waste.

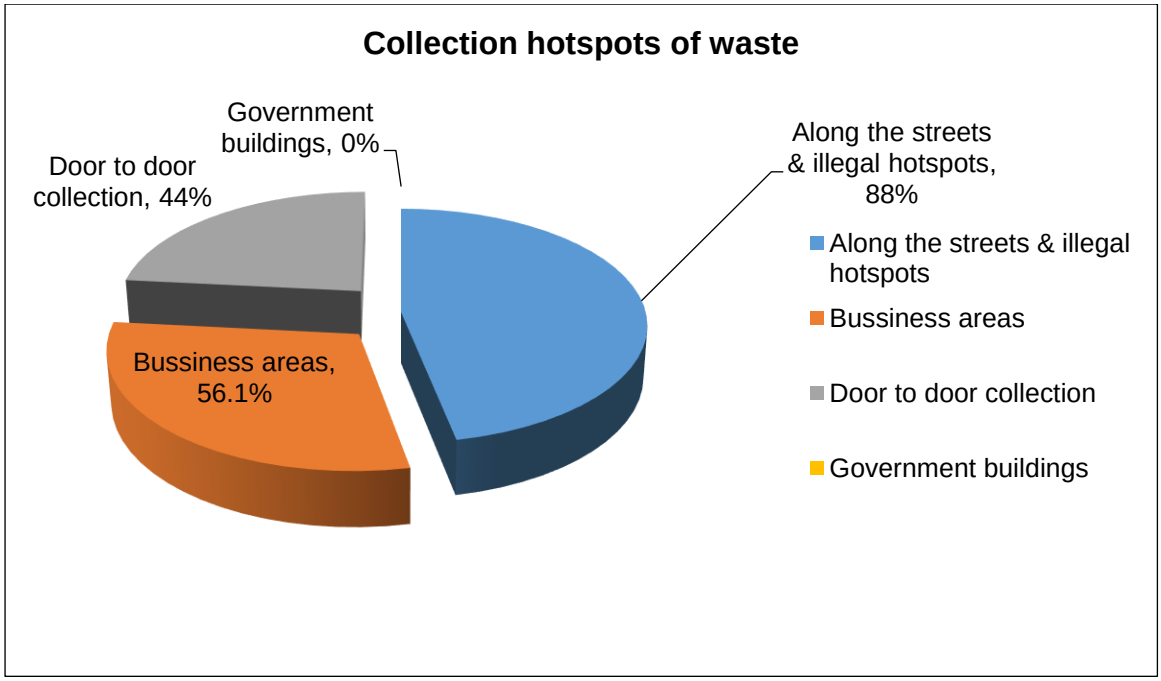

Figure 4.23: Source where most of waste is collected

This result supported the statements given by municipal representatives that the municipality has not collected e-waste to this point, even though they regard it as hazardous waste.

According to Ntusi *et al.* (2022), most waste pickers were collecting 100% aluminium cans. One of the reasons given is that aluminium can give them more money at a value of R4.00 per kilogramme and that it can be recycled all over again. The study indicated further that recyclable materials such as aluminium cans use a higher amount of energy during the remaking of new ones than virgin materials. The findings of Ntusi *et al.* (2022) support the findings in this study. This result is similar to the study of Mathako (2019), about the study of waste management at Vhembe District Municipality, which revealed that waste pickers at Collins Chabane collect 51% of 18 tonnes of aluminium cans and 49% of 17 tonnes of bottles. The outcome of the study revealed that instead of e-waste being recovered, bottles and aluminium cans are being recovered the most.

Respondents were not asked why they opted to do waste picking; however, reviewed literature indicated that waste pickers earn a living through the collection of different recyclables (Duan *et al.*, 2020; Dzah *et al.*, 2022; Ntusi *et al.*, 2022; Shoroma *et al.*, 2022). One of the respondents revealed that they opt to spend more time collecting

the goods that can be recycled since it is their job to put food on their table and to avoid idling around without providing for their loved ones.

4.7.5 Place they send waste to be recycled in the study area of Collins Chabane Local Municipality

Without understanding the practises of waste pickers, we cannot completely appreciate the role they played. In order to understand the role played by waste pickers in the field of waste management, the following questions were posed to them: Waste pickers were therefore asked to indicate the source of e-waste they were collecting and where they were sending it for recycling, as indicated in Figures 4.23 and 4.24. The results obtained emphasised that waste pickers were not collecting e-waste because they were exposed to other types of recyclable materials rather than e-waste. In order to develop an understanding of where they are sending the recyclables they collect; a question was given to them asking about the place they are recycling their waste. As illustrated in Figure 4.24, 68.75% indicated that they were sending collected waste to the collection point, and 31.25% were selling to people who had cars to access recycling places. Respondents indicated further that the collection point was around Malamulele town.

This statement of the respondents was supported by the outcome of Mathako (2019), where the waste pickers revealed the existence of the recycling company called Kensha Mills Recycling at Malamulele Township. Furthermore, Mathako revealed that waste pickers at Collins Chabane Local Municipality recycled aluminium cans and bottles the most but did not recycle e-waste. The results support the findings by Mathako (2019) about the existence of recycling companies within the study area.

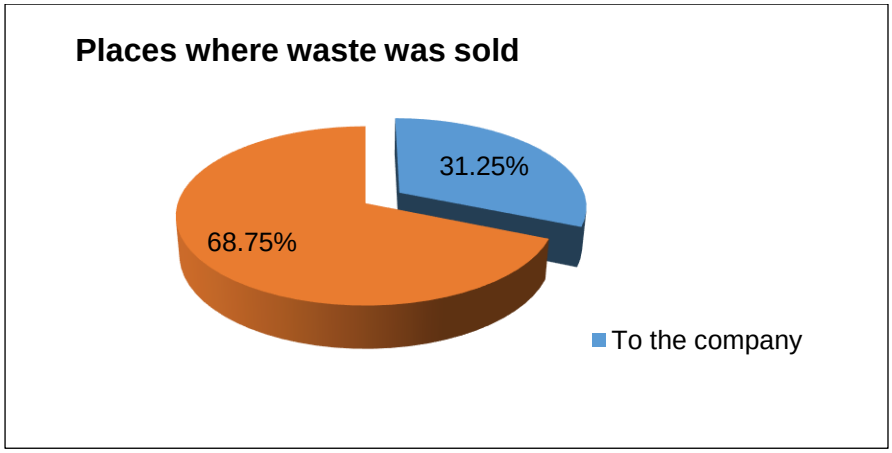

Figure 4.24: Place where waste is recycled

Representatives of Collins Chabane at the waste directorate indicated that the municipality does not have waste pickers and that no company does recycling within the municipality. The results of Mathako (2019) revealed that at Thulamela and Collins Chabane municipalities, waste recycling forums meet monthly to discuss issues related to recycling. This statement contradicts the statement given by the waste management representatives and respondents from Malamulele Township, who indicated the lack of companies dealing with waste in their municipality.

4.7.6 Challenges experienced by waste pickers

To understand more about the challenges faced by waste pickers, they were asked some questions that prompted them to reveal any challenges they may have experienced and to find out if they have formal groups they work with. Figure 4.25 represents the challenges faced by waste pickers at Collins Chabane Local Municipality, including respondents who did not belong to any group (75%), but a few (25%) were working as a group informally. A 100% of respondents revealed that they struggled with a lack of support from the local municipality; 86% were troubled with the limited number of recycling companies to send their recyclables to. Lack of transport was another challenge faced by waste pickers (24%), while 21% were worried that they work individually.

Others indicated that they would like to be granted the right of entry to enter the landfill at Xigalo landfill sites to access waste. Xigalo landfill sites are now demarcated with a palisade fence and with security personnel guarding against any illegal entrance, so

waste that is supposed to be recycled ends up destroyed since access to the landfill is not possible for any member of the community except the municipal workers dealing with waste.

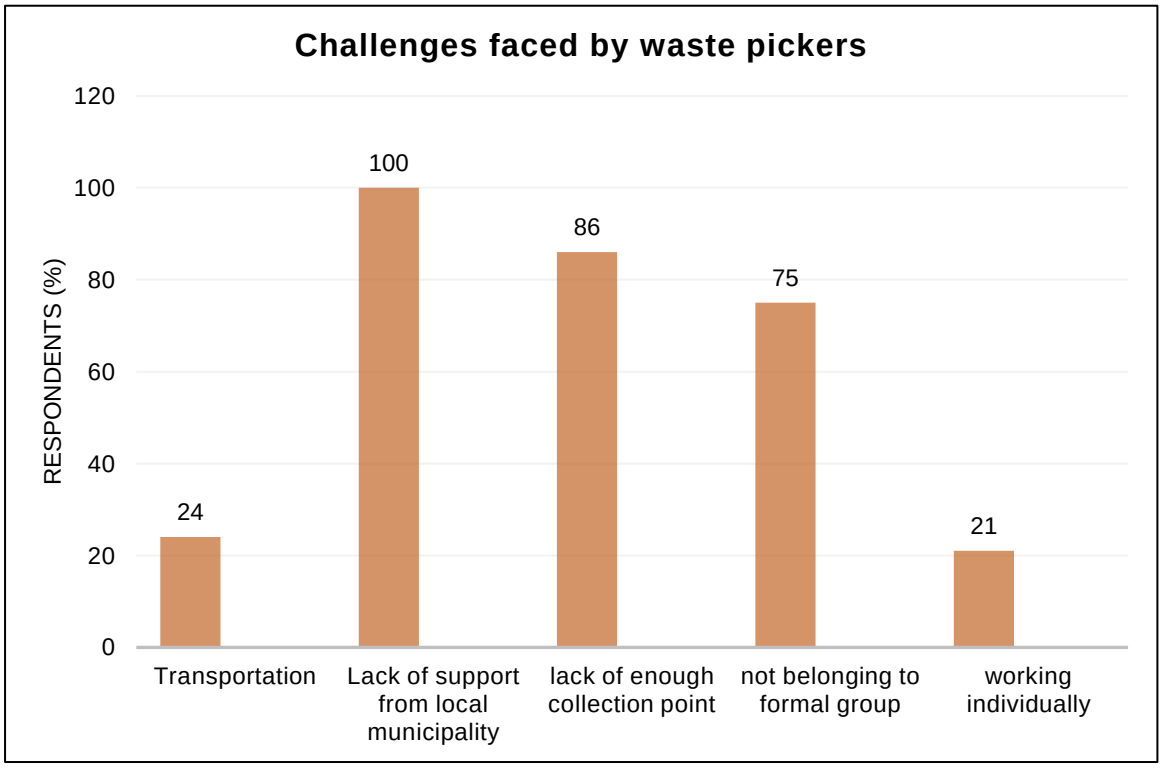

Figure 4.25: Challenges experienced by waste pickers

4.7.7 Knowledge of health challenges associated with e-waste

According to Mothiba (2016), waste pickers choose to look for means to survive harsh socio-economic conditions rather than think twice about their health. Waste pickers around Malamulele and Saselamani were not different from others in the same field; Shoroma *et al.* (2022) indicated that some waste pickers are being cut by sharp objects as they deal with bottles at their working places (landfill sites or collection points). Obtained data illustrated in Figure 4.26 indicated that 68.7% of respondents were aware of health issues related to waste picking, while 31.25% were not aware (Ogbenna & Raymond, 2018).

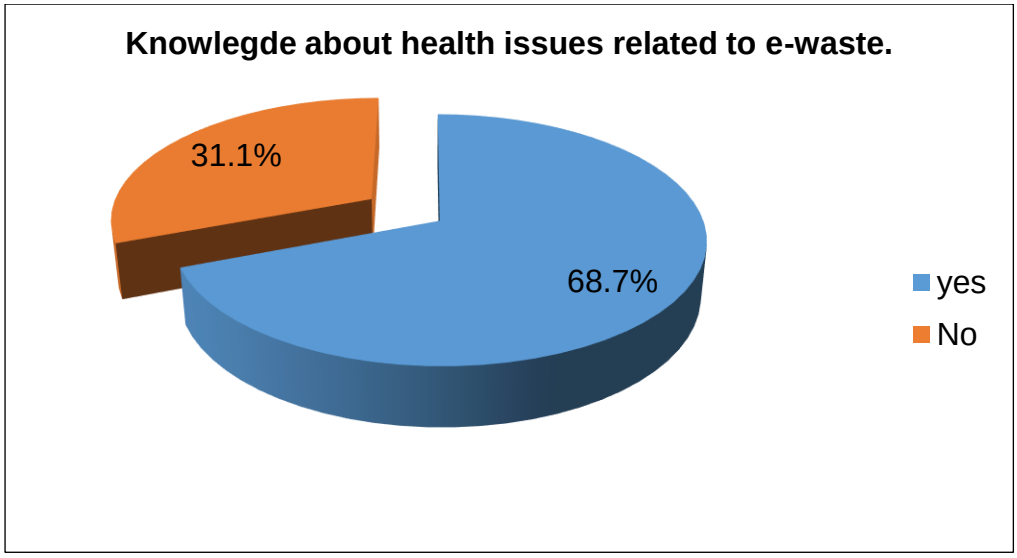

Figure 4.26: Level of awareness waste pickers had on health issues associated with e-waste

Various studies in South Africa acknowledged that waste pickers played a very important role in reducing the amount of waste reaching landfills while also benefiting by getting money to provide for their families. (Snyman *et al.*, 2017 ; Viljoen *et al*., 2021 ; Ntusi *et al*., 2022; Shoroma *et al*., 2022). Waste pickers at Collins Chabane municipality play a role in minimising waste, even though their efforts are not recognised by the waste management directorate of the municipality.

Waste pickers truly assist in diverting waste from reaching landfills, which reduces air pollution formed during the compacting of waste into the ground. Ntusi *et al.* (2022) and Viljoen *et al*. (2021) also agree that waste pickers assist in cost reduction and indicate further that informal waste picking truly needs to be recognised by relevant stakeholders from the municipality in order to create more job opportunities while protecting the environment (Mkhwanazi, 2021).

According to Samson (2020), in a “technical report: Integrating reclaimers into our understanding of the recycling economy,” it was indicated that “the South African National Government had not provided municipalities with targets or guidance on the development of policy on waste picker integration, leaving each municipality to chart its own way forward.” This statement gives a better understanding of why other local municipalities’ by-laws do not regard waste pickers as vital key players in the fight to reduce waste, while others do. The report indicates that local municipalities are not

receiving any training or funds needed to support waste pickers and to work cooperatively with them in reducing all types of waste, thus overlooking the role waste pickers play in waste management (Samson, 2020).

4.8 Conclusion

The findings in this chapter conclude that Collins Chabane Local Municipality produces e-waste; however, there are no by-laws regulating the proper management and flow of e-waste from generation to disposal. Households at Collins Chabane Local Municipality are generating a variety of waste, in particular consumable waste from electrical and electric equipment; nevertheless, the municipal by-laws do not regulate e-waste, and therefore, more waste, including e-waste, is expected to be generated.

Moreover, households had a low level of awareness in relation to e-waste management and its consequences, which may lead to an escalation of challenges faced by most local municipalities, Collins Chabane Local Municipality included. The main challenge of e-waste in the study area is the lack of policies put in place to regulate the management of e-waste. Lack of policy led to a lack of information about the number of tonnes of e-waste generated by communities.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter summarises the research findings, draws conclusions, and provides relevant recommendations drawn from the current study.

5.2 Summary of findings

The study found that there is no collection of e-waste at Collins Chabane Local Municipality (Malamulele and Saselamani). By-laws regulating waste at the study area or current management strategies did not include e-waste, even though e-waste is classified as hazardous waste, which needs to be managed with high care. Most of the community members are storing large amounts of e-waste and communication electrical appliances in their households. Very few households discarded e-waste like old tablets in the open field, while other households burned their old e-waste. The majority of the families were found to have stored a variety of broken household electrical equipment or old ones, and most had reached their life span, thus leading to an increase in e-waste that is not addressed. Others had stored cell phones that were either broken or had stopped working, and the number of stored phones is expected to rise since the demand for cellular phone usage is rinsing swiftly. It is therefore expected that the generation of e-waste within the municipality will increase.

Moreover, this study discovered that communities in Collins Chabane Local Municipality are not aware of e-waste. Few community members are enlightened about e-waste, but not to the extent of understanding the effect e-waste has on the environment or human health. Furthermore, communities are not aware of the hazardous constituents found in our electrical equipment and the impact this can have on the environment and human health when handled negligently. Low levels of e-waste awareness in communities had an influence on e-waste management, and that had proved to be the main reason why the majority had kept their e-waste in storerooms.

Results from this study indicated further that waste pickers from the area are able to recycle other types of waste except e-waste since there are no recycling companies dealing with e-waste within the borders of the municipality. Municipal officials and

representatives from the waste management directorate indicated that there is no formal relationship between waste recycling companies or waste pickers. Again, communities are not aware of the existence of a recycling company in their municipality, thus causing them to neglect the sorting of waste to avoid sending waste that could have been recycled to the landfill.

5.3 Conclusions

The conclusions of the current study are presented according to the objectives presented in Chapter 1.

5.3.1 To identify types of e-waste generated at Collins Chabane Local Municipality

According to the data collected, 65.3% of e-waste was generated from bigger household appliances, while 34.4% was generated from smaller households' electrical appliances. The results indicate the breakage of electrical appliances as the key factor causing e-waste, with 5.6% of e-waste being a result of electrical appliances being outdated or having reached their life span. The study revealed that 93% of telecommunications electrical appliances are owned by household members in the study area, of which most are cell phones, which in the future will become e-waste.

5.3.2 To assess e-waste methods used at Collins Chabane Local Municipality

The results revealed that about 71.1% of respondents do not use environmentally friendly methods to manage e-waste. The results indicated further that the methods used, such as storing e-waste in the storerooms or keeping it in the chest’s drawers, selling it, and disposing of it in the backyard together with solid waste, are not proper and are likely to impact the environment negatively in the future. Respondents were managing e-waste in a manner that they knew best because, according to the municipality, there are no specific regulations outlined that can be used as a guideline to manage e-waste; hence, the community is also not aware of the correct procedure to follow in order to manage e-waste correctly.

5.3.3 To evaluate the level of community awareness on e-waste

This study's findings revealed that most community members from Malamulele and Saselamani are not aware of e-waste and are not knowledgeable about e-waste and the negative effects e-waste has if not managed correctly. About 90% of respondents have indicated that they have never heard of or attended the community meetings (imbizo) to be educated about e-waste management. Their statement was proven when 66% of respondents could not give an accurate answer about what e-waste is because they were not knowledgeable about e-waste. In light of the above, there is a clear indication that educational awareness about e-waste management needs to be given to communities in Collins Chabane Local Municipality.

Furthermore, respondents are not aware of the negative impact e-waste can have on the environment. About 65% of the respondents indicated that they are not aware of any danger e-waste can pose to the environment or how. Again, it was discovered that respondents were not even aware of the kinds of household electrical appliances containing hazardous elements.

5.3.4 To assess e-waste reclamation at Collins Chabane Local Municipality

Waste pickers at Collins Chabane Local Municipality are playing an important role in minimising waste, except e-waste. The purpose of interviewing waste reclaimers was to identify the type of e-waste recovered the most. Nevertheless, recovering e-waste by reclaimers was a mission since the majority in the study area were not disposing of their e-waste but stored it in their store rooms. However, waste pickers managed to minimise solid waste that was supposed to reach landfills, such as aluminium cans and bottles. Like in many other municipalities, the effort to minimise waste is not recognised by the waste management directorate of the municipality. Mathako (2019) indicated that waste pickers around Collins Chabane Local Municipality recycle 51% of aluminium cans and 49% of bottles that are supposed to reach the landfill. Waste pickers truly assist in diverting waste from reaching landfills as that assists in the reduction of air pollution formed during the compacting of waste into the ground; however, their role is overlooked.

In conclusion, this study revealed that there is no proper waste management policy or strategy put in place to regulate e-waste at Collins Chabane Local Municipality. There

are no waste recycling companies recycling e-waste in the municipality. It is likely that waste pickers from the area can only reduce the amount of other solid waste rather than e-waste. Moreover, households had a low level of awareness in relation to e-waste management and its consequences. Communities are expected to continue to store or keep their obsolete electronic equipment due to a lack of knowledge. Households at Collins Chabane Local Municipality are generating a variety of waste, in particular consumable waste electrical and electric equipment. Since their municipal by-laws do not regulate e-waste, more waste is expected to be generated; hence, no guidelines are given to communities on how to manage it. e-Waste is hazardous; it is therefore of great concern that proper and environmentally friendly policies are put in place and enforced in order to avoid incorrect management of e-waste.

5.4 Recommendations

5.4.1 Recommendations for improving and regulating e-waste management practices at Collins Chabane Local Municipality

The study was conducted with the purpose of assessing e-waste management practises in Collins Chabane Local Municipality. According to the results obtained, it is therefore recommended that Collins Chabane Local Municipality consider developing by-laws that can be used to regulate the proper management of e-waste. The programme should be comprehensive and user-friendly and should focus mainly on best practises to manage e-waste. The municipality may focus on developing policies to regulate e-waste according to the guidance of the national department of environmental affairs. When developing e-waste regulations and policies, the municipality should do so according to the available infrastructure that can be used to implement the policies.

It is also recommended that the municipality implement and run educational campaigns to raise awareness of e-waste. The campaigns may include communities, private institutions, and schools, where they can be discouraged from storing desolate electrical appliances in their houses or places or to dispose of them in landfills. However, they must be encouraged to recycle desolate waste with the aim of recovering useful elements and protecting the environment. Through the partnerships that the municipality is having with local businesses, they may encourage them to bring

the business of recycling e-waste to their municipality. In order for recycling to be encouraged, during the development of e-waste legislation, the municipality should include a clause that can address EPR clearly and informal recycling. That may help to address the economic status of waste reclaimers as they assist in reducing desolate electrical appliances that were supposed to be stored in houses, reached landfills, or disposed of in open fields.

For the suggested recommendations to be achieved, there should be policies put in place to ensure that there is compliance in relation to e-waste regulation by all stakeholders involved (Mouton, 2020). Through educational awareness, the municipality should encourage communities to attend community meetings, in particular the awareness meetings that can empower them with knowledge of proper e-waste management and its effect on the environment. The municipality may provide drop-off centres for e-waste in places that are going to be protected, such as tribal offices, for communities to drop off their electrical appliances that are no longer in use to avoid storing them in their homes.

Developing Asian countries such as India are experiencing a lot of illegal reclamation of e-waste, irrespective of the many studies conducted on e-waste (Bimir, 2020). It is therefore imperative for developing regions such as South Africa to develop e-waste regulations and policies that can help provide proper guidance in matters related to appropriate e-waste management. These policies and regulations can be adopted by developed regions, as outlined in the Bamako Convention and other related conventions (Salhofer, 2017), to provide necessary training for waste pickers on e-waste reclamation.

5.4.2 Recommendations for further research

The research assessed management practises for e-waste, the level of community awareness, and the role waste reclaimers played in reducing e-waste. Further research on e-waste management in remote rural areas covering more villages is needed since this study was limited to one rural village and one township. Further research can be conducted on a wider scale in order to establish the reason why local municipalities are unable to collect, transport, and dispose of e-waste, since the discovery of this study indicated that to date, the Collins Chabane Local Municipality

is unable to manage e-waste since it is not outlined in their by-laws regulating waste management. Reviewed articles had indicated the benefits and opportunities of doing formal recycling of waste electrical and electricity equipment, especially for the environment and the socio-economic status of the unemployed (Ohajinwa *et al.*, 2018; Ichikowitz & Hattingh, 2020; Miner *et al.*, 2020; Sakr *et al.*, 2021). Therefore, this study recommends that further research on the development of formal recycling of e-waste be taken into consideration. Since the study focused on management practises for e-waste from households, further studies assessing how local businesses, schools, and FET are managing e-waste at Collins Chabane Local Municipality are recommended. Further research should be conducted on technologies and methods to help improve the working conditions of waste pickers and their proper use of personal protective equipment. Moreover, another study on e-waste management needs to be conducted at Collins Chabane Local Municipality on the negative impact e-waste can pose to human health and the surrounding environment so they can start managing e-waste better. Studies about the formal recycling of e-waste in remote rural municipalities need to be conducted in order to get a better understanding of what should be done to encourage the legal recycling of e-waste.

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APPENDIX A: QUESTIONNAIRES

QUESTIONNAIRES FOR HOUSEHOLDS

Background information for the participants.

Please draw a cross next to the correct answer

Reference no: 50704494

Section A: Demographic information

Gender	a. Male b. Female c. Prefer not to say
Place of residence	a. Saselamani b. Malamulele
Family size	a. 1-2 b. 3-4 c. 5-6 d. 7+
Educational status	a. Primary level (Gr 1 to 7) b. Secondary level (Grade 8 to 12) c. Tertiary level d. No formal education
Employment status	a. Self employed b. Employed c. Unemployed
Age	a. 18-25 b. 25-35 c. 36-45 d. 46-55 e. 56-60

SECTION B: Types of electronic waste generated

1. From the list of electronic and electrical equipment's below, please circle electrical equipment's you have.	Refrigerator, dishwasher, washing machine, TV, portable audio player, iron, electrical kettle, desktop (including CPU, keyboard, mouse and screen), pressure cook, blender, electric stove, mobile phones, notepad, power bank charger, play station, tablet, personal printer, fans, micro oven, heater, DVD player, fluorescent lights, toaster, hoover, hair dryer, vacuum cleaner, griller, loan mower, electric toys, driller, electric coffee machines, air conditioners, food processor, ice cream maker, sewing machine, generator. Other: Please specify …… …… ……
2. From the list you have circled, what could be the cause of e-waste generation in your household?	a. Broken. b. Reached its life span. c. Outdated. d. Other: Please specify …… …… ……
3. Apart from the above list of electrical equipment's, how many telecommunication gadgets (cell phones, tablets etc.) do you own in your household?	a. 1-3. b. 4-5. c. 6-8. d. 9 +
4. How often do you change your electrical gadgets?	a. Every year. b. Every two years. c. When there is a need. d. Uncertain.

	e. Other: Please specify ……. …….
5. For the kinds of ICT gadgets, electronics, and electrical appliances you owing, how do you manage them when they reach their life span?	a. Keep it in my chest drawers. b. Keep it in the store room. c. Sell them. d. Dispose it. e. Donate them. f. Other: Please specify…… …… …
6. If you manage your e-waste by keep them, why do you keep them?	a. We do not consider it appropriate to throw it in garbage: b. We do not know what to do with it: c. Waiting to repaired it: d. Not knowing the best methods to dispose it: e. Not knowing the place, we can send for recycling:
7. Precisely, what do you normally do to broken electronic equipment?	a. Store them: b. Sell to scrap dealer: c. Sell them to e-waste business: d. Give them back to the company for servicing: e. Other: Please specify …….
8. When you store your e-waste, are you able to store according to its categories (bigger appliances/ smaller appliances?)	a. Yes b. No

9. Are you aware of any electronic recycling company in your area?	a. Not at all b. We do not have one c. It is far from us d. Yes
10. Should you have a recycling company in your area, would you like to recycle your e-waste?	a. Yes b. No c. Maybe
11. Who is collecting e-waste in your area?	a. Municipality b. EPW workers c. Self-disposal d. Other: Please specify ……
12. How often is the collection taking place?	A. Once a week B. Twice per month C. Once per months D. Other: Please specify ……

SECTION C: Community awareness on electronic waste

1. Have you ever heard of the term e-waste?	a. Yes b. No
2. e-Waste refers to electronic and electrical equipment's that have reached its life span, or that is no longer useful to the owners.	a. True b. False c. Not sure
3. Are you aware of any environmental impact electronic waste had on the environment?	a. Yes b. No

4. Are you aware of any negative impact electronic waste had on human health?	a. Yes b. No
5. Are you aware that most of the electronic appliances contain hazardous elements in it?	a. Yes b. No
6. Are you aware that some of the e-waste in your households need to be dispose of specially since they are hazardous?	a. Yes b. No
7. According to your knowledge, do you think the following electrical appliances contain hazardous elements: TV; Electric Iron, microwave oven, cell phones, blender.	a. Ye b. No
8. Is there an institution, private or government sector that communicates with you concerning electronic waste?	a. Yes b. No
9. Have you ever attended an “imbizo” awareness about electronic waste in your area?	a. Yes b. No
10. If workshop could be organized on waste management, would you consider attending?	a. Yes b. No

NB: Participation in this interview is voluntary. All information will be treated with confidentiality and used for academic purposes only.

Thank you for your participation!

D. SEMI-STRUCTURED INTERVIEW QUESTIONS OF MUNICIPAL OFFICIALS

Reference/Recording no: …….

Dear participant

All interviews will be recorded using a tape recorder or a mobile phone.

Participation in this interview is voluntary. All information will be treated with confidentiality and used for academic purposes only.

Do you agree to continue participating in the study?

Yes	**No**

1. What is your job title?
2. How many years of experience do you have?
3. What type of waste is generated the most in your municipality?
4. How do you manage hazardous waste as the municipality?
5. Do you consider electronic waste hazardous?
6. How do you collect, transport, and dispose electronic waste?
7. Do you measure the amount of electronic waste generated in the municipality?
8. Generally, what are the challenges experienced in waste management directorate that relates to proper waste management in the area?
9. What are the challenges experienced in electronic waste management?
10. Is there any company dealing with e-waste that works together with the municipality?
11. Is there any Programme or awareness given to communities about proper management of e-waste?
12. Is there any group of waste reclaimers existing in the area that is recognized by the municipality?
13. Are you consciously aware of the impact e-waste can pose to human health and the environment?

Thank you

NB: Participation in this interview is voluntary. All information will be treated with confidentiality and used for academic purposes only.

Thank you for your participation!

E. INTERVIEW QUESTIONS FOR ELECTRONIC WASTE PICKERS/RECLAIMERS

Reference/ recording no: …….

Questionnaire number

Dear participant,

All interviews will be recorded using a tape recorder or mobile phone.

Participation in this interview is voluntary. All information will be treated with confidentiality and used for academic purposes only.

Do you agree to continue participating in the study?

Yes	No

1. What is your gender (Male, female or prefer not to say)?

Male	Female	Other.

2. What is your level of education (No formal education, Primary level, Secondary level, and Tertiary level)?

No formal education.	Levels
Primary level	Gr: 1-4 Gr: 5-7

Secondary level	Gr. 8-9 Gr. 10-12
Tertiary level.	Diploma. Degree

3. What kind of waste do you collect and which one is the dominant types of waste found? Please tick the correct answer, choose as many options as possible.

Papers	Card box	Bottles	Tin cans	e-waste

4. On which days do you normally collect waste? Tick the correct choice.

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday

5. What is the source of your e-waste? Tick the correct choice.

Broken e-waste	Old e-waste	Other.

6. Which are the most types of waste recycled/ collected. Tick the correct choice.

papers	glass	cans	e-waste

7. Where do you collect most of your waste? Choose the correct point.

Households	Business centre	Government institutions	Other, specify	Landfill site

8. Where do you send the recycled materials? Please tick the correct choice.

To the company	We sell to those who are having cars to send to companies.	To our collection points

9. How long you have been gathering recyclable materials? Tick the correct choice.

2 years	4 years	5 years	More than 5 years

10. What are the challenges you encounter as you do your work? Please explain.

    ……

    ……

    ……

11. Do you belong to a group or you are working individually? Choose the correct choice.

Formal Group	Informal group	Individually

12. Are you knowledgeable of the health challenges associated to electronic waste?

Yes	No

NB: Participation in this interview is voluntary. All information will be treated with confidentiality and used for academic purposes only.

Thank you for your participation!

F. Waste management (collection and disposal) Observation checklist:

Name of the researcher: Makamu Nkhensani Nancy

Date of observations: ……

Questions	Yes	No	comments
1. Are the waste collectors wearing (PPE)personal protective equipment?			
2. Are the clothes suitable for the kind of job done?			
3. Does the e-waste and normal waste collect together?			
4. is the any waste bin provided for the house?			
5. Are the business sector provided with skips and waste bins?			
6. Is the waste separated from the source?			
7. Is the type of transport suitable to collect e-waste?			
8. Are there any observable challenges associated with waste management?			
9. At the municipal offices, is the any waste management strategies put in place?			

APPENDIX B: LETTER ASKING PERMISSION TO CONDUCT RESEARCH

UNISA | University of South Africa

03 March 2021

Collins Chabane Local Municipality

225 Hospital Road

Malamulele

0982

Dear Municipal Manager

RE: PERMISSION TO CONDUCT AN ACADEMIC RESEARCH PROJECT

I am writing to request a permission for my student to conduct a research project in your municipality. Her name is Nkhensani Nancy Makamu (student no: 50704494). The title of her study is "An assessment of electronic waste management practices in Collins Chabane Local Municipality, Limpopo Province, South Africa". The research is compulsory and is part of the Master studies in Environmental Management at the University of South Africa.

The study will focus on the following: The electronic waste generated in Collins Chabane Local Municipality. The electronic waste management practices such as collection, transportation and disposal of. The level of community awareness on electronic waste. The availability of electronic waste reclaimers from the study area. The student would also like to take photographs of electronic waste collection and dumping sites. No waste reclaimers , municipal employees or recycling companies employees will be taken any photographs to ensure their anonymity for this study.

The researcher intends to use Malamulele Townshi, Xigalo and Saselamani as study area. Please return your signed permission letter to tshimtp@unisa.ac.za and 50704494@mylife.unisa.ac.za

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

APPENDIX C: LETTER GRANTING PERMISSION TO CONDUCT A STUDY

225 Collins Chabane Dr
DCO Building
Malamulele
0982

Private Bag X9271
Malamulele
0982
Tel (015) 851 0110
Fax (015) 851 0097

COLLINS CHABANE LOCAL MUNICIPALITY

MS TP Tshimbana
UNISA
Muckleneuk
Pretoria
0002

PERMISSION TO CONDUCT A RESEARCH

1. The above matter bears refer.

2. Permissions is granted to Nkhensani Nancy Makamu to conduct her research. she is a student from University of South Africa who is currently doing her Master's Degree in the Department of Environmental Sciences .

3. Kindly note that the Municipality is not responsible for the payment of stipend for the students and this is only an opportunity for them to order the integrate theory with practice as part of fulfilling the requirements of their degree.

Yours Sincerely,

R.R SHILENGE
ACTING MUNICIPAL MANAGER

11/08/2021
DATE

Vision: "A spatially integrated and sustainable local economy by 2030"

Mission: To ensure the provision of sustainable basic services and infrastructure to improve the quality of life of our people and to grow the local economy for benefit of all citizens

APPENDIX D: ETHICS APPROVAL FROM

UNISA

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 03/11/2021

NHREC Registration # : REC-170616-051
REC Reference # : 2021/CAES_HREC/096
Name : Ms NN Makamu
Student #: 50704494

Dear Ms Makamu

Decision: Ethics Approval from 03/11/2021 to 31/10/2024

Researcher(s): Ms NN Makamu
nkhensanimakamu@yahoo.com

Supervisor (s): Ms TP Tshimbana
tshimtp@unisa.ac.za; 011-471-2410

Mr ND Baloyi
baloynd@unisa.ac.za; 011-471-2689

Working title of research:

An assessment of electronic waste management practices in Collins Chabane local municipality, Limpopo Province, South Africa

Qualification: MSc Environmental Management

Thank you for the application for research ethics clearance by the Unisa-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is granted for three years, **subject to submission of yearly progress reports. Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.**

The researcher is cautioned to adhere to the Unisa protocols for research during Covid-19.

Due date for progress report: 31 October 2022

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

APPENDIX E: PARTICIPANT INFORMATION SHEET

Ethics clearance reference number: **REC-170616-051**

Research permission reference number: **2021/CAES_HREC/096**

Date signed: **02 May 2021**

Title: An assessment of electronic waste management practices in Collins Chabane Local Municipality, Limpopo province, South Africa.

Dear Prospective Participant

My name is **Nkhensani Nancy Makamu** and I am doing research with **Tshimbana T.P and Baloyi N.D** lectures, in the Department **of Environmental Sciences**. Department of **Agriculture and Environmental Sciences** towards a **Master's degree** at the University of South Africa. We have funding from **Unisa Finance department** for **M&D bursary funding**. We are inviting you to participate in a study entitled **an assessment of electronic waste management practices in Collins Chabane Local Municipality, Limpopo province, South Africa.**

WHAT IS THE PURPOSE OF THE STUDY?

I am conducting this research to find out the types of electronic waste generated in Collins Chabane Municipality. The research will become an eye opener to CCLM more especially to the manager of waste directorate on the types of e-waste generated in the area. The research may suggest the ideal e-waste management strategies to waste management directorate, that can be employed at waste facilities. The research may result in recommending the involvement of stakeholder's when strategizing proper methods of managing e-waste. The research may result in recommendations of the use of educational awareness to inform communities about the value of recycling e-waste, and the role waste picking can do in e-waste management facilities. Communities may benefit to learn about the importance of recycling e-waste economically and environmentally. The outcome of the study will help to get a better understanding about electronic waste challenges at Collins Chabane Local Municipality and can assist in building up a case of statistical data of electronic waste in the country.

WHY AM I BEING INVITED TO PARTICIPATE?

Why did you choose this particular person/group as participants?

The community members were chosen because they are residents of the jurisdiction where the study is being conducted. Contacts details of the participants such as cell phone numbers will not be needed, however the researcher will inform the ward canceller and ward committee of the study area to alert the community members about the days in which the data will be collected. The personal information of the participants such as confidential information will not be disclose and the researcher will not need the confidential details of the participant except their time to answer prepared questionnaires.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

Describe the participant's actual role in the study.

The study involves *questionnaires / semi-structured interviews (open ended and close ended questions) and observations.* The nature of the participants is to provide answers to the questions they are going to be asked by the researcher. All questions asked will be related to the electronic waste management by CCLM, level of community awareness on electronic waste and how waste pickers collect and segregate electronic waste reclamation in the study area for recycling. Participants from the municipality (municipal officials) and the waste reclaimers will be answering the questions in the form of a semi-structured interview, while the households will be answering the closed-ended questionnaires.

Time allocation for household's questionnaire is about 10 -15 minutes per questionnaire.

Time allocated to conduct interviews is about 15 - 20 minutes per individual for reclaimers.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. However, you cannot withdraw from participation the moment you start filling the questionnaire.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

There are no monetary benefits of taking part in this study. However, the municipality will benefit from the study since recommendation will be made after the study has been conducted.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no negative consequences pertaining to participating in this study. There is only minor risk the participants might experience during interviews. Examples include loss of time and profit during interviews. However, mitigation measures to minimize the risks will be put in place such as assurance that the interview will not take much of their time and a consent form will be provided to every participant with all the details stating all the conditions as well as the reason for the study. The information obtained from the participants will be treated as confidential. Participants will be asked to sign the consent form.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Confidentiality of the participant will be protected and honored, the researcher will not use any name of the participant. Questionnaires to be administered to the participants will be confidential, only the researcher and the authorised personnel will have the access to the questions. Authorised personnel in this research includes the transcriber, external coder, editor, and Research Ethics Review Committee from the University. Data to be obtained will only be used for purpose of this study. Any

electronic gadget to be used to store information (data) will have a password and that only the researcher and the sanctioned personnel will access it.

All data collected during the research will be kept strictly confidential and participants will remain anonymous. However, the data may be seen by Ethical Review Committee and may be published in a journal and elsewhere without giving your name or disclosing your identity.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet at the University where the researcher is registered or future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After five years the filled papers will be destroyed by using shredding machine and latter recycle the papers. Soft copy or electronic copies will be deleted completely from the computers.

All data collected during the research will be kept strictly confidential and participants will remain anonymous. However, the data may be seen by Ethical Review Committee and may be published in a journal and elsewhere without giving your name or disclosing your identity.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

Participation in this study is completely voluntarily and there is no amount of money nor gifts to be offered in exchange of their time.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study has received written approval from the Health Research Ethics Committee of the College of Agriculture and Environmental Sciences, Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Ms Nkhensani Makamu on 071 893 2506 or nkhensanimakamu@yahoo.com. The findings are accessible for period of five years. Should you require any further information or want to contact the researcher about any aspect of this study, please contact Ms Tshimbana TP at 071 419 3211 Or 011 417 2410 or tshimtp@unisa.ac.za

Should you have concerns about the way in which the research has been conducted, you may contact Mr. Baloyi N.D 011 417 or baloynd@unisa.ac.za. Contact the research ethics chairperson of the CAES Health Research Ethics Committee, Prof MA Antwi on 011-670-9391 or antwima@unisa.ac.za if you have any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

Signature: Makamu N.N

Nkhensani N Makamu

CONSENT TO PARTICIPATE IN THIS STUDY

I, _____ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the **questionnaire**

I have received a signed copy of the informed consent agreement.

Participant Name & Surname…… (please print)

Participant Signature……Date……

Researcher's Name & Surname…… (please print)

Researcher's signature……Date……

APPENDIX F: EDITING LETTER

Marieta Grundling (MBA)

366 Rosemary Street
Grootfontein Country Estates
Pretoria, 0081
081 354 1596
edit@profeditmba.co.za
22 July 2023

To Whom It May Concern

This serves to confirm that the dissertation: *AN ASSESSMENT OF ELECTRONIC WASTE MANAGEMENT PRACTICES IN COLLINS CHABANE LOCAL MUNICIPALITY, LIMPOPO PROVINCE, SOUTH AFRICA* by **Nkhensani Nancy Makamu** was edited. The language, presentation, referencing system (both in-text and against the Reference List), were checked and corrected.

M Grundling
22 July 2023