



Understanding public knowledge and awareness of e-waste management practices in Maseru, Lesotho

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PREFACE AND ACKNOWLEDGMENTS

This study was conducted on e-waste in Maseru, Lesotho to understand public awareness of the waste stream and their willingness to contribute to good practices in the future. The study provides some recommendations for improvement and further studies.

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ABSTRACT

E-waste is the fastest growing waste stream globally and its rapid increase has become a global concern. Due to the lack of e-waste legislation, public knowledge, recycling infrastructure, and framework for the e-waste take back or implementation of extended producer responsibility (EPR) in Lesotho, e-waste is often disposed of with general waste to the landfills, or end up in open burning or open dumping. The study aimed at establishing the level of knowledge and awareness of e-waste management practices amongst members of the public in Maseru, Lesotho. Door-to-door semi-structured interviews were conducted with selected households in certain Maseru suburbs. The surveys were conducted to determine current e-waste management practices and respondents' awareness, knowledge and willingness around e-waste practices. Three-hundred-and-fifty-four (354) respondents were interviewed, and 92% response rate was achieved. The literature review also aimed to inform the context of the current study, focusing on "knowledge", "awareness" and "willingness" aspects around waste in general, but also focusing on e-waste management practices.

According to the results of the survey, knowledge of e-waste was very limited, with approximately 94% of respondents not being aware or having knowledge of what e-waste was. Approximately 88% of respondents indicated that they were willing to recycle their e-waste products, however they were not willing to pay the recycling fee. The recycling of e-waste is generally insufficient, with limited amounts of e-waste being recycled or re-sold. The current e-waste management practices established were the storage of e-waste in the households and disposal to the landfill together with general waste. Where e-waste was disposed of, practices were generally poor, with the majority of e-waste being disposed to own dumps, the Tsosane dump site or end up being burned. Many of the malpractices may be attributed to a lack of awareness and the absence of legislative and regulatory measures. Command-and-control measures, together with economic instruments should be considered to improve the management of e-waste in Maseru, Lesotho. E-waste management regulations should consider the polluter pays principle to electronic devices importers and manufactures through mandatory extended producer responsibility (EPR), and incentive schemes for producers of e-waste.

Keywords: *Electronic waste, E-waste, Awareness, Survey, Maseru, Lesotho.*

ABBREVIATIONS AND ACRONYMS

ARF	Advanced Recycling fee
CFCs	Chloroflouro Carbons
COSC	Cambridge Oversees Senior Certificate
ECA	Environmental Conservation Act 73 of 1989
EEE	Electrical and Electronic Equipment
EPA	Environmental Protection Agency
EPR	Extended producer responsibility
EU	European Union
E-waste	Electronic and electric waste
EoL	End-of-life
IndWMPs	Industrial Waste Management Plans
IT	Information Technology
LCA	Life Cycle Assessments
MCA	Multi Criteria Analysis
MFA	Material Flow Analysis
NEMA	National Environment Management Act 107 of 1998
NEMWA	National Environment Management Waste Amendment Act 26 of 2014
NGOs	Non-Governmental Organisations
NWA	National Water Act 36 of 1998
NWMS	National Waste Management Strategy
PAHs	Polycyclic aromatic hydrocarbons

PBDEs	Polybrominated diphenyls ethers
PBBs	Polybrominated Biphenyls
PBTs	Persistent Bioaccumulative and Toxic chemicals
PC	Personal Computer
PCBs	Polychlorinated Biphenyls
SPSS	Statistical Package for Social Science
UNEnvironment	United Nations Environment Programme
WEEE	Waste Electronic and Electrical Equipment

DEFINITIONS

The definitions provided below are given with specific reference to and context of this study, and do not necessarily speak to the same (international) terminologies given in the literature review.

Awareness: Knowledge that something exists or understanding of the situation or subject at the present time (Meriam-Webster Inc., 2020).

Extended Producer Responsibility: Is a policy approach under which producers are given a significant responsibility, financial and/or physical, for the treatment or disposal of post-consumer products. Assigning such responsibility could in principle provide incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals (OECD, 2001).

E-waste: Electronic waste or e-waste is a generic term for various forms of electric and electronic equipment that have ceased to be of any value to their owners without the intent of reuse (Lydall *et al.*, 2017).

Although there is no standard definition for WEEE as yet in Lesotho, the European Union (EU) Directive defines “Electrical or electronic equipment waste as all components, sub-assemblies and consumables, which are part of the product at the time of discarding (EU, 2002).

Knowledge: Facts, information, and skills acquired through experience or education (Hasa, 2020).

Practices: A habitual or customary action or way of doing something (Oxford Dictionary, 2020).

Willingness: The quality or the state of being prepared to do something (Lexico, 2020).

Recycling: Is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products (EPA, 2017).

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CHAPTER 1 INTRODUCTION

1.1 Background

E-waste is the fastest growing waste stream globally and its rapid increase has become a global concern (WEF, 2019:9). Over the past two decades, the global market for electronic and electrical equipment (EEE), has been growing exponentially, while the life span of these products has been reduced (Khurram *et al.*, 2011). As a result, the annual increase in e-waste generation and as a complex and hazardous waste stream, poses a threat to the environment and human health and considerable measures must be put in place for its sound management (Kamal, 2017).

Africa hosts a low number of EEE manufacturers, however, the continent generates a significant amount of 2.2 Mt e-waste per year from domestic output (Baldé *et al.*, 2017:66). Most of the generated e-waste is derived from imports of new and used equipment and a few local plants. Locally generated e-waste contributes to between 50 and 85% of e-waste generated, while the rest of the e-waste is from illegal transboundary import of waste from China, America and Europe, thus posing serious challenges for e-waste management. Most African countries are aware of the inherent dangers of e-waste and they have ratified the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes. South Africa, for example, has promulgated regulations to govern the import and export of waste, which includes e-waste (GN. 22 of January 2019). Nevertheless, most countries have not domesticated the convention nor promulgated national legislation to manage e-waste, and therefore lack the legal and infrastructural framework for sound management of this hazardous waste stream and activities related thereto (Baldé *et al.*, 2017:66).

In the absence of regulations, standards of disposal and public awareness, e-waste in developing countries often ends up in landfills with general waste, or being recycled as part of the general waste stream, thus leading to soil, groundwater and air contamination. A lack of reliable data is also a challenge when it comes to policy-making and decisions around e-waste management, and to the industry wishing to make investment decisions (Oteng-Ababio, 2012:150). Insufficient public knowledge in e-waste management and recycling, poses a challenge in the management of this complex waste stream. Awareness raising on the health hazards and disposal practices of e-waste play an important role among the consumers in curbing the environmental threats and saving the human health (Duraismy *et al.*, 2017:2147)

E-waste in Lesotho is disposed together with general waste, thus ending up in landfills, roadside or being burned due to the lack of knowledge and awareness of the toxic nature of this waste

stream (Enviroxcellence, 2012:103). There is a general lack of data on the amount of e-waste produced, collected and recycled per year. To add to the problem, there is no legislation that governs the management of e-waste nor the infrastructure for formal recycling (Enviroxcellence, 2012:103).

1.2 Defining electronic waste (e-waste)

Kwatra *et al.* (2014:753), define e-waste as “the equipment that cannot be used any further, repaired or reused, as whole or as part of it”. The authors further explain that waste electrical and electronic equipment (WEEE) constitutes of electronic appliances such as laptops, televisions, DVD players, computers, mobile phones, micro ovens and so on. These appliances are discarded by the users because they have exhausted their life span.

Oteng-Ababio (2012:152), defines e-waste as “old, end of life electronic and electrical equipment or waste generated from any equipment running on electricity or battery, which have been disposed by the original user”. The European Union (EU) Directive defines e-waste as “Electrical or electronic equipment waste as all components, sub-assemblies and consumables, which are part of the product at the time of discarding” (EU, 2002).

There is no formal definition for e-waste in the Lesotho context. For the purposes of the study, e-waste will be regarded as defined by the EU and other authors mentioned above.

1.3 Problem statement and rationale for the study

Most of the obsolete equipment is shipped from developed to developing countries for access to information technology (Osibanjo & Nnorom, 2007; Sahle-Demmessie *et al.*, 2018). Due to the lack of e-waste legislation, public knowledge, recycling infrastructure, and framework for the e-waste take back or implementation of extended producer responsibility (EPR), e-waste is often disposed of with general waste to the landfills, or end up in open burning or open dumping (Osibanjo & Nnorom, 2007; Sahle-Demmessie *et al.*, 2018). The inappropriate handling of e-waste in Africa, has resulted in serious implications on human health and the environment due to the presence of heavy metals and hazardous substances contained in EEE (UNEnvironment, 2018; Azodo *et al.*, 2017: 1036). Other than inappropriate handling of e-waste, lack of public awareness of e-waste management practices in developing countries affects consumer recycling behaviour, which in most cases is driven by demographic and socio-economic factors, environmental knowledge, current practices, habits that include storing of e-waste at home, and convenience disposal (Schevchenko *et al.*, 2019:8).

As much as studies on public awareness of e-waste have been undertaken in most developing countries as per desktop search results, Lesotho is lagging behind in terms of research on general e-waste management. It has been established through desktop search that the only published study on e-waste is Assessment of e-waste report written by Enviroxllence in 2012. This study has been the only one informing the researcher on the background of e-waste management in Maseru.

In Maseru, e-waste from the offices, households and industries gets disposed to the dumpsites, or burned (Enviroxllence, 2012). There is a general lack of awareness of the harmful effects of e-waste components, in the industrial sector, informal recyclers, landfill operators, as well as household consumers (Enviroxllence, 2012). Thus, in the view of this emerging concern, it is important to establish the level of public awareness of e-waste management practices in order to establish management practice gaps, as a way to inform the development of e-waste public awareness programmes (Kwatra *et al.*, 2015:755; Hasan, 2004:491).

Waste management in Lesotho is the responsibility of Maseru municipality. The municipality waste collection coverage rate is 40%. However, community contracting is used in some of planned settlements while force account is used in some of the settlements where there is a problem of access roads. These systems of waste collection extend services to areas of the municipality where waste is not being formally collected. Self-disposal is still practiced in some of the city wards, and waste is often managed through open burning, animal feeding and composting. In terms of driving recycling in the city, waste picking is largely practiced at the landfill site, this is due to lack of waste separation at source. The waste pickers sell the recyclable waste to the informal buy back centres, where waste is finally transported to South Africa for recycling. Some of the recyclable waste is sold to local recyclers of paper and plastic. (Africacleancities, 2018).

1.4 Aims and research questions

The study aimed at establishing the level of knowledge and awareness of e-waste management practices amongst members of the public in Maseru, Lesotho.

The research questions included:

1. What is the *current knowledge and awareness* of the public in Maseru, regarding e-waste management practices and how *willing* would they be to participate in certain e-waste management practices? (RQ1);

2. What is the significance (as per chi square analysis) of *variables, such as gender, household size, age, etc.* as it relates to knowledge and awareness of e-waste management practices? (RQ2);
3. How can e-waste management practices in Maseru *be improved* (based on gaps when compared to international best practices)? (RQ 3).

1.5 Delineating the scope of the study

The study was conducted in Maseru, Lesotho. The focus of the study was on the current *knowledge and awareness* of the public in Maseru (based on a sample of respondents). The study only aimed on identifying current e-waste management practices of consumers, but not verifying those practices. Three-hundred-and-fifty-four (354) questionnaires were administered in three suburbs, namely, Ha Tsolo, Koalabata and Sekamaneng. The sample size is considered to be representative of approximately 0.11% of the total population in Maseru (of approximately 331 000), which is considered to be representative of the population at a confidence level of 95% and a confidence interval (margin of error) of 5. The study could be regarded as a pilot study to inform future research on e-waste in Maseru, or the larger Lesotho. The research was limited to **e-waste** management knowledge and awareness, and did not include any other waste streams.

The study focused on variables such as gender, age, education level, household size and employment status and their relationship on e-waste awareness and e-waste management practices. No minors (aged younger than 21) were included in the study, due to the NWU's ethical protocol on working with minors.

The study focused on household e-waste management practices, and their knowledge and awareness in the waste management context. The intent of the study was not to provide an in-depth study of behaviour (i.e. is not a behavioural study) and was, therefore, not designed as such. Apart from references included in the literature review, the study does not include any inputs from behavioural or social scientists.

1.6 Limitations of the research

There was a challenge with access to houses with tight security, and these are households owned by mostly literate people. There may, therefore, be a possibility that the data collected during this research does not adequately represent the views of educated, literate people. In some cases, people were not willing to participate in the surveys, and part of the reason was that data were collected during the time when the public was warned by the utility company against people who claim to have been sent by the company to test electricity at homes yet they had the ulterior motives of stealing from the public. As a result, people were very cautious when

it came to questions related to their household appliances. Another reason was attributed to the fact that the utility company had some unattended faults in some areas, so the subject relating to electricity/electronic products was linked to the utility company and they were hoping that the researchers have come with solutions to long unattended faults. Once the participants realised that the intervention (research) was not about solving their electricity faults, they resisted participation in the study. Of the 384 participants initially identified for inclusion in the study, thirty individuals refused to participate, which limited the responses to 354 households.

1.7 Outline of the dissertation

Chapter 1 of this dissertation outlines the background and problem statement of the research, and provides the research aim and questions. It further delineates the scope of the study, and introduces the limitations against which the research was conducted. The literature review is discussed in Chapter 2 of the dissertation. The literature review focuses on the significance of variables, such as gender, household size, and age as it relates to knowledge and awareness of e-waste management practices. The discussion further focuses on the international best practices for the management of e-waste, and the current practices relating to e-waste management in developing countries.

Chapter 3 outlines an overview of the methodology followed during the study. The chapter describes the sample size and the method of selection of participants. It provides an insight on the data that were collected and how it related to the research questions. The chapter also details how the data were analysed to address each research question.

Chapter 4 presents data analysis using data coding, also presents the results, and a discussion of the results. Chapter 5 covers conclusions and recommendations for future research. It also outlines what the researcher has learned about the research questions and the problem under study, and how this can contribute to literature and to improve practice.

1.8 Chapter summary

This chapter outlined the background on the challenges that e-waste poses to developing countries, including Lesotho. These challenges include a lack of public knowledge and understanding of e-waste, insufficient legislation, and insufficient formal recycling infrastructure. The chapter further outlines the problem statement of the research, research aim and research questions. Study limitations, delineations of study scope and outline of the dissertation are also reflected in this chapter.

Chapter 2 of this dissertation reflects on the literature review of both developing and developed countries, to provide insight into e-waste management practices. The literature review also seeks to address research questions.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

The literature that has been reviewed is from both developed and developing countries. The purpose of the literature review was to provide background to the research and to provide some context to the research questions:

- *What is the significance of variables, such as gender, household size, age, etc. as it relates to knowledge and awareness of e-waste management practices and how willing would they be to participate in certain e-waste management practices? (RQ 2); and*
- *How can e-waste management practices in Maseru be improved (based on gaps when compared to international best practices)? (RQ 3).*

The research was conducted in Maseru, Lesotho, which is a developing country. The purpose of reviewing literature from developed countries is to familiarize the researcher with the best environmental practices adopted to effectively manage e-waste streams, and how these practices have contributed in achieving high rates of re-use and recycling. Literature from developing countries has been reviewed to provide a comparative context for the current study, which was conducted in Lesotho to establish the role that public knowledge and awareness play in effectively managing the e-waste stream. According to Heeks *et al.* (2015: 654) developing countries have high volumes of e-waste, with potential to re-use and recycle, but there is general gap in the knowledge of consumers when it comes to e-waste handling, re-use, recycling and disposal.

The adoption of best practices in the management of e-waste streams by the developing countries creates opportunities in material recovery and recycling, thus limiting the informal e-waste processing and recycling, as well as inappropriate disposal, which pose a threat to human health and the environment due to the toxic nature of e-waste. Presently, in Africa, the threats outweigh the opportunities. For example, India is recycling almost 5% of the world's e-waste, with recycling being done by the informal sector operating in hazardous and polluted conditions. This inappropriate management of e-waste is influenced by an absence of policy, weak legislation and enforcement, as well as lack of public awareness and knowledge in developing countries (Heeks *et al.*, 2015: 654).

2.2 The e-waste management problem

Africa is faced with a problem of sound e-waste management due to lack of infrastructure for environmentally sound management, legislation dealing with e-waste management, and e-waste take back framework, as well as inadequate public education and awareness on the impacts

linked to the uncontrolled importation of e-waste. Open dumping, burning and landfilling are the common method of disposal in Africa, with potential serious implications for human health and the environment. When e-waste is inappropriately handled and disposed of it may affect human health and the environment negatively (UN Environment, 2018:48).

Research done in 2017 (Baldé *et al.*, 2017:66) suggests that Africa generates approximately 2.2 Mt of e-waste per year of which 50% - 85% is e-waste generated locally, while the rest is from the transboundary illegal import from developed countries. Approximately 4 000 tonnes of e-waste is documented to be collected and recycled by the formal sector in Africa. Large portions of e-waste, though not documented, end up in the informal recycling sector which is dominated by ill equipped informal sectors and with no skill to resource recovery, thus causing and environmental pollution and also impacting their lives and those surrounding them (Baldé *et al.*, 2017:66).

2.2.1 Unsound e-waste management practices in developing countries

This section focuses on the general e-waste management practices employed by the public in developing countries. Due to the fact that literature on e-waste management in Lesotho is limited, literature from other developing countries was reviewed to provide context to this study.

Most African countries are aware and concerned of the dangers associated with poor management of e-waste but there is a general lack of legal and infrastructural framework (Baldé *et al.*, 2017:60). Only a few countries have any formal official documents in relation to e-waste management. Although most African countries have ratified Basel Convention, most have not domesticated the legislation to govern the movement of various hazardous waste streams. However, there are notable initiatives from some of the countries with regard to e-waste management. There have been draft on e-waste bills in countries like Ghana, Madagascar and Kenya between 2015 and 2016, while countries like Zambia and Nigeria are still awaiting the draft bill to be passed in parliament. Based on these initiatives, many African governments have begun to pay more attention on e-waste management through adoption of integrated and comprehensive approaches (Baldé *et al.*, 2017:60).

In most developing countries particularly the low income and middle income countries, e-waste is disposed of in domestic waste landfill sites. Informal e-waste recycling is also widely practiced and it is often not addressed as a part of a municipality's solid waste and resources management system. Reclamation and recycling of e-waste in Africa mostly takes place by informal recyclers, without no to little regard for their health and safety, or for the environment. Furthermore, the lack of resource recovery policies in the existing waste management strategies promotes the

recycling of e-waste by the informal sector. In the informal sector, many unsafe practices take place, with wires being burned to remove plastic and recover copper, acid extraction is used to recover precious metals such as gold, platinum, palladium and silver from printed circuit boards. Countries such as China, India, Pakistan, Nigeria and Ghana, engage in these informal e-waste recycling practices (Ikhlayel, 2017:119,121).

Data on e-waste generation and estimation on e-waste levels, as well as data on e-waste flow are generally lacking in developing countries due to absence of standardized methods for e-waste generation and also a lack of infrastructure to appropriately manage e-waste (Ikhlayel, 2017:121). Managing e-waste flow in developing countries, especially in Africa, where promotion for access to technology is attracting massive imports of used and new computers, is quite a challenge. Difficult access to data, coupled with the sector being characterized by informal, rather than formal e-waste recycling activities, with limited to no access to data, creates a barrier to determining and managing the flow of e-waste (Schluep & Munyua, 2008:1; Ikhlayel, 2017: 122).

Household behavior as it relates to the management of waste is also quite inconsistent, with limited awareness around e-waste management good practice. The majority of electrical and electronic equipment (EEE) users in Malaysia store the e-waste in their households before it can be sold, or disposed of together with other solid waste (Afroz *et al.*, 2013: 191). A study conducted by Borthkur and Govind (2018:1060) in India highlighted that citizens give their obsolete electronic products to relatives and friends rather than having it disposed of, which could be viewed positively in the context of waste minimization. The study further revealed (similarly to the study done by Afroz *et al.*, 2013) that a lack of knowledge of the management of e-waste has led to consumers storing obsolete EEE in their homes, thus suggesting that the lack of resource availability and limited opportunities restrict opportunities for e-waste re-use and recycling. E-waste in India is collected through door to door scrap collection, mostly by the informal recycling sector (Borthkur & Govind, 2018:1060).

Ghana is also faced with a similar challenge regarding a lack of awareness on e-waste management practices. A study conducted by Owusu *et al.* (2017:82) revealed that most of the citizens in Ghana were not informed of e-waste management and disposal practices. The study implied that the citizens do not have regard for the impacts of e-waste on the environment due to a lack of awareness and education (Owusu *et al.*, 2017:82).

In developing countries, e-waste collection is driven by recovery of precious metals but not for environmental and human health protection. The reselling of household e-waste as scrap, dismantling or informal recycling have been found to be the preferred methods of e-waste management in Ghana, as it is a means of generating income and supports livelihoods (Owusu

et al., 2017:82-83). However, the dismantling of e-waste is generally carried out in an unsafe manner by the informal recyclers, resulting in the release of toxic chemicals that pose risk to human health and the environment. Nonetheless, some participants of the study by Owusu *et al.* (2017) were of the opinion that no harmful gases are released when the e-waste is buried and that burning prevents indiscriminate disposal of waste. This lack in knowledge highlights that there is insufficient awareness when it comes to the management of e-waste and its potential adverse effects on the environment and health of humans (Owusu *et al.*, 2017:82-83).

In Nigeria, Nnorom *et al.* (2009), have found that a lack of knowledge of sound e-waste management practices creates the wrong perceptions regarding the recycling practices among the Nigerian public. Results of the study indicated that Nigerians perceive e-waste recycling as a private profit generating scheme, with limited incentive to the generator of the e-waste, and may influence their willingness to recycle e-waste (Nnorom *et al.*, 2009). Not only does these uncoordinated waste management practices pose a risk to the health and safety of the public, it also has the potential to cause detrimental environmental impacts.

2.2.2 Environmental impacts of unsound e-waste management

During open, informal burning of e-waste (that takes place in less oxygen and in low temperatures, compared to controlled combustion) to extract copper from plastic insulations, toxic air pollutants such as dioxins and furans are released into the environment (Karthkir, 2016:354).

Landfill disposal of e-waste also leads to toxic emissions. The chlorofluorocarbons (CFCs) found in refrigerators and air conditioning units are ozone depleting and they are likely to escape into the environment during disposal at the landfill (Robinson, 2009:186). Other toxic substances from e-waste contributing to harmful landfill emissions include polychlorinated biphenyls (PCBs), nickel, Hydrochloroflourocarbons (HCFCs), asbestos and dimethylene mercury (Babu *et al.*, 2007:309). Furthermore, uncontrolled fires that may occur at landfills, may also release extremely toxic furans and dioxins (Babu *et al.*, 2007:309; Karthkir, 2016:355).

The uncontrolled handling and disposal of e-waste may also result in soil and water pollution (Karthik, 2016:355). Some studies have indicated that limited, enclosed e-waste components disposed of at engineered landfills (with the necessary liners and cover material), produce leachates with heavy metals concentrations that do not exceed environmental limits, as per the toxicity characteristic leaching procedure (TCLP) test. Nonetheless, it has been established that the leachate cocktail of different e-wastes on landfill sites have a cumulative impact on the aquatic environment (Gaidajis *et al.*, 2010:195).

Large amounts of heavy metals contained in e-waste, such as cadmium, mercury, lead and flame retardants are considered to be PBTs (persistent bioaccumulative toxic chemicals) and they do not degrade easily in the environment. Through the improper handling of e-waste, these pollutants can move thousands of kilometres from their sources of emission and accumulate in polar latitudes where they accumulate at high concentrations (Karthik, 2016:350-351). PBTs may eventually find their way into the human body through the food chain, as well as by means of exposure through the respiratory system and skin, and has a potential to cause health effects. Section 2.2.3 elaborates on the health effects of e-waste.

2.2.3 Health impacts of unsound e-waste management

Human exposure to high levels of PBTs can lead to acute and chronic health effects such as cancer, brain and liver damage, kidney failure, skin diseases, neurological disorders and even death (Ouabo *et al.*, 2019:2).

The presence of heavy metals, such as lead, cadmium and mercury, in e-waste, and their negative impacts on human health is a cause for concern. The main applications of lead in computers are glass panels and gasket, in computer monitors, and solder in printed circuit boards. Lead causes damage to the central and peripheral nervous system, kidney and reproductive systems in humans (Frazolli *et al.*, 2010:396). Cadmium is found in certain components of devices such as surface mount devices, chip resistors, infrared detectors and semi-conductors. Cadmium compounds are toxic, they can bio-accumulate and pose a risk of irreversible effects on human health. Mercury is used in devices such as thermostats, relays, switches, medical equipment, lamps, mobile phones and in batteries. Mercury can cause damage to organs such as the brain and kidneys.

The developing foetus, babies and children are more vulnerable to PBTs and heavy metal poisoning, and this may prompt poor health conditions through the life cycle, from impaired neurobehavioral development to increased risk of cardiovascular disease and stroke in the adult life (Frazolli *et al.*, 2010:392, Babu *et al.*, 2007:309).

2.3 Opportunities for e-waste re-use and recycling

E-waste collection and recycling is an important economic activity that has extended means of income to 64 million people in developing world. The industry contributed to US\$5.6 billion in 2001, and it was projected to grow to US\$14.7 billion by 2014 (Grant & Oteng-Abiabo, 2013:4). The latest forecast revealed that e-waste is worth US\$62.5 billion annually, which is more than the GDP of most countries. It is also worth three times the output of all the world's silver mines (WEF, 2019:15). A more effective use of e-waste products is the re-use of the product, also

referred to as “the second life”, which keeps the value of material higher. The global markets for second life products such as cellphones, are well developed. There is room for improvement to retain the precious metals, which is worth billions of dollars, which are currently being disposed of. In order to leverage this opportunity, countries need to make a shift from a linear to circular economy in electronics (WEF, 2019:15).

Figure 2-1 below shows the linear vs circular economy models, and simply illustrates that the linear economy puts a lot of pressure on the world ‘s natural resources needed as raw materials to make new products which ultimately become waste that ends up in the landfills and having negative environmental impacts on the environment and human health, while the circular economy emphasises the importance of keeping resources in use as long as possible, and once the maximum value has been extracted, there should be recovering and recycling of resources so that they can be used again.



Figure 2-1: Linear vs circular economy (Source: Instarmac, 2018)

Besides metals, there are other valuable materials found in e-waste, such as plastic, glass and ceramics. Moving towards circular economy in electronics, has a potential to turn the waste material into secondary raw material, which can serve as valuable inputs in different companies, for the manufacturing of different products (UNEnvironment, 2018).

E-waste collectors make a living from creating their own jobs, as opposed to earning a living in regular formal employment. In Africa, e-waste recycling is an industry led by the informal sector,

however they do not operate in the separate economic realms, since informal e-waste circuits depend on the local formal economy. A web of activities constitutes the e-waste economy; global agents, brokers, importers, warehouseers, backyard processors, waste and metal intermediaries, secondhand electronics markets, formal or informal industry representatives (Grant & Oteng-Abiabo, 2013:4). In a study conducted by Oteng-Abiabo (2011:14-15) Ghana, it has been concluded that e-waste scavenging as a livelihood means in Accra, addresses the need for a response to rapid urbanization, neoliberal, globalization, and a lack of formal job opportunities. The researcher, further concluded that based on the increased rate of cheap labor, e-waste scavenging does not only generate income earning opportunities for thousands of mostly extremely poor people, but have led to emergence of dynamic entities with strong linkages to the formal and informal sector. It was also revealed that e-waste scavenging is no longer done by the informal sector, but also formal sector employees who were previously assumed to be stable economically.

E-waste recycling does not only create jobs; it also reduces the dependence on virgin resources. A recycling company in China produces more cobalt than the country mines in a year. Recovery of precious metals over mineral mining results in reduction in primary raw materials sourcing therefore reducing production cost, less energy use and carbon footprint, as well as minimal environmental pollution and impact on climate change (Asante *et al.*, 2019:115).

2.4 Addressing the e-waste management problem

The toxic nature of metals found in e-waste poses both environmental and health threats. However, there are opportunities in recycling and re-use of e-waste, in order to recover the precious metals that can be used as secondary raw materials to minimise extraction of already depleted virgin materials. The e-waste problem may be addressed through policy, legislation and infrastructure, and the correct tools applied according to domestic e-waste challenges, supported by adequate knowledge and awareness of e-waste.

The next sub-sections outline some measures for addressing the e-waste problem.

2.4.1 Policy and legislation on e-waste

The management of e-waste in developed European countries has been supported by the release of European Union (EU) e-waste directive in 2002, which provided for the establishment of collection schemes where consumers return their e-waste free of charge (Kidde *et al.*, 2013:1241; EC, 2019). With this directive, Europe has developed regulations, with each of the 27 countries having their own domestic policy, aim to recycle 85% of e-waste by 2019.

In UK, Canada has a developed recycling industry which is regulated by the industry standard for proper electronics recycling and processing. Australia has the National Television and recycling scheme which forms part of government regulations and industry action to take responsibility for the collection and recycling of e-waste. While the U.S has not ratified the Basel Convention, half of the states, has legislation regarding e-waste management and the recycling of electronic products. Costa Rica, Peru, Columbia, and Mexico have e-waste rules in Latin America. In Asia, only Taiwan, South Korea, Japan, China and India have e-waste policy (Garlapati, 2016:878).

E-waste legislation is absent in large parts of Africa, the Caribbean, Central Asia, and Melanesia (Baldé *et al.*, 2017:48-49). The absence of legislation in developing nations pose problems in e-waste management on the generated quantities and the illegally imported used goods. Even though South Africa does not have a specific and effective law addressing the e-waste management, the National Environmental Management Waste Act (59 of 2008) (NEMWA), and other related legal framework such as the national waste management strategy (NWMS), the National Environmental Management Act (107 of 1998) (NEMA) and the National Water Act (36 of 1998) (NWA), address most of the issues related to the handling and disposal of hazardous waste (Ghosh *et al.*, 695).

Other than the waste legislation highlighted above, there have been developments in the e-waste management industry. These include; South Africa's ratification of Basel Convention on control of transboundary movement of hazardous waste, South Africa's involvement in the swiss e-waste programme, the election of e-waste recycling authority as producer responsibility organisation and the call for Industrial waste management plans (Sadan, 2019:70).

Lesotho does not have any specific legislation that addresses the management and disposal of e-waste. However, Lesotho is party to Basel convention on transboundary movement of hazardous waste. Lesotho has a small fraction of EEE manufacturers, and for the lack of legislation on e-waste and enforcement of law, most manufacturers are not implementing any environmentally sound management plans in their operations (Enviroxllence, 2012:64).

2.4.2 Tools for e-waste management

To address the global problem of e-waste several tools have been developed and applied to e-waste management. These tools include life cycle assessments (LCA), material flow analysis (MFA), multi criteria analysis (MCA), and extended producer responsibility (EPR). LCA is a tool used to design environmentally friendly electronic devices, in terms of eco design, product development, and environmental impacts. MFA is the tool used to study the route of e-waste

material flowing into recycling sites or disposal areas, and stocks of materials in space and time. This tool can be applied in e-waste management that is inclusive of the consideration of the flow of e-waste and its assessment in terms of environmental and socio-economic values. MCA is a decision making tool developed for considering strategic decisions and solving complex multi criteria problems that pertain to qualitative/quantitative aspects of the problem. EPR is an environment policy approach that lays responsibility on manufacturers in taking back obsolete equipment and is based on polluter pays principle (Kidde *et al.*, 2013:1241-1242).

In South Africa, industry waste management plans are used as a tool to manage e-waste. The e-waste IndWMPs takes care of all e-waste categories, including those that have precious metals and those considered non-valuable. Through EPR, producers acknowledge to take of their products when they become e-waste. The plan seeks to enhance existing recycling infrastructure, industry growth and job creation, through engagement of multi stakeholder approach, where all actors play an important role in e-waste recycling (SAWIC, 2015).

These tools and regulations, supported by public knowledge and awareness, is important for effective participation sound e-waste management practices (Deniz *et al.*, 2019:106).

2.5 Knowledge and awareness of e-waste in developing countries

Knowledge and awareness direct e-waste management practices. In a study conducted in Malaysia, it was established that most residents were aware of what e-waste is and the associated negative impacts on the environment. Environmental awareness has been demonstrated through purchasing of electronic and electrical equipment that are environmentally friendly through eco labelling. However, it has been found that despite their knowledge about e-waste, only three percent (3%) of the population was involved in recycling practices, such as returning their e-waste to the recycling centers and to the manufacturers (Afroz *et al.*, 2013: 191,192).

A study conducted in India, revealed that most informal recyclers were not knowledgeable of the harmful effects of e-waste. The educated informal recyclers were aware of health impacts that can be caused by e-waste but they did not consider it as a serious problem. The results of the study indicated that they found the business to be too luxurious to expect any kind of illness as a result of handling e-waste in an unsafe manner (Mishra *et al.*, 2017:147).

In Ghana, survey results on public perception of e-waste revealed that most citizens did not know about e-waste at all, and this has been more pronounced by the participants' response to the related questions. For instance, most of the participants displayed their ignorance when mentioning substances like cyanide and methane, which are generally not associated with e-

waste. The lack of knowledge has been partly ascribed to poor sensitization around e-waste information and existing programmes in Ghana. The study also revealed that a very low number of participants were aware of the adverse impacts of e-waste on environment and human health, at a time when the world is raising awareness on the problems associated with e-waste (Owusu *et al.*, 2017:84).

A survey carried out in Nigeria, on assessment of public knowledge of waste management, revealed that most e-waste importers are not aware of the harmful content of e-waste, and unaware of the national legislation regulating e-waste. This lack of knowledge also applied to e-waste collectors and members of households, as the respondents highlighted that they dispose of e-waste together with general waste, with some indicating that they keep their obsolete equipment with the hope that the need for them might arise. This lack of awareness and law enforcement suggests that government must make meaningful interventions to design effective awareness strategy and roll out adequate information dissemination (Okoye & Odoh, 2013:127).

2.5.1 Variables influencing knowledge and awareness of waste, and waste management practices

Nguyeni *et al.*, (2019:17), determined that in Vietnam, demographic variables, such as education, gender and household size, have a contribution to predicting residents' pro-environmental behavior. Similarly, Sidique *et al.*, (2010:169), in a study to assess the attitudes and behavior of residents, also reveals that socio-economic variables such as household size and income, are correlated with household consumption and are good predictors of recycling behavior compared to gender and marital status.

A study conducted by Sivathanu (2016:420), concluded that consumers who are aware of e-waste and its management were mostly post-graduates and professionals. The results revealed that there is a significant relationship between the education and income levels of the consumers and their e-waste awareness. These consumers also have preference for proper disposal and management of e-waste.

On the other hand, a study conducted in Iran revealed that there is a poor correlation between demographic variables and solid waste source reduction when relevant demographic such as age, education, and occupation were studied. However, the increase in respondents' education provided the largest set of significant groups of source separation and recycling knowledge as well as their willingness to recycling. Nonetheless the study could not achieve a concrete conclusion that relates the impact of education level to the citizen's awareness on solid waste management, it can therefore be argued that education enhances the development of general

knowledge which consequently stimulates responsibility towards the environment (Babaei *et al.*, 2015:97).

Apart from demographic variables, other variables such as the availability of infrastructure, environmental knowledge, and convenience also play a role in waste management practices. Sidique *et al.*, (2010:169) concluded that there is a high potential for utilization of drop-off centers if they are located conveniently relative to higher income and older neighborhoods. Similarly, a study conducted in Nigeria, on consumers' intention to participate in formal recycling revealed that adequately managed e-waste collection infrastructure situated close to households, together with environmental knowledge, attitude as well as subjective norms, has a potential to influence the recycling intentions of consumers (Nduneseokwu, 2017:14).

2.6 Willingness to engage in e-waste best practices

The factors influencing the willingness of participants to be involved in proper e-waste management practices relate mainly to gaining some type of incentive, as well as the availability of infrastructure, within relative proximity of where the e-waste is being generated (Babaei *et al.*, 2015).

It has been found that in Malaysia most e-waste generators are expecting payment for their e-waste, as they are aware of the precious metals contained in e-waste. However, there is still a significant percentage that is willing to participate in paying for the improvement of e-waste management (Afroz *et al.*, 2013:192). Similarly, in India, people are reluctant to discard their e-waste immediately without any financial gain as e-waste is considered a worthy commodity (Borthkur & Govind, 2018:1061).

Other than people's intentions to participate in e-waste best management practices, it has been found that lack of infrastructure influences a reluctant participation in formal e-waste collection in Nigeria (Nduneseokwu *et al.*, 2017:881). Similarly in Malaysia, (Senawi & Sheau-Ting, 2016:2) it has been established that inconvenience of e-waste recycling infrastructure in terms of distance, reduces the rate of citizens to participate in recycling activities.

2.7 Best practices and lessons to be learned from developed countries

Developed countries have conventions, directives and laws mostly based on EPR to regulate e-waste disposal. E-waste management systems in developing countries consists of three elements, namely: the national registry, the collection system and logistics (Sthiannopkao & Wong, 2013:1150).

Analyses of developed countries' e-waste management indicates that Japan has the best functioning system in terms of scope and compliance levels. Korea, Canada and Australia also have well-developed systems. Switzerland's system is seen as a model of comprehensive management. The Swiss, Norway, Belgium, Sweden and the Netherlands have exceeded minimum EU e-waste directive's collection and recycling targets (Sthiannopkao & Wong, 2013:1150-1151).

Based on the above highlighted achievements of developed countries' e-waste management, developing countries can learn from and adopt these e-waste management systems to effectively manage e-waste. The following sub-sections elaborate on the e-waste management systems and the public awareness strategies used in some of the developed countries.

The practices summarised in the sub-sections aim to inform research question 3, which aims to determine international best practices for the management of e-waste (to compare practices in Maseru with best practice) to identify gaps and make recommendations for improvement.

2.7.1 Lessons to be learned from Switzerland

Switzerland ranks among the top countries in the world that take environmental protection very seriously. Environmental concerns as well as citizens' awareness on environmental issues is high on the Swiss agenda, and this has been realized when 62.6% of the citizens demanded the government to give environmental issues a priority. To this end the Swiss government introduced the *polluter pays* principle in waste management legislation (Khetriwal *et al.*, 2009:156). Not surprisingly, Switzerland was the first country in 1998 among the European countries to develop and implement an effective e-waste management system for collection, transportation, recycling and disposal of e-waste (Islam *et al.*, 2016:730).

The extended producer responsibility (EPR) approach was supported by the law on *The Return, The taking back, and The Disposal of Electrical and Electronic Equipment* (Doan *et al.*, 2019:159). The consumers are charged an advanced recycling fee (ARF) at the sales price of the product, which is used for all operations throughout e-waste management system. The ARF is only applicable if the disposal cost is higher than the value of recoverable materials. The consumers are required by law to return end of life appliances and are not allowed to dispose them of with other household waste. In 2017, Switzerland processed 122,800 tonnes of e-waste and achieved a recycling rate of 73%. The high recycling rate has been achieved through engagement of the four producer responsibility organizations in the collection system, focusing on different e-waste devices (Islam *et al.*, 2018:712).

Even though Switzerland is achieving a high recycling rate, it has been noted that only 15% of mobile phones purchased are returned for recycling, while it is assumed that the other 85% of mobile phones are stored in by households for years. The Swiss Association for Information, Communication and Organisational Technology (SWICO) recycling programme, has made efforts to change this behaviour by using google maps where mobile phone users can verify and locate the nearest recycling centre. One of the responsibilities of the civil society is to impart education to the citizens, and it is through this platform that the public is encouraged to participate in e-waste recycling. An additional role of the civil society is to start up a discussion on the usefulness and characteristics of mobiles (GISwatch, 2010: 220,221).

2.7.2 Lessons to be learned from Japan

EPR for e-waste has been established as early as 1990s through the law on Promotion of Effective Utilization of Resources with emphasis to improve methods for recycling e-waste and minimizing waste generation and the *Law on Recycling of Specified Kinds of Home Appliances* which sets out the responsibilities of companies and consumers on recycling of obsolete home appliances. The consumers pay for the recycling fee and local government collects the disposed e-waste. The retailers provide collection points, and the recycling is done by the manufacturers. Many computer and other IT device manufacturers offer take-back programs even where not mandated by law. The country has achieved a collection rate of 74% through this system (Sthiannopkao & Wong, 2013:1150).

The PC 3R (Reduce, reuse and recycle) promotion association established in 2004 under the auspices of Japan Electronics and Information Technology Industries Association, among its other functions, runs the awareness program, publicity and educational initiatives promoting 3R (Honda *et al.*, 2016:94). Publicity and educational activities are related to active collection and recycling of used PCs and the publication of results as they relate to the active collection and recycling. The association also responds to the enquiries from the stakeholders with regard to collection and recycling (Honda *et al.*, 2016:94).

2.7.3 Lessons to be learned from Sweden

Sweden as a member of EU, is bound by the directives and regulations developed by the EU in relation to e-waste management, and these regulations take precedence over national legislation should there be conflict. Sweden has domesticated EU regulations and the WEEE Directive, nonetheless Sweden established a substantial framework to govern voluntary recovery, collection and recycling of electronic waste goods, prior to the Directive (Zhang & Bashiri, 2016:15). In 1997, the country tested the EPR system through a pilot project on take back of cell

phones that have reached the end of life. The programme has been very successful (Mahesh, 2012:14).

The EU regulations and WEEE Directive have been implemented through the establishment of ordinance of the producer responsibility for electronic and electrical products set in the Swedish statutes of 2005. The ordinance provides for among others, the collection system of e-waste, financial guarantees for waste equipment coming from the households, information dissemination for recyclers on how they can obtain and make use of e-waste, information dissemination on where e-waste generators can take back their equipment when it reaches end of life. Additionally, the ordinance provides for registration of new electrical and electronic manufacturers at Swedish EPA for the collection and recycling of their products when they reach end of life. The collection system is maintained through two producer responsibility organizations, Swedish EPA, Swedish waste management and recycling associations (Zhang & Bashiri, 2016:15,28).

EI-Kretsen, as one of the two producer responsibility organisations, runs a nationwide collection and recycling system of e-waste. This system is run together with the municipalities of Sweden. The system is very simple for the households to use as they dispose of e-waste together with their general waste for the municipality to collect. The waste is segregated into general waste and e-waste at the municipal sites. The e-waste is collected by EI-kretsen for recycling (Mahesh, 2012:15).

2.7.4 Lessons to be learned from China

In China, laws and regulations have been developed using the EPR principle in order to promote the recycling of e-waste. The publishing of the Regulation on Management of e-waste Recycling and Disposal, and the statutory proclamations including Administrative Measure on e-waste Recycling Enterprises Permit (commonly known as measure) among others, in 2011 and 2012 respectively, implied that China was about to implement the EPR system similar to EU and Japan. The Measure put EPR into effect through tax administration, general rules, subsidy utilization, supervision and supplemental rules. The measure is applicable to domestic EEE producers and importers who were taxed by the State Administration of Taxation and by customs respectively. These taxes are used as subsidies for e-waste recycling and fees for management information system construction (Cao, *et al.a*, 2016:884).

Apart from the initiatives made by the government on publication and implementation of legislation and the enterprises in creating the formal market for e-waste recycling, public awareness raising is a significant factor for effective collection and recycling. It has been

established through surveys conducted by Coa *et al.* in 2016, that the Chinese have a gap in e-waste management knowledge, however their knowledge is gradually improving as compared to three and half years before this study was conducted, which positively inspire more e-waste management policies (Cao *et al.*, 2016:890). However, in the survey conducted by Cao *et al.* (2016:318) on public perception of e-waste recycling, it has been found that the majority of the respondents were of the opinion that government should take full responsibility for recycling of e-waste, and this misconception increases the government's pressure and deters the government's subjective initiatives and moreover it is harmful for the establishment of effective e-waste recycling system.

2.8 Conclusion

The lack of legislation in most African countries has attracted illegal e-waste import from developed countries. The lack of legislation coupled with lack of proper infrastructure for the sound management of e-waste and poverty in Africa, has encouraged the booming of informal e-waste recycling industry and poor e-waste management practices in Africa. These practices have put the environment at a high conservation risk, and the human health vulnerable to exposure of toxic pollutants (emanating from uncontrolled combustion of e-waste) and heavy metals contained in e-waste which have a potential to cause diseases such as cancer, brain and liver damage, as well as skin disease. However, e-waste also contains the precious metals that can be recovered for re-use to avoid extraction of virgin materials, thus saving energy, stimulating economic growth and job creation.

Even though there are a number of e-waste management tools, according to reviewed literature it is evident that EPR remains the most preferred principle in first world countries. The EPR can be also be adopted by the developing countries as international best practice, as it has proved to be effective in e-waste collection and recycling through a robust collection system that is driven by the producer responsibility organizations.

E-waste knowledge and awareness is generally lacking in developing countries, suggesting that the information dissemination to the public is not carried out effectively by the government departments. The educated people who are well informed about the health effects of e-waste are also not handling or disposing e-waste in a safe manner because they think that the effects are not detrimental. E-waste is generally kept within the households with the owner hoping that it will have another beneficial use, and it eventually ends up being treated like general waste when being disposed of. For some consumers who know the value of e-waste, they sell it to informal waste reclaimers.

According to research, the majority of authors agree that demographic variables such as gender, age and education play a role in predicting the pro environmental behavior. The willingness to participate in recycling is influenced by a number of factors, but is mostly incentive driven and depends on the proximity of the recycling infrastructure.

The best practices and key lessons learned from developed countries include:

- In Switzerland, e-waste legislation uses the EPR system as the management tool, the consumers pay advanced recycling fee included in a product price, which is used to cover for the e-waste management. The e-waste is managed by the four producer responsibility organisations, focusing on different e-waste devices. The civil society is responsible for education and awareness creation on e-waste, thus encouraging recycling. SWICO, is making efforts to locate the nearest recycling centres through google maps for mobile phone users to locate.
- In Japan, EPR system is also used to manage e-waste, through the Law on Recycling of Specified Kinds of Home Appliances. The consumers pay for the recycling fee and the local government collects the disposed e-waste at the collection points provided by the retailers and the manufacturers are responsible for recycling. The awareness program, publicity and educational initiatives promoting 3R are run by the PC 3R association aiming at active collection and recycling of used PCs.
- In Sweden, the ordinance of the producer responsibility for electronic and electrical products set in the Swedish statutes of 2005 was established to give effect to EU regulations and WEEE Directive. The ordinance provides for the collection system of e-waste, financial guarantees for waste equipment coming from the households, awareness for recyclers on how they can obtain and make use of e-waste, and awareness on where e-waste generators can take back their equipment when it reaches end of life. Prior to ordinance and Directive, the Swedish government established a substantial framework to govern voluntary recovery, collection and recycling of electronic waste goods, and has tested the EPR system through a pilot project on take back of cell phones that have reached the end of life.
- In China, the Measure placed EPR into effect through tax administration, general rules, subsidy utilization, supervision and supplemental rules. The measure is applicable to domestic EEE producers and importers who were taxed by the State Administration of Taxation and by customs respectively. These taxes are used as subsidies for e-waste recycling and fees for management information system construction.

CHAPTER 3 METHODOLOGY

3.1 Introduction

The aim of the study was to establish the level of knowledge and awareness of e-waste management practices of the public in Maseru, Lesotho. The research questions were:

- *What is the current knowledge and awareness of the public in Maseru, regarding e-waste management practices and how willing would they be to participate in certain e-waste management practices? (RQ1)*
- *What is the significance of variables, such as gender, household size, age, etc. as it relates to knowledge and awareness of e-waste management practices? (RQ2)*
- *How can e-waste management practices in Maseru be improved (based on gaps when compared to international best practices)? (RQ 3).*

This chapter provides detail on the methods used to collect data, data collection instruments used and sampling procedure followed, as well as data analysis to address research question 1 and 2.

3.2 Research design

To address the aim of this study, a mixed method approach has been used (Table 3-1). A mixed method study involves the collection or analysis of both qualitative and quantitative data in a single study and the process involves concurrent and sequential collection of data at one or more stages (Borrego *et al.*, 2009:58). Triangulation design has been used as a strategy for mixed method approach. In this design, the integration of results occurs during the interpretation phase, allowing researchers to address a broad range of research questions towards discerning complex phenomena (Borrego *et al.*, 2009:59).

As much as the study was aiming to understand the e-waste management practices of Maseru citizens, through the use of semi-structured questionnaires (using mostly close-ended questions and predetermined sets of answers), it was also imperative to get more insight and discover new information on the problems behind the potential reluctance in citizens' participation in formal recycling, through open-ended questions. Thus, this combination of qualitative and quantitative data collection methods aimed to achieve a deeper level of insight through the exploratory nature of the research in addition to statistical evidence to support research decisions (Cresswell, 2016:3).

The research questions were further addressed by means of literature review on e-waste management practices and best practices, internationally. The aim of the literature review was

to inform research question 3, focusing on the international best practices for the management of e-waste to allow for comparison of Maseru practices with best practices to identify gaps and make recommendations for improvement. The literature review also informed the development of the semi-structured questionnaires to answer research questions 1 and 2, based on similar studies done elsewhere in the world, or similar studies focusing on other waste types.

Table 3-1: Research design for the study

Research question	Method	Justification
<p>What is the <i>current knowledge and awareness</i> of the public in Maseru, regarding e-waste management practices and how <i>willing</i> would they be to participate in certain e-waste management practices? (RQ1)</p>	<p>Household survey using semi-structured questionnaire focusing on:</p> <ul style="list-style-type: none"> The definition of e-waste, knowledge of the precious and hazardous metals contained in the e-waste, as well as the knowledge of the existing collection centres around town. The current practices on disposal methods of e-waste, the willingness to participate in formal recycling The informal e-waste collection, and the voluntary EPR practiced by some retailers. 	<p>According to DeJonckheere & Vaughn (2019) semi-structured questionnaires are suitable for collecting open ended data, to explore participant thoughts, feelings and beliefs on a topic of interest, and delve deeply into personal and sometimes sensitive issues. Adejimi <i>et al.</i>, (2010), also asserts that the questionnaire can be structured in a manner that gives qualitative-ness to the quantitative data so as to give a research a richer and meaningful, especially when a research involves personal opinions.</p>
<p>What is the significance of <i>variables, such as gender, household size, age, etc.</i> as it relates to knowledge and awareness of e-waste</p>	<p>Household survey using semi-structured questionnaire focusing on:</p> <ul style="list-style-type: none"> On the role that age, education level, gender and household size of the 	

Research question	Method	Justification
management practices? (RQ2)	respondent play on e-waste awareness, management practices and willingness to recycle	
How can e-waste management practices in Maseru be <i>improved</i> (based on gaps when compared to international best practices)? (RQ 3).	<p>Comparison of the results of the study to e-waste good practices found in literature.</p> <p>The literature review focused on:</p> <ul style="list-style-type: none"> E-waste legislation E-waste management tools Education and awareness strategies <p>Key literature included:</p> <ul style="list-style-type: none"> Doan <i>et al.</i> (2019) Islam <i>et al.</i> (2016) Sthiannopkao & Wong (2013) Honda <i>et al.</i> (2016) Zhang & Bashiri (2016) Cao, <i>et al.</i>a (2016) 	<p>The results of the study provided information on e-waste management practices in Maseru. Best or good practices from international literature was identified, with a focus on e-waste storage, re-use, recycling and disposal.</p> <p>These practices provided a baseline for comparison to Maseru's practices to identify gaps and make recommendations for improvement.</p>

3.3 Research methodology

The research questions were answered by making use of household surveys, supported by a literature review, as explained in table 3-1 above.

3.3.1 Household surveys

Household surveys were conducted to determine current e-waste management practices and respondents' awareness, knowledge and willingness around e-waste practices. The research also aimed to draw correlations between the demographic profile of respondents and their current

e-waste management practices, as well as their awareness, knowledge and willingness to engage in e-waste management practices.

3.3.1.1 Area selection and sample size

The data were collected at three different villages in Maseru, namely Thetsane, Koalabata and Sekamaneng over the period of 6 weeks, from July to August, 2019. Koalabata and Sekamaneng villages were selected as study areas because of the proximity to where the researcher stays (convenience sampling), while Thetsane was selected because of availability of people who have a tertiary education. A sample size of 384 respondents was calculated, based on the population size of Maseru of 330 760 at a confidence level of 95% and a confidence interval (or margin of error) of 5. Due to the unavailability of participants, only 354 respondents participated in the study. This is considered to be representative of the population size at a confidence level of 95% and a confidence interval of 5.2.

The respondents were randomly selected at the households in the above mentioned villages which were as far as possible, connected to electricity, to complete the questionnaire. The reason to have respondents from the households connected with electricity was to ensure that there is a possibility that they would own electric or electronic equipment. Random selection was meant to ensure that each member of the community had an equal chance of being a participant of the research (Statpak, 2017).

3.3.1.2 Semi-structured questionnaires

The household surveys were conducted in person by the researcher and two research assistants. The language used for the semi-structured questionnaires was English. Questions and clarifications were translated to Sesotho, where necessary. Semi-structured questionnaires (Annexure A) were used to collect data from the participants. The contents of the questionnaire were pilot tested before use on five respondents to check efficacy. The sample on which piloting was done has been kept out of the final sample to avoid any bias resulting from sensitization (Kwatra et al., 2015:755).

The surveys were facilitated by the researchers and data were collected during engagements with the respondents to increase the response rate of the participants and to also gather in-depth information and people's opinions and preferences. Discussions between the researcher and the respondents gave the researcher an opportunity to clarify questions and request follow up information where necessary. Respondents were informed about the objectives of the research, and they were made aware that their participation is voluntary and the information provided will be treated with confidentiality and anonymity. The questionnaire consisted of

section A, which dealt with the personal details of the respondents, such as gender, age, household size, etc. (related to research question 2). Section B consisted of seventeen questions (five open-ended questions; and twelve close-ended questions with predetermined sets of answers) which covered the knowledge and awareness of e-waste management (related to research question 1).

3.3.2 Literature review

The purpose of the literature review was three-fold:

- To provide context and background to the current research;
- To inform the methodological design of the current research; and
- To specifically address research question 3, focusing providing recommendations for the improvement of waste management practices in Maseru (based on gaps when compared to international best practices)? (RQ 3).

The literature review aimed to inform the context of the current study, focusing on “knowledge”, “awareness” and “willingness” aspects around waste in general, but also focusing on e-waste management practices. Some key literature which informed the research included:

- Afroz, R., Masud, M. M., Akhtar, R., & Duasa, J. B. 2013. *Survey and analysis of public knowledge, awareness and willingness to pay in Kuala Lumpur, Malaysia-A case study on household WEEE management. Journal of cleaner production. 52:185-193;*
- Sidique, S., Lupi, F., & Satish, J. *The effects of behaviour and attitudes on drop-off recycling activities. Resources conservation and recycling. 54: 163-170;*
- Nduneseokwu, C., K., Qu, Y., & Appollino, A. 2017. *Factors influencing consumers' intentions to participate in a formal e-waste collection system: a case study of Onitsha, Nigeria. Sustainability. 9(6):1-17;*
- Borthakur, A. & Govind, M. 2018. *Public understandings of E-waste and its disposal in urban India: from a review towards a conceptual framework. Journal of cleaner production. 172: 1053-1066; and*
- Zhang, Y. & Bashiri, P. 2016. *An investigation into Swedish e-waste collection and recycling system. Masters' dissertation. <https://core.ac.uk/download/pdf/85145165.pdf> Date of access:23 October, 2019.*

The literature review was conducted through using the academic journals and thesis from google scholar, google, science direct and EBESCO-Host through the North West University library database.

Chapter 2 of this dissertation provides the full literature review.

3.4 Data presentation and analysis tools

Data were collected through semi-structured questionnaires which were transcribed and analysed in SPSS (Statistical Package for Social Science) and through thematic analysis.

In this research, the data analysis explores the use of descriptive and exploratory methods of analysis in describing patterns and relationships between variables in the data sets. While the descriptive analysis is concerned with describing the data and the underlying patterns in a single variable in the data set (Trochim, 2020), exploratory data analysis will test for relationship between variables (Patil, 2020). These approaches become valid and relevant for this research because of the nature of the data recordings, which are largely categorical (some measured as Likert scale responses). Specifically, under the descriptive analysis, data patterns have been described by generating various descriptive measures such as the median and mode.

In descriptive analysis, measures of the central tendency: the median and the mode, have been used to describe the distribution of Likert scale responses assigned for each theme while counts have also been adopted to describe the distribution of responses mainly on categorical variables. The scale is composed of four Likert type items as such: Strongly Disagree, Disagree, Agree and Strongly Agree. To allow for the computation of statistical analyses, each Likert-type item was assigned a corresponding value. The following are the assigned values corresponding to each value label: Strongly Disagree=1, Disagree =2, Agree = 3 and Strongly Agree = 4. Here, the conversion of the Likert-type items, from *string* type to *numeric* variables, in line with the SPSS nomenclature (the analysis software), becomes necessary to allow for valid statistical computations which are largely permissible with numeric data and limited with string variables

Alternatively, for exploratory data analysis, tests of homogeneity between aspects across themes have been evaluated using the Chi-Square test. In this case, the p-value was calculated to determine the relationship between the demographic data and the recycling behaviour of the participants. The p-value is a statistical tool used to challenge the researcher's null hypothesis when the result is statistically significant. A p-value of less than 0.05 indicates that the null hypothesis can be rejected and it can be asserted that the findings are statistically significant. Rejecting the null hypothesis means that the findings are unlikely to have arisen by chance and rejecting the idea that there is no difference between the two values. When the p-value is less than 0.05, the degree of difference and association being tested would occur by chance only five times out of hundred (Gupta, 2012).

The quantitative data (closed-ended questions) was analysed by the statistician through SPSS software program. The program offers advanced statistical analysis, a vast library of machine

learning logarithms, source analysis, open text extensibility, integration with big data and seamless deployment into applications (IBM SPSS platform).

The qualitative data (i.e. open-ended questions related to awareness, knowledge and willingness) was analysed through thematic analysis using Microsoft excel. This method of analysis is applied to a set of texts such as interview transcripts. The researcher read the collected data to pick common themes such as topics, ideas, and patterns of meaning that come up repeatedly (Caulfield, 2019).

After data familiarization, the text was then coded and researcher came up with the shorthand labels to describe their content. The patterns were then identified, and then broader themes were created out of several codes. The number of times that the theme appears was described and the percentage calculated (Caulfield, 2019).

3.5 Ethical considerations

According to the North-West University (NWU, 2018), ethical considerations should be acknowledged and taken into consideration during research. The study involved human participants, but did not include any sensitive respondents (i.e. children, persons with disabilities, etc.). The research proposal was submitted to the Scientific Committee of the Environmental Management Research Group (EMRG) in the Unit for Environmental Sciences and Management of the North-West University, Potchefstroom Campus for consideration. The scientific committee has found that the project proposal was in accordance with the scientific method and adhered to the required standards as set out in the Academic Rules for Master's and Doctoral Students at North-West University. The Scientific Committee concluded that proposed methodology posed a low ethical risk, hence expedited review by the Faculty of Natural and Agricultural Sciences (FNAS) Ethics Committee was proposed. The low risk proposal was approved by the FNAS Ethics Committee (NWU-01444-20-A9).

3.6 Methodological assumptions and limitations

There was a problem with access to houses with tight security, and these are households owned by mostly literate people. There may, therefore, be a possibility that the data collected during this research does not adequately represent the views of educated, literate people.

In some cases, people were not willing to participate in the surveys, and part of the reason was that data were collected during the time when the public was warned by the utility company against people who claim to have been sent by the company to carryout electricity testing at homes yet they had the ulterior motives of stealing from the public. As a result, people were very

cautious when it came to questions related to their household appliances. Another reason was attributed to the fact that the utility company had some unattended faults in some areas, so the subject relating to electricity/electronic products was linked to the utility company and they were hoping that the researchers have come with solutions to long unattended faults. Once the participants realised that the intervention (research) was not about solving their electricity faults, they resisted participation in the study.

3.7 Summary

The chapter provided details of the mixed research design used to address the research questions. The data were collected through a household surveys at three villages in Maseru. The demographic and quantitative data were analysed through SPSS, while qualitative data gathered was analysed through data coding using Microsoft excel.

The next chapter is on results presentation and discussion of the findings. The purpose of this chapter is to structure findings from data collected in questionnaires so that there can be a meaningful base for critical decision making in relation to the research problem of this study.

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of the analysed data captured in the surveys that were conducted at Sekamaneng, Koalabata, Ha Foso, and Ha Thetsane to address the research aim on establishing the level of knowledge and awareness of e-waste management practices amongst members of the public in Maseru, Lesotho. The first section of this chapter presents results and discussion on the respondents' demographics and the analysis of the significance of these demographic variables as they relate to knowledge and awareness of e-waste management. The third section concludes the chapter, establishing the level of knowledge and awareness of e-waste management practices amongst members of the public in Maseru, Lesotho, and comparing these results to research done by other authors.

4.2 Results

The results related to research questions 1 to 3 are discussed in the sub-sections to section 4.2.

4.2.1 Respondent demographics and household size

Research question 2 aimed to determine the significance of variables, such as gender, education, age, etc. as it relates to knowledge and awareness of e-waste management practices. Section 4.2.1 to 4.2.2, therefore, provides an overview of the demographic distribution of respondents, focusing on gender, age, and educational level. Sections 4.2.3 to 4.2.4 provide an analysis of the significance of these demographic variables as it relates to knowledge and awareness of e-waste management.

Table 4-1 illustrates the results of respondents by gender, age and education level. The majority of respondents were females, constituting 65.3%. Respondents, characterised by the young population accounted for the larger share of respondents, with the composition of respondents ranging between participants aged 21-25 years, 36-40 years, and 31-35 years, which constituted of 23.2%, 18.6% and 15.3%, respectively. Participants above 40 years of age accounted for approximately 44% of the respondents.

By educational attainment, respondents with Cambridge Overseas Senior Certificate (COSC) as their highest level of education, at 25.7% accounted for the largest share, while those with no-schooling (5.4%) were the least represented.

Table 4-1: Respondents by gender, age and education level

Demographics	Count	Proportion (Percentage)
Gender		
Male	123	34.7%
Female	231	65.3%
Age Group		
21 – 25	82	23.2%
26 – 30	42	11.9%
31 – 35	54	15.3%
36 – 40	66	18.6%
41 – 45	34	9.6%
46 – 50	28	7.9%
51 – 55	16	4.5%
56+	29	8.2%
Not Stated	3	0.8%
Education Level		
No Schooling	19	5.4%
Primary	53	15%
Junior Certificate	60	16.9%
COSC	91	25.7%
Diploma	52	14.7%
Degree	58	16.4%
Not Stated	21	5.9%
Total	354	100

Table 4-2 presents the summary of statistics related to household size. The average household size was reported as four individuals per household, with the distribution being symmetrical (also refer to Figure 4-1), as evidenced by the mean and median values.

Table 4-2: Summary of statistics generated for respondent's household size

Test	Value
N	354
Mean	4.084746
Median	4
Mode	4
Skewness	0.686065
Std. Error of Skewness	0.129642
Kurtosis	1.15844
Std. Error of Kurtosis	0.258569

Again, by illustration in Figure 4-1, the shape of the distribution is bell shaped (*i.e.* normally distributed). The normality of the plot is further corroborated by the skewness = 0.686 \approx 0 by truncation, further confirms a perfectly symmetric distribution. The average household size (at 4) further conforms with Lesotho's average family/household size, estimated at four members (BOS¹, 2020).

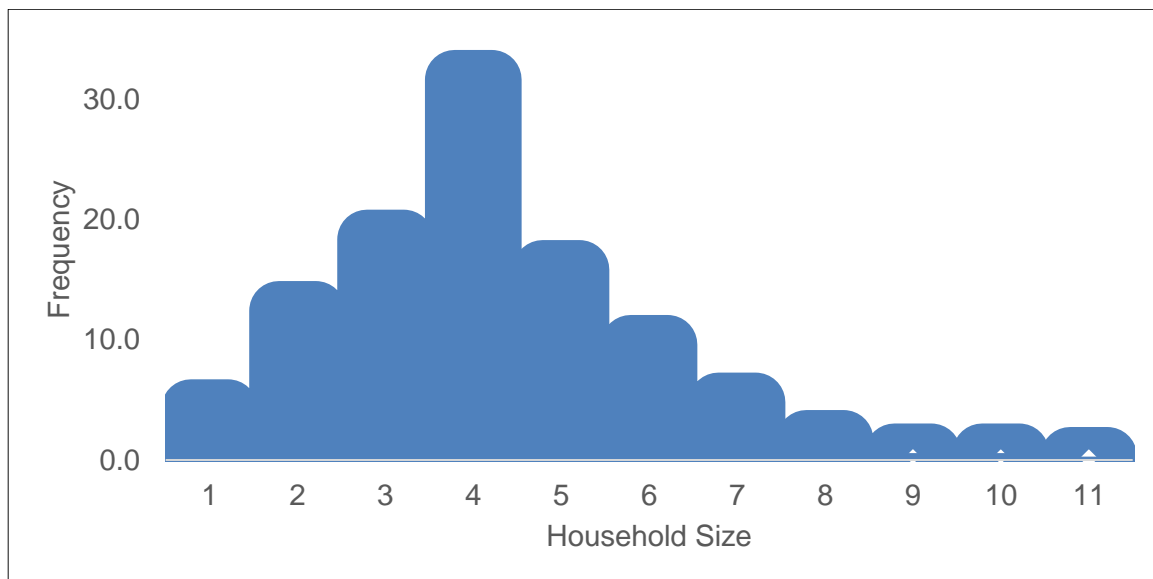


Figure 4-1: Histogram plot for household sizes

¹ Bureau of Statistics, Lesotho

4.2.2 Respondent employment status

Table 4-3 presents the distribution of respondents by employment status. Approximately 37% of respondents were unemployed, while 62.7% were employed. The latter (employed respondents) were distributed as such: full-time (35%), part-time (3.4%), and self-employed (24.3%). Respondents were largely engaging in a variety of employment activities. For example, by occupation, the majority of the respondents were engaged as entrepreneurs, civil servants, machine operators and teachers (see Figure 4-2). A further noticeable share of respondents was employed as accountants, hairdressers, farmers, drivers or employed by the mining sector.

Table 4-3: Respondent employment status

Employment Status	Count	Proportion (Percentage)
Full-time	124	35%
Part-time	12	3.4%
Self-employed	86	24.3%
Unemployed	132	37.3%
Total	354	100

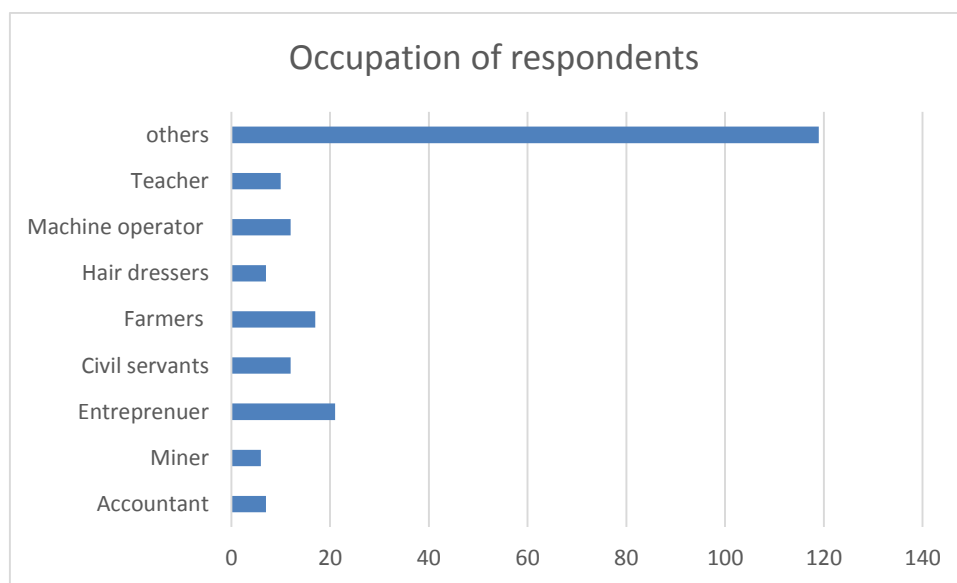


Figure 4-2: Occupations of respondents

4.2.3 Knowledge and awareness of e-waste management (RQ 1)

The aim of research question 1 was to determine the *current knowledge and awareness* of the public in Maseru, regarding e-waste management practices. Results related to knowledge and awareness of e-waste are shown in Figure 4-3. According to the results of the survey, knowledge

of e-waste was very limited, with 93.8% of respondents not being aware or having knowledge of what e-waste was.

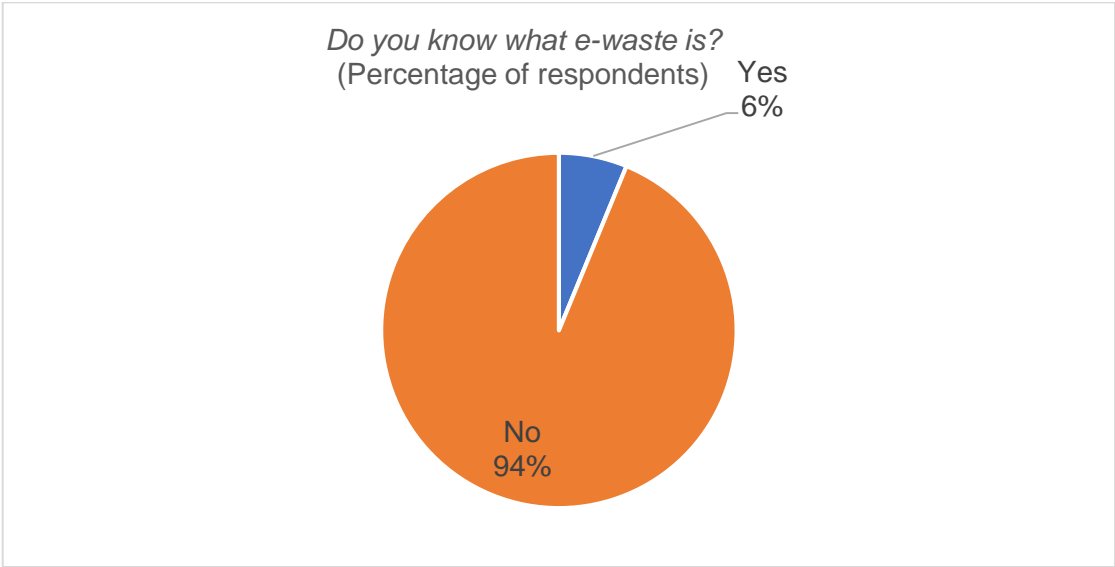


Figure 4-3: Respondent knowledge of e-waste

A similar study conducted in Ghana also revealed that most citizens did not have knowledge about e-waste at all, and this has been more pronounced by the participants' response to the related questions. For instance, most of the participants displayed their ignorance when mentioning substances like cyanide and methane, which are generally not associated with e-waste (Owusu *et al.*, 2017:84). A study in India revealed similar results and concluded that a significant fraction of middle-class population was unaware of e-waste (Kwatra *et al.*, 2014).

Conversely, a study conducted in Nigeria, revealed that 67.5% of respondents knew what e-waste was, while 32.5% did not have an idea on what e-waste was. However, those who were aware of e-waste, did not have detailed knowledge and education on the proper handling and management of e-waste (Miner *et al.*, 2020:1047). Lack of education and awareness on e-waste handling and management in developing countries is a common challenge, that is influenced by the lack of resources and institutional support (Miner *et al.*, 2020: 1047).

The research further attempted to understand specific aspects of knowledge, where respondents were questioned about their understanding of the toxicity and value of e-waste, using a four-point Likert scale (1=Strongly disagree, 2=Disagree, 3= Agree and 4=Strongly agree). For both questions, the majority of respondents agreed (scale 3) with the notion e-waste may be both precious and toxic.

The research explored respondents' perception of e-waste value through the requesting examples of precious metals. Following their responses on the level to which the participants considered some e-waste materials as toxic and some as precious. Thirty-eight percent (38%) of respondents gave an example of copper as a precious metal found in e-waste, while 18% mentioned aluminium, 14% mentioned iron, and 10% of respondents giving steel as an example. The remaining 20% was shared by the occurrence of gold, magnesium, zinc, cobalt and lithium. The examples of precious metals provided by the respondents mostly provided an accurate reflection of the precious metals actually found in electronic products (Bakas *et al.*, 2016; Fornalczyk *et al.*, 2013).

The research further explored respondents' perceptions and understanding of the negative impacts related to e-waste (mostly linked to toxic materials present in e-waste). Data coding indicated that the themes mentioned by respondents included negative impacts to human health (19%) and environmental impacts (21%), however most responses were around electricity faults (60%) and safety risks related therewith. Responses related to electricity faults included; unearthed electronics may result in electric shock if touched; faulty electricity wiring could put people's lives in danger; and loose electric cables may result in electric shock if they get in contact with the surface. These findings align with the results of the study conducted in Ghana, which revealed that a very low number of participants were aware of the adverse impacts of e-waste on environment and human health, at a time when the world is raising awareness on the problems associated with e-waste (Owusu *et al.*, 2017:84). Conversely, in India, the majority of respondents were able to link impacts of improper e-waste management with detrimental health and environmental impacts (Kwatra *et al.*, 2014).

4.2.4 Willingness of respondents to participate in e-waste recycling (RQ1)

Following the questions on e-waste knowledge, the study also determined the willingness of the respondents to recycle e-waste, and the willingness to pay an e-waste recycling fee. Two questions were posed: 1. *If there were a collection centre around Maseru, would you consider taking your e-waste there and why?;* 2. *If the government built recycling infrastructure for household e-waste and improved the collection and disposal system of household e-waste, would you be willing to pay an associated recycling fee?*

Approximately 88% of respondents indicated that they were willing to recycle their e-waste products, while 12% indicated that they were not willing. Most respondents (58%) indicated that improved environmental protection from informal recycling and improper disposal will be their objective to participate in e-waste recycling. Similarly, the findings by Nguyen *et al.* (2018:19), concluded that the respondents who participated in the e-waste recycling in Vietnam, do so

because they understand that such behaviour contributes to save natural resources and eliminate environmental problems. Approximately 27% of respondents indicated that their intention to recycle was influenced by the incentive (money) they could get from taking their e-waste to a collection centre, while 9% were driven by the availability of the information on the nearby e-waste collection centre. Effective e-waste collection systems (3%), job creation for those in the e-waste recycling industry (2%), and no fee associated with participating in the recycling program (1%) were also mentioned, but at lower frequencies.

On the other hand, 12% of respondents indicated that they were not willing to take their e-waste to the recycling centre. The reason provided included lack of incentive provided when taking e-waste to the recycling centre (60%), lack of knowledge of why they should be taken to the recycling centre instead of disposing them with general waste (30%), and lack of transport to collect e-waste from the households (10%).

Approximately 36% of respondents indicated that they were willing to pay an e-waste recycling fee, while 64% indicated that they were unwilling. The respondents' willingness to pay an e-waste recycling fee was driven by improved environmental protection (66%), improved formal recycling (12%), green jobs sustainability (12%), and affordability of a recycling fee (10%). Furthermore, there were also reasons stated on the unwillingness of respondents to participate in recycling through the payment of recycling fee (64%). Approximately 90% of unwilling participants asserted that it is an unnecessary expense to incur, while 5% affirmed that they do not have e-waste to pay for, and another 5% claimed that they did not understand the reason why they should be paying for e-waste. Similarly, a study conducted in China, reported that only 48% of respondents in China expressed their willingness to pay for e-waste recycling fee (Yin *et al.*, 2014),

4.2.5 Significance of demographic variables as it relates to knowledge and awareness of e-waste (RQ2)

While knowledge of e-waste was generally minimal (6%), the research assessed knowledge by gender, age and education (Table 4-5).

Table 4-4: Respondents knowledge of e-waste by gender, age and education level

	Knowledge of e-waste				Total	Statistical significance (p-value)
	Yes		No			
	n	%	n	%		
Gender						
Male	9	7.3%	114	92.7%	123	p = 0.53
Female	13	5.6%	218	94.4%	231	
Total	22	6.2%	332	93.8%	354	
Age Group						
21-25	7	8.5%	75	91.5%	82	p = 0.728
26-30	1	2.4%	41	97.6%	42	
31-35	4	7.4%	50	92.6%	54	
36-40	3	4.5%	63	95.5%	66	
41-45	3	8.8%	31	91.2%	34	
46-50	3	10.7%	25	89.3%	28	
51-55	0	0%	16	100%	16	
56+	1	3.4%	28	96.6%	29	
Not stated	0	0%	3	100%	3	
Total	22	6.2%	332	93.8%	354	
Education level						
Primary	0	0%	53	100%	53	p = 0.001
JC	0	0%	60	100%	60	
COSC	8	8.8%	83	91.2%	91	
Diploma	3	5.8%	49	94.2%	52	
Degree	10	17.2%	48	82.8%	58	
No Schooling	0	0%	19	100%	19	
Not stated	-	-	-	-	21	
Total	21	6.3%	312	93.7%	333	

By gender, 7.3% of males and 5.6% of females indicated that they had knowledge of e-waste (Table 4-7), however, the relationship between gender and e-waste knowledge was statistically insignificant ($p = 0.531$). This finding thus concurs with a study conducted in India, which revealed that there was no statistically significant difference between the gender of respondents and their knowledge of respondents on e-waste (Ritu & Shalini, 2013:40). Research conducted in China,

Laos and Thailand, conversely revealed that female respondents were generally less knowledgeable (on how to improve environmental conditions as a result of indiscriminate e-waste disposal), than male respondents (Liang & Sharp, 2016:392).

Approximately eleven percent (10.7%) of respondents aged 46 to 50 years indicated that they had knowledge of e-waste, representing the largest proportion, comparatively, while respondents aged 26 to 30 had the lowest level of knowledge (2.4%), comparatively (Table 4-7). The relationship between age and knowledge of e-waste was, however, not statistically significant ($p = 0.728$). Liang & Sharp (2016: 396) had similar findings, where older respondents generally had more knowledge of e-waste than younger respondents (especially aged younger than 17) in China, Laos and Thailand.

The relationship between education level and e-waste knowledge was statistically significant ($p = 0.001$), where respondents with a college education or a degree indicated a higher knowledge of e-waste than respondents with lower levels of education. For example, 17.2% of respondents with a degree had knowledge of e-waste, being the largest proportion, comparatively. This finding aligns with the results of a study conducted in India, which asserted the significance between education and e-waste knowledge, whereby the respondents with post-graduate degrees were more aware and knowledgeable on e-waste (Sivathanu, 2016:421) compared to other respondents.

Saphores *et al.*, (2012), assert that findings on the demographic variables appear to be inconsistent, and where socio-demographic variables are found to be statistically significant, the explanatory power attributed seems to be small. For instance, most of the respondents who were knowledgeable on e-waste among the degree holders were those who were employed. The unemployed graduates were mostly not knowledgeable.

4.2.6 Waste management practices in Maseru (RQ3)

Research question 3 attempted to determine the waste management practices in Maseru (to ultimately compare it to international best practices – as outlined in the Literature Review Chapter) in an attempt to identify gaps, and finally, make recommendations for improvement.

Several questions were posed to assess how the respondents manage their e-waste. While some of the terminology related to *e-waste* could be new or foreign to respondents, especially those with lower educational attainment (see Table 4-7), an attempt was made to introduce the topic to explain what e-waste is. Following the introduction of the term e-waste, all the respondents were able to give examples of e-waste, and the most mentioned electronic devices were kettles, stoves and pressing irons.

The respondents were then asked two questions in relation to the management of electrical products either working but unwanted or defunct: (1) *What do you do with working electronic or electrical products that you no longer use?*; (2) *What do you do with broken electrical or electronic products?* The distribution of their responses is presented in Figures 4-4 and 4-5.

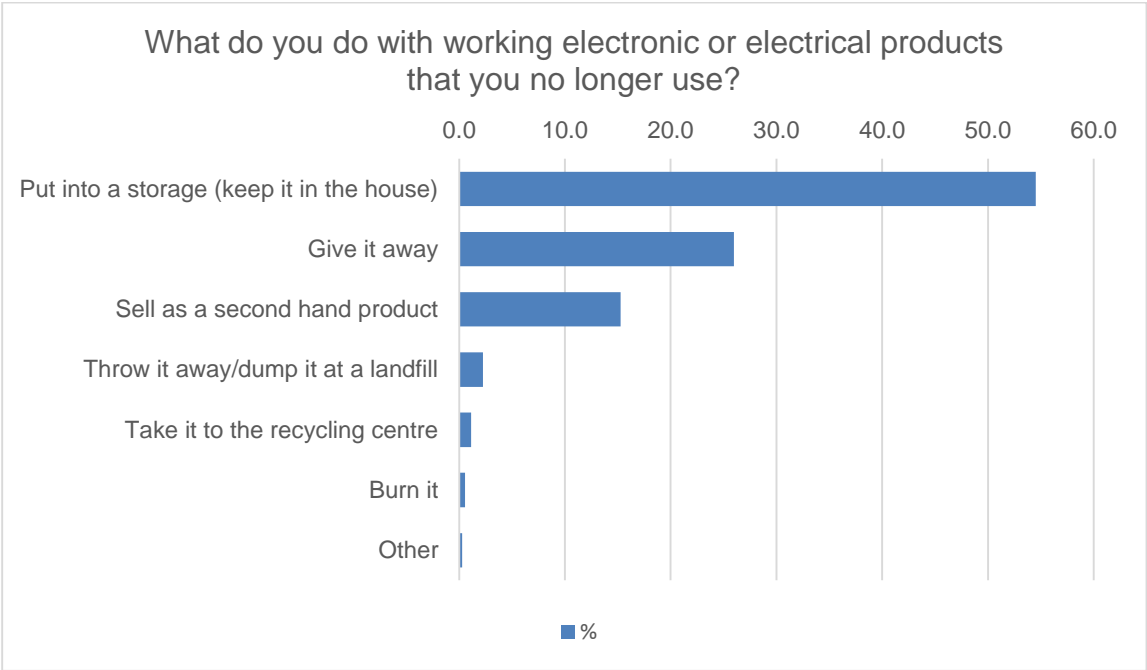


Figure 4-4: E-waste management practices of working electronics no longer in use

Figure 4-4 outlines the distribution of responses for different management of working electronic or electrical products that respondents no longer used (but, for example have been replaced with new products). The majority of respondents (54.5%) stored working electronic or electrical products they no longer used in their houses. This finding aligns with the conclusion drawn by Miner *et al.* (2020:9), that storing e-waste at homes is caused by the lack of door to door collection program in Nigeria. Additionally, Shah (2014: 32) concluded that the prevalence of home storage of e-waste in India is mostly attributed to a lack of feasible options for disposing it effectively or reclaiming it for other uses (Shah, 2014:32).

Approximately 26% of respondents indicated that they gave their devices away and 15% sold their devices as second hand products. Miner *et al.* (2020), concludes that selling e-waste as a second hand product is a sustainable practice of dealing with the waste stream. Approximately 2% indicated that they threw their unused (working) electronic products away (mostly to landfill), while 0.6% (two) of the respondents indicated that they burn their working, no longer used electronic products. Only 1% of respondents indicated that they took their e-waste to recycling

centres. Although this is considered to be good practice, recycling of e-waste is currently being outranked by unsustainable e-waste management practices.

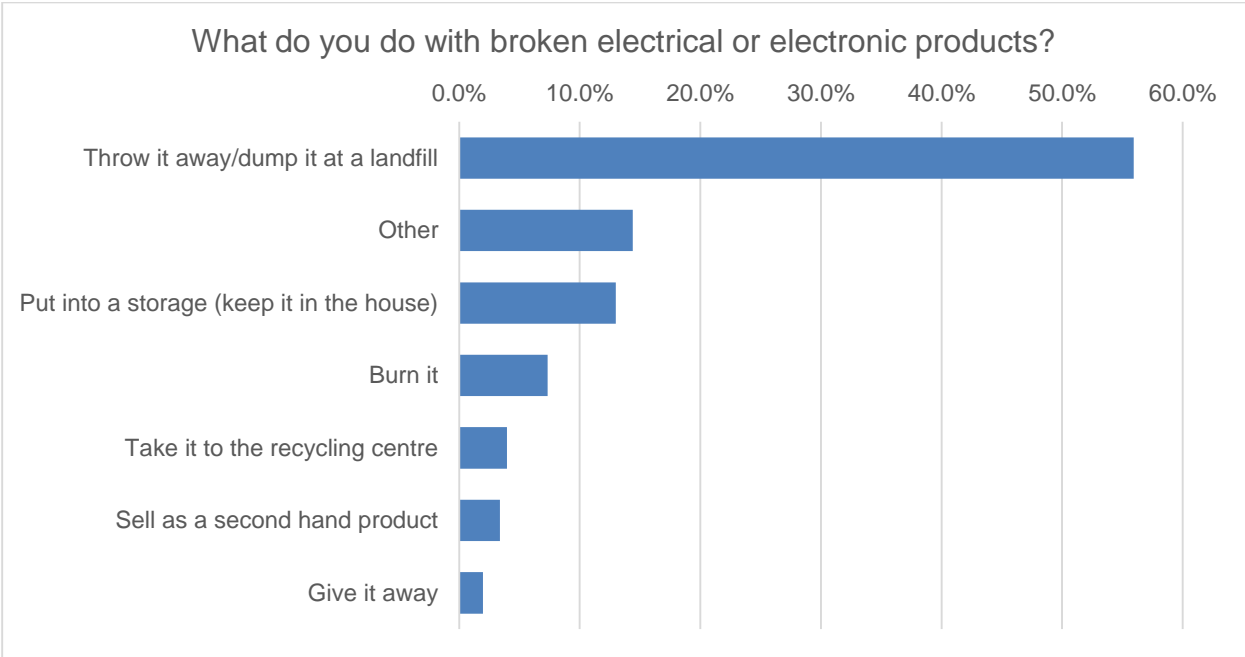


Figure 4-5: Respondents detailing how they manage broken electrical and electronic products

Conversely, for broken/defunct electrical and electronic products, the majority of respondents (55.9%) specified that they threw it away or dumped it at landfills. The research further determined that the most practiced means of e-waste disposal were at resident’s own refuse dumps (89% of respondents), with only 6% indicating that they disposed their e-waste at the Maseru landfill site. This is believed to be caused by the lack of waste collection services, at the study areas. A study conducted in Malaysia revealed that the majority of e-waste ends up in landfill sites without proper treatment due to the lack of segregation, and inadequate disposal systems (Tiep *et al.*, 2015).

Thirteen percent (13%) of respondents specified that they stored their broken electronics at home with a hope that they will be repaired. In India, approximately 75% of obsolete or broken e-waste products are stored at home due to uncertainty on how to properly manage e-waste, as well as a pervasive view of e-waste as a commodity, causing the tendency to hold on to the e-waste product for as long as possible. Approximately 7.3% of the respondents (which was higher than the 0.6% for working devices) indicated that they burned their defunct e-waste products, while taking defunct devices to recycling centres (making mention of scrap yards and collection centres), selling it as second hand products (i.e. at Cash Crusaders), and giving broken electronics away were reported at lower frequencies, at approximately 4%, 3% and 2%, respectively.

The research further established the significance of education level as it relates to current e-waste management practices. The hypothesis was that respondents with a higher level of education (which also indicated a higher awareness/knowledge of e-waste, refer to Section 4.2.2) would be more prone to sustainable e-waste management practices (such as recycling).

As illustrated in Table 4-6, irrespective of educational attainment ($p=0.479$), the majority of respondents put working electronics or electronics not currently in use in storage, with percentages ranging between 41.5% for respondents with primary education to 63.7% for respondents with COSC qualification. Studies conducted in Finland revealed that 85% of consumers stored their old mobiles at home, until possible future use (which may never come), despite the proximity and convenience of current waste management systems (Yiä-Mella *et al.*, 2015:381; Tanskanen, 2013:1006). Schevchenko *et al.* (2019:11), concludes that the problems of storing e-waste are associated with the lack of economic incentive for effective return of e-waste, irrespective of education level.

Table 4-5: Level of education and management (practices) of working electronic or electrical no longer in use

Management of working electronic or electrical no longer utilised for intended purpose									
Education	Statistic	Sell as second hand product	Put into a storage (keep it in the house)	Give it away	Burn it	Take it to the recycling centre	Throw it away/dump it at landfill	Total	Statistical significance (p-value)
Primary	Count	10	22	18	0	1	2	53	p = 0.479
	Proportion	18.9%	41.5%	34%	0%	1.9%	3.8%	100%	
JC	Count	8	37	11	1	1	2	60	
	Proportion	13.3%	61.7%	18.3%	1.7%	1.7%	3.3%	100%	
COSC	Count	9	58	22	1	1	0	91	
	Proportion	9.9%	63.7%	24.2%	1.1%	1.1%	0%	100%	
Diploma	Count	10	23	17	0	0	2	52	
	Proportion	19.2%	44.2%	32.7%	0%	0%	3.8%	100%	
Degree	Count	10	34	12	0	0	2	58	
	Proportion	17.2%	58.6%	20.7%	0%	0%	3.4%	100%	
No schooling	Count	5	9	4	0	1	0	19	
	Proportion	26.3%	47.4%	21.1%	0%	5.3%	0%	100%	
Total	Count	52	183	84	2	4	8	333	
	Proportion	15.6%	55%	25.2%	0.6%	1.2%	2.4%	100%	

4.2.7 Identifying gaps in e-waste management practices in Lesotho and making recommendations for improvement (based in best practices (RQ3))

The literature review chapter has reviewed the best international practices in e-waste management to compare with the e-waste management practices in Maseru, and thus provide practical recommendations in the context of a developing country in Chapter 5. In order to address RQ3, the comparisons have been highlighted below to establish the gaps.

It must be noted that there is a **general lack of public awareness and knowledge** of e-waste in Lesotho. Lessons from the developed countries could guide Lesotho through the relevant Ministries and NGOs on how to better impart knowledge and understanding of e-waste stream, therefore positively influencing the recycling behaviour. In terms of knowledge and awareness education in developed countries, Switzerland has been making use of civil society to create platforms where they can engage with the public and start up discussions on e-waste awareness (GISwatch, 2010: 220,221). Similarly, Japan has also been engaging IT associations to drive the public awareness program on personal computers, and also publicize the results as they relate to collected and recycled e-waste (Honda *et al.*, 2016:94).

In terms of management practices, the results of the study indicated that **e-waste disposal was generally inappropriate** in Lesotho. The e-waste is either dumped along with household waste, either at the owner's refuse dump where it ends up being burned or taken to the landfill with general waste. There is a common practice of storing electronics that are working but no longer used, and the defunct electronics. The study has also established that most respondents were **not willing to pay a recycling fee**, that will facilitate effective collection, safe disposal and recycling of e-waste. In Switzerland, the management of e-waste is done through extended producer responsibility (EPR). The EPR is implemented through advanced recycling fee, which is charged from the consumers during the purchasing of the product. The fee is used to manage the operations of the e-waste management system. There is also a law which prohibits the disposal of e-waste to the landfill (Islam *et al.*, 2018:712). In terms of e-waste that is stored in the households, the European countries have implemented economic incentives such as discount coupons or purchase discount, and monetary payments are used in e-waste collection schemes, along with donation to charity and entry into prize draws (Schevchenko *et al.*, 2019:12).

Based on literature in the developing country context, and observations and information available on e-waste management in Lesotho, the following gaps were identified:

- Lack of *environmentally sound e-waste recycling infrastructure* to handle increasing volumes of e-waste, thus leaving the consumers with a limited choice on adoption of international best

practices. Nonetheless, there are e-waste collection containers situated around town, but the public is not aware of the purpose of the containers.

- There is a *low market* (demand) for refurbished electronics. Enviroxcellence (2012) established that most users in Lesotho, prefer new electronics to refurbished or second hand electronics because they claim it is cheaper and easy to buy the new electronics as opposed to maintenance of old electronics.
- There is a *lack of legislation* with regard to e-waste management. Enviroxcellence (2012:67) noted that there is a lack of legal instruments, standards, guidelines and technical know-how for the sound management of e-waste. As a result, e-waste handling and dismantling facilities are in many instances not regulated.
- Most e-waste is disposed in *illegal dumps and the landfill site* where it is salvaged for informal recycling. The e-waste products are dismantled and separated using toxic chemicals and technologies exposing their health and nearby communities' health to these toxic chemicals. Furthermore, the prices for the recyclables are not fixed and this creates a possible exploitation of reclaimers (since they are not knowledgeable about market forces) by the companies who buy these commodities (Enviroxcellence, 2012:67,68).
- There are *no data* available on the amount of e-waste by type, thus the extent of e-waste impact is unknown (Enviroxcellence, 2012:67). The informal sector is the only responsible entity involved in e-waste collection and thus there is no quantification done.
- The e-waste stream *is not a priority* like other hazardous waste such as health care risk waste. The government seeks international funding to run simple programs such as awareness raising on e-waste. In the absence of international funding no implementation can be done in terms of e-waste management.

Recommendations to address these gaps are outlined in Section 5.2 (of the Conclusions and Recommendations Chapter) of this dissertation.

4.3 Summary

In this chapter data analysis methods, study results, discussion and interpretation of the findings have been presented. Findings from this study were found to be consistent with related studies on e-waste awareness and management practices. Interpretation and discussion of data were primarily done to provide meaning to the data collected and to further determine conclusions that will follow in Chapter 5. Suggested recommendations related to the study are also provided in Chapter 5.

CHAPTER 5 CONCLUSIONS AND RECOMMENDATIONS

Chapter 5 provides the conclusions and recommendations which relate to the three research questions:

1. *What is the current knowledge and awareness of the public in Maseru, regarding e-waste management practices and how willing would they be to participate in certain e-waste management practices? (RQ1)*
2. *What is the significance of variables, such as gender, household size, age, etc. as it relates to knowledge and awareness of e-waste management practices? (RQ2)*
3. *How can e-waste management practices in Maseru be improved (based on gaps when compared to best practices)?*

The chapter also provides recommendations for further research.

5.1 Conclusions

The conclusions on each of the three research questions are provided in the sub-sections to Section 5.1 of this dissertation.

5.1.1 Conclusions related to RQ1: Current knowledge and awareness of the public in Maseru regarding e-waste management practices and willingness to participate in certain e-waste management practice

The study concludes that there is a general lack of knowledge and awareness in e-waste. Ninety-four percent (94%) of the respondents did not know what the term e-waste meant. However, after the researcher explained the term, most of the respondents were able to relate to the term through provision of examples which were mostly around household electronics and the precious metals contained in e-waste. As the study further explored the respondents' understanding of e-waste, it was also established that most respondents were not aware of the adverse impacts of e-waste. The majority of respondents (88%) were willing to participate in e-waste recycling, in terms of taking their e-waste to the recycling centre. The main reason provided was to improve environmental protection from improper disposal and informal recycling. However, many respondents (64%) were not willing to pay an associated recycling fee stating that it was an unnecessary expense to incur.

5.1.2 Conclusions related to RQ2: Significance of variables such as gender, household size, age etc. as it relates to knowledge and awareness of e-waste management practices

The research aimed to draw relationships between socio-demographic variables, such as gender, age, household size, education level and level of income and knowledge/awareness of e-waste management practices, since literature suggests that these variables may influence knowledge and behaviour. The study concludes that the relationship between knowledge of e-waste and gender ($p=0.53$) as well as age ($p=0.728$) were statistically insignificant, while the relationship between education and e-waste knowledge was statistically significant ($p=0.001$). Saphores *et al.* (2012), concluded that for households in the United States, findings on the relevance of demographic variables as it relates to e-waste knowledge also appear to be inconsistent, and where socio-demographic variables were found to be statistically significant, the explanatory power attributed seems to be small.

5.1.3 Conclusions related to RQ3: Identifying gaps in e-waste management practices in Maseru (compared to best practices) and making recommendations for improvement

The findings of the research concluded that gaps in e-waste management practices existed as far as:

- E-waste *knowledge and awareness* were generally *limited*, with the majority of respondents not having knowledge of the potential environmental impacts of e-waste mismanagement;
- The *recycling* of e-waste is generally *insufficient*, with limited amounts of e-waste being recycled or re-sold;
- Although many respondents were willing to participate in recycling in future, the majority of respondents were *unwilling to pay any fees* for the recycling of e-waste; and
- Where *e-waste was disposed* of, practices were generally *poor*, with the majority of e-waste being disposed to own dumps, the Maseru landfill site or end up being burned.

The following gaps were identified based on general literature regarding e-waste in developing countries, as well as observations made and information available on e-waste in the Maseru area:

- Lack of *environmentally sound e-waste recycling infrastructure*;
- There is a *low market* (demand) for refurbished electronics;
- There is a *lack of legislation* with regard to e-waste management;
- Most e-waste is disposed in *illegal dumps and the landfill site* where it is salvaged for informal recycling;

- There are *no data* available on the amount of e-waste by type;
- The e-waste stream *is not a priority* like other hazardous waste such as health care risk waste.

Recommendations for addressing these gaps are outlined in Section 5.2.1 of this dissertation.

5.2 Recommendations

Section 5.2.1 provides recommendations for improvement of e-waste management practices in Maseru, while Section 5.2.2 provides recommendations for further research.

5.2.1 Recommendations for improving and regulating e-waste management practices in Maseru

The study was conducted with the aim to establish the public awareness and current management practices of e-waste. Subsequent to the findings of the study, it is recommended that an *awareness programme* is developed and implemented in Maseru. The programme should be inclusive and should focus on simplified examples of e-waste and e-waste management practices, since as much as e-waste is an internationally recognised term, the study established that it is a foreign term among the Maseru citizens. The awareness programme should also focus on the negative impacts associated with the improper disposal of e-waste, and provide examples of good practices. The Maseru City Council together with the Department of Environment should identify the mechanism for rolling out an awareness programme, and drive the programme, supported by schools, tertiary institutions and NGOs (where necessary) to effectively impart knowledge of e-waste.

To discourage the storage of e-waste at homes, as well as other unsustainable e-waste management practices (such as landfill disposal or burning), and encourage the recycling of e-waste, it is important to provide *incentives for e-waste recycling*, such as discount coupons or purchase discounts. The government (through e-waste legislation) should encourage consumers with incentives, such as lower tax rates to buy refurbished products.

To improve on the e-waste management practices, the Government of Lesotho, through the Department of Environment has to consider the development of e-waste management *regulations* providing guidance for the management of e-waste and prohibition of landfill disposal. These regulations will, however, only be able to change e-waste management practices, if the necessary infrastructure and services are available to divert the waste from landfill and other insufficient waste management practices. A comprehensive e-waste legislation must also be inclusive of EPR and addresses informal e-waste recycling. Compliance with the e-waste regulations must be enforced through systematic reporting, site visit and auditing (Enviroxcellence, 2012:84; Patil

& Ramakrishna, 2020: 14422). The e-waste law's effectiveness must be assessed for continuous improvement and amended. The manufacturers of electronic products must be provided with the *guidelines* on restriction on the usage of hazardous substances and virgin raw materials to encourage resource reuse (Patil & Ramakrishna, 2020: 14424).

Additionally, paying an *advanced recycling fee* at the point of electronics purchasing (because there is a reluctance to pay a recycling fee) may be considered, which may be earmarked to contribute to the effective collection, safe disposal and recycling of e-waste. These practices should, however, be sensitive towards cost, since many respondents may not be in a position to pay related fees. The consumers must also be mandated by the law to give back their products when they become e-waste, this could be done at a point of purchase by signing the agreement (Patil & Ramakrishna, 2020:14424). The e-waste recycling infrastructure should also be established for effective recycling of e-waste.

Since the importation of e-waste from other countries may be problematic, the e-waste management regulations should consider the polluter pays principle to electronic devices importers and manufactures through mandatory *extended producer responsibility (EPR)*. For effective e-waste management, the EPR must consider:

- Influencing the manufacturers to change product design to increase its recyclability;
- Providing additional funds for recycling programmes, resulting in higher recycling rates;
- Improving recycling programme efficiency, leading to less cost; and
- Resulting in fairer system of waste management in which individual consumers pay the cost of their own consumption rather than general taxpayers (Rogoff, 2014).

It is important that these recommendations must be considered in the developing country context, where there are currently limited legislation or regulation for the management of e-waste, infrastructure is lacking, illegal reclamation of e-waste is a concern, and awareness and knowledge are generally lacking. Best practices proposed within the developed country context may, therefore, need to be modified or adapted to suit developing countries.

5.2.2 Recommendations for further research

There is a need for a baseline data on the e-waste generated from which more informed e-waste management and policy decisions can be made (Mmereki *et al.*, 2016:70).

Further research on the underlying *reasons* for the current e-waste mismanagement practices and behaviour may be useful (For instance, why the e-waste is stored at home or being burned, instead of being recycled?).

It may also be valuable to understand the types of e-waste, being generated and the management practices related to these wastes. Some studies suggest that the owners of e-waste products still have sentimental attachment to certain electronics, such as smartphones and also hope that they will be repaired and function again.

It is also recommended that there should be further research to establish the important factors that will lead to a success of e-waste recycling infrastructure, as studies in Nigeria have indicated that recycling infrastructure do not receive enough volumes of e-waste to viably recycle these wastes.

BIBLIOGRAPHY

- Adajimi, A., Oyediran, O.S. & Ongusanmi E., B. 2010. Employing qualitatively enriched semi structured questionnaire in evaluating ICT impact on Nigerian 'construction chain integration'. *The Built and Human Environment Review*, 3(1): 49-62.
- Africa clean cities. 2018. Maseru.
https://africancleancities.org/assets/data/Organization/Maseru_EN.pdf Date of access: 8 October, 2020.
- Afroz, R., Masud, M.M., Akhtar, R. & Duasa, J. B. 2013. Survey and analysis of public knowledge, awareness and willingness to pay in Kuala Lumpur, Malaysia-A case study on household WEEE management. *Journal of Cleaner Production*, 52:185-193.
- Asante, K. A., Amoyaw-Osei, Y. & Agusa, T. 2019. E-waste recycling in Africa: risks and opportunities. *Green and Sustainable Chemistry*, 18: 109-117.
- Azodo, A.P., Ogban, P.U. & Okpor, J. 2017. Knowledge and awareness implication on e-waste management among Nigerian collegiate. *Journal of Applied Science and Environmental Management*, 21(6): 1035-1040.
- Babaei, A.A., Alavi. N., Goudrazi, G., Teymouri, P., Ahmadi, K. & Rafiee, M. 2015. Household recycling knowledge, attitudes and practices towards solid waste management. *Resource, Conservation and Recycling*, 102: 94-100.
- Babu, B.R., Parande, A.K. & Basha, C. A. 2007. Electrical and electronic waste, a global environmental problem. *Waste Management and Research*, 25: 307-318.
- Baldé, C.P., Forti, V., Gray, V., Kuehr, R., Stegmann, P. 2017. The global e-waste monitor: quantities, flows and resources. Date of access: 03 May 2018.
- Bakas, I., Herczeg, M., Vea, E.V., Frâne, A., Youhanan, A., & Baxter, J. 2016. Critical metals in discarded electronics. Mapping recycling potentials from selected waste electronics in the Nordic region. TemaNord. Denmark. <https://www.diva-portal.org/smash/get/diva2:936670/FULLTEXT02> Date of access: 05 June, 2020.
- Borthakur, A. & Govind, M. 2018. Public understandings of E-waste and its disposal in urban India: from a review towards a conceptual framework. *Journal of Cleaner Production*, 172: 1053-1066.
- Borrego, M., Douglas, E.P., & Amelink C.T. 2009. Qualitative, Quantitative and Mixed methods in engineering education. *Journal of Engineering Education*, 18: 52-66.

- Cao, J., Lu, B., Chen, Y., Zang, X., Zhou, G., Jiang, B., & Schnoor, J.L. 2016. Extended producer responsibility system in China improves e-waste recycling: Government policies, enterprise, and public awareness. *Renewable and Sustainable Energy Reviews*, 62: 882-894.
- Cao, J., Chen, Y., Chin, B., Lu, B., Zang, X., Yu, X., Zhou, J., Zhai G., Zhu, C. & Zhou, G. 2016. WEEE recycling in Zhejiang Province, China: generation, treatment, and public awareness. *Journal of Cleaner Production*, 127: 311-324.
- Caulifield, J. 2019. How to do the thematic analysis. <https://www.scribbr.com/methodology/thematic-analysis/> Date of access: 10 March, 2020.
- Cresswell, J.W. 2015. *A concise introduction to mixed method research*. Thousand oaks. California: SAGE.
- DeJonckheere, M. & Vaughn, L.M. 2019. Semi structured interviewing in primary care research: a balance of relationship and rigour. *Family Medicine and Community Health*, 11: 1-8.
- Delcea, C., Crăciun, L., Loanăș, C., Ferruzi, G. & Cofas, L. 2020. Determinants of individual's e-waste recycling decision: A case study from Romania. *Sustainability*, 12: 4387.
- Deniz, P.Ö., Aydin, Ç.Y. & Kiraz, E.D.E. 2019. Electronic waste awareness among the students of engineering department. *Cukurova Medical Journal*, 44: 101-109.
- Doan, L.T.T., Amer, Y., Lee, S.H. & Phuc, P.N.K. 2019. Strategies of e-waste management. A literature review. *International Journal of Energy and Environmental Engineering*, 13(3):157-162.
- Duraisamy, S., Narayanappa, R.R. & Sobagiah, R.T. 2017. Self-reported practices of e-waste disposal and awareness about its health hazards on people at various levels in selected urban slums of Bangalore: A cross sectional study. *International Journal of Medicine and Public Health*, 4(6): 2146-2150.
- Enviroxcellence. 2012. Assessment of e-waste report. <https://africainstitute.info/download/study-e-waste-assessment-report-lesotho/> Date of access: 17 January 2020.
- European Commission. 2019. Waste electrical and electronic equipment. https://ec.europa.eu/environment/waste/weee/index_en.htm Date of access 09 September, 2019.
- Fornalczyk, A., Willner, J., Francuz, K. & Cebulski, J. 2013. E-waste as a source of valuable materials. *International Scientific Journal*, 63(2): 87- 92.

- Frazolli, C., Orisakwe, O., E., Dragone, R. & Mantovani, A. 2010. Diagnostic health risk assessment of electronic waste on the general population in developing countries' scenarios. *Environmental Impact Assessment Review*, 30: 388-399.
- Garlapati, V.K. 2016. E-waste in India and developed countries: Management, recycling and biotechnological initiatives. *Renewable and Sustainable Energy Reviews*, 54: 874-881.
- Gaidajis, G., Angelakoglou, K. & Aktsoglou, D. 2010. E-waste: environmental problems and current management. *Journal of Engineering and Technology Review*, 3(1): 193-199.
- GISwatch. 2010. Focus on ICTs and environmental sustainability. https://giswatch.org/sites/default/files/gisw2010countryswitzerland_en.pdf Date of access: 02 March, 2020.
- Grant, R. & Oteng-Ababio, M. 2013. Mapping the invincible and the real African economy: urban e-waste circuitry. *Urban Geography*, 33: 1-21.
- Ghosh, S.K., Debnath, B., Baidya, R., De, D., Li, J., Ghosh, S.K., Zheng, L., Awasthi, A.K., Liubarskaia, M.A., Ogola, J.S., & Tavares, A.N. 2016. Waste electrical and electronic equipment and Basel convention compliance in Brazil, Russia, India, China and South Africa (BRICS) nations. *Waste Management and Research*, 34(8): 693-707.
- Gupta, S.K. 2012. The relevance of confidence interval and p-value in inferential statistics. *Indian Journal of Pharmacology*, 44: 143-144.
- Gurauskienė, I. 2008. The behavior of consumers as one of the most important factors in e-waste problem. *Environmental Research, Engineering and Management*. 4(46): 56-65.
- Heeks, R., Subramanian, L. & Jones, C. 2015. Understanding e-waste management in developing countries: strategies, determinants, and policy implications in the Indian ICT sector. *Information Technology for Development*, 21(4): 653-667.
- Honda, S., Khatriwal, D.S. & Kuehr, R. 2016. Regional e-waste monitor: East and South Asia. <http://ewastemonitor.info/pdf/Regional-E-Waste-Monitor.pdf> Date of access: 02 March, 2020.
- Ikhlayel, M. 2017. An integrated approach to establish e-waste management systems for developing countries. *Journal of Cleaner Production*, 170: 119-130.
- Islam, M.T., Abdullah, A.B., Shahir S.A., Kalam, M.A., Masjuki, H.H., Shumon, R. & Rashid, M. H. 2016. A public survey on knowledge, awareness, attitude and willingness to pay for WEEE management: Case study in Bangladesh. *Journal of Cleaner Production*, 137: 728-740.
- Kamal, B. 2017. Africa: Where Do 50 Million Tonnes a Year of Toxic E-Waste Go?. Date of access 26 November, 2019. <http://allafrica.com/stories/201709300031.html>

- Karthkir, O. 2016. E-waste recycling environmental and health impacts. *Remediation of Heavy Metals in the Environment*, 339-364.
- Khetriwal, D.S., Kraeuchi, P. & Widmer, R. 2009. Producer responsibility for e-waste management: Key issues for consideration e Learning from the Swiss experience. *Journal of Environmental Management*, 90: 153-165.
- Khurram, M., Bhutta, S., Omar, A. & Yang ,X. 2011. Electronic Waste: A Growing Concern in Today's Environment. *Economics Research International*, 12:1-9.
- Kiddee, P., Naidu, R. & Wong, M.H. 2013. Electronic waste management approaches: overview. *Waste Management*, 33:1237-1250.
- Kwatra S., Pandey S. & Sharma S. 2014. Understanding public knowledge and awareness on e-waste in an urban setting in India: A case study for Delhi. *Management of Environmental Quality: An International Journal*. 25(6): 752-765.
- Lexico. 2020. English and Spanish dictionary, thesaurus, and Spanish to English translator. <https://www.lexico.com/definition/willingness>. Date of access: 30 June, 2020.
- Liang, L. & Sharp, A. 2016. Determination of the knowledge of e-waste disposal impacts on the environment among different gender and age groups in China, Laos, and Thailand. *Waste Management and Research*, 34(4): 388-395.
- Mahesh, P. 2012. EPR: Sustainable solution to electronic waste. http://toxicslink.org/docs/06167_EPR_Sustainable_solution_to_ewaste.pdf Date of access: 22 October, 2019.
- Merriam-Webster Inc. 2020. *Merriem-Wenbster dictionary*. <https://www.merriam-webster.com/dictionary/awareness> Date of access : 30 June, 2020.
- Miner, K.J., Rampedi, I.T., Ifegbesan, A.P. & Machete, F. 2020. Survey on household awareness and willingness to participate in e-waste management in Jos, Plateau State, Nigeria. *Sustainability*, 1047(12): 1-16.
- Mishra, S., Samanna, B.R. & Kannan, S. 2017. Exploring the awareness regarding e-waste and its health hazards among the informal handlers in Musheerabad Area of Hyderabad. *Indian Journal of Occupational and Environmental Medicine*, 21(3):143-148.
- Mmerekhi, D., Li, B., Baldwin, A. & Hong, L. 2016. The generation, composition, collection, treatment and disposal system, and impact of e-waste. In Mahai F-C (ed) E-waste in transition- from pollution to resource. InTech. 65-93.

- Nduneseokwu, C.K., Qu, Y. & Appollino, A. 2017. Factors influencing consumers' intentions to participate in a formal e-waste collection system: a case study of Onitsha, Nigeria. *Sustainability*, 9(6):1-17.
- Nguyen, H.T.T., Hung, R., Lee, C. & Nguyen, H.T. T. 2019. Determinants of residents' e-waste recycling behavioral intention: a case study from Vietnam. *Sustainability*, 11 (164): 1-24.
- Nnorom, I., C., Ohakwe, J. & Osibanjo, O. 2009. Survey of willingness of residents to participate in electronic waste recycling in Nigeria – A case study of mobile phone recycling. *Journal of Cleaner Production*, 17: 1629-1637.
- OECD. 2001. *Extended producer responsibility. A guidance manual for Governments*. Organisation for cooperations and development.
- Okoye, A. & Odoh, C. 2013. Assessment of the level of awareness of e-waste management and concern for the environment amongst the Populace in Onitsha, Southeastern Nigeria. *Journal of Environmental Protection*, 5: 120-134.
- Orisakwe, E.O., Frazolli, C., Llo, C.E. & Oritsemuelebi, B. 2019. Public health burden of e-waste in Africa. *Journal of Health and Pollution*, 9(22): 1-12.
- Osibanjo, O. & Nnorom, I.C. 2007. The challenge of electronic waste management in developing countries] [Abstract]. *Waste Management and Research*.
<https://doi.org/10.1177/0734242X07082028>
- Oteng-Ababio, M. 2011. When necessity begets ingenuity: e-waste scavenging as a livelihood strategy in Accra, Ghana. *African Studies Quarterly*, 13:1-21.
- Oteng-Ababio, M. 2012. Electronic waste management in Ghana-issues and practices. *Sustainable Development-authoritative and Leading Edge Content for Environmental Management*, 12: 149-166.
- Ouabo, R., E., Ogundiran, M., B., Sangodoyin, A., Y. & Babalola, B., A. 2019. Ecological risk and human health implications of heavy metals contamination of surface soil in e-waste recycling sites in Douala, Cameroun. *Journal of Health Pollution*, 9(21):1-9.
- Owusu, G., Donkor, A., Ziwu, C., Nyarko, S., Tawia, R., Bonzongo, J., C., Dubey, B., Asante, I. & Nyame, F. 2017. Public perception of e-waste management and disposal practices in Accra metropolis, Ghana. *Science and Development*, 1:79-87
- Patil, R.A. & Ramakrishna S. 2020. A comprehensive analysis of e-waste legislation worldwide. *Environmental Science and Pollution Research*, 27:14412-14431.

Ritu, S., & Shalini, A. 2013. Knowledge of e-waste among young adults. *International Journal of Engineering Science Invention*, 2(7): 39-41.

Robinson, B.H. 2009. E-waste an assessment of global production and environmental impacts. *Science and the Total Environment*, 408:183-191.

Rogoff, M. I. 2014. *Solid waste recycling and processing: Planning of solid waste recycling and facilities*. 2nd Ed. Elsevier science.

Sahle-Demessie, E., Glaser, J., & Richardson, T. 2018. *Electronic waste management, challenges and opportunities*. Paper presented at Fall 2018 National Meeting and Exposition, August 19-23, Boston, MA.

https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=343158&Lab=NRMRL Date of access: 16 January, 2020.

Saphores, J-D., Ogunseitan, O.A. & Shapiro, A.A. 2012. Willingness to engage in pro-environmental behavior: An analysis of e-waste: recycling based on a national survey of US households. *Resources Conservation and Recycling*, 60:49-63.

Sawic. 2015. E-waste IndWMP. ppt presentation.

<http://sawic.environment.gov.za/documents/3937.pdf> Date of access: 21 February, 2020.

Schevchenko, T., Laitala, K. & Danko, Y. 2019. Understanding consumer e-waste recycling behaviour: introducing a new economic incentive to increase the collection rates. *Sustainability*, 11:1-20.

Shah, A. 2014. An assessment of public awareness regarding e-waste hazards and management strategies. *Independent Study Project Collection*, 1820

Sidique, S., Lupi, F. & Satish, J. The effects of behaviour and attitudes on drop-off recycling activities. *Resources Conservation and Recycling*, 54: 163-170.

Sivathanu, B. 2016. User's perspective: knowledge and attitude towards e-waste. *International Journal of Applied Environmental Science*, 2: 413-423.

Statpak. 2017. Survey sampling methods. <https://www.statpac.com/surveys/sampling.htm> date of access 03 March 2020.

Sthiannopkao, S. & Wong, M.H. 2013. Handling e-waste in developed and developing countries: Initiatives, practices, and consequences. *Science of the Total Environment*, 463-464: 1147-1153.

Tanskanen, P. 2013. Management and recycling of electronic waste. *Acta Materialia*. 61:1001–1011.

Tiep, H.S., Kon, T.D.Y., Ahmed, E.M. & Teck, L.C. 2015. E-waste management practices of households in Meleka. *International Journal of Environmental Science and Development*, 6:811-817.

UNEnvironment. 2018. Turning e-waste into gold: the untapped potential of African landfills. <https://www.unenvironment.org/news-and-stories/story/turning-e-waste-gold-untapped-potential-african-landfills> Date of access: 17 January, 2020.

United States. Environmental Protection Agency. Recycling basics. <https://www.epa.gov/recycle/recyclingbasics#:~:text=Recycling%20is%20the%20process%20of,your%20community%20and%20the%20environment>. Date of access: 30 June, 2020.

World Economic Forum. 2019. A new circular vision for electronics. Time for a global reboot. http://www3.weforum.org/docs/WEF_A_New_Circular_Vision_for_Electronics.pdf Date of access: 11 February, 2020.

Ylä-Mella, J., Keiski, R.L & Pongracz, E. 2015. Electronic waste recovery in Finland: Consumers' perceptions towards recycling and re-use of mobile phones. *Waste Management*, 45: 374–384.

Yin, J., Gao, Y. & Xu, H. 2014. Survey and analysis of consumers' behaviour of waste mobile phone recycling in China. *Journal of Cleaner Production*, 65: 517–525.

Zhang, Y. & Bashiri, P. 2016. An investigation into Swedish e-waste collection and recycling system. Masters' dissertation. <https://core.ac.uk/download/pdf/85145165.pdf> Date of access: 23 October, 2019.

ANNEXURE A: SEMI-STRUCTURED QUESTIONNAIRE

Understanding public knowledge and awareness of e-waste management practices in Maseru, Lesotho.

My name is Tumisang Masoabi. I am carrying out an academic research on understanding public knowledge and awareness of e-waste management practices in Maseru, Lesotho, for the fulfillment of masters' degree in Waste Management with North-West University. You are invited to participate in this survey as you are a resident of Ha Thetsane suburb which is the study area of interest for this survey, because of its composition of different social classes.

Confidentiality statement

Your response to this questionnaire is voluntary, you may choose not to participate. If you decide to participate, you may withdraw at any time, and you will not be penalised. Your personally identifiable information will be kept confidential, and your responses shall be combined with those of many others and summarised in a report to further protect your anonymity.

Part A- Personal details

Please complete or tick where appropriate

1. Name:
2. Contact details:
3. Gender: Male Female
4. Age group: 21-25 26-30 31-35 36-40 41-45 46-50 51-55 56+
5. Household size:
6. Employment: Full-time Part-time Self-employed Unemployed
7. Occupation: _____
8. What is your level of education: Degree (please specify: _____)
Diploma C.O.S.C. J.C. Primary Never went to school

Part B- knowledge and awareness on e-waste management practices

Please tick where appropriate

1. Do you know what "e-waste" is? Yes No Uncertain
If no/uncertain, the researcher will explain to you what e-waste is.
2. Please give an example of e-waste.

3. What do you do with working electronic or electrical products that you no longer use?
 - a. Sell as a second hand product
 - b. Put into a storage (keep it in the house)
 - c. Give it away
 - d. Burn it
 - e. Take it to the recycling centre
 - f. Throw it away/dump it at a landfill
 - g. Other: Please specify _____
4. What do you do with broken electrical or electronic products?
 - a. Sell as a second hand product
 - b. Put into a storage (keep it in the house)
 - c. Give it away
 - d. Burn it
 - e. Take it to the recycling centre
 - f. Throw it away/dump it at a landfill
 - g. Other: Please specify _____
5. Have you disposed of electrical or electronic products that are broken or no longer in use in the last 2 years?

- a. Yes. Please explain where they were disposed of _____
- b. no

6. On a scale of 1-6, how much do you know about the material used in the electronic or electrical products?
- 1. I know nothing
 - 2. I don't know much
 - 3. I know a bit
 - 4. I know more than average
 - 5. I know quite a lot
 - 6. I know about all stages

7. On a scale of 1-4, do you agree that some materials used in electronic or electrical products are toxic to the environment and human health
- 1. I strongly disagree
 - 2. I disagree
 - 3. I agree
 - 4. I strongly agree

Please name examples of impacts to the environment or human health, if you have selected 3 or 4:

8. On a scale of 1-4, do you agree that some materials contained in electronic or electrical products are precious metals?
- 1. I strongly disagree
 - 2. I disagree
 - 3. I agree
 - 4. I strongly agree

Please name precious metals, if you have selected 3 or 4:

9. Do you consider your unused electronics to be waste, or to have another purpose? Please explain if you believe they have another purpose. _____
- a. It has a purpose: can be repaired and/or reused
 - b. It has a purpose: can utilize components/raw materials
 - c. Yes, it is waste

10. Do you know of any e-waste collection centre around Maseru?
- a. Yes, I know _____centre
 - b. No, I do not know of any centre around Maseru

11. If there were a collection centre around Maseru, would you consider taking your e-waste there?

- a. Yes, I would if

- b. No, I would not, because

12. If the government built recycling infrastructure for household electrical and electronic waste and improved the collection and disposal system of household e-waste, would you be willing to pay an associated recycling fee.

- a. Yes, I would because

- b. No, I would not because

13. What are the challenges of taking e-waste to the collection centres around the city?

- a. The lack of interest
- b. The lack of information about where they are located
- c. The lack of nearby collection centres
- d. The lack of incentive/refund for e-waste
- e. Other, please specify:

14. Are there people who collect waste electrical or electronic products from your households in exchange for money?

- a. Yes
- b. No

15. If answered yes to question 13, have you sold your electronic or electrical products to them?

- a. Yes
- b. No

16. In the past two years of electrical or electronic products purchased, were you informed of the possibility of the products to be returned to the shop once they have become waste?

- a. Yes
- b. No

17. In the past two years, have you ever returned electrical or electronic products to where you have purchased it?

- a. Yes
- b. No