

An Evaluation of E-waste Management Practices in the Selected North West District Municipalities, South Africa

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Abstract

The production and widespread utilisation of electronic products have enhanced modern lifestyles. However, the consistent increase in electronic waste (e-waste) production threatens environmental quality and public health. Previous studies have addressed various kinds of solid waste but often overlooked the unique challenges associated with e-waste. There is also limited literature about e-waste management at the municipal level, particularly in South Africa. This paper examines how e-waste is managed in the selected North West District Municipalities in South Africa. The study adopted a case study approach to assess and suggest strategies for e-waste management. The case study examined e-waste management practices in the selected municipalities. Semi-structured interviews were conducted with 22 IT and Procurement/Supply Chain participants because of their technical skills, knowledge, and experience to promote sustainable e-waste management practices. The study found that the life cycle assessment of electronic products is not conducted, and up-to-date policies and systems for replacing electronic equipment are nonexistent. Similarly, efforts to bring about a circular economy are not promoted due to a lack of hardware repair and upgrades, refurbishment, and recycling of obsolete electronic equipment. Furthermore, environmental considerations are often overlooked during procurement, thus contributing to unsafe disposal practices. The study offers insights into the unique challenges and strategies for e-waste management at the municipal level. It is, therefore, important for municipalities to adopt sustainable e-waste practices to prevent environmental harm.

Keywords: circular economy, e-waste management, extended producer responsibility, environmental sustainability, green design, and green procurement

1. Introduction

Electronic products are the core of technological innovation and at the forefront of modern consumer culture. However, the consistent increase in electronic waste (e-waste) production threatens the environmental quality and public health (Forti, Baldé, Kuehr, & Bel, 2020; Kumar, & Bhaskar, 2016). It is projected that in 2016, nearly 44.7 million tons (Mt) of e-waste were produced. A few years afterward, in 2019, the global statistical breakdown of e-waste quantities generated was as follows: (1) Asia 24.9 Mt (5.6 per capita), (2) America 13.1 Mt, (3) Europe 12 Mt (16.2 per capita), (4) Africa 2.9 Mt (2.5 kg per capita), and Oceania 0.7 Mt (16.1 kg per capita) (Dhir, Koshta, Goyal, Sakashita, & Almotairi, 2021). This consistent increase in e-waste was expected to contribute to carbon emissions of about 3% to 4% per year, reaching 57.4 million tons in 2020, and 59.4 million tons in 2022 (Dhir, Koshta, Goyal, Sakashita, & Almotairi, 2021). Without any intervention, this growing accumulation is expected to increase significantly in the future, reaching an overwhelming 75 million metric tons by 2050 (Dhir, Koshta, Goyal, Sakashita, & Almotairi, 2021; Forti, Baldé, Kuehr, & Bel, 2020; Ichikowitz, & Hattingh, 2020; Shevchenko, Laitala, & Danko, 2019).

The US Environmental Protection Agency study found that it is inexpensive to export waste rather than process waste. Hence, approximately 1.3 million tons of obsolete electronic equipment are dispatched yearly from developed countries to developing countries (Baldé, Kuehr, Yamamoto, McDonald, D'Angelo, Althaf, ... Wagner, 2026; Ichikowitz, & Hattingh, 2020). Sometimes, this shipment of e-waste is conducted illegally under the disguise of donations, direct use, repair, refurbishment, and recycling and passes through the ports without being detected by authorities (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017; Fatema, Hassan, Hasan, & Roy, 2025; Skrdlik, 2023). As a

result, developing countries such as South Africa may become dumping grounds for such waste materials (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017; Kubanza, & Simatele, 2020).

The African continent has about 1.2 billion people, each generating an average of 2.5 kilograms of e-waste annually (Forti, Baldé, Kuehr, & Bel, 2020; Traverso, Mankaa, Pedal'a, & Covais, 2024; World Economic Forum, 2019). However, the scientific data indicate that e-waste generation per capita remains relatively low in developing countries (Baldé, Kuehr, Yamamoto, McDonald, D'Angelo, Althaf, ... Wagner, 2026; Kumar, & Bhaskar, 2016; Shamim, Mursheda, & Rafiq, 2015). The general problem with e-waste is the relative lack of detailed regulations and systems for collecting and disposing of obsolete electronic equipment, which creates challenges for developing countries (Srivastava, & Pathak, 2020).

Electronic waste comprises several forms of electronic equipment that have ultimately reached their end of use (i.e., obsolete) in their life span and thus are no longer needed by their owners (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017; Kubanza, & Simatele, 2020; Moyo, Lubbe, Klopper, & Meyer, 2020). It consists of discarded computers, laptops, printers, scanners, compact discs, circuit boards, semiconductor chips, cathode ray tubes, and batteries (Heacock, Kelly, Asante, Birnbaum, Bergman, Bruné, ... Suk, 2016). Such waste items release toxic substances that can harm the environment (Forti, Baldé, Kuehr, & Bel, 2020; Okeke, Enochoghene, Ezeudoka, Kaka, Chen, Mao, & Wu, 2024). This indicates that e-waste is presenting a danger to environmental sustainability around the globe (Forti, Baldé, Kuehr, & Bel, 2020; Kumar, & Bhaskar, 2016; Shamim, Mursheda, & Rafiq, 2015).

While e-waste management is part of resource management in several institutions and organizations, there is limited literature about its management at the municipal level, particularly in South Africa. This is in stark contrast to the circumstances in India, where some investigations have been performed on the disposal practices of e-waste. Most organizations lack the proper understanding and applicable skills to deal with electronic waste (Maphosa, & Maphosa, 2020; McMahon, Uchendu, & Fitzpatrick, 2021). To overcome this deficiency, preventative plans and strategies, proper legislation, safe disposal practices, and proper collection systems are required to lessen the growing accrual of e-waste (Godfrey, & Oelofse, 2017; Moyo, Lubbe, & Ohei, 2023; World Economic Forum, 2019).

As a result of the identified literature gap on insufficient focus on e-waste management as a distinct and independent area of study, particularly within the context of local municipalities in the North-West Province. Previous research has extensively addressed solid waste management but largely overlooked the challenges associated with e-waste, thus demonstrating the rationale for the proposed study. This gap highlights the need for a study that isolates e-waste as a separate issue, especially in the context of local municipal operations where large quantities of electronics such as laptops, computers, printers, scanners, and telecommunications devices are procured and eventually discarded. The study intends to fill this gap by examining e-waste management practices among local municipalities in the North-West Province, offering insight into unique challenges and strategies for e-waste management.

2. Literature Review

2.1 *The Impact of the Short Life Cycle of Electronic Equipment*

The rapid technological advancement of electronic equipment, new electronic products in the marketplace with lower prices, attractive consumer designs, increasing consumer demand for electronics, upgrading, compatibility issues, shorter life cycles of computers and laptops, and persistent crashing of electronic equipment with limited options to repair are contributing significantly to the increase in e-waste generation “throw-away society” (Baldé, Kuehr, Yamamoto, McDonald, D'Angelo, Althaf, ... Wagner, 2026; Ichikowitz, & Hattingh, 2020; Mulckhuyse, Samlal, & Drenth, 2021; Murthy, & Ramakrishna, 2022; Shevchenko, Laitala, & Danko, 2019). Technological innovations in electronic devices have significantly reduced the average lifespan of new computers by about 50 percent, ranging from five years to two years, with limited repair options (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; Ichikowitz, & Hattingh, 2020; Mohammed, 2023). Electronic equipment manufacturers exacerbate this situation by intentionally designing products for shorter life cycles (De Froberville, 2019; Parajuly, Fitzpatrick, Muldoon, & Kuehr, 2020). Consequently, organizations replace electronic devices every two years and discard obsolete electronic devices to maintain operational efficiency and effectiveness (Lebbie, Moyebi, Asante, Fobil, Brune-Drise, Suk, & Carpenter, 2021; Shevchenko, Laitala, & Danko, 2019).

2.2 *Green Design for Electronic Equipment*

In accordance with the Waste Electrical and Electronic Equipment (WEEE) Directive of the European Parliament and the Council (2002/96/EC), the reduction, reuse, and recycling of e-waste were encouraged in 2003. This directive seeks to promote green design in the manufacturing of electronic devices, encourage the use of advanced technologies, collect, sort, recover, and recycle e-waste, and make producers accountable for the financing and return of electronic

devices (Lebbie, Moyebi, Asante, Fobil, Brune-Drise, Suk, & Carpenter, 2021; Lepawsky, 2018; Maphosa, & Maphosa, 2020).

Green design, also known as sustainable or eco-friendly, embraces the design's durability, adaptability, reuse, repairability, and recycling, and ensures that the electronic equipment is kept longer in circulation. The aim is to ensure compliance with economic, social, and ecological sustainability principles (Meloni, Souchet, & Sturges, 2018). It intends to increase electronic products' energy efficiency and biodegradability, reducing environmental impact and creating a sustainable and resilient future for the inhabitants and the planet (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; World Economic Forum, 2019).

Despite the benefits of green design, it suffers some drawbacks associated with increased production costs and affordability that are likely to be passed to the consumers, thus making green products unaffordable (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017). For instance, green features are likely to compromise the performance of electronic equipment, introducing complexity or compatibility issues, causing frustration or inconvenience to consumers, and resulting in greenwashing, where producers are likely to exaggerate their claims about improvements in sustainability without oversight and verification (Baldé, Kuehr, Yamamoto, McDonald, D'Angelo, Althaf, ... Wagner, 2026; Mohammed, 2023). Notably, some consumers focus on the price, performance of the electronic product, and brand reputation rather than the environment (World Economic Forum, 2019). As a result, innovative solutions must be developed to facilitate the adoption of environmental sustainability since some of these concerns cannot be ignored (Agyepong, & Nhamo, 2017).

2.3 Green Procurement of Electronic Products

In South Africa, green procurement is a policy that ensures social, economic, and environmental outcomes of design, material use, production methods, service delivery, maintenance, reuse, recycling, disposal, and supplier competency are adequately addressed throughout the supply chain process (Agyepong, & Nhamo, 2017). Green procurement is essential because it can assist organizations in reducing environmental harm by extending the life cycle of electronic devices (Agyepong, & Nhamo, 2017; Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023). This process ensures that all the decisions for purchasing and the provision of contracts, price, quality, and delivery identify any potential adverse environmental impacts that can be caused by e-waste (Meloni, Souchet, & Sturges, 2018). Therefore, the elements that should be prioritized during the procurement process of electronic equipment are associated with brand reputation, durability, repair, upgradability, lifestyle compatibility, refurbishment options, recyclability, natural resource depletion, carbon emissions and toxicity, reliability, and sustainability (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023). Green products are more efficient in energy use than other products and can be recognized with labels or certifications such as ENERGY STAR, EPEAT, or USDA Organic (Mohammed, 2023).

Although green procurement offers organizations some benefits, it faces daunting challenges related to behavior change among procurement professionals and resistance from individuals and organizations that deviate from the standard procurement process. As a result, the adoption rate is low because of issues relating to high costs, restriction of supplier choices, reduced competition, deception, exaggerated claims about the benefits of the electronic product on the environment, and lack of standardization in procurement practices (Meloni, Souchet, & Sturges, 2018; Mohammed, 2023). Nevertheless, some organizations have recognized the importance of green procurement and are integrating sustainability into their procurement processes (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023).

2.4 The Switzerland Model for Managing E-waste

Switzerland's (Swiss) model is considered a good benchmark for managing e-waste effectively and efficiently (Agyepong, & Nhamo, 2017; Baldé, Forti, Gray, Kuehr, & Stegmann, 2017; Mohammed, 2023) because their system uses the decree on the return, the tracing back, and the disposal of electronic equipment. The Swiss model encourages producers, importers, and retailers to charge the consumer an advance recycling fee while selling new electronics. This amount caters to safely disposing of electronic equipment at the end of their life cycle to promote environmental sustainability (Daum, Stoler, & Grant, 2017; Fatema, Hassan, Hasan, & Roy, 2025; Mohammed, 2023). As a result, when electronic equipment becomes obsolete, the consumer can return the equipment without charge to any designated collection site in Switzerland. This practice is intended to avoid obsolete electronic equipment ending up in landfills (Mohammed, 2023; Murthy, & Ramakrishna, 2022; Shamim, Mursheda, & Rafiq, 2015).

2.5 The Role of Extended Producer Responsibility

The rapid growth of electronic equipment production and consumption, characterized by the linear process “make, consume, and dispose” model, has significantly contributed to global environmental challenges (Shamim, Mursheda, & Rafiq, 2015). Historically, many countries have lacked market mechanisms to deal with e-waste in an environmentally sustainable manner. Hence, EPR has been introduced to promote environmental sustainability (Forti, Baldé, Kuehr, & Bel, 2020; Kumar, & Bhaskar, 2016; Tumu, Vorst, & Curtwiler, 2023).

EPR legislation sets out the responsibilities of manufacturers when their products reach end-of-life. It creates a “cradle-to-grave” framework that presumes the environmental costs and market prices associated with the products and ensures that manufacturers make decisions about their products' final destination (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; Ichikowitz, & Hattingh, 2020; Torres, Guzman, Kuehr, Magalini, Devia, Cueva, & Basiniani, 2016). This means the producer's responsibility for developing electronic products extends beyond the post-consumer stage of the lifecycle of their products (Lepawsky, 2018; Maphosa, & Maphosa, 2020; Torres, Guzman, Kuehr, Magalini, Devia, Cueva, & Basiniani, 2016). However, the producers are not legally accountable for implementing EPR and are permitted to use a third-party entity known as the producer responsibility scheme to handle the take-back of electronic equipment (Forti, Baldé, Kuehr, & Bel, 2020; Murthy, & Ramakrishna, 2022).

EPR implementation inspires consumers to buy electronic equipment that conforms to environmental credentials. It encourages redesigning electronic products to increase lifespan and promote environmental sustainability in production and consumption (Heacock, Kelly, Asante, Birnbaum, Bergman, Bruné, ... Suk, 2016; Meloni, Souchet, & Sturges, 2018). The development and implementation of EPR policies play a critical role in effectively managing e-waste (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; Srivastava, & Pathak, 2020; Tumu, Vorst, & Curtwiler, 2023). The primary concern about EPR is that it places enormous financial responsibility on the manufacturers, which can increase consumer product prices. In the same vein, some manufacturers can resist EPR adoption because of additional cost concerns that can affect their profits, while others can use it inappropriately to mislead the public (greenwashing). Ultimately, these manufacturers can claim environmental responsibility without playing any role in promoting environmental sustainability (Mohammed, 2023; Shamim, Mursheda, & Rafiq, 2015). This complexity can cause the EPR implementation to be ineffective or inconsistent (Ichikowitz, & Hattingh, 2020). Implementing an efficient EPR system requires the collaboration of several stakeholders because it can be complex (Shamim, Mursheda, & Rafiq, 2015).

2.6 The Importance of Circular Economy

The circular economy is an emerging concept that refers to an economic system that aims to reduce waste, make full use of resources, and create opportunities (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023). Its goal is to protect all components of electronic products and maintain their maximum value through strategies such as remanufacturing, reuse, refurbishment, recovery, reprocessing, recycling, and safe disposal (De Froberville, 2019; Shevchenko, Laitala, & Danko, 2019; World Economic Forum, 2019). These strategies are intended to harness the economic value of materials, create investment initiatives in infrastructure and employment, and encourage electronic products to be used longer (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017; De Froberville, 2019; Srivastava, & Pathak, 2020; World Economic Forum, 2019). It is a substitute or replacement for the traditional linear economic model (Srivastava, & Pathak, 2020).

Similar to the Swiss model, the circular economy also encourages the producer to offer buy-back of returned old electronic equipment for reuse and prevent them from being sent to landfills (Moyo, Lubbe, & Ohei, 2023; World Economic Forum, 2019). Research predicts that a circular model for electronic devices could decrease consumer costs by approximately 7% in 2030 and 14% by 2040 because the principles emphasize the significance of increasing consumer awareness, responsible consumption, and disposing of electronic devices in an environmentally sustainable manner (Baldé, Forti, Gray, Kuehr, & Stegmann, 2017; Daum, Stoler, & Grant, 2017; De Froberville, 2019; Godfrey, & Oelofse, 2017; Srivastava, & Pathak, 2020). As a result, societies can transform into more sustainable and resilient models by embracing a circular economy to address environmental concerns while promoting economic growth and social well-being (Parajuly, Fitzpatrick, Muldoon, & Kuehr, 2020). Municipalities can also significantly contribute to the circular economy through supportive policies and regulations (De Froberville, 2019).

2.7 Disposal of Electronic Waste

The impact of e-waste on the environment is the world's main issue. The current global economic environment of free trade between nations has caused this e-waste problem to spread to many countries without the relevant technology or facilities to address this prevalent problem (Moyo, Lubbe, & Ohei, 2023). Studies estimate that approximately 50 to

71 kilotonnes of brominated flame-retardant plastics are still found in unrecorded e-waste flows, leading to an increased environmental footprint globally (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; Ichikowitz, & Hattingh, 2020; Lebbie, Moyebi, Asante, Fobil, Brune-Drise, Suk, & Carpenter, 2021). E-Waste Association South Africa has released a report showing that the country produces approximately 16.2 kg of e-waste annually (De Froberville, 2019), which is expected to be disposed of according to government or local regulations to prevent environmental harm (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; Kubanza, & Simatele, 2020). E-waste contributes to about 5-10 percent of municipal solid waste production in South Africa and is increasing faster than any other form of waste (Gupta, Abidi, Bansal, & Jain, 2013; Okeke, Enochoghene, Ezeudoka, Kaka, Chen, Mao, & Wu, 2024; Traverso, Mankaa, Pedal'a, & Covais, 2024; Tetteh, & Lengel, 2017; World Economic Forum, 2019). In proportion to this data, there is a need to reduce this waste stream through sustainable practices.

2.8 Health and Environmental Impact of E-waste

E-waste is comprised of 1,000 hazardous and non-hazardous substances or materials of different sizes and shapes, such as arsenic, antimony, beryllium, brominated flame retardants, cadmium, chlorofluorocarbons, hexavalent chromium, lead, polychlorinated biphenyls, polybrominated biphenyls, and polybrominated diphenyl ether. These toxic substances are corrosive, flammable, or explosive, posing a serious threat to human health and the environment (Borthakur, & Singh, 2020; Forti, Baldé, Kuehr, & Bel, 2020; Moyo, Lubbe, & Ohei, 2023; World Economic Forum, 2019). Some of these substances are carcinogenic (triggering the formation of cancer cells), teratogenic (triggering developmental malformations), and mutagenic (increased modification of genetic material, usually deoxyribonucleic acid (DNA) (Forti, Baldé, Kuehr, & Bel, 2020; Okeke, Enochoghene, Ezeudoka, Kaka, Chen, Mao, & Wu, 2024), and can also bioaccumulate toxins (building up) within the tissues of organisms because of increased exposure (Torres, Guzman, Kuehr, Magalini, Devia, Cueva, & Basiniani, 2016; Tetteh, & Lengel, 2017). Furthermore, some of these substances are not biodegradable (can persist in the environment for a long period of time) and contribute to air pollution exceeding permissible limits, get deposited on soil surfaces, groundwater resources, contamination or pollution via leaching into water bodies affecting aquatic life and other biota, land degradation, and loss of biodiversity or aesthetic concerns due to improper disposal (Baldé, Kuehr, Yamamoto, McDonald, D'Angelo, Althaf, ... Wagner, 2026; Okeke, Enochoghene, Ezeudoka, Kaka, Chen, Mao, & Wu, 2024; Shamim, Mursheda, & Rafiq, 2015). This indicates that e-waste is presenting a danger to environmental sustainability around the globe (Forti, Baldé, Kuehr, & Bel, 2020; Kumar, & Bhaskar, 2016).

2.9 Legislative Framework for Sustainable E-waste Management

The Constitution of the Republic of South Africa (No. 108 of 1996), Section 24, prescribes that every person has the right to be in an environment that is free from any harm to their health or welfare, ensuring that the environment is safeguarded for the benefit of the current and upcoming generations, through the application of the legislation and other measures to avert pollution and environmental degradation, promoting the preservation and ecologically sustainable development, through the use of natural resources, and endorsing defensible economic and social development (International Telecommunication Union, 2023; Republic of South Africa, 1996). The legislation is an essential tool for creating guidelines and legal frameworks to promote responsible, sustainable e-waste management practices, reducing severe health and environmental consequences, fostering awareness, setting standards for appropriate disposal and recycling practices, promoting the circular economy, encouraging sustainable practices through the life cycle of electronic equipment, and imposing penalties and enforcement (Maphosa, & Maphosa, 2020; Mohammed, 2023; Patil, & Ramakrishna, 2020). However, e-waste is not receiving attention on the political agenda, and often, legislation is not adequately enforced (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; World Economic Forum, 2019).

2.10 Policy Formulation for E-waste Management

The formulation of policies plays a critical role in the successful management of e-waste for both developed and developing countries by setting some standards to regulate the actions of stakeholders associated with e-waste in the private sector and government (International Telecommunication Union, 2023; Maphosa, & Maphosa, 2020; Murthy, & Ramakrishna, 2022; Patil, & Ramakrishna, 2020). The main driving force behind policy development is to promote clean, healthy, sustainable economic and environmental development through prevention, reduction, and conservation of resources, pollution control and abatement, and management of toxic wastes (Borthakur, & Singh, 2020; Daum, Stoler, & Grant, 2017; Miner, Rampedi, Ifegbesan, & Machete, 2020; Republic of South Africa, 1998). This means adopting eco-friendly technologies, green policy development, and regulatory policies that protect workers, society, and the environment (De Froberville, 2019; Ghisellini, Cialani, & Ulgiati, 2016; Kubanza, & Simatele, 2020). However, e-waste policy faces challenges relating to the lack of comprehensive legislation at national and international levels, which can lead to inconsistent application of the regulations, enforcement gaps, and challenges in managing e-waste

effectively across borders (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; Patil, & Ramakrishna, 2020).

2.11 Public Finance Management Act (No. 1 of 1999)

The intent of the Public Finance Management Act (PFMA) (No. 1 of 1999) is to control the financial management of the national and provincial government to ensure that all the revenues, expenses, assets, and liabilities are proficiently and effectively managed. This includes promoting openness, transparency, accountability, and proper management of revenue, expenditure, assets, and liabilities for the municipalities impacted by the provision of this Act. In the context of e-waste management, the PFMA requires that the process of procurement should be conducted fairly, equitably, transparently, competitively, and cost-effectively. From this perspective, the procurement process should be able to provide value for the municipalities' money in managing e-waste. However, price is not solely a reliable indicator of acquiring value for money. Hence, value for money is unrelated to accepting lower prices that meet the requirements. It entails achieving the best possible outcome when considering the costs and gains associated with the procurement cycle, ensuring that the environmental and operational objectives of e-waste management are achieved sustainably (Republic of South Africa, 1999).

3. Materials and Methods

3.1 Geographical Characteristics of the Study Area

The study area is in the North-West province of South Africa, which lies near the Botswana border, and shares the boundaries of the provinces of Gauteng, Free State, and Limpopo to the east, south, and west, respectively (Figure 1). Its capital is Mahikeng (formerly known as Mafikeng). As indicated in Table 1, it comprises four districts and eighteen local municipalities. According to the list of South African provinces by population, the North-West is ranked the seventh province by population size, with a population of approximately 4,027 160 people. All four district municipalities and three local municipalities, Klerksdorp (City of Matlosana), Wolmaransstad (Maquassi Hills Local Municipality), and Mahikeng, were selected for data collection. The researcher faced significant challenges relating to time and resources, difficulty in accessing participants, financial constraints, and travel and logistical challenges.

Table 1. Background information on North-West District Municipalities

North West District Municipalities	Description of District Municipalities
Ngaka Modiri Molema (5 municipalities)	Mahikeng with a population of 291 527, Lichtenburg (Ditsobotla) 168 902, Zeerust (Ramotshere Moiloa) 150 713, Delareyville (Tswaing) 124 218, and Delareyville - Setlagole village (Ratlou) 107 339.
Dr. Ruth Segomotsi Mompati (5 municipalities)	Taung (Greater Taung), with a population of 177 642, Ganyesa (Kagisano-Molopo) 105 789, Vryburg (Naledi) 66 781, Schweizer-Reneke (Mamusa) 60 355, and Christiana (Lekwa-Teemane) 53 248.
Dr. Kenneth Kaunda (3 municipalities)	Klerksdorp (City of Matlosana) with a population of 417 282; Potchefstroom (JB Marks Local Municipality) 243 527; and Wolmaransstad (Maquassi Hills Local Municipality) 82 012
Bojanala Platinum District (5 municipalities)	Rustenburg, with a population of 549 575, Brits (Madibeng) 447 381, Mogwase (Moses Kotane) 242 554, Makapanstad (Moretele) 186 947, and Koster (Kgetlengriver) 51 049.

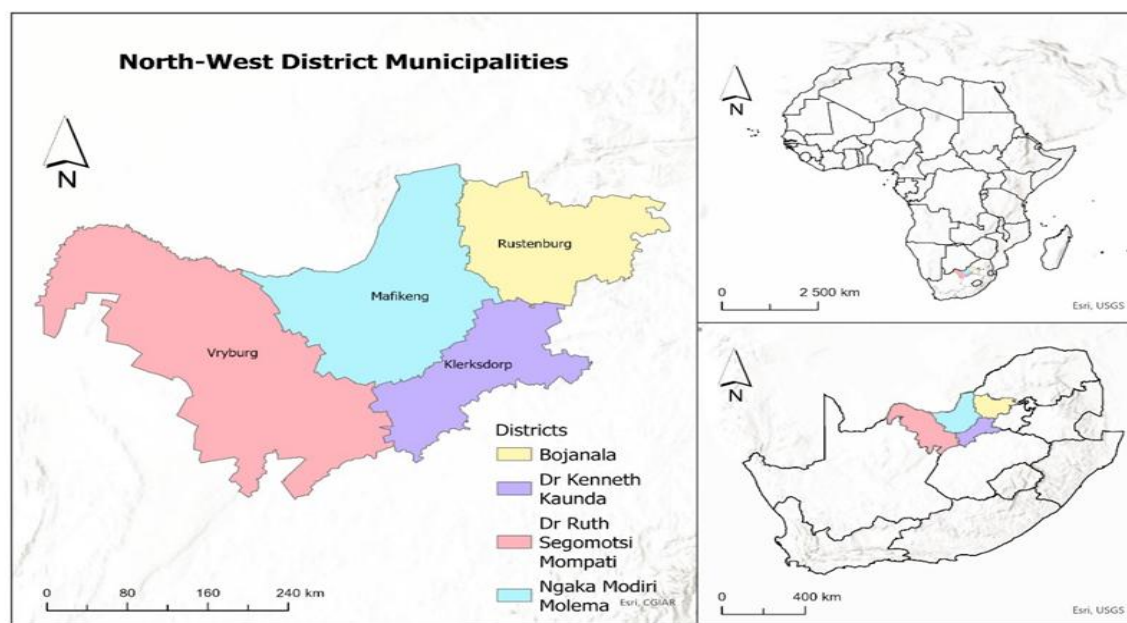


Figure 1. Map displaying North West Province District Municipalities in South Africa

3.2 Research Methodology

A case study design was used to explore, understand, and interpret e-waste practices in the selected North West District Municipalities, and to draw conclusions. It allowed the selected participants to respond in their own words rather than being persuaded to select from a rigid set of answers. This approach provided rich contextual data and high-quality information to understand how participants explain their experiences and the realm of e-waste practices around them. It also sheds light on complex problems and explores the overall picture because the researcher was more interested in understanding the meaning of e-waste phenomena (Denzin, & Lincoln, 2005).

3.3 Population and Sampling Selection

The population of this study was selected using a purposive sampling method. Each person has a slight or even zero chance of being selected in this type of sampling because the selection is subjective (Leedy, & Ormrod, 2015). The purposive sampling technique was used in the study to gain a deeper understanding of the e-waste phenomenon. This sampling technique allows the researcher to choose participants based on his knowledge, expertise, and decision-making about the study population. The primary motivation was to select meaningful samples to provide correct and rich information about the e-waste phenomenon under study to accomplish the research objectives (Hox, & Boeije, 2005; Nicholls, 2009). The sample of this study was 22 IT and Procurement/Supply Chain personnel from the selected North West District Municipalities. The sample comprises of IT managers (6), IT Specialists (4), IT Technicians (6), IT interns (2), Supply Chain managers (2), and Supply Chain officers (2).

3.4 Conceptual Saturation

The researcher was expected to continue developing a sample until data saturation. This means that the researcher was expected to collect data until there was no longer new insight about the e-waste phenomenon of concern in connection to the core questions. The researcher reached saturation when no new information or categories came to light in the study of the 22 interviewed participants (Leedy, & Ormrod, 2015).

3.5 Data Collection Methods

The researcher used primary and secondary data for this study. The information gathered from secondary sources played a critical role in helping the researcher refine the research topic and identify key areas for collecting valuable empirical data. Data collection for this research was conducted through semi-structured interviews with the IT managers/officers, Asset managers/officers, and Procurement/Supply Chain managers/officers from the sampled local

municipalities to assist the researcher in contextualizing how e-waste is managed at district and local municipalities to determine e-waste disposal trends. Semi-structured interviews intend to obtain factual and significant information, allow participants to respond explicitly and in more detail, and provide a balanced structure and adaptability by enabling the researcher to ask systematic questions while probing for deeper insights (Leedy, & Ormrod, 2015).

3.6 Interview Development Construction

The interview development matrix was utilized to construct the research questions. This matrix is a structured tool used in qualitative research to systematically design and organize interview questions. It ensured that the questions were aligned with the research objectives and addressed key themes or variables under investigation. This matrix helped the researcher map out how specific questions should contribute to answering the research questions and achieving the study's objectives (Klopper, & Lubbe, 2011). All the research interviews were recorded with the participants' authorization (consent). The researcher used handwritten notes and a digital voice recorder to record information, and the interviews were transcribed into computer files, labeled according to relevance to the study, and then analyzed by the researcher. The researchers took great care to ensure that participants were not identified, including not revealing their workplaces in subsequent reporting. Participants were informed that the interview records would be destroyed once the final research report was completed.

3.7 Data Analysis and Interpretation

The data analysis was also conducted through a continuous relative method, including matching one data section with another to identify resemblances and distinctions (content analysis). The researcher can evaluate theoretical concepts to improve understanding of the phenomena under study in content analysis (Leedy, & Ormrod, 2015). The researcher prepared and organized the data, listened to the interview recordings, and read the data; the information was then coded and segmented, sub-themes were developed, and responses for the presentation were prepared; then, the data was interpreted to derive meaning from the responses.

3.8 The Test Used in the Data Analysis

Software packages such as the Statistical Package for the Social Sciences (SPSS) and Microsoft Excel (Version 2016) were used for processing and coding because they can categorize defined interrelationships among the identified data and attach data meaning to common themes. The descriptive statistics and Chi-square goodness-of-fit tests were performed on categorical variables using univariate tests to test whether any response option was more or less appropriately selected than the others, and qualitative thematic analysis was used to analyze data manually.

3.9 Coding Process

The researcher was involved in verbatim transcription of all study interviews, and data was coded using an iterative process of reviewing the transcribed data and simplifying transcription to guarantee the anonymity of participants, as well as preparation of study transcripts for coding and statistical analysis. This way, essential meanings and patterns from the analysis were used to evaluate e-waste practices in the selected North West Provincial District Municipalities.

4. Results and Discussion

4.1 Demographic Profile of Respondents

The demographic profile of respondents included gender, age, race group, educational qualifications, years of service within the municipality, and years in their current roles managing electronic equipment. It also includes participants' job titles, specified their qualifications relevant to their current positions, and explored participants' involvement in the municipalities in Table 2.

Table 2. Demographic Characteristics of Participants

	Frequency	Percentage	Average Values	Mean	Standard Deviation
Gender					
Male	17	77	11.0	11.0	8.49
Female	5	23	11.0	11.0	8.49
Age range					
20-30 years	5	23	7.3	7.33	4.04
31-40 years	12	54	7.3	7.33	4.04
41-50 years	5	23	7.3	7.33	4.04
Race/ ethnic group					
Blacks	20	91	11.0	11.0	12.73
Coloreds	2	9	11.0	11.0	12.73
Qualifications					
Diploma	3	14	5.5	5.5	5.80
Degree	14	64	5.5	5.5	5.80
Postgraduate diploma/degree	4	18	5.5	5.5	5.80
Master's degree	1	4	5.5	5.5	5.80
Years of service					
1-2 years	3	14	4.8	3.67	2.16
3-4 years	7	32	4.8	3.67	2.16
5-6 years	5	23	4.8	3.67	2.16
7-8 years	4	18	4.8	3.67	2.16
9-10 years	2	9	4.8	3.67	2.16
10+ years	1	4%	4.8	3.67	2.16
Years in current position					
1-2 years	3	14	3.7	3.67	2.16
3-4 years	7	32	3.7	3.67	2.16
5-6 years	5	23	3.7	3.67	2.16
7-8 years	4	18	3.7	3.67	2.16
9-10 years	2	9	3.7	3.67	2.16
10+ years	1	4	3.7	3.67	2.16
Job title of participants					
IT managers	6	27	3.7	3.67	1.97
IT Specialists	4	18	3.7	3.67	1.97
IT technicians	6	27	3.7	3.67	1.97
IT interns	2	9	3.7	3.67	1.97
Supply Chain managers	2	9	3.7	3.67	1.97
Supply Chain Officers	2	9	3.7	3.67	1.97

Qualification related to the job					
Yes	20	91	11.0	11.0	12.73
No	2	9	11.0	11.0	12.73
Involvement in the company					
Business	4	18	11.0	11.0	9.90
IT	18	82	11.0	11.0	9.90
Type of post					
Managerial	8	36	11.0	11.0	9.90
Non-managerial	14	64	11.0	11.0	9.90

4.1.1 Gender of Participants

The sample in this study consists predominantly of males (77%, n=17), reflecting a significant gender gap in IT and Procurement roles within the District and selected municipalities. However, preference was not given in connection with sex or gender. The Chi-square value is 3.27, less than 3.841, and not statistically significant at the 0.05 level, while the mean number of participants per group is (11.0); and a high SD (8.49) suggests considerable group variability. This disparity may stem from broader industry trends or recruitment practices that perpetuate the underrepresentation of females in traditionally male-dominated sectors, incorrect application of employment equity legislation, inequality, cultural stereotypes, workplace culture, and gender bias. Historically, IT has been dominated by males in South Africa. Addressing this imbalance requires targeted strategies, such as inclusive recruitment practices and mentorship programs, to promote gender diversity and inclusivity.

4.1.2 Age of the Participants

The statistical analysis shows that the largest age group of participants is between 31-40 years (54%, n=12), followed by 20-30 years (23%, n=5) and 41-50 years (23%, n=5), reflecting a significant concentration of younger professionals under the age of 40 years (77%) in the IT and Procurement/Supply Chain in the selected North West District Municipalities. This group of participants is the working group with technological skills who have sufficient knowledge and experience in the management of e-waste in their municipalities. The Chi-square value is 4.48, which is less than the critical value of 5.991, and is not statistically significant at the 0.005 significance level. The SD (4.04) indicates moderate variability around the mean age, suggesting that most participants are clustered within this range. However, the limited presence of older employees is a serious concern about leadership succession and potential retention challenges. This indicates the need to develop strategies to address long-term workforce stability and knowledge transfer. This age distribution may reflect recent recruitment efforts or an industry trend favoring younger professionals.

4.1.3 Race Group of the Participants

The racial composition of the workforce shows a strong representation of Black participants (91%, n=20), with Colored participants forming a small minority (9%, n=2). However, the preference of the research interviews was not given according to race. This imbalance highlights a lack of racial diversity within the workforce. The Chi-square value is 14.72, which is greater than the critical value of 3.841 and indicates a statistically significant difference between observed frequencies. In other words, the observed distribution is not in line with the expected distribution. The SD (12.73) indicates some dispersion, and the skewed distribution toward a single group suggests a need for more inclusive recruitment and retention strategies, with a mean of (11.0). This imbalance may stem from existing demographic trends or organizational recruitment practices; broad-based economic empowerment policies to address historical inequalities; and the inclusion of blacks and coloreds. Therefore, for a more inclusive workforce, techniques such as targeted outreach, inclusive recruitment policies, and diversity training programs should be considered to address underrepresentation and promote equitable representation of all racial groups.

4.1.4 Qualification of the Participants

The majority of participants (64%, $n=14$) hold undergraduate degrees, with 18% ($n=4$) possessing postgraduate diplomas or degrees and only 4% ($n=1$) holding a Master's degree. The Chi-square value is 18.37 and greater than the critical value of 7.815, which is statistically significant between the observed frequencies of qualifications. This suggests that the distribution of qualifications does not align with the expected distribution. The SD (5.80) and mean (5.5) indicate moderate variability across qualification levels. This shows that the employees are well-educated. However, advanced qualifications such as Master's degrees are rare. There is a gap in advanced qualifications within the workforce, which may impact skills development and career progression. The observed disparity in educational attainment may stem from barriers such as financial constraints or limited organizational support for further studies. However, most of the participants working in the selected North West District Municipalities are highly qualified and have the necessary knowledge and skills, which is an advantage for the North West District Municipalities. This gap can be addressed by supporting employees pursuing advanced qualifications to improve their skills.

4.1.5 Years of Service in the Company

The highest representation in years of service falls between 3 and 4 years (32%, $n=7$), followed by 5 and 6 years (23%, $n=5$) and 7 and 8 years (18%, $n=4$). Only 4% ($n=1$) of employees have more than 10 years of service in their respective municipalities. This shows that the municipal workforce of the interviewed participants has a relatively short tenure. This may reflect challenges in employee retention in several municipalities. The Chi-square value is 6.3 and is less than the critical value of 11.070. This means that the data do not indicate a significant deviation from the expected distribution of years in the current position. A low SD (2.16) and mean (3.67) suggest that long-term tenure is uncommon in various municipalities. The limited presence of employees with over 10 years of service is alarming regarding retaining institutional knowledge for municipal sustainability over the long term. This could be attributed to retirement and staff resignations, workplace culture, and individual career aspirations. However, the results show that the participants have sufficient length of service, knowledge, and experience to execute their tasks in their municipalities. Therefore, municipalities should focus on retention strategies to improve employee satisfaction and encourage longer tenure within municipalities.

4.1.6 Years in a Current Position Dealing With Electronic Equipment

The years of service in current positions are predominantly between 3 to 4 years (32%, $n=7$), followed by 5 to 6 years (23%, $n=5$), and 7 to 8 years (18%, $n=4$). This reflects typical alignment and tenure patterns within the municipalities. The results show that most participants have sufficient knowledge and experience to deal with e-waste. The Chi-square value is 6.3 and is less than the critical value of 11.070. This means that there is no statistically significant difference, and the observed distribution does not deviate from the expected distribution of years in the current position. The low SD (2.16), with a mean of 3.67, suggests potentially high turnover or frequent promotions, with a concentrated distribution, with most employees clustered around mid-term service durations. While this indicates a workforce with moderate tenure levels, further analysis of retention trends could provide insights into whether this represents stable employee retention or if there are opportunities for longer-term workforce development.

4.1.7 Job Title of the Participants

The distribution of roles within the IT department shows a concentration of employees in IT Manager positions (27%, $n=6$) and Technicians (27%, $n=6$), with fewer employees in specialized roles like IT Specialists (18%, $n=4$) and other positions (9%, $n=2$). The Chi-square value is 5.24 and less than the critical value of 11.070, which means that there is no statistical difference in the observed job title distribution. This implies that the observed distribution does not deviate significantly from the expected distribution of job titles. The low SD (1.97) and mean (3.67) indicate that the workforce is concentrated in a few job titles. This imbalance suggests a gap in specialized expertise and entry-level opportunities, which may limit the department's overall versatility and future growth. Most participants are possibly field workers in IT, while a few occupy managerial positions, and a limited number are from the procurement/supply chain.

4.1.8 Qualification(s) Related to Current Job

The majority of participants (91%, $n=20$) hold qualifications aligned with their jobs, which indicates a strong alignment of participants' education and roles. The Chi-square value is 0.00022, and the critical value is 3.84, which means there is no connection between qualification being related to the job and observed frequencies. The SD (12.73) is high, and the mean qualification score is (11.0). This indicates that there are some inconsistencies between qualifications and roles. Most employees' qualifications closely match their job requirements. However, some roles may experience mismatches because of underqualified and overqualified staff. This could be ascribed to inappropriate job placement

or sometimes redeployment in municipalities. The municipalities can address this concern by ensuring better alignment between skills and job requirements.

4.1.9 Involvement in the Company From an IT or Business Perspective

A great number of participants (82%, n=18) are involved in IT, reflecting the IT-centric nature of their field. While a small number (18%, n=4) are engaged in business. The response to this question indicates that most participants have an IT background to enable and secure technology infrastructure. At the same time, the business perspective optimizes the operational workflow to achieve organizational goals. This indicates a need for greater integration between IT and business functions. The Chi-square value is 8.90 is greater than the critical value of 3.841, which means that there is a statistically significant difference between the observed distribution of involvement in the municipalities. The data indicate that involvement in the municipalities is not equally distributed between Business and IT departments. IT involvement is dominant, with a mean of (11.0) and SD (9.90), indicating a significant disparity in the representation of IT and business involvement perspectives. This imbalance suggests a concentration of expertise in IT, which could limit the diversity of skills in the workforce, particularly in business functions, indicating a gap in interdisciplinary collaboration.

4.1.10 Type of Post in the Workplace

Non-managerial roles (64%, n=14) dominate the workforce, with a smaller proportion occupying managerial positions (36%, n=8). This indicates a hierarchical structure with a more extensive operational base and a narrower management layer. This means that the majority are conducting technical work rather than managerial work. The Chi-square value is 1.64 and less than the critical value of 3.841, which means that there is no statistically significant difference between the observed distribution of types of posts in the workplace. The data suggest that the distribution of job posts in this sample is relatively balanced and not unusual. The SD (9.90) and mean (11.0) indicate that most interviewed participants occupy non-managerial roles. This can be ascribed to a lack of leadership development and succession planning. Also, the participants' nature of business or function is to provide technical support.

4.2 Research Questions

The study seeks to provide answers to the following questions?

- What are the factors that influence the procurement of electronic equipment in the selected North West District Municipalities?
- What types of electronic equipment are contributing to e-waste generation at the selected North West District Municipalities?
- What measures can be used by the selected North West District Municipalities to increase the lifespan of electronic equipment?
- What approach or method is implemented for e-waste management in the selected North West District Municipalities to dispose of obsolete electronic equipment?
- What sources of legislation can be implemented pertaining to e-waste management to ensure regulatory compliance?

4.3 The Factors That Influence the Procurement of Electronic Equipment

The following highlights the diverse perspectives shared by participants regarding the factors that influence the procurement of electronic equipment in Table 2.

Table 3. Factors that influence the procurement of electronic equipment in organizations.

Preferential Procurement Policy Framework Act (No. 5 of 2000).	22	100%
Procurement policies	22	100%
Technology trends.	22	100%
Product performance.	22	100%
Budget constraints.	16	73%
Financial policies (budget constraints and cost considerations)	16	73%
Client requirement	10	46%
Vendor reputation.	14	64%
Compatibility and integration of multiple IT systems (seamless operation to avoid disruptions).	22	100%
Environmental regulatory compliance.	22	100%
Corporate sustainability goals	11	50%
Scalability (increased workloads).	12	55%
Life cycle and maintenance costs.	9	41%
Security requirements (configured to protect data).	22	100%
Environmental impact.	12	55%
User requirements	22	100%

Preferential Procurement Policy Framework Act (No. 5 of 2000): To a great extent, the participants (100%, n=22) agreed that they adhere to the PFMA process and internal IT policies while procuring electronic equipment due to their obligation to comply with these regulations. They noted that this legislative framework intends to prioritize suppliers and support B-BBEE objectives. This legislative framework promotes cost-effectiveness, encourages fair competition, and prevents corruption and procurement irregularities by ensuring that potential and qualifying suppliers are afforded a fair opportunity to compete, according to participants. The participants also highlighted that their role as officials is to provide the employees with tools of the trade while ensuring adherence to the Public Finance Management Act (No. 1 of 1999) throughout the procurement process. Given the drive to procure electronic equipment, the PFMA was identified as the key contributory factor influencing the procurement of electronic equipment because it ensures that all the assets and liabilities are managed efficiently and effectively in line with municipal objectives.

Procurement policies: An overwhelming majority of the participants (100%, n=22) indicated that the procurement policies influence their procurement decisions regarding purchasing electronic equipment. According to them, it is imperative to comply with the procurement policy when purchasing electronic equipment. The participants also emphasized the importance of adhering to procurement policies to ensure compliance with applicable regulations. Similarly, all the participants (100%, n=22) reported that they consider the environmental aspects during the procurement process by establishing green procurement policies. These green procurement policies help them to reduce the ecological impact of their electronic products. In contrast, a few participants (9%, n=2) expressed a neutral stance on whether their municipalities have clear procurement policies. Green procurement is a policy that ensures social, economic, and environmental outcomes of the design, material use, production methods, service delivery, maintenance, reuse, recycling, disposal, and supplier competency are properly addressed throughout the supply chain process (Agyepong & Nhamo, 2017). However, most participants (64%, n=14) affirmed that their municipalities actively employ environmentally sustainable practices within their supply chain processes. These findings suggest that while several municipalities acknowledge and apply green procurement policies, there may be gaps in clarity and implementation.

Technology trends: The participants (100%, n=22) unanimously agreed that technology trends play a critical role in procuring electronic equipment. They indicated that technology is developing rapidly, and users are embracing the latest technology in the market. Therefore, they must use the latest technology to ensure their electronic equipment is compatible with their existing networks. According to them, outdated technology poses performance challenges and creates security vulnerabilities for their municipalities. This finding underscores the significant role that technology trends play in the procurement process. In contrast, most participants (68%, n=15) preferred electronic equipment that

is not only technologically advanced but also manufactured in an environmentally friendly fashion. These participants indicated that such equipment brings both social and economic benefits. In contrast, some participants (32%, n=7) indicated that their procurement decisions are heavily influenced by the technology industry, often depending on the latest technology version in their purchasing process. This suggests that some participants focus on environmental sustainability by prioritizing technological advancement during the procurement process.

Product performance: All the participants (100%, n=22) stated that they prioritize procuring the latest technology versions available on the market, highlighting the significance of technology and product performance in their procurement decisions. To a large extent, most participants (82%, n=18) preferred Hewlett-Packard (HP) products because of superior performance, reliability, and durability. This preference is supported by literature, which suggests that electronic products should be designed for durability to ensure that they remain in use for an extended period (Meloni, Souchet, & Sturges, 2018).

Financial policies and budget constraints: The overwhelming majority of participants (73%, n=16) specified that some of the District Municipalities do not allocate sufficient budgets to enable them to provide effective and efficient service delivery. They explained that the budget is managed centrally, and this centralization is a key factor influencing the procurement of electronic equipment. According to these participants, inadequate funding impedes their ability to provide quality service to their organizations. Surprisingly, some participants (27%, n=6) did not respond to this question. Without a sufficient budget, the potential adverse environmental impact caused by e-waste cannot be addressed (Meloni, Souchet, & Sturges, 2018). Then again, all the participants (100%, n=22) confirmed that their suppliers determine the pricing of computers and laptops through bidding or tender. Through this process, preference is based on reputable, cost-effective brands to minimize maintenance expenses. This highlights the importance of balancing quality and affordability when making procurement decisions in the context of budget constraints.

Client requirement: Nearly half of the participants (46%, n=10) mentioned that they do not deal directly with clients during the procurement process but with employees only. They clarified that they provide specifications based on the client's requirements, which appears contradictory, as they do not interact directly with clients. Interestingly, a significant number of participants (54%, n=12) did not respond to this question, which is surprising given the influence of client requirements on the procurement of electronic equipment. This finding suggests that while client requirements may be a factor in the procurement process, there may be ambiguity or inconsistencies in how participants understand or address these requirements.

Vendor reputation: A great number of participants (64%, n=14) mentioned that cost, quality, delivery, customer service, and supplier reputation are considered before the procurement process. However, other participants (36%, n=8) did not answer this question. According to the participants, vendor reputation is important for maintaining high-quality standards and minimizing risks during the procurement process. In essence, factors such as reliability, trustworthiness, cost, quality, delivery, customer service, and supplier reputation significantly influence the procurement of electronic equipment. Then again, all the participants (100%, n=22) agreed that support and service from reputable brands are critical because they are compatible with their networks and provide quality products. The participants (86%, n=19) also highlighted that they conduct thorough assessments and analyses of potential suppliers to determine their suitability for procuring electronic equipment. Remarkably, most participants (82% n=18) indicated that they prefer the HP brand because of its reliability and quality. This emphasizes the importance of vendor reputation and brand reliability in procurement decision-making. Studies indicate that the buying process of electronic equipment should consider brand reputation, repair, upgradability, life cycle, compatibility, refurbishment options, recyclability, and sustainability of electronic devices (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023).

Compatibility and integration of multiple IT systems (seamless operation to avoid disruptions): All the participants (100% n=22) specified the importance of procuring electronic equipment compatible with their network to prevent disruptions and ensure seamless operation. To maintain smooth operations in their municipalities, they indicated that compatibility and integration of multiple IT systems should be key considerations in the procurement process. Persistent software upgrades, which are incompatible with the latest software version, are contributing to the increased e-waste phenomenon (Kumar, & Bhaskar, 2016).

Environmental regulatory compliance: All the participants (100%, n=22) confirmed that they consider environmental regulations to ensure compliance during their procurement process since IT is regulated and governed under a policy framework. They specified that the municipal council adopts its policy framework and establishes IT policies to ensure compliance with the regulations. Thus, their commitment to protecting the network from potential security threats is closely tied to their environmental regulatory compliance efforts. As a result, environmental regulations significantly

influence the procurement of electronic equipment. The legislation is a critical tool for creating guidelines and legal frameworks to promote responsible sustainable e-waste management practices (Mohammed, 2023).

Corporate sustainability goals: This finding revealed a mixed understanding of corporate sustainability among the participants. Half of the participants (50%, n=11) did not understand or grasp the corporate sustainability goals. In comparison, another (50%, n=11) of participants did not attempt to respond to this question. This was surprising, given that corporate sustainability goals are critical for municipalities to properly manage environmental, social, and economic impacts. Essentially, most organizations are now reporting on sustainability goals to demonstrate their commitment and care for the environment by implementing sustainable practices. Despite the lack of clarity regarding corporate sustainability goals, most participants (64%, n=14) also confirmed that their municipalities are implementing sustainable practices within the supply chain processes. This suggests that while there may be gaps in understanding the broader sustainability goals, sustainability is recognized and applied in procurement and operations in various municipalities. Integrating sustainability in the procurement process is important for organizations to achieve corporate sustainable goals (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023).

Scalability (increased workloads): A large number of participants (55%, n=12) indicated purchasing electronic equipment based on specific requests made during recruitment, while (45%, n=10) of participants did not respond to this question. The need for scalability in procurement is critical for organizational growth because it ensures the organization can manage increased workloads without sacrificing efficiency. However, adequate resources, including scalable electronic equipment, are required for an organization to sustain its output level while accommodating growth. As such, scalability is an essential factor influencing the procurement of electronic equipment because it enables municipalities to meet their demands while maintaining operational effectiveness.

Life cycle and maintenance costs: A limited number of participants (41%, n=9) specified that life cycle and maintenance costs do not influence their decision to purchase electronic equipment. The participants highlighted that electronic equipment's life cycle and maintenance costs require proper budgeting, which ultimately influences procurement decisions. This statement aligns with studies suggesting that the life cycle of electronic equipment should be considered early in the procurement process (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023). Quietly disappointing, the overwhelming majority of participants (59%, n=13) did not respond to this question.

Security requirements (configured to protect data): It was astounding that all participants (100%, n=22) specified that security requirements do not influence their decision to purchase electronic equipment. In actual fact, this finding was somewhat unexpected because of the critical importance of security in protecting data and preventing cybersecurity threats. In contrast, all participants (100%, n=22) confirmed that they are responsible for providing their network security, suggesting that while security may not directly influence the procurement of electronic equipment, it is still a critical consideration for the overall IT infrastructure. This highlights a potential gap in understanding the role of security features in the procurement process despite the strong emphasis on network security management within their municipalities.

Environmental impacts: Another surprising finding emerged from the study, with the majority of the participants (55%, n=12) indicating that the environmental impacts caused by electronic equipment do not influence their procurement decisions. This was entirely unexpected because organizations are increasingly aware of their ecological footprints, particularly of the electronic products they purchase, and are expected to conduct research during the purchasing process of electronic equipment to ensure compliance with environmental credentials (Moyo, Lubbe, & Ohei, 2023). The ecological impact did not appear to be a primary consideration for many participants despite it being critical in procurement decisions due to efficiency, regulatory compliance, and alignment with corporate sustainability goals.

User requirements: All the participants (100%, n=22) specified that user requirements do not influence the procurement process of electronic equipment. This finding was appalling because user requirements are typically key in guiding purchasing decisions, specifically in organizations where technology is critical in day-to-day operations. Therefore, understanding the specific needs of users ensures that the selected electronic equipment aligns with organizational goals, enhances productivity, and supports the functionality required by employees. The lack of consideration for user requirements in the procurement process suggests a potential gap in the alignment between technology investments and organizational needs. Therefore, municipalities need to reassess their procurement strategy to ensure user requirements are addressed in electronic equipment purchases.

The study concludes that the above factors significantly influence the procurement of electronic equipment in municipalities. As a result, management should carefully consider these factors when procuring electronic equipment. Municipalities can optimize their procurement processes and contribute to reducing e-waste generation. Furthermore,

a strategic approach to procurement that incorporates these factors will support municipal efficiency and environmental sustainability, ensuring responsible and long-term use of electronic equipment.

4.4 Types of Electronic Equipment Contributing to E-Waste Generation

All the participants (100%, n=22) identified electronic equipment, primarily computers, laptops, and printers, as contributing to e-waste generation in their municipalities. In addition, a smaller number of participants (45%, n=10) also highlighted that scanners contribute to e-waste generation in their municipalities. Studies show that at the heart of the technological boom, the regular replacement of electronic products with new versions is contributing to the phenomenon of e-waste (Forti, Baldé, Kuehr, & Bel, 2020).

4.5 Measures That Can be Used to Increase the Life Span of Electronic Equipment

A significant number of participants (86%, n=19) reported conducting minor repairs on laptops and computers that are still under warranty. In some cases, these repairs involve returning faulty devices to suppliers or vendors, while others use parts from defective devices to perform repairs. Conversely, fewer participants (14%, n=3) indicated they did not perform any form of repairs. Instead, they donate computers and laptops that are still functional but have reached their lifespan to schools or non-profit organizations. However, none of the participants reported recycling obsolete electronic equipment.

The participants (73%, n=16) also highlighted that extending the lifespan of electronic equipment is expensive, while other participants (27%, n=6) specified that they do not try to extend the lifespan of their computers or laptops. However, most participants (86%, n=19) indicated that their employees prefer brand-new computers or laptops over refurbished ones, while a minority of the participants (14% n=3) indicated that they provide reconditioned computers or laptops to their employees; however, these devices are not well received by employees because they do not prefer them. Scientific studies show that increasing the lifespan of electronic equipment gives new life to electronic components by creating greater value beyond their original intended functionality (Mohammed, 2023). The study concludes that while minor repairs and maintenance of computers or laptops are conducted. The repairs (hardware components) to increase their lifespan are not frequently conducted. Another concern is that replacing obsolete electronic equipment is uncommon due to employees' preference for brand-new electronic devices. In the same vein, the recycling of obsolete electronic equipment is also not conducted. Therefore, management should explore opportunities to implement comprehensive repair and maintenance programs, encourage the use of refurbished equipment, and establish recycling initiatives for obsolete devices to promote sustainability and reduce e-waste. These actions could significantly extend the lifespan of electronic equipment and minimize e-waste generation.

4.6 Approaches or Methods That Can Be Implemented to Dispose of Obsolete Electronic Equipment

The study discovered that the reasons for discarding obsolete electronic equipment in the selected North West District Municipalities are related to factors such as obsolescence, performance issues, compatibility challenges, security concerns, end-of-life, high maintenance costs, energy efficiency, regulatory compliance, space constraints, and the need to enhance employee productivity. E-waste management is effective when organizations maintain good inventory control to address the growing accumulation of e-waste (Murthy, & Ramakrishna, 2022). However, all the participants (100%, n=22) specified that their municipalities maintain an inventory of unserviceable, obsolete, or redundant electronic equipment through the asset register. Studies encourage organizations to dispose of e-waste according to governmental or local regulations to prevent harm to the environment (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023; Moyo, Lubbe, & Ohei, 2023).

An overwhelming majority of participants (86%, n=19) indicated that their municipalities donate obsolete computers and laptops to schools, charity organizations, or non-governmental organizations (NGOs) or auction these items to generate income. Although donating or auctioning electronic equipment may provide some benefit in the short term, the study expresses concern that this approach could become a burden for schools or charity organizations once electronic equipment becomes obsolete. Previous studies lend support that redundant electronic equipment should not be disposed of but offered to charity organizations (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023). Then again, the municipalities sometimes resort to scrapping or writing off computers or laptops that no longer meet the minimum specifications. Therefore, the municipalities should consider developing and implementing structured e-waste disposal methods to improve sustainability and reduce e-waste.

The study also established that while most participants acknowledged the need to dispose of electronic equipment, they highlighted the negative impact of such disposal on their budgets. However, it was quite disappointing that some participants (14%, n=3) did not know what happens to the obsolete electronics once the municipal council approved disposal. The study identified a gap of lack of formal policy for the disposal of electronic. This aspect is alarming

because the impact of e-waste on the environment is critical. Without clear policies for disposal, municipalities may inadvertently contribute to the growing environmental burden of e-waste. Therefore, e-waste management in these municipalities should be urgently addressed by developing a comprehensive e-waste policy and exploring sustainable disposal methods to minimize environmental harm.

The study revealed that most participants (91%, $n=20$) prefer buying electronic equipment frequently rather than repairing and refurbishing obsolete computers and laptops. However, only a few numbers (9%, $n=2$) specified that they are conducting minor repairs, such as replacing damaged or broken parts of computers and laptops, particularly the motherboard. In contrast, most participants (100%, $n=22$) take back computers and laptops under warranty for repair to the manufacturers or suppliers but do not have trade-in programs. Adopting the circular economy encourages the manufacturer of electronic products to offer buy-back or return value for the refurbished obsolete equipment (Meloni, Souchet, & Sturges, 2018; World Economic Forum, 2019).

In the same light, the majority of participants (82%, $n=18$) also specified that they do not upgrade due to the cost-effectiveness of purchasing new electronic equipment with a warranty at the point of sale. However, other participants (18%, $n=4$) mentioned that they upgrade the hardware or replace parts from broken/damaged computers/laptops. According to them, old computers and laptops are often incompatible with newer ones. As a result, integrating upgraded old hardware into the existing network system becomes complex since they cannot order electronic parts. Research shows that persistent software upgrades that are incompatible with the latest version contribute to increased e-waste (Kumar, & Bhaskar, 2016). Mohammed (2023) advocates that organizations should repair, maintain, and restore electronic equipment to its original state according to the manufacturer's specifications.

This study identified a missed opportunity by municipalities to extend the life cycle of electronic equipment through repair, refurbishment, and upgrading. As a result, their frequent purchases contribute to the growing accumulation of e-waste. Therefore, municipalities should consider adopting practices to repair and refurbish electronic devices in alignment with sustainability goals rather than defaulting to purchasing new electronic equipment.

On the other hand, all the participants (100%, $n=22$) cited regular software upgrades as the key practice within their municipalities to reduce security vulnerabilities and protect against cybercrimes. According to the participants, these updates are essential in keeping the municipality network system compatible with the latest technology, improving overall system performance, and ensuring the electronic system remains compatible, secure, and efficient. Similarly, the participants also emphasized that they experience problems with software rather than hardware in their municipalities. Studies show that the risk of data breaches and privacy is a serious concern for outdated electronic equipment that is out of warranty (Torres, Guzman, Kuehr, Magalini, Devia, Cueva, & Basiniani, 2016).

A great number of participants (100%, $n=22$) indicated that they do not possess the necessary competencies or infrastructure to recycle e-waste. Hence, they prefer to donate electronic equipment every three years instead of pursuing recycling or other methods to manage obsolete electronic devices. Although this practice is beneficial for charitable organizations, there are various concerns regarding the environmental impact and long-term sustainability of disposing of e-waste in this manner, as it does not address the core issues of responsible recycling or reusing materials. The participants' reliance on software upgrades to enhance performance and security and their preference for donating electronic equipment suggest a lack of comprehensive e-waste management practices. From a bird's point of view, the municipalities could benefit from developing e-waste recycling programs and increasing their capacity to manage electronic waste responsibly, contributing to environmental sustainability and reducing the negative impacts of e-waste.

An overwhelming majority of participants (82%, $n=18$) specified that they identify all the electronic equipment that requires disposal and store it in a designated area such as a storeroom. Then, their Asset Unit facilitates the process of scrapping the electronic equipment, and they auction or give those electronic equipment as donations to charity organizations. According to the participants (73% $n=16$), the Asset Unit is responsible for ensuring the safe disposal of e-waste. In contrast, some participants (18% $n=4$) specified that the environmental personnel facilitate this process.

A few participants (9% $n=2$) mentioned that some of their e-waste ends up in landfills, raising concerns about improper disposal methods. Nevertheless, all the participants (100%, $n=22$) acknowledged that the environmental consequences of improper disposal could create air pollution, greenhouse gas emissions, soil and water contamination, resource depletion, and land use impact. This highlights the need for a structured approach to e-waste management because there are still gaps in the e-waste disposal process. In their study, Ilankoon et al. (2018) and Okeke et al. (2024) discovered that the toxic substances from electronic equipment are not biodegradable and contribute to air pollution, get deposited on soil surfaces, open surfaces, and groundwater resources, and cause contamination or pollution via leaching into water bodies, affecting aquatic life and biota, land degradation, and loss of biodiversity or aesthetic

concerns due to improper disposal. Municipalities should implement effective and sustainable e-waste management practices to promote environmental sustainability.

The study concludes that the selected North West District Municipalities face significant challenges in managing e-waste. The standard practices for dealing with obsolete electronic equipment, such as donating computers and laptops to schools, charity organizations, or NGOs, auctioning them to generate income, or scrapping or writing them off, are not sustainable. Furthermore, safe and environmentally responsible disposal processes for obsolete electronic equipment are lacking, and some e-waste ends up in landfills after the municipal council has approved it. This indicates a serious gap in the appropriate management of e-waste. Studies prohibit the disposal of e-waste in landfills to promote environmental sustainability (McMahon, Uchendu, & Fitzpatrick, 2021; Patil, & Ramakrishna, 2020). The municipalities also demonstrate limited knowledge of effective e-waste management strategies. They do not repair or refurbish damaged or broken parts of computers or laptops because they prefer to purchase new electronic equipment. Furthermore, they do not conduct hardware upgrades or implement a take-back program for electronic devices to suppliers. Since software upgrades of electronic equipment are conducted to protect the organization's data from cybercrime, the absence of recycling programs due to a lack of competency is a serious concern. Therefore, management should explore opportunities to improve the disposal process of obsolete electronic equipment by ensuring that e-waste does not end up in landfills. Furthermore, exploring options for upgrading hardware and implementing recycling programs could contribute to a sustainable and environmentally friendly approach to e-waste management. By implementing sustainable e-waste management practices, municipalities can reduce their environmental footprint and align with global sustainability goals.

4.7 Sources of Legislation That Can Be Implemented to Ensure Regulatory Compliance

A large proportion of participants (55%, n=12) specified that their organizations have IT policies to mitigate electronic equipment's deleterious impact, while some participants (36%, n=8) highlighted that they do not have such policies. According to the participants, their municipalities are not harming the environment, and a limited number (9%, n=2) were not sure about the existence of such policies in their organizations. Studies warn that without strong measures to reduce the massive quantities of e-waste, the earth cannot become a sustainable environment (Ichikowitz, & Hattingh, 2020; International Telecommunication Union, 2023). Then again, the majority of participants (68%, n=15) indicated that their organizations have sufficient regulations, legislation, and policies to address environmental issues related to e-waste. However, some of the participants (23%, n=5) highlighted that they do not have such policies that address harmful environmental impacts but rely on the National Environmental Management Act (No. 107 of 1998), and a small number of participants (9%, n=2) were uncertain about the existence of such policies. This indicates a gap in policy enforcement and awareness regarding environmental regulations specific to e-waste in some municipalities. Furthermore, while the IT department may focus primarily on data and security, there is less emphasis on integrating environmental regulations into their processes.

Municipalities should develop or update specific e-waste management policies, enhance training and awareness, establish cross-departmental collaboration, and expand the role of the IT department in environmental policy to enhance compliance and address the environmental impacts of e-waste. By addressing these gaps, municipalities can improve their e-waste management practices and ensure compliance with environmental legislation while reducing their environmental footprint. A great number of participants (77%, n=17) utilize the ISO 14001 standard as a guideline to minimize or reduce e-waste and address environmental concerns within their municipalities. The participants are of the opinion that this standard provides a framework that fosters the implementation of environmental policy. Since they are not officially certified against the standard, they presume that it provides a useful framework for implementing environmental policies and ensuring compliance with legal requirements. The participants are of the opinion that their municipalities' practices align with environmental laws and contribute to reducing e-waste. However, a small group of participants (23%, n=5) mentioned that their municipalities do not have specific systems or standards in place but instead foster environmental awareness through internal policies and audits for safety, health, and environment (SHE) compliance. Mohammed (2023) states that waste minimization strategies should be implemented by organizations to reduce the quantity of waste generation. The study concludes that municipalities do not have sufficient policies to address harmful environmental impacts caused by electronic equipment. Furthermore, formal systems and standards are lacking to minimize or reduce e-waste and address ecological concerns. As such, this lack of formalized approaches indicates a gap in the organization's sustainability efforts concerning e-waste management. In this regard, municipal management should explore opportunities to develop e-waste management policies, implement standards and systems, and conduct environmental training and awareness, monitoring, and audits. By implementing these strategies, municipalities can reduce the negative environmental impacts of e-waste and promote environmental sustainability.

5. Conclusions and Recommendations

This study addressed the results per research question, provided e-waste management approaches and strategies, and highlighted future research opportunities. The research aims and objectives were achieved, and significant advancements in sustainable e-waste practices have been unveiled. This study emphasized some of the concerns and continuous deliberation about the pros and cons of poor e-waste management practices in the selected North West District Municipalities in South Africa.

The findings of this study indicate that several factors influence the procurement of electronic equipment in municipalities. These factors include procurement policies, technology trends, product performance, financial constraints, client requirements, vendor reputation, the compatibility and integration of IT systems, environmental regulatory compliance, and an overall lack of understanding of corporate sustainability goals. Other factors include scalability, life cycle and maintenance costs, security requirements, environmental impact, and user needs.

The study unveiled a gap that common contributors to e-waste generation are devices such as computers, laptops, monitors, keyboards, printers, and scanners. The study also revealed that there is a lack of repair, hardware upgrades, refurbishment, and recycling of obsolete electronic equipment, particularly computers and laptops. This shortcoming is primarily due to a lack of technical competency. In addition, the life cycle of these devices is not adequately managed, and environmental considerations are often overlooked during procurement. Also, recycling is not prioritized at the outset, and unsafe disposal practices, such as stockpiling and landfill dumping, contribute to the growing e-waste problem. Moreover, there is also a clear absence of take-back programs, policies, and systems for replacing and disposing of electronic equipment, which are critical in mitigating the environmental impact caused by e-waste.

Municipalities should explore opportunities to repair, upgrade hardware, and refurbish obsolete computers and laptops, as well as maintain and recycle them, where feasible, to extend their lifespan and avoid frequent purchases of new equipment. Although employees may prefer brand-new computers or laptops, embracing repair and refurbishment as viable alternatives can save resources and align with broader sustainability goals. Therefore, by adopting these measures, municipalities can reduce costs and contribute to the global effort to minimize e-waste generation.

Municipalities should also prioritize brand reputation, durability, repairability, upgradability, compatibility with existing systems, refurbishing options, recyclability, reliability, and overall sustainability when purchasing electronic equipment to minimize environmental impact. They should also explore implementing a trade-in program as a viable method for managing obsolete electronic equipment. Studies have shown that electronic equipment can be returned to the supplier or traded in for a financial return, reducing the environmental impact of e-waste and offering an economic incentive (Awasthi, Iacovidou, Awasthi, Johnson, Parajuly, Zhao, ... Pandey, 2023).

Furthermore, the municipalities should explore the safe disposal of obsolete electronic equipment to prevent e-waste from ending up in landfills, which can have long-lasting adverse effects on the environment and public health. Improper disposal can contribute to the growing burden on landfills, where electronic devices containing hazardous materials like heavy metals continue to pollute the environment. Therefore, municipalities should develop and implement policies to mitigate these risks and ensure electronic equipment's safe and responsible disposal. These measures should align with national and local e-waste disposal regulations.

Lastly, the municipalities should explore the opportunity to develop systems to create environmental awareness, sensitizing employees to care for the environment and adopt sustainable practices. These systems can help reduce harmful environmental impacts by encouraging a culture of environmental responsibility.

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Authors' contributions

Dr. Tlhalefo Petterson Moyo and Prof. Issac Tebogo Rampedi were responsible for study design and revision. Dr. Tlhalefo Petterson Moyo was also responsible for data collection. Prof. Isaac Tebogo Rampedi drafted the manuscript, and Dr. Thea Schoeman revised it. All authors contributed substantially to the conception, design, literature review, writing, revision, and finalization of the manuscript. All authors read and approved the final manuscript. No special authorship agreements or equal-contribution arrangements apply to this study.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors declare that they don't have any potential conflicts of interest.

Informed consent

This study was approved by the University of Johannesburg Research Ethics Committee in the Faculty of Science in 2023. The study's ethical approval had the following reference number: Ethics Reference Number: 2023-10-05/Moyo_Rampedi. Participants were informed about the research objectives, procedures, data collection methods, and their rights through written invitations and consent forms. They were assured of anonymity and allowed to refuse to answer questions without repercussions. The study posed minimal risk, and measures were taken to uphold integrity, prevent coercion, and protect participants' interests throughout the research process.

Ethics approval

The Publication Ethics Committee of Sciedu Press.

The journal and publisher adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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