

Exploring the potential for formalising the informal e-waste sector in South Africa

O Hougaard



orcid.org/ 0000-0001-5852-6505

Dissertation accepted in fulfilment of the requirements for the degree *Master of Engineering in Industrial Engineering* at the North-West University

Supervisor:

Prof T Hattingh

Graduation:

November 2023

ABSTRACT

E-waste is rapidly growing in South Africa without the required e-waste management system in place to manage this growth. There, therefore, exists a need to improve the e-waste management system of South Africa. The aim of the study is to motivate the importance of and explore the benefits of utilising the informal e-waste sector through formalisation. The aim is further to determine the willingness of the formal e-waste sector to be a part of the formalisation process and identify the accompanying key considerations. The biggest challenge that faces the South African formal e-waste sector is the limited e-waste volumes that e-waste recycling facilities are able to collect to sustain their operations. Currently, the informal e-waste sector plays a significant role in e-waste collection within the e-waste management system. The informal e-waste sector is not formally a part of the e-waste management system, making it difficult to manage and improve the system. Also, the informal e-waste sector is associated with a myriad of safety, health, and labour concerns. It could be argued that formalising the informal e-waste sector by drawing it closer to the formal e-waste sector could address many of these challenges. Formalising is, however, complicated. To overcome this challenge, a better understanding is required. Therefore, the research questions and objectives explore the current state and potential of the informal e-waste sector by considering the formal e-waste sector's perceptions and experiences of the current state and the potential for formalisation.

The research methodology uses a research design and context to explain the mindset behind the study, the chosen data collection method, and the setting. Literature is used to understand the context, circumstances, potential, challenges, and opportunities of both the formal and informal e-waste sectors, locally and internationally, and the relationship between these two e-waste sectors. Data is collected to explore the willingness of the formal e-waste sector to be a part of the formalisation process. Data was collected through qualitative interviews with 12 participants from the formal e-waste sector of South Africa. The participants were asked a series of questions to obtain their perception of which activities take place within the e-waste management system, the relationship between the two e-waste sectors, opportunities and challenges for e-waste collection, the potential for improvement opportunities and formalisation, and key considerations for a sustainable e-waste management system. The data analysis process clustered views and evidence, noting emergent codes while comparing these codes across the interviews to identify themes to build a logical argument. The findings provide insight into various elements of the e-waste management system and are used to provide recommendations for future work to be considered if a formalisation approach is chosen in the future. Seven main themes emerged from the data analysis that can inform

future work that considers the development of a formalisation framework. The themes are 1) Formal collection trade-offs; 2) Overcoming formal e-waste sector gaps; 3) E-waste legislative development; 4) Lack of e-waste awareness from different stakeholders; 5) Formal e-waste recycling facilities concerns; 6) Reflection of social factors; and 7) Formalisation requirements and success factors.

The conclusion of the study shows that there is a significant difference between the formal and informal e-waste sectors on various levels. This is seen through education, level of income, regulation compliancy, and recycling methods. These differences lead to competition between the two e-waste sectors, wasted resources, and counter-productivity to optimally collect e-waste. Yet, each e-waste sector is important and plays a unique part in the e-waste management system. Stakeholder engagement is crucial for big changes like formalisation. Even though the formal e-waste sector has not been approached in previous e-waste studies, there proves to be a willingness to be a part of the formalisation process if their perceptions and experiences are considered. There is potential to remove the challenges currently faced between the two e-waste sectors with the correct formalisation approach.

It is recommended that the formal and informal e-waste sectors be integrated through an incremental and continuous formalisation process that is adaptable and flexible. A sustainable and applicable formalisation framework must be developed by the key stakeholders within the e-waste management system. If the challenges of formalisation can be overcome, it will be mutually beneficial for both e-waste sectors. The key challenges include acquiring initial financial and legislative support from the government, deciding which formalisation approach is best suitable for South Africa, establishing a sustainable relationship between the two e-waste sectors, and ensuring that formalisation does not negatively impact the reputation of formal e-waste recycling facilities. Contrarily, the benefits for the informal e-waste sector include better, stable working conditions, monetary incentives, and increased income. The benefits for the formal e-waste sector include higher volumes of e-waste collected and overcoming production gaps.

Keywords: E-waste, informal e-waste sector, formal e-waste sector, formal e-waste recycling facilities, formalisation, collection, recycling

Table of Contents

1. INTRODUCTION	11
1.1. Background	11
1.1.1. E-waste definition and statistics.....	11
1.1.2. Challenges of e-waste recycling in developing countries	12
1.2. The rationale for this research	14
1.2.1. The potential of e-waste recycling	14
1.2.2. The motivation for the study	15
1.2.3. Problem statement	17
1.3. Research aim	17
1.4. Research questions and objectives.....	17
1.5. Research audience.....	18
1.6. Overview of the thesis	18
2. LITERATURE REVIEW	20
2.1. The existing South African e-waste management system and influencing factors.....	20
2.1.1. The government	22
2.1.2. The formal e-waste sector	23
2.1.3. The informal e-waste sector	23
2.1.4. Sector comparison	26
2.1.5. Factors of a successful e-waste management system.....	27
2.2. Importance of the informal e-waste sector	28
2.3. Developed and developing countries	30
2.4. Legislative development within the South African e-waste industry.....	31
2.4.1. Protection of the informal e-waste sector.....	33
2.4.2. International e-waste challenges and regulatory frameworks.....	34
2.5. The potential for formalising the informal e-waste sector.....	37
2.5.1. Extended Producer Responsibility	37

2.5.2.	Mutual support system	40
2.5.3.	Approaches to formalise	41
2.5.4.	Considerations for and challenges of successful formalisation	47
2.5.5.	Attempts to formalise waste picking in South Africa.....	54
2.6.	Theoretical formalisation summary	58
2.6.1.	Utilising existing channels and stakeholders.....	59
2.6.2.	Partnerships and relationships	61
2.6.3.	Extended Producer Responsibility application	65
2.6.4.	Protocols and incentives.....	66
2.6.5.	Monitoring	71
2.7.	Chapter summary.....	72
2.8.	Synthesis of the research topic.....	73
3.	RESEARCH METHODOLOGY.....	75
3.1.	Research design.....	75
3.2.	Research context	76
3.3.	Methodology	76
3.3.1.	Data collection.....	78
3.4.	Method	80
3.4.1.	Qualitative interview development	80
3.4.2.	Population and sampling	83
3.4.3.	Recruitment of participants.....	84
3.4.4.	Data collection process	85
3.4.5.	Data handling	86
3.4.6.	Data analysis.....	86
3.5.	Validity and reliability.....	87
3.6.	Ethical considerations	88
3.6.1.	Process of obtaining informed consent.....	88
3.6.2.	Anonymity	88
3.6.3.	Confidentiality.....	88
3.6.4.	Risk-benefit analysis	88

3.7. Chapter summary.....	89
4. FINDINGS.....	90
4.2. Overview of the interviewed stakeholders.....	90
4.3. Introduction to the findings	91
4.4. Overview of the informal e-waste sector	91
4.4.1. Collection activities and income.....	91
4.4.2. Collection challenges.....	94
4.4.3. (Un)Willingness to formalise	94
4.5. Introduction to the themes	95
4.6. Theme 1: Formal collection trade-offs.....	97
4.6.1. Transport cost versus value.....	97
4.6.2. Collection encounters	97
4.7. Theme 2: Overcoming formal e-waste sector gaps	98
4.7.1. Informal e-waste sector collection.....	98
4.7.2. Informal sector e-waste sourcing	99
4.7.3. Manual e-waste dismantling	99
4.8. Theme 3: E-waste legislative development	100
4.8.1. Costly and time-consuming legislation.....	100
4.8.2. Lack of government support and legal implementation	102
4.8.3. Government control over Extended Producer Responsibility	104
4.9. Theme 4: Lack of e-waste awareness from different stakeholders	105
4.9.1. Lack of awareness and education	105
4.9.2. Informal e-waste sector training.....	106
4.10. Theme 5: Formal recycling facility concerns	107
4.10.1. Constraints leading to an unwillingness to formalise.....	108
4.10.2. Reputational risk.....	110
4.11. Theme 6: Reflection on social factors	111
4.11.1. Perceived image.....	111
4.11.2. Mutual respect.....	111

4.11.3. Community engagement	112
4.12. Theme 7: Formalisation requirements and success factors	113
4.12.1. Structured approach	114
4.12.2. Supporting links.....	115
4.12.3. Requirements to accept informal e-waste.....	116
4.12.4. Incentives	117
4.13. Chapter summary	118
5. DISCUSSION	119
5.2. Theme relationship.....	119
5.3. Theme discussion	122
5.3.1. Formal collection trade-offs & overcoming formal e-waste sector gaps	122
5.3.2. E-waste legislative development	124
5.3.3. Stakeholder awareness & reflection on social factors.....	125
5.3.4. Formal recycling facility concerns.....	126
5.3.5. Formalisation requirements and success factors	127
5.4. Limitations	128
5.5. Research novelty and impact.....	129
6. CONCLUSION AND RECOMMENDATIONS	130
6.2. Conclusion.....	130
6.3. Recommendations	133
6.4. Suggestions for further research.....	135

LIST OF TABLES

Table 1: Strengths and weaknesses of the formal and informal e-waste sectors, adapted from Mccann et al. (2015)	26
Table 2: Comparison of e-waste in developed and developing countries, extracted from Mmereki et al. (2016)	30
Table 3: International regulatory framework and legislative challenges	34
Table 4: EPR system approach examples extracted from Jaiswal et al. (2015) and Neilsin (2010)	38
Table 5: Challenges and success factors of formalisation approaches adapted from Aparcana (2017b)	43
Table 6: Five factors that influence the e-waste management system adapted from Guerrero et al. (2013)	51
Table 7: Five categories that act as formalisation challenges adapted from Aparcana, 2017a; Yose (2014)	53
Table 8: The interview framework stemming from the research purpose and questions of the study	82
Table 9: E-waste categories and buy-back prices	93
Table 10: Interview themes and sub-themes	95
Table 11: Law and license requirements for formal e-waste recycling facilities	101
Table 11: E-waste categories and examples adapted from Deubzer (2011) and Neilsin (2010)	148
Table 12: Informal recycling techniques and environmental impact	149
Table 13: Profiles of the interviewed participants	150

LIST OF FIGURES

Figure 1: Literature review structure.....	20
Figure 2: E-waste recycling phase and stakeholders adapted from Finlay & Liechti (2008), Grant & Oteng-Ababio (2021) and Sadan (2019).....	22
Figure 3: Legislation developments in the South African e-waste management system extracted from Sadan (2019)	32
Figure 4: Mutual support system adapted from Raghupathy et al. (2010).....	40
Figure 5: Theoretical formalisation summary based on literature	58
Figure 6: Reimbursement model providing collection incentives	68
Figure 7: Conceptual framework of theoretical concepts	74
Figure 8: Overview of the research method design	77
Figure 9: A framework for obtaining interview questions stemming from the research purpose extracted from Wengraf (2001)	81
Figure 10: Interview recruitment process.....	85
Figure 11: Stakeholders involved in e-waste flow in the South African e-waste management system	92
Figure 12: Formal e-waste sector interview thematic map.....	96
Figure 13: Key findings concerning the thematic map of the study.....	120
Figure 15: Interview data capturing and organisation	153
Figure 16: Interview data coding and categorisation	154

LIST OF ABBREVIATIONS

ARF	Advanced Recycling Fee
CBO	Community-Based Organisation
CPCB	The Central Pollution Control Board
CTS	Collective takeback scheme
DEA	The Department of Environmental Affairs
DED	The Department of Economic Development (DED) and buy-back centres"
EAR	Elektro-Altgeräte Register
EC	European Community
EISD	The Environment and Infrastructure Services Department
ElectroG	Electrical and Electronic Act
EoL	End of Life
EPR	Extended produced responsibility
EU	European Union
eWASA	eWaste Association of South Africa
IBTS	Individual brand-selective takeback schemes
ICT	Informative and Communication Technologies
ID	Identification document
INTS	Individual non-selective takeback schemes
ISWM	Integrated Sustainable Waste Management
IWMSA	Institute of Waste Management of Southern Africa
MRF	Material recovery facilities
MSE	Micro- and Small Enterprise
NEMWA	National Environmental Management: Waste Act
NGO	Non-profit Government Organisation
PRO	Producer Responsibility Organisation
PuWaMA	Public Waste Management Authorities
RoHS	Restriction of Hazardous Substances
SECO	Swiss E-waste programme
SENS	Stiftung Entsorgung Schweiz
SLRS	Swiss Lighting Recycling Foundation
StEP	Solving the E-waste Problem
SWICO	The Swiss Association for Information Communication and Organisational Technology
SWM	Sustainable Waste Management
WEEE	Waste Electrical and Electronic Equipment

1. Introduction

The world is experiencing a paradigm shift towards environmental stewardship and sustainable source management (Sadan, 2019). This is due to the rapid exhaustion of natural resources and the continuous demand therefor (Sadan, 2019). Approximately one billion electronic devices were discarded between 2017 and 2022, and this will continue if e-waste recycling is not improved (Kumar et al., 2017). Incorrectly discarded e-waste is an increasing challenge due to the significant risk posed to the environment and the health of people and animals. Therefore, e-waste recycling is integral to enabling this paradigm shift. There are four stages of the e-waste management system; 1) Consume (usage) of electronic or electrical devices; 2) Collection of e-waste; 3) Material recovery of e-waste; and 4) Disposal of e-waste (Salhofer et al., 2017). Grant (2019) and Williams & Ongondo (2011) have identified that the collection stage of e-waste is the biggest challenge for Africa. Lydall et al. (2017) echo this for South Africa and state that collection is the “single biggest challenge” facing the e-waste management system. This is since is not cost-effective for formal e-waste recycling facilities to collect small volumes of e-waste. There is also insufficient e-waste recycling awareness from consumers to realise the potential harm of e-waste and how to form a part of e-waste recycling (Mmereki et al., 2016).

The informal e-waste sector is South Africa’s biggest e-waste collector (Chaudhary & Vrat, 2018; Lucier & Gareau, 2019; WIEGO, 2020). Between 60 000 – 90 000 informal recyclers participate in e-waste activities in South Africa (Grant, 2019; Muswema et al., 2016). E-waste is collected from businesses, households, and the government through on-site (at houses or businesses), off-site (landfills, donations, and drop-off centres), and curb-side collection (Viljoen et al., 2021). To address the challenges associated with low e-waste availability and for e-waste volumes to grow, the contribution and potential of expanding the informal e-waste sector need to be explored.

1.1. Background

The background explains what e-waste is, the classification of e-waste, and important statistics relevant to South Africa. It then further explores the challenges of e-waste recycling in developing countries such as South Africa.

1.1.1. E-waste definition and statistics

To understand the current status of the e-waste management system, a clear understanding of e-waste recycling in South Africa is needed. E-waste is anything that runs on electricity that

has been discarded, damaged, or permanently stored. When electronic products reach end-of-life (EoL), it becomes e-waste (de Frobert, 2019).

According to the Waste Electrical and Electronic Equipment (WEEE) Directive, there are various e-waste categories, which include consumer electronics, information and communication technology (ICT), small and large household appliances, lighting equipment, electronic and electrical tools, medical equipment, and security devices (Deubzer, 2011; Finlay & Liechti, 2008; Neilsin, 2010). Refer to **APPENDIX A** for examples within these categories. It is important to be able to distinguish between the e-waste categories to identify which categories the formal and informal e-waste sectors collect. Informal recyclers are usually unable to collect great volumes of e-waste at once and avoid large electronic and electrical appliances.

Electronics are becoming obsolete at an exponential rate increasing the production of hazardous materials (Nagajothi & Kala, 2015). E-waste is globally one of the fastest-growing waste streams, with 60 million tons (Mt) being produced in 2016 (Islam et al., 2018). The projected e-waste production for 2030 is estimated at 74 Mt, and 111 Mt in 2050, increasing by 2 Mt each year from there (Herat, 2021; Shittu et al., 2021). According to the e-Waste Association of South Africa (eWASA), South Africa is the fourth highest e-waste generator in Africa and generates 6.2 kilograms of e-waste per person annually, which equates to roughly 360 000 tons of e-waste produced annually (Grant, 2019). Only 12% is recycled (de Frobert, 2019), of which only 20% of this is recycled formally, while the remaining e-waste is often sent to landfills or incinerated (Grant, 2019). Most e-waste is, therefore, collected and recycled informally.

1.1.2. Challenges of e-waste recycling in developing countries

The informal e-waste sector cherry-picks valuable metals within e-waste and incorrectly disposes of the other materials (McCann et al., 2015; Widmer et al., 2008). Due to a substantial number of informal recyclers, e-waste recycling is unregulated, especially in developing countries such as South Africa. E-waste recycling is often conducted in scrapyards (Ilankoon et al., 2018). Scrapyard recycling refers to “backyard operations” and can lead to toxic waste at landfills, the release of toxic residues into the open environment, cyanide leaching, the release of hazardous chemicals (Vijarania et al., 2017), and environmental pollution (Kumar et al., 2017). These toxins are categorized into three groups – original constituents (lead and mercury), constituents added during recovery (cyanide), and constituents formed during recycling (dioxins and furans) (Herat, 2021; Nagajothi & Kala, 2015; Neilsin, 2010). These informal recycling techniques and their impacts can be seen in **APPENDIX B**.

The life and work environments of the informal recyclers overlap, which negatively affects their health and increases neglect and disrespect from neighbours (Gunsilius et al., 2011). This lack of a supportive network in turn leads to easier exploitation from bigger companies (Aparcana, 2017a), middlemen, and corrupt policemen (Gunsilius et al., 2011). In addition, informal recyclers have reported that the relationship between the two recycling sectors is exploitative (DEA, 2015).

The lack of regulations also causes a lack of recordkeeping and traceability of processed e-waste volumes (Ambrosi, 2018; Ilankoon et al., 2018; Shittu et al., 2021). Without good recordkeeping, it is difficult to convince municipal authorities or the formal e-waste sector of the benefits that the informal e-waste sector delivers (Wilson et al., 2009). This in turn makes it difficult for informal recyclers to voice their concerns and diminishes their negotiation power (Grant, 2019).

E-waste management in developing countries is worsened by unlicensed and unsafe e-waste recycling, but also an inadequate classification of the roles and responsibilities of stakeholders. The lack of finances, skilled human resources, and organisational structures add to the problem. This is exacerbated in Africa due to an underdeveloped e-waste management system with limited information, insufficient awareness of the impact of e-waste, and inadequate policies and policing (Mmereki et al., 2016). Existing legislation has proved to be inconsistent and ineffective. Corruption, mismanagement, and the lack of careful planning are recurring themes that lead to an unsustainable e-waste management system (Dlamini & Simatele, 2016).

Increasing pollution levels, rapid urbanisation, and economic growth have accelerated the need for waste management in developing countries. Effective and efficient waste management is usually the responsibility of municipalities. Municipalities, however, struggle as they often face problems that go beyond their ability and authority (Guerrero et al., 2013). The South African government has tried to introduce e-waste legislation to motivate recycling but has not been successful due to the complexity of e-waste. It is more difficult to recycle e-waste than solid waste due to various hazardous chemicals found in certain electronic and electrical products. These hazardous chemicals necessitate formal e-waste recycling facilities to recycle with more caution and advanced knowledge (Arnoldi, 2018). As a result, the amount of e-waste recycling in South Africa is small compared to solid waste recycling. Only 12% of e-waste is recycled compared to 52% of paper and 63% of tinplate steel cans (Ichikowitz & Hattingh, 2017).

In some contexts, to support and overcome municipal and authority challenges, an Integrated Sustainable Waste Management (ISWM) Model is considered. An ISWM considers all stakeholders in the flow of waste and final disposal (Guerrero et al., 2013). The involvement of all stakeholders is required to deliver a successful e-waste management system. All stakeholders must be in consensus for an integrated and sustainable e-waste management approach (Dlamini & Simatele, 2016). Stakeholders at all levels require more experience and training to fill critical gaps seen in South Africa

1.2. The rationale for this research

Research on the informal e-waste sector in South Africa does exist but with a focus on solid waste management and collection rates, illegal activities, and the cause of illegal operations. There are no in-depth explorations into the potential for formalisation. The perceptions and experiences of stakeholders within the e-waste management system are also not considered. This chapter looks at the potential of e-waste recycling – the economic and environmental value. The motivation for the study – why the informal e-waste sector is a valuable link in the e-waste management system and why it should be supported. The chapter ends with the problem identified for this study.

1.2.1. The potential of e-waste recycling

Electronic products contain various materials, such as heavy metals, that are highly toxic. Even though the use of heavy metals is regulated in specific products and may even be prohibited, they are still found in e-waste streams. Due to these material risks, the need for advanced skills and technologies is crucial for proper recycling (Herat, 2021). Developed countries rather ship their e-waste to developing countries without good regulatory frameworks and monitoring (Herat, 2021; Nagajothi & Kala, 2015; Neilsin, 2010).

There are, however, opportunities that emerge from e-waste that need to be utilised. Electronic products contain extremely valuable metals. Formally extracting and reusing the metals saves energy by reducing the need to mine raw materials (Herat, 2021) and does not pollute the environment (Kumar et al., 2017). It is also economically beneficial as it creates a recycling business, a market for recovered products, makes post-consumer waste accessible, and aids job creation (DEA, 2011). The recycling industry creates 296 jobs for every 10 000 tons of e-waste discarded (Kumar et al., 2017). The benefits of increased e-waste collection and recycling link to the motivation of the study.

1.2.2. The motivation for the study

Research supports that the majority of e-waste is currently being directed to the informal e-waste sector, leaving the formal e-waste sector without sufficient e-waste to operate their recycling facilities profitably and sustainably (Lines et al., 2016; Panwar et al., 2018). The low availability of e-waste is identified as the biggest problem within the e-waste management system (Lydall et al., 2017).

The two channels through which e-waste is collected are the formal and informal e-waste sectors. To increase the volume of e-waste channelled to formal e-waste recycling facilities, the collection operations of the formal e-waste and/or informal e-waste sectors need to be increased. This study chooses to focus on the informal e-waste sector by exploring the potential of integrating it into the e-waste management system through formalisation.

The choice of supporting the informal e-waste sector is based on two main factors. Firstly, the informal e-waste sector is South Africa's biggest e-waste collector (Chaudhary & Vrat, 2018; Lucier & Gareau, 2019; WIEGO, 2020). Therefore, the greatest potential for increased e-waste collection lies in the informal e-waste sector. Secondly, the informal e-waste sector can also not continue to operate independently, as the activities of the informal e-waste influence the e-waste management system. The incorrect recycling methods of the informal e-waste sector also pose a risk to themselves. For the informal e-waste sector to be a key lever in increasing collection volumes, it must become more valued and recognised as a key player in the e-waste management system.

As early as 2009, Wilson et al. identified the significance of the informal e-waste sector, especially in developing countries, and emphasised the need to build on their strengths and potential. Godfrey (2021) echoes the importance of the informal e-waste sector and its key role in the South African recycling value chain. The informal e-waste sector is the bridge between municipal services and the formal e-waste sector. The majority of waste collected in South Africa is done by the informal e-waste sector with little to no cost to the government. Aparcana (2017b) and Panwar et al. (2018) highlight the definite advantages that the informal e-waste sector has above the formal e-waste sector and that these advantages must be utilised. Dlamini (2016) also states that most successful e-waste management systems in developing countries build on informal systems.

Velis et al. (2012) stated that more and more stakeholders realise the significance of the informal e-waste sector and that it cannot and should not be ignored. Chi et al. (2011) and Mihai et al. (2019) support this by affirming that ignoring the informal e-waste sector will lead

to untenable interventions and banning them would be even more counterproductive, especially as it already has a well-established recycling network.

The idea of formalisation exists to legalise and integrate the formal and informal e-waste sectors for the benefit of both e-waste sectors (Widmer et al., 2008). Formalisation incorporates the informal e-waste sector into a transparent e-waste management system to better control environmental and safety impacts (Lundgren, 2012), as well as the flow and handling of e-waste. The motivation for formalisation is further supported by the improved safety and health effects on communities and the environment. As an effect of formalisation, the use of incorrect e-waste recycling methods that release toxic chemicals will decrease, working conditions for the informal e-waste sector will improve and stabilise, and formal e-waste recycling facility labour gaps can be addressed. Often the term formalisation has been misunderstood. Some formal and informal recyclers understand formalisation in the direct sense of legalising and formalising the activities of the informal e-waste sector, thereby eliminating the informal e-waste sector. In a developing country such as South Africa, the informal e-waste sector plays a crucial role in job creation and has an impact on society. Eliminating the informal e-waste sector would negatively impact the socio-economic-political environment. For this study, formalisation is seen as the integration of the informal e-waste sector into the formal e-waste management system to be a part of specific formal e-waste activities, while receiving support from the formal e-waste sector, e-waste institutions, and the government. During this process, illegal activities are minimised, and the informal e-waste sector is motivated to operate within a structured set of guidelines.

DFFF & DSI (2020) formally defines integration as “the creation of a formally planned recycling system that values and improves the present role of informal recyclers, builds on the strengths of their existing system for collecting and revaluing materials, and includes informal recyclers as key partners in its design, implementation, evaluation and revision.” Integration also includes legal, political, economic, and environmental factors. Timm et al. (2020) add to this by mentioning that integration includes showing respect towards the contributions and knowledge of informal recyclers, eliminating the stigma of informal recyclers, ensuring participation of both the formal and informal e-waste sectors, and improving the working conditions, security, and incentives that informal recyclers receive.

The position of this study adopts the definition from DFFF & DSI (2020) on formalisation which is essentially the adoption of an existing theoretical framework. This study intends to support the development of the e-waste management system in South Africa and developing countries. E-waste is rapidly increasing with few changes in approaches to managing it. Therefore, older, outdated research could be complemented by newer, updated research and

perspectives. Furthermore, other literature does not produce the same insights as the study. In addition to new primary data being generated, already existing data is being transformed into a new form. This study aims to provide insight that will allow future researchers to build on these themes, transform them, and apply them for future research. This aim is then further to address the problem of this study.

1.2.3. Problem statement

The informal e-waste sector is not fully utilised within the formal South African e-waste management system, leading to detrimental environmental and economic effects, the lack of e-waste traceability, and over 50% loss of e-waste for formal recycling. Although international practices suggest that formalising the informal e-waste sector by integrating it into the entire e-waste management system should address many of these challenges, it is unknown what the potential of formalisation is in South Africa. There is uncertainty regarding the current state, opportunities, challenges, and considerations to take into account.

1.3. Research aim

The aim of this study is to motivate the importance of the informal e-waste sector, explore the benefits of utilising the informal e-waste sector through formalisation, understand the current state of formal and informal e-waste sectors and the relationship between them, and focus on the willingness and considerations of the formal e-waste sector to be a part of the formalisation process. The aim is then to use these findings to provide recommendations for future work if a formalisation approach for an integrated e-waste management system is considered in future.

1.4. Research questions and objectives

The following research questions and objectives are designed to address the study's aim.

Research question 1: What is the current state of the formal and informal e-waste sectors in South Africa?

- Objective 1: To identify the key stakeholders of the e-waste management system and define their roles, responsibilities, and relationships.

Research question 2: What is the potential for formalising the informal e-waste sector in South Africa?

- Objective 2: To identify the challenges that prevent an integrated e-waste management system.
- Objective 3: To identify key considerations for an integrated e-waste management system.
- Objective 4: To understand if the formal and informal e-waste sectors could be integrated, and what benefits and opportunities could be realised from this.

1.5. Research audience

The outcome of this research will be valuable for all stakeholders interested in e-waste recycling, particularly in South Africa but also in other developing countries. It will especially be useful for recyclers, recycling institutions, practitioners, legislators, and researchers in the field of recycling.

The scope of the study targets e-waste recyclers and experts from the formal e-waste sector. The scope also focuses on the reverse logistics or collection of e-waste and not the specific treatment or recycling. The study does not include data that is directly obtained from the informal e-waste sector as the risk for the researcher and the institution associated with interacting with the informal e-waste sector was considered too great. It was determined that the risks outweighed the benefits.

The limitations of the study include:

- Limited e-waste recycling data available on the informal e-waste sector due to its illegal and undocumented activities.
- Limited e-waste recycling data available on the formal e-waste sector kept private due to the competitive nature between the formal and informal e-waste sectors.
- Limited input received from the formal e-waste sector due to an unwillingness to participate in interviews, which influences saturation.

1.6. Overview of the thesis

Chapter 1 explains that e-waste is ever-increasing, emphasizing the need to develop a successful e-waste management system in South Africa. To overcome the challenge of low e-waste availability, the informal e-waste sector must be considered as a part of an e-waste management system. The aim is, thus, to motivate the importance of the informal e-waste sector, explore the benefits of utilising the informal e-waste sector through formalisation, and collect data on the willingness and considerations of the formal e-waste sector to be a part of the formalisation process.

Chapter 2 includes a literature review that discusses the flow of the current e-waste management system and the roles and responsibilities of the main stakeholders, with emphasis on the challenges, importance, and potential of the informal e-waste sector. Applicable case studies of local and international e-waste recycling and formalisation are also explored.

Chapter 3 introduces the methodology through the research approach for the study and introduces a detailed explanation of the method for data collection, analysis, and interpretation. The chapter then also focuses on the validity and reliability and ethical considerations of the study.

Chapter 4 presents the observations and findings of interviews conducted with formal e-waste recycling facilities to understand the current e-waste management system, the relationship between the two e-waste sectors, and the potential for integration of the two e-waste sectors.

Chapter 5 discusses the insights gained from the data collection process, elaborating on the relationships between themes that emerged throughout the study. Recommendations for the way forward and future topics are then provided.

Chapter 6 presents the conclusion and recommendations of the study that highlight the main insights for the formalisation and concludes with future work to further improve the e-waste management system of South Africa.

2. Literature review

In this chapter the existing e-waste management system of South Africa is discussed, highlighting the different e-waste sectors and their roles and responsibilities. Thereafter, the importance of the informal e-waste sector is investigated to understand the key role it plays in the existing e-waste management system. To further create a comprehensive overview of e-waste recycling, developed and developing countries are compared, as well as the different legislation found in these countries. The current legislation applicable to both e-waste sectors is also explored. Next, the potential for formalisation is discussed, which links to the importance of the informal e-waste sector. Here, applicable lessons to South Africa are extracted from international e-waste recycling and formalisation case studies. Lastly, a theoretical formalisation summary created from the literature is provided. The structure of the literature review can be seen in Figure 1.



Figure 1: Literature review structure

2.1. The existing South African e-waste management system and influencing factors

Africa is one of the main countries to which e-waste is exported. Together with this large volume of e-waste, Africa's consumption of electronics is rapidly growing and will increase the volume of e-waste generated locally. This is a significant problem as there is an absence of the needed infrastructure to recycle e-waste correctly within the e-waste management system (Mihai et al., 2019).

To understand the e-waste management system, the different phases and stakeholders of the system are explained in Figure 2. The phases are sequential and divided into four phases, with a detailed explanation following:

1. Consume
2. Collect
3. Material recovery
4. Disposal

The e-waste management system starts with *consume* – the usage of electronic products until they become obsolete or unwanted. When the devices change into e-waste, the next phase is the *collection*. The primary modes of collection in South Africa are door-to-door pick-up, permanent drop-off facilities, or occasional drop-off events. These collections are done through formal and informal channels (Salhofer et al., 2017). E-waste is collected from businesses, households, and the government. Viljoen et al. (2021) explain that household waste management includes curbside, on-site, and off-site management. To ease on-site collection, households are motivated to separate waste at the source. Households are also motivated not to burn or bury their e-waste. Off-site management includes disposal at landfills, donations, and delivery to drop-off centres or recycling facilities. Curbside management is lastly the curbside disposal of e-waste, mixed or separated, for collection from various possible parties. When e-waste is collected, the next phase is *recovery* and function, where it is determined if the e-waste can be restored. Lastly, *disposal* ends the recycling system if the e-waste cannot be restored.

Within all four phases, the three different stakeholders are classified (Finlay & Liechti, 2008; Guerrero et al., 2013) into:

- The government
- The formal e-waste sector
- The informal e-waste sector

The government controls e-waste imports, refineries, municipal landfills, and hazardous waste facilities, all of which are overseen by recycling permits, regulations, and monitoring. The formal e-waste sector is focused on self-organising. The formal e-waste sector includes manufacturers, retailers, recycling companies, and private initiatives. Lastly, the informal e-waste sector is involved in the second-hand market, collecting e-waste from households and landfills, engaging with scrap dealers and recyclers, and performing manual dismantling

(Finlay & Liechti, 2008). Currently, the informal e-waste sector is the largest recycling sector in South Africa, especially within the collection phase (Mihai et al., 2019).

Even though each stakeholder takes on different roles, all the activities are interconnected. Figure 2 explains the interconnection between all the stakeholders throughout all four phases (Finlay & Liechti, 2008; Grant & Oteng-Ababio, 2021; Sadan, 2019).

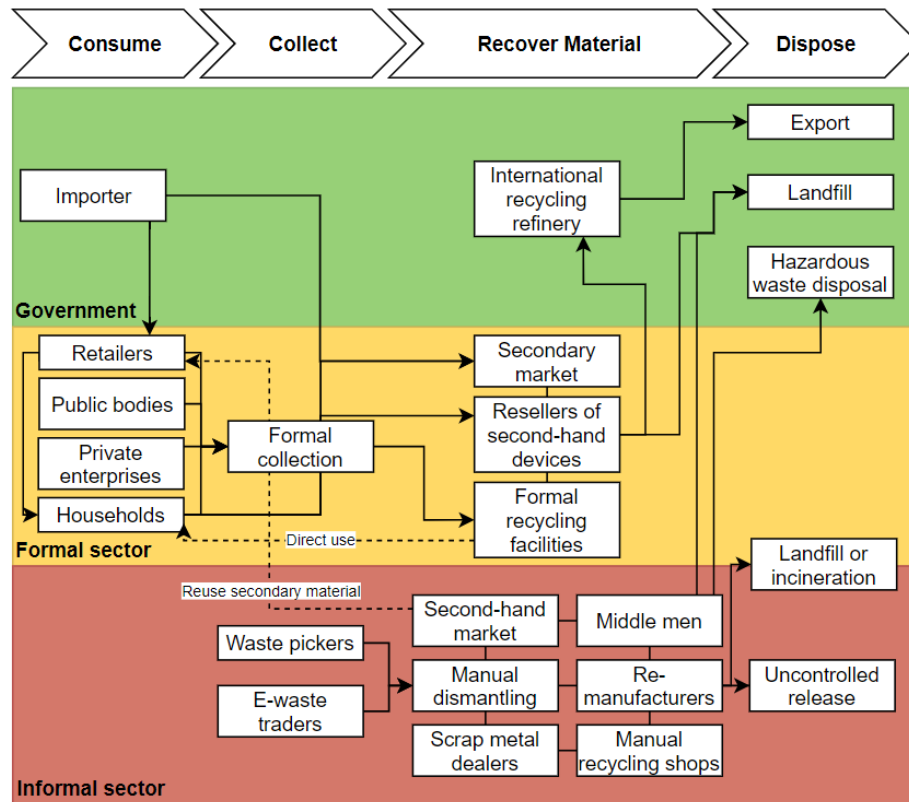


Figure 2: E-waste recycling phase and stakeholders adapted from Finlay & Liechti (2008), Grant & Oteng-Ababio (2021) and Sadan (2019)

The roles and responsibilities of the government, the formal e-waste sector, and the informal e-waste sector are explained in more detail.

2.1.1. The government

It is the responsibility of the government to set up the correct legislation to regulate and monitor e-waste recycling. It is also important that this legislation defines the types of e-waste and what type of recycling technique is needed. Moreover, the government must motivate programmes for e-waste collection and recycling that incorporate all stakeholders and influential parties. These programmes should also stipulate the desired collection rates. Unfortunately, the South African government does not adhere to all their responsibilities and is, thus, not fulfilling its role (Deubzer, 2011).

2.1.2. The formal e-waste sector

The formal e-waste sector is legal collectors and recyclers of e-waste who follow the appropriate channels as required by law (Deubzer, 2011; Lydall et al., 2017). The formal e-waste sector should ensure that consumers can return their e-waste to either the place where the device was purchased or formal e-waste recycling facilities. Thus, taking responsibility for facilitating the repair, reuse, disassembly, and recycling of electronic devices (Deubzer, 2011).

There are three groups of formal collectors. The first is large integrated waste management facilities that have a diversified network of clients and extensive logistics. The second is smaller companies that collect and process e-waste directly from consumers, municipal waste, or private companies. Lastly, consumers act as collectors when participating in drop-offs or trade-ins (Lydall et al., 2017). Depending on the type of formal collector, companies and consumers either pay or receive incentives for their e-waste. The e-waste received is then either repaired and reused or recycled. If the e-waste can be reused, legal channels are used to sell the repaired devices or valuable metals that are extracted.

The formal e-waste sector functions according to set regulations – which expect that activities are legal, unharmed, and promote a green environment and growing economy. Being a part of the formal e-waste sector necessitates formalising business processes such as recognition as a formal entity, paying taxes, social security and work hours for employees, working in appropriate areas, and adhering to building and working standards (Lines et al., 2016). A significant contrast is, however, seen within the informal e-waste sector.

2.1.3. The informal e-waste sector

According to Velis et al. (2012), *“the informal solid waste sector refers to individuals or enterprises who are involved in recycling and waste management activities but are not sponsored, financed, recognised or allowed by the formal solid waste authorities, or who operate in violation of or in competition with formal authorities”*. This definition is also applicable to the informal e-waste sector. The informal e-waste sector is also referred to as informal collectors or informal recyclers (Salhofer et al., 2017).

This section further looks at statistics regarding the informal e-waste sector and classifications of e-waste that the informal e-waste sector works with. Furthermore, the reason for the existence of the informal e-waste sector is explored.

Informal e-waste statistics and e-waste classifications

Lundgren (2012) and Hinchliffe et al. (2020) stipulate that the informal e-waste sector is unregulated and operates outside of legal control, is not registered, involves low earnings, and is undertaken by individuals or groups using basic technology. Between 2011 and 2012, the daily income of informal recyclers was calculated at R72.11 (Hinchliffe et al., 2020; Lundgren, 2012). Waste picker earnings can, however, vary significantly, depending on hours of work, geographic area, types of collection, and the type of e-waste collected.

Recycling within the informal e-waste sector often takes place in a legal grey zone where events are prohibited but accepted. Illegal recycling activities are accepted either because formal recyclers intercept e-waste collected by the informal e-waste sector or because of the lack of legislative implementation. Informal recycling is often paired with illegal dumping and safety hazards (Sadan, 2019), and is typically performed by poor and marginalised social groups who rely on waste picking as a form of survival income (Chi et al., 2011). The informal e-waste sector does currently not have stipulated responsibilities. It, however, takes on the role of e-waste collection and manual dismantling. The informal e-waste sector collects from landfills, shopping malls, refuse bins, and households before the formal e-waste sector has the opportunity to (Mihai, 2019). These collection locations can be divided into four collection categories (Wilson et al., 2009):

1. Itinerant waste buyers – collecting door-to-door that is sold to recycling traders.
2. Street waste picking – collecting e-waste from bins or waste found on the street.
3. Municipal waste collection – obtaining e-waste from municipal vehicles transporting e-waste combined with solid waste.
4. Landfill waste picking – informal recyclers recover e-waste from landfills before it is completely discarded or from rural areas (Wilson et al., 2009). The collection is done using rickshaws, wheelbarrows, trolleys, motorcycles and trucks (Guerrero et al., 2013).

The e-waste that the informal e-waste sector collects is often sold to middlemen, dealers, and recycling facilities, or kept for manual dismantling (Wilson et al., 2009). There are four material flow types that the informal e-waste sector sells to middlemen (Williams et al., 2013):

- Type 1 – Materials and parts for direct use by the formal e-waste sector (Central Processing Units, Dynamic Random-Access Memory).
- Type 2 – Materials and parts that are less expensive to process formally (Circuit boards).

- Type 3 – Materials and parts that are less expensive to process informally (Copper wires). Here incentives are needed for the informal e-waste sector to sell these materials to formal facilities.
- Type 4 – Residual waste that is difficult to recycle due to its low value (Plastics). Type 4 wastes usually flow to sanitary landfills or solid waste recycling facilities, depending on cost and location.

Reasons why the informal e-waste sector exists

It is important to understand why the informal e-waste sector exists to know what approaches can be used to help prevent illegal activities. One reason why informal e-waste recycling occurs is due to the economic value of e-waste, socio-economic conditions, and industrial interdependence (Torres et al., 2016; Wang & Huisman, 2010). The main focus of informal recyclers is the flexibility of self-employment and support for their families and livelihoods through any means necessary (Dlamini, 2016; Sadan, 2019). The lack of legislation in developing countries makes it easier for informal recycling to take place (Arora & GTZ_ASEM, 2008). The e-waste management system of South Africa is not formally developed, ill-defined, and unorganised, making it easier to thrive in the grey market (Wath et al., 2010).

Currently, the informal e-waste sector will also remain a reality due to numerous tedious registration formalities and expenses (Sadan, 2019; Yose, 2014). It takes a minimum of 10 months to set up a formal recycling facility, with the minimum start-up cost being R165 000 and a monthly operating cost of R40 000 (Yose, 2014). Registration formalities, which differ for each province, include being declared as a legal entity, obtaining e-waste and start-up capital, receiving authority to operate, acquiring operation requirements, identifying markets to sell dismantled electronics to, and ensuring transportation for e-waste (Yose, 2014).

The informal e-waste sector does not only exist due to the monetary value of e-waste and the tedious registration process. There is also a sufficient supply of illegally imported e-waste. Additionally, the low cost of treatment and pollutive methods of the informal e-waste sector. Manual separation of e-waste saves costs and increases the recovery of components. Lastly, the informal e-waste sector's trading network is comprehensive and efficient, with a continuous downstream market prepared to pay for e-waste components, and a lack of quality control that allows for untested devices (Chi et al., 2011).

2.1.4. Sector comparison

To illustrate the key features of both sectors, Table 1 compares the formal and informal e-waste sectors (Mccann et al., 2015; Wang & Huisman, 2010). It must be noted that informal recyclers do not always operate illegally, just as some formal recyclers do not always operate legally. The main differences identified between the two e-waste sectors are, however, that the informal e-waste sector does not pay taxes, is much less transparent, and its skills are self-taught. A major concern is also that the informal e-waste sector is not considered in official e-waste statistics and policies (Mccann et al., 2015).

Table 1: Strengths and weaknesses of the formal and informal e-waste sectors, adapted from Mccann et al. (2015)

E-waste management steps	Formal e-waste sector		Informal e-waste sector	
	Advantages	Disadvantages	Advantages	Disadvantages
Reuse	Some focus on reuse issues	Not much intervention compared to the informal e-waste sector	Identify reusable devices and resell them to consumers	Not always done legally
Separation at the source	Job creation: Labour-intensive	Expensive – dependent on consumers	Able to access e-waste even if it is not separated at the source Inexpensive and labour-intensive	
Collection	Consumers who bring e-waste to facilities	Expensive if collection from households is needed	Thousands of informal recyclers collect Higher collection rate	Cherry-picking
Dismantling	Safe and environmentally friendly	Some processes do not deliver 100% recovery	Recovery of most valuable materials	Unsafe and hazardous
Recycling	Safe recycling Toxicity and pollution control			Lack of funding Hazardous
Disposal	Investments for safe disposal			Not interested in final disposal

To add to Table 1, during recycling, the informal e-waste sector can only extract 25% of the gold in circuit boards, while the formal e-waste sector can recover up to 95% of the valuable metals. Not only does the formal e-waste sector recover more materials but they do it safely (Mccann et al., 2015; Williams et al., 2013).

2.1.5. Factors of a successful e-waste management system

Household and consumer factors, logistics and infrastructure, and e-waste management approaches are discussed in this section. A suitable e-waste management approach is needed to ensure a successful e-waste management system. There are four types of e-waste management scenarios (Shittu et al., 2021):

1. A formally documented system in which e-waste is collected formally or through the municipality. E-waste is then transported to recycling facilities and treated under controlled conditions. The requirements of this system are stipulated thoroughly by legislation.
2. The simultaneous disposal of e-waste and household waste. The combined waste is then either sent to landfills or incineration.
3. E-waste collection through the informal e-waste sector where the e-waste either flows to formal e-waste recycling facilities or second-hand dealers. In this system, the collection of e-waste is not documented, and activities become illegal.
4. E-waste collection is done through the informal e-waste sector without any regulations or enforcement of legislation.

Currently, South Africa faces a combination of scenarios two and three. This, unfortunately, has detrimental effects on the environment and negatively impacts the economy. A more regulated system as seen in the first scenario is needed for a developing country (Mihai et al., 2019). For South Africa, a combination of scenarios one and three is desired.

Household and consumer factors

The current e-waste management system is influenced by various household and consumer factors – family size, education level, monthly income, household attitude towards separation and recycling, and community committees' involvement in recycling (Guerrero et al., 2013; Viljoen et al., 2021), collection fees, drop-off locations, and peer influence (Guerrero et al., 2013). Awareness creation also influences the behaviour of consumers and the need to participate and find solutions to recycling problems (Guerrero et al., 2013; Hougaard, 2021).

Logistics and infrastructure factors

Logistic and infrastructure factors include improper bin collection systems, lack of collection information, poor scheduling and route planning, insufficient infrastructure (Guerrero et al., 2013; Viljoen et al., 2021), and lack of knowledge from authorities regarding e-waste recycling (Chung & Lo, 2008; Viljoen et al., 2021). The lack of participation at a municipal level, limited

knowledge of practices and technology, lack of collection equipment, and the lack of decision-makers limit the advancement of waste separation and recycling programmes (Guerrero et al., 2013).

Logistics also relate to the location of e-waste collection points. Numerous collection points close to households are crucial to motivate proper disposal (Viljoen et al., 2021). Tadesse et al. (2008) mention that insufficient disposal and collection choices, as well as further travel distance to recycling facilities, increase the probability of incorrect disposal. Drop-off facilities and curb-side collection reduce the cost and time of recycling and the need for storage. Door-to-door collection from households is especially successful in rural communities (Viljoen et al., 2021).

Various of these household, consumer, infrastructure, and logistic factors can be overcome by integrating the informal e-waste sector into the formal e-waste management system. For example, providing more collection options to consumers and households (Viljoen et al., 2021), bridging the problem of drop-off points located too far, and overcoming the problems of poor road quality and insufficient infrastructure.

2.2. Importance of the informal e-waste sector

Even though various challenges regarding the informal e-waste sector have been discussed, the importance of the informal e-waste sector must not be underestimated. Timm et al. (2020) state that the informal e-waste sector plays a vital role in South Africa's waste management system. Many studies worldwide (Diaz et al., 2007; Gerdes & Gunsilius, 2010; Gunsilius, 2011; Hetz & Lemke, 2011; Medina, 2008; Paul et al., 2012; Scheinberg et al., 2010; SWAPP, 2006) have shown that the informal e-waste sector significantly contributes to e-waste management.

This contribution is seen through a significantly higher collection rate from the informal e-waste sector compared to e-waste collected through formal channels (Chaudhary & Vrat, 2018; Lucier & Gareau, 2019; WIEGO, 2020). The informal e-waste sector is currently not restricted by legislation, has a greater workforce, and collects and recycles e-waste with more motivation as their livelihoods depend on it. The informal collection is also more successful due to service convenience, availability, and flexibility (Chaudhary & Vrat, 2018; Gerdes & Gunsilius, 2010; Inclusive Innovations, 2017; Wang et al., 2016). Informal recyclers collect and sell e-waste daily, whereas formal collectors tend to only collect over weekends (Dlamini, 2016). The informal e-waste sector is much more active on the street, at trader facilities, and disposal sites (Gerdes & Gunsilius, 2010), and divert e-waste away from landfills (DFFF & DSI, 2020; MoHUA, 2016).

Another reason why informal recyclers are so successful is because of the disposal habits of consumers. A study in South Africa revealed that 51% of consumers dispose of their e-waste with solid waste, where informal recyclers then collect it at landfills. Another 8% of consumers place their e-waste outside for curb-side collection (Finlay & Liechti, 2008).

In South Africa, informal recyclers have become very important in bridging the service component in the value chain, competing with the private sector, and working with the government in buy-back schemes. The government cannot compete with the door-to-door collection of informal recyclers (Inclusive Innovations, 2017). Shevchenko et al. (2021) state that formalisation is, thus, needed to increase the amount of e-waste that formal e-waste recycling facilities obtain through a more cost-efficient informal e-waste sector that can reach larger amounts of e-waste, faster.

Opportunities for stakeholders

The importance of forming a partnership with the informal e-waste sector is further explained with a focus on different stakeholders. Producer Responsibility Organizations (PROs) must generally comply with certain collection and recycling targets. To meet these targets, enough e-waste must be accessed. As mentioned, the informal e-waste sector has a much higher collection rate and can thus benefit PROs. A positive public image and transparency throughout the system are created.

The same principles apply to the formal e-waste sector. Sources of e-waste are hard to obtain as the e-waste streams are mainly within local communities, managed by the informal e-waste sector (Hinchliffe et al., 2020). Informal recyclers are very resourceful as they have better knowledge about the streets and collection locations, disposal patterns, and the economic value of e-waste (Davis & Garb, 2015; Oxford, 2022). In effect, this partnership will help prevent the cherry-picking of devices and ensure reliable cash flow (Hinchliffe et al., 2020).

Insight into the importance of the informal e-waste sector was further obtained through a study about South African e-waste recycling. Recycling facilities and stakeholders were interviewed to gain an understanding of their knowledge of the e-waste industry. During this study, participants regarded the informal e-waste sector as important; *“Informal recyclers are probably the most valuable asset in waste recycling. Without such people, recycling will probably not take place”* (Hougaard, 2021).

Informal waste recycling significantly contributes to minimising e-waste and e-waste discarded to landfills, cleans up communities while reducing municipal expenses, and helps the government achieve higher recycling rates (Aparcana, 2017a; Davis & Garb, 2015; Dlamini,

2016). The activities of the informal e-waste sector also provide financial benefits to the formal e-waste sector, as seen through cost reductions. The formal e-waste sector collects much less e-waste, which in turn leads to lower labour, transport, and infrastructure costs (Aparcana, 2017a; Wilson et al., 2009). The cost savings will increase even more if the e-waste management system is modernised and the informal e-waste sector is formalised (Wilson et al., 2009).

Lastly, if the informal e-waste sector can be integrated into the formal e-waste sector, four categories of opportunities are realised:

- Environmentally – Correct recycling will lead to much less toxic and hazardous chemicals released, safer disposal, fewer health and risk problems (Ambrosi, 2018), reduced pollution, and better resource management (Lundgren, 2012).
- Culturally – Awareness is created, education is improved, and the skills of both sectors and consumers are enhanced (Ambrosi, 2018).
- Socially – Jobs are created, social gaps decrease, knowledge expansion, and social responsibility (Ambrosi, 2018). Informal recyclers also benefit from teamwork, regular work hours, reduced vulnerability, and better working conditions (Gunsilius et al., 2011; Paul et al., 2012).
- Economically – Reverse mining is encouraged to reduce energy consumption and waste, increase employment opportunities, and improve the quality of these jobs and environmental costs are lowered (Ambrosi, 2018).

2.3. Developed and developing countries

To understand why the informal e-waste sector is important for South Africa, the difference between developed and developing countries is important. Table 2 provides a comparison between developed and developing countries regarding the key processes in the e-waste management system.

Table 2: Comparison of e-waste in developed and developing countries, extracted from Mmereki et al. (2016)

Process	Developing countries	Developed countries
Sector	Informal e-waste sector	Formal e-waste sector
Dismantling	Manual dismantling	Manual dismantling
Separation	Manual separation	Semi-automation separation
Recovery	Recovery of metals by heating, burning, and acid leaching of e-waste scrap in small workshops	Recovery of metals by state-of-the-art methods in smelters and refineries
Disposal	Open burning, open dumping	Incineration with MSW, landfill disposal

Developed countries set clear targets for collection, recovery, and recycling for all stakeholders. Developed countries also have high-cost systems and sophisticated disposal schemes that are less hazardous for waste handling. The objective is to reduce hazardous materials that end up in landfills and increase recyclable materials. Most developed countries have laws and mandates that promote the proper collection, recycling, and safe disposal of all waste (Mmereki et al., 2016).

The e-waste management system of developing countries is not as organised as in developed countries (Mmereki et al., 2016). Developing countries struggle with in-country e-waste generation, illegal exportation from developed countries, and the lack of investments received for recycling improvement (Neilsin, 2010). Developing countries also tend to have bigger populations, which inevitably leads to more e-waste (Mmereki et al., 2016). The research of Mmereki et al. (2016) shows that developing countries are facing e-waste increases of 200-400% in South Africa and China, and 50% in India from 2007 to 2020. The quantification of e-waste collected by the informal e-waste sector is often neglected as this information is invisible to statistics. Therefore, establishing baseline levels of information is required to achieve sustainable development targets and informed policy and management decisions (Mmereki et al., 2016).

The population size also makes it difficult to follow a formalised e-waste management system that disregards the informal e-waste sector (Lundgren, 2012) – which is often the biggest source of labour for e-waste collection. In most developing countries, the informal e-waste sector dominates the e-waste management system. Estimates of the total volume of e-waste managed informally range from 50% to 80% for China, India, and the Philippines (McAllister, 2013) and 49% for Romania (Ecotic, 2015). In India, formal e-waste sector collection is only 2%, but around 95% of collection efficiency is from the informal e-waste sector (Chaudhary & Vrat, 2018).

2.4. Legislative development within the South African e-waste industry

The e-waste management system in South Africa is largely influenced by legislation. Political will is a major factor that influences the level of integration reached. Political will refer to both national policy and the attitude towards the informal e-waste sector. Attitude also includes the willingness of decision-makers to use the existing legislation to create initiatives for the informal e-waste sector. The initiatives can then, later on, be developed into legislation (Gerdes & Gunsilius, 2010).

The development of this legislation is shown in Figure 3, which contains all the major influential legislation for e-waste in South Africa. The Basel Convention was first introduced in 1994 to try and prevent the transboundary movement of e-waste. Between 2003 and 2009 the Swiss e-waste program (SECO) was developed and implemented to give more guidance to South Africa. Between 2013 and 2021, legislation was introduced to focus on banning e-waste from landfills, setting up a PRO to help with e-waste management, and establishing an e-waste management plan. These laws have either been developed specifically for South Africa or influence South Africa significantly. Many of these laws are not obeyed and emphasise the lack of enforcement and monitoring of e-waste legislation in South Africa (Grant, 2019; Sadan, 2019).

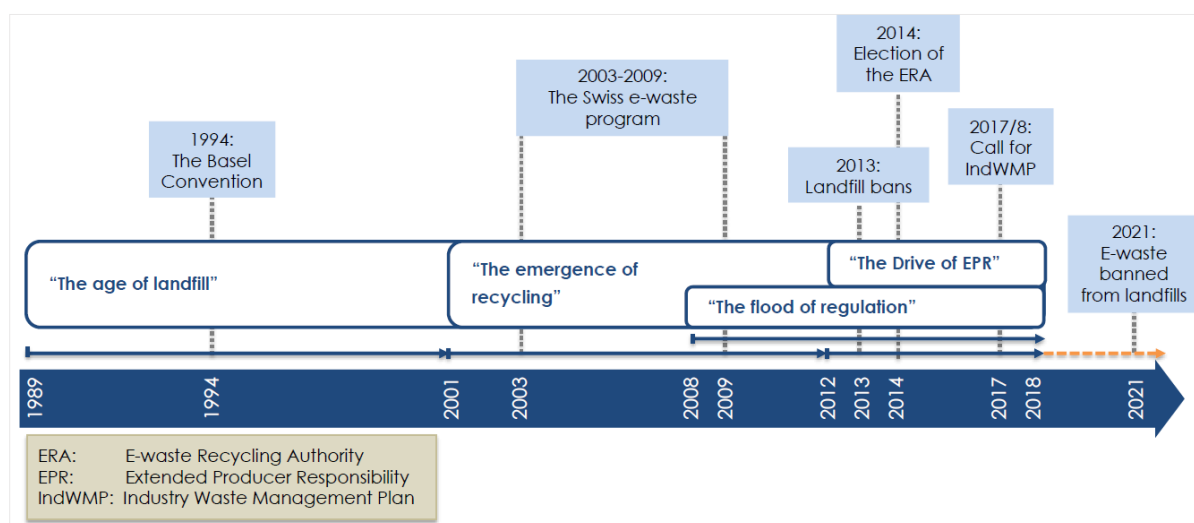


Figure 3: Legislation developments in the South African e-waste management system extracted from Sadan (2019)

A major issue for many countries is weak and inefficient law enforcement (Patil & Ramakrishna, 2020). Africa is the continent with the most poorly covered e-waste legislation (Baldé et al., 2017; Mihai et al., 2019). Northern and Southern Africa (in which South Africa falls) have no explicit e-waste legislation to adhere to. Only Kenya, Madagascar, and Ghana have passed formal e-waste bills into law (Baldé et al., 2017).

Compared to other African countries, South Africa has sufficient regulations in place for labour safety, consumer and environmental protection, and waste management for solid waste (SAWIC, 2015). However, the current South African e-waste legislation is inadequate and not comprehensive enough compared to established e-waste management systems of developed countries (Mmereki et al., 2016). The legislative framework of South Africa does also not recognise the informal e-waste sector (Dlamini & Simatele, 2016; SAWIC, 2015), nor understand how to integrate the informal e-waste sector into this legislative framework for

effective e-waste management (Dlamini, 2016). The integration of informal recyclers into policy planning should form the basis of environmental sustainability.

This is a significant problem as national e-waste legislation and policies establish control measures and standards to manage e-waste. These policies must define a practical and sustainable economic and financial model and, thus, include aspects such as collection, logistics, and recycling. E-waste legislation should also help to create awareness among all consumers and necessitate a monitoring and record-keeping system. Inventory record-keeping is crucial to forecast trends, help authorities develop policies, measure progress and have accurate, reliable data sources (Ilyassova et al., 2021).

One of the reasons for the lack of a legislative framework is due to insufficient accountability within the e-waste management system, the lack of transparency and structural challenges within authoritative institutions, and corruption (Dlamini & Simatele, 2016). It is difficult to standardise legislation for each country or even specifically for each province, but it is still important to create interlinked and integrated legislation that can be implemented based on the same principles (Ilyassova et al., 2021). There is a great need to identify e-waste problems and ratify regulations dedicated to preventing these problems and motivating further growth (Kumar & Singh, 2013).

2.4.1. Protection of the informal e-waste sector

Legislation in South Africa has not given enough attention to the protection of the informal e-waste sector and the environment. Special standards are needed to protect workers in the e-waste field for human life and health are the main priority. Increased awareness of the informal e-waste sector is needed within the legislation, as well as positively influencing the view of the public towards informal recyclers (Ilyassova et al., 2021). The informal e-waste sector must be recognised within and protected by the legislative framework of South Africa (Yu et al., 2010). The adaption of legislation paves the way for successful integration and further development (Gerdes & Gunsilius, 2010).

Even though the legislation in South Africa needs improvement, it does not imply that only more bans must be set in place. Bans within legislation lead to bigger informal e-waste sector collection, illegal activities, and organised crime. The effectiveness of bans is also a problem. Thus far, bans have been unsuccessful in preventing informal recycling due to insufficient enforcement. Financial and job security for the informal e-waste sector is highly uncertain due to unpredictable e-waste flow and the number of informal recyclers (Sadan, 2019). Thus, legislation gaps must not be filled with more bans but with comprehensive processes that

consider the informal e-waste sector and its activities. It is important to explore alternative policies that focus on environmental impacts whilst improving social and economic benefits for all stakeholders (Patil & Ramakrishna, 2020).

Informal recyclers are classified as vulnerable working groups, have little to no say or bargaining power, and face extremely difficult working conditions. They, therefore, require appropriate legislation to protect their livelihoods and health. Legislation alone is vital, but not sufficient. Proper implementation and enforcement of policies – which include funding for collection, recycling, development of technologies, and participant cooperation – is crucial (Ilyassova et al., 2021).

2.4.2. International e-waste challenges and regulatory frameworks

Before an e-waste management system is developed, various questions such as what and who makes up the e-waste management system and who is responsible for certain roles and activities should be answered (Chung & Murakami-Suzuki, 2008). An e-waste legislative framework must then be set up according to the answers to these questions.

As guidance to develop improved e-waste legislation in South Africa, various regulatory frameworks and legislative challenges from international countries are presented in Table 3. Even though legislation is set up according to an individual country, there are overlapping factors that all countries need to consider. The positive factors of one country can be used within another. From Table 3 it is clear that numerous international regulatory frameworks could be referenced for designing appropriate legislation in South Africa.

Table 3: International regulatory framework and legislative challenges

Region	Regulatory framework	Function	Legislative challenges	Reference
European Union (EU)	“Waste Electrical and Electronic Equipment Directive (WEEE)” (2002/96/EC) and (2012/19/EU) (revised)	Preventing e-waste generation through promoting the recovery, reuse, and recycling thereof, whilst improving the life cycle of electronic devices	Incomplete existing guidelines Illegal exports to developing countries due to soft laws and low consequences	Regulatory: (Ilyassova et al., 2021; Kumar & Singh, 2013; Patil & Ramakrishna, 2020; Thakur & Kumar, 2021)
	“European Commission Regulation” (1013/2006)	Transportation guidelines for e-waste	Limited monitoring and effectiveness	Challenges: (Mohanty et al., 2015)
	“Directive” (2005/32/EC)	Establishing eco-design requirements for electronic devices	assessment due to the lack of reporting and information gaps within	

Region	Regulatory framework	Function	Legislative challenges	Reference
	“Restriction of Hazardous Substances Directive (RoHS)” (2002/95/EC) and (2011/65/EU) (revised)	Protection of human health, environmentally friendly handling of e-waste, changing electronic device design, and increasing recycling rates	the e-waste management system Lack of risk assessment and inspection of collection, recycling, and disposal methods	
	“Basal Convention”	Avoid the exportation of hazardous waste between countries		
	“Solving the E-waste Problem (StEP)”	Promote reusability of recycled e-waste components to the limit e-waste generation		
Australia	Similar to EU	Focused on the collection and environmentally friendly processing of e-waste, as well as EPR	Illegal exports to developing countries E-waste regulations only limited to televisions and computers Stakeholders' roles not clarified Low recycling targets Lack of auditing, reporting, and assessment of regulatory compliance Similar to EU	Regulatory: (Patil & Ramakrishna, 2020) Challenges: (Morris & Metternicht, 2016)
New Zealand	Similar to EU	Focused on the collection and environmentally friendly processing of e-waste, as well as EPR		Regulatory: (Patil & Ramakrishna, 2020)
Japan	Similar to EU	Focused on the collection and environmentally friendly processing of e-waste, as well as EPR	Illegal exports to developing countries Similar challenges to the EU and Australia	Regulatory: (Patil & Ramakrishna, 2020) Challenges: (Chung & Murakami-Suzuki, 2008)
Korea	Similar to EU	Focused on the collection and environmentally friendly	Illegal exports to developing countries Similar challenges to the EU and Australia	Regulatory: (Patil & Ramakrishna, 2020) Challenges:

Region	Regulatory framework	Function	Legislative challenges	Reference
		processing of e-waste, as well as EPR		(Chung & Murakami-Suzuki, 2008)
Taiwan	Similar to EU	Focused on the collection and environmentally friendly processing of e-waste, as well as EPR	No specific and comprehensive legislation for e-waste recycling The informal e-waste sector is not identified and incorporated into formal collection Lack of environmental and safety standards for recycling	Regulatory: (Patil & Ramakrishna, 2020) Challenges: (Chung & Murakami-Suzuki, 2008)
Singapore	Similar to EU	Focused on the collection and environmentally friendly processing of e-waste, as well as EPR		Regulatory: (Patil & Ramakrishna, 2020)
China	“Measures for the Administration of Prevention and Treatment of Pollution by Electronic Information Products”	Usage restriction of six toxic and hazardous elements in electronic devices	The current regulatory framework is fragmented and inadequate – legislation has not been developed systematically and only covers certain aspects of e-waste	Regulatory: (Chi et al., 2011; Yu et al., 2010) Challenges: (Lu et al., 2015)
	“Technical Policies for Controlling Pollution of WEEE”	Pollution prevention through reducing reuse, recycling, and the control of design, dismantling, usage, and disposal of e-waste	Illegal imports from developed countries Enforcement and control of environmental protection regulations are weak	
	“Administrative Measures for the Prevention and Control of Environmental Pollution by WEEE”	Permit requirements to conduct e-waste operations and responsibilities of all stakeholders to prevent e-waste pollution	The informal e-waste sector is not formalised and recognised in legislation	
	“Regulation on the Administration of the Recovery and Disposal of WEEE”	EPR for electronic devices, the collection, and treatment thereof	Lack of assessment of the impact of the informal e-waste sector	
	“The Circular on Strengthening the	Prohibit environmentally harmful processes and		

Region	Regulatory framework	Function	Legislative challenges	Reference
	Environmental Management of WEEE"	toxic substances from manufacturing to disposal		
India	"The Environmental Protection Act"	Prevention, control, and reduction of environmental pollution	Illegal imports from developed countries Child labour is used for processing e-waste	Regulatory: (Patil & Ramakrishna, 2020) Challenges: (Yadav & Bandyopadhyay, 2015)
	"The Hazardous Wastes Management, Handling, and Transboundary Movement Rules"	Requirements of facilities treating hazardous waste to request permission to dispose of e-waste	Lack of public awareness and monitoring from governing bodies –	
	"The E-waste Management and Handling Rules"	E-waste regulation for every level of electronic devices	leading to improper disposal of e-waste No penalties in place for non-compliance	

2.5. The potential for formalising the informal e-waste sector

As explained in the previous sections, the informal e-waste sector has great potential for e-waste collection in South Africa. This chapter further explores the implications of Extended Producer Responsibility (EPR), the potential of a mutual support system, approaches to formalise, the considerations and challenges of successful formalisation, and learnings from formalisation attempts.

2.5.1. Extended Producer Responsibility

Extended Producer Responsibility is a collection strategy focused on producers and plays a significant role in e-waste management. EPR requires that producers develop a green design approach, take back their products at EoL, and recycle, re-utilise, or dispose of the devices (Baldé et al., 2017; Jaiswal et al., 2015). EPR promotes beneficial environmental designs, choosing safer recyclable materials, providing information to aid recycling, and making recycling more cost-effective (ITU, 2018; Torres et al., 2016; Wath et al., 2010). Better e-waste designs are also more sustainable, less expensive, easier to process, and more environmentally beneficial (Baldé et al., 2017; StEP et al., 2015). An EPR model is, thus, an environmental protection strategy that places the financial and physical responsibility for operating e-waste on the producer for the product's entire life cycle (ITU, 2018; Torres et al., 2016; Wath et al., 2010).

Table 4 represents the various ways in which an EPR system can function (Jaiswal et al., 2015; Neilsin, 2010).

Table 4: EPR system approach examples extracted from Jaiswal et al. (2015) and Neilsin (2010)

Type of EPR approach	
Product take-back programs	Mandatory take-back
	Voluntary or negotiated take-back programs
Regulatory approaches	Minimum product standards
	Prohibitions of certain hazardous materials or products
	Disposal bans
	Mandated recycling
Voluntary industry practices	Voluntary codes of practice
	Public/private partnerships
	Leasing and “servicing”
	Labelling
Economic instruments	Deposit-refund schemes
	Advance recycling fees (ARFs)
	Fees on disposal
	Material taxes/subsidies

EPR is an alternative to a free market-based or tax-based system. A free market-based system is a free regulation system that sets goals through legislation but does not assign specific roles and responsibilities. A tax-based system requires that producers pay taxes to the government. The government is then responsible for the collection and disposal of e-waste through private partnerships. An EPR model places the selection choice on the individual producers (ITU, 2018). The EPR principle can either be implemented collectively where producers of the same product category have mutual responsibility or individually where producers are responsible for themselves (Baldé et al., 2017; Henzler et al., 2018).

Many developed countries have accepted an EPR model for their e-waste management system. More developing countries are also trying to do the same. Following are a few examples of successful EPR models that can potentially be implemented for South Africa.

Switzerland is the first country in the world to develop and implement a formal, sustainable e-waste management system for transportation, collection, recycling, and disposal (Wath et al., 2010). Their legal and functioning framework is based on an EPR model. To execute the EPR model, Switzerland has four Producer Responsibility Organizations (PROs). “The Swiss Association for Information Communication and Organizational Technology (SWICO)”, “Stiftung Entsorgung Schweiz (SENS)”, “Swiss Lighting Recycling Foundation (SLRS)”, and

“Inobat” that is responsible for the e-waste management system on behalf of producers. SWICO is responsible for brown goods and IT equipment, SENS for large household items, SLRS and SENS for lighting equipment, and Inobat for batteries. The PROs are non-profit organizations solely focused on collecting e-waste and the participation of producers (Wath et al., 2010). Multiple levels of independent controls guarantee the system’s success and financial and material flows at every stage – preventing free-riding, pilferage, and ensuring environmental and quality standards. A key aspect is the nationwide comprehension and acceptance of the scheme (Wath et al., 2010).

Germany also follows an EPR model associated with the “Electrical and Electronic Act (ElectroG)”. ElectroG stipulates the obligations of all stakeholders to manage e-waste. These stipulations focus on waste prevention, reuse, and extensive recycling. Key actors are the “Public Waste Management Authorities (PuWaMA)”, the clearinghouse “Elektro-Altgeräte Register (EAR)”, producers, and consumers. All producers are required to register with the EAR. PuWaMA is then responsible for the collection of e-waste for producers. PuWaMA sets up collection points where consumers can bring e-waste based on local conditions or collect it from households. The e-waste collected is then handed over to producers. Another responsibility of PuWaMA is to keep a record of e-waste recovery and targets (Chaudhary & Vrat, 2018). Producers have three strategies for take-back schemes. The “individual brand-selective takeback schemes (IBTS)” where manufacturers only take back e-waste from their brands, the “individual nonselective takeback schemes (INTS)” where manufacturers take back all e-waste regardless of the brand, or the “collective takeback scheme (CTS)” where manufacturers jointly finance and organise the collection of all e-waste (Chaudhary & Vrat, 2018).

The Japanese e-waste management system is also based on the EPR model. The difference is that retailers are responsible for collecting EoL products from households. Old products are accepted by consumers when similar new products are bought, or products sold by a specific retailer. With computers, consumers can contact producers directly or take them to the post office, where retailers will collect them. If retailers or the municipality does not collect the e-waste, legal entities are appointed by the government (Chaudhary & Vrat, 2018).

A partnership between the formal and informal e-waste sectors can be used to support producers in adhering to the ERP regulations. The informal e-waste sector can act as a bridge for e-waste collection that producers need to set up as a part of ERP. A mutual support system is explained in more depth in the next section.

2.5.2. Mutual support system

Many developing countries have recognised that the formal and informal e-waste sectors are interdependent (Wang et al., 2016). In support, various institutions believe that a partnership will increase the volume of e-waste collected and provide access to secondary raw materials (Lucier & Gareau, 2019). A mutual support system throughout the process of formalisation is, thus, ideal for developing countries (Raghupathy et al., 2010). This support system considers the needs and capabilities of both e-waste sectors and provides a balance between informal labour-intensive operations and formal mechanised operations (Raghupathy et al., 2010). Figure 4 displays this mutual support system.

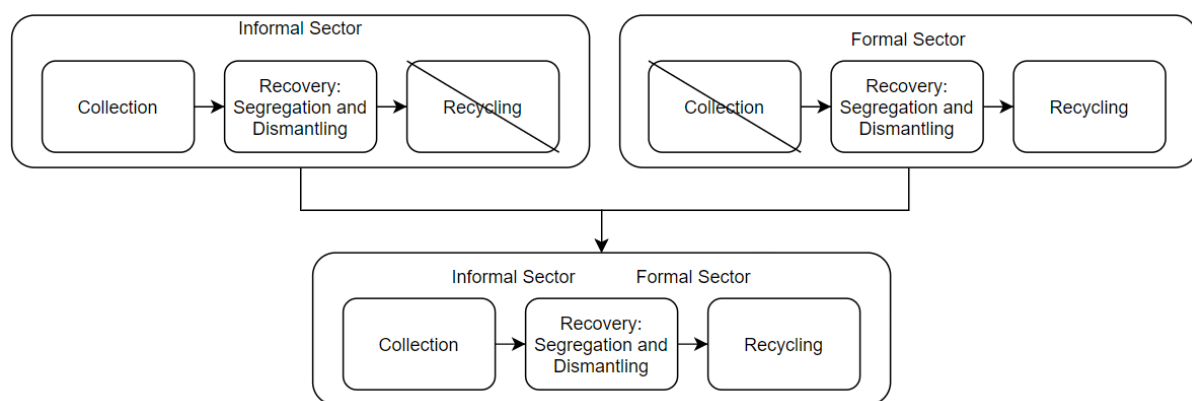


Figure 4: Mutual support system adapted from Raghupathy et al. (2010)

Numerous activities in the e-waste management system interlink the formal and informal e-waste sectors. For the informal e-waste sector, aligning these activities through formalisation will only be viable if it is economically and environmentally sustainable. The degree of formalisation is important to consider for this (Hinchliffe et al., 2020). The main area where the informal e-waste sector uses illegal activities is recycling, where they are much less effective in extracting valuable materials (Raghupathy et al., 2010). It is, therefore, proposed that the collection and recovery of non-hazardous materials be done primarily by the informal e-waste sector. The formal e-waste sector then mostly focuses on the recovery and recycling of higher-order processes (Raghupathy et al., 2010).

Integrating the two e-waste sectors will increase acceptance by local authorities and decrease social risks. This will also lead to the development of successful legislation and reduce competitiveness between the two e-waste sectors (Hinchliffe et al., 2020). Finally, opportunities to create working sites that are no longer contaminated will be possible, to reduce health and safety risks (Hinchliffe et al., 2020).

2.5.3. Approaches to formalise

A mutual support system is elaborated based on the chosen approach to formalisation. Approaches must acknowledge the considerations and challenges that accompany formalisation. Traditional approaches have rarely asked the informal e-waste sector what its true needs are and do not recognise it as a key stakeholder within the e-waste management system (Wilson et al., 2009). A progressive approach is rather to identify all the activities that the informal e-waste sector is a part of and manage these activities to develop an economy and operational functions that improve the e-waste management system, whilst considering the informal e-waste sector's needs (Wilson et al., 2009).

The type of formalisation is based on many factors. Various progressive approaches to formalisation can be adopted. The section explains three different approaches; 1) Cooperatives; 2) Micro- and Small Enterprises (MSEs) or Community-Based Organisations (CBOs); and 3) Formal workers.

Interface organisations and cooperatives

The first approach is to organise municipalities and informal recyclers into interface organisations which then further expands into cooperatives. How informal e-waste recycling activities are organised influences income generation, social status, and working conditions. A more organised system is capable of involving more people and adding more value (Medina, 2000). Informal activities, therefore, need to be organised into cooperatives to enhance the capability of adding value to e-waste recycling (Medina, 2000; Raghupathy et al., 2010). Cooperatives would, additionally, help with the registration and certification of the informal e-waste sector (Raghupathy et al., 2010). The informal recyclers then agree to contracts regarding collection services and in some cases, recycling (Gerdes & Gunsilius, 2010). The income received by the informal e-waste sector is variable and depends on the quantity and quality of the e-waste collected and the value it can be sold for. In some cases, the income can be semi-fixed where a fixed amount is paid to informal recyclers by municipalities and additional income is generated by sales of recycled materials.

Non-profit Government Organisations (NGOs) can act as cooperatives and create a crucial link between the formal and informal e-waste sectors (Gerdes & Gunsilius, 2010) by providing technical, financial, and social aid (Aparcana, 2017a; Gerdes & Gunsilius, 2010). NGOs are also trustworthy as they have no priority conflicts. Municipal protection of NGOs is crucial to ensure powerful companies do not exploit and push out NGOs when working with the informal e-waste sector (Gerdes & Gunsilius, 2010).

The probability of success and sustainability of cooperatives are higher when the work conditions and habits of the informal e-waste sector are considered and used to create a structured environment for partnerships (Gerdes & Gunsilius, 2010). DFFF & DSI (2020) further states that there are certain conditions cooperatives must meet to ensure success. The members of cooperatives should be committed and agree to work collectively. Furthermore, a formal contract between cooperatives and municipalities is wise to stipulate responsibilities, financials, dispute resolutions, monitoring and evaluation. A long-term integration and operations plan. Support for the informal e-waste sector to create bids for tenders. Continuous mentorship programmes to support informal recyclers and facilitators committed towards these programmes. Complete transparency in all aspects. Sufficient provision for storage and working space. Lastly, regular monitoring and evaluation of the cooperative and integration process.

Micro- and Small Enterprises and Community-Based Organisations

An alternate approach is to organise informal recyclers into MSEs or CBOs. With CBOs, the informal recyclers form groups to provide a service to communities with poor living conditions. Informal recyclers can use the e-waste collected as an income source and simultaneously create a clean environment for themselves and communities. The municipalities and other stakeholders are indirectly involved in this approach.

With MSEs, informal recyclers organise themselves to provide e-waste to MSEs in exchange for fixed fees, supported by municipalities as they are the legally obligated entity that contract MSEs. In some countries, the responsibility falls to residents who pay the local government for this service, which in turn pays the MSEs (Aparcana, 2017a). The capacity of the informal e-waste sector to structure its activities and determine normal working hours enhances the potential to act as a contracting partner for the government and formal e-waste recycling facilities (Gerdes & Gunsilius, 2010). In developing countries, this can be an unsustainable model if the local government is untrustworthy and does not regularly pay MSEs. A better approach would then be for communities to pay the MSEs directly (Aparcana, 2017a).

Formal workers

The third approach is to integrate the informal e-waste sector into the formal e-waste management sector without middlemen. Informal recyclers are also motivated to formalise individually even if the whole informal e-waste sector does not formalise. The initiation of this approach ideally starts with a project to officially show the informal e-waste sector that it can work within the formal e-waste sector. The formal e-waste sector then buys e-waste from

informal recyclers and provides services and support programmes. Some formal recycling companies can also employ informal recyclers. However, the preferred approach is to recruit informal recyclers for collection and recycling for specific activities (Aparcana, 2017a).

Approach challenges

Approaches one and two have a greater link between each other than approach three. Approach one and two provide better support for formalisation and encourage strong stakeholder engagement, partnerships, communication, and collaborations, which is a necessity to organise the informal e-waste sector. Approach three limits negotiation and communication with other stakeholders as informal recyclers are recruited individually (Gerdes & Gunsilius, 2010; Gutberlet, 2011; Velis et al., 2012). Financial and economic measures in approaches one and two are handled the same for the informal e-waste sector, whereas approach three determines this by the type of arrangement between the informal recyclers and formal employers (Aparcana, 2017b).

The challenges and success factors of these three formalisation approaches have been tabulated by Aparcana (2017b), as displayed in Table 5.

Table 5: Challenges and success factors of formalisation approaches adapted from Aparcana (2017b)

Formalisation approach	Country	Case study	Challenges	Success factors	Reference
Cooperatives	The Philippines	Linis Ganda Programme, Metro Manila, Illoilo City	Corruption around waste services, power conflicts around authorities Lack of data, awareness, infrastructure	Diversification of waste, strong leadership, support of public authorities Development of local services, pilot projects, diversification of products, stakeholder involvement	(Bennagen et al., 2002) (Paul et al., 2012)
	Brasil	Joao Pessoa	Lack of management authorities in public administration, education and data, and trust	Local government investment and coordination, awareness activities, and education programmes	(Casanova et al., 2009)
		Diadema	-	Legal support, diversification	(Gutberlet, 2011; Yates & Gutberlet, 2011)
		Londrina			

Formalisation approach	Country	Case study	Challenges	Success factors	Reference
			Bad infrastructure, health, logistics integrating problems,	Government commitment, income through waste fees, contractual relationships, stakeholder involvement, transparency	(Gutberlet, 2011; Terraza & Sturzenegger, 2010)
			-	Diversification	(Medina, 2000)
	Colombia	Medellin Bogota	A high percentage of rejected material	Diversification	(Terraza & Sturzenegger, 2010; WIEGO, 2009)
	Peru	San Vicente de Canete	Lack of diversification, funding, involvement, and awareness; mistrust	Awareness and support, increase social inclusion	(Aparcana & Salhofer, 2013)
	India	Pune	Low willingness to pay	Diversification, increase bargaining power through sorting and storing places	(Chikarmane, 2012)
		Mumbai	Lack of support from communities; revenue recovery	Diversification, user pay principle, adequate legislation	(Gutberlet, 2011; Terraza & Sturzenegger, 2010)
MSEs and CBOs (low-income communities)	Kenya	CBOs in Nakuru	Consumers unwilling to pay for collection, lack of awareness, financing, and appropriate disposal sites	Use pay principle, public sector support and involvement	(Mwanzia et al., 2013)
		CBOs in Mombasa	By-laws still in progress; lack of municipal support, technical capacities, health schemes, and commitment of informal recyclers to stay in organisations; corruption; poor leadership	Improved services	(Kuria & Muasya, 2010)

Formalisation approach	Country	Case study	Challenges	Success factors	Reference
	Egypt	CBOs in Cairo	Lack of informal recycler empowerment	Diversification	(Gerdes & Gunsilius, 2010)
	Kenya, Zambia, Tanzania, and Uganda	MSEs East Africa	Lack of business capacity; dependant on external funding; lack of authority support; poor working conditions; consumers unwilling to pay for collection	Privatisation	(Casanova et al., 2009; ILO-IPEC, 2004)
	Honduras	MSEs in Comayagua	-	Cooperation with the public and private sector; municipality support and awareness	(Grosen, 2012)
Formal workers	Indonesia	Gianyar	Lack of good marketing	Local stakeholders' involvement, reduced social conflict	(Zurbrügg et al., 2012)
		Banda Ache Plastic Recycling	-	Social benefits; job security; fixed income	(Periathamby & Tanaka, 2014)
	Peru	Santiago de Surco	Only short-term contracts; lack of health services; low motivation and awareness from informal recyclers	Fixed and stable income	(Aparcana & Salhofer, 2013)
	Bangladesh	Dhaka	Lack of business capacity; difficulty in obtaining permits	Collaboration of authorities; support through legislation; transparency and good governance	(Casanova et al., 2009)
	India	Chennai city	Lack of coordination between stakeholders	Community involvement; effective source separation; reduced fees for households;	(Baud et al., 2001)

Monetary and non-monetary incentive models

In all three of these approaches, the key link for formalisation is incentives. Introducing monetary incentives is the motivational tipping point to direct e-waste from the informal e-waste sector to the formal e-waste sector. Incentives can either follow a subsidy, dysfunctional market, or economic model. The best profitability model depends on the economic and technological conditions, as well as policy regulation. A trade-off between these models needs to be determined within each country. If the informal e-waste sector is more profitable, the financial gap needs to be filled with public subsidies. However, if the formal e-waste sector is more profitable, functional markets are a better option (Williams et al., 2013). The next section explains the three profitability models in more detail.

Firstly, looking at the higher informal profitability – *subsidy model* (Williams et al., 2013). The market forces alone will not lead to enough motivation for formalisation and therefore public subsidy is needed. The subsidy should be just enough to ensure that informal recyclers are paid more by cooperatives or formal recyclers than informal buyers. If cooperatives are used for formalisation, public funds can be billed on behalf of public organisations. Funding within public funds is either collected from local or international domestic recycling funds, EPR or deposits according to the volume and materials per channel, and recycling fees paid by consumers (Williams et al., 2013).

Next is higher formal profitability – *dysfunctional markets* (Williams et al., 2013). Even though economic profitability flow from the informal to the formal e-waste sector is possible, it is not ensured. This is, thus, why the markets are referred to as dysfunctional. Dysfunctionality can transpire due to market failures, such as social or organisational barriers, which occur because of the non-optimal allocation of economic resources. In practice, this can be seen in information asymmetries, externalities, non-competitive markets, or public goods. Five obstacles can lead to market failure for which an environmental policy could intervene to try and resolve these market failures (Williams et al., 2013):

1. The legislation regarding informal recycling – Even though interface organisations do engage in informal collection or dismantling, any illegal activities of the informal e-waste sector can still place them at risk.
2. Insufficient knowledge to create links with the formal e-waste sector.
3. A lack of capital to establish collection, purchasing, and selling channels for e-waste materials – The time delay between purchasing e-waste from informal recyclers and receiving payments from selling e-waste indicates that a financial buffer between these activities is needed.

4. The negative image associated with the informal e-waste sector – Companies might be reluctant to purchase materials from interface organisations that work for the informal e-waste sector.
5. The strong loyalties within the informal recycling chain can prevent e-waste flow to the formal e-waste sector.

2.5.4. Considerations for and challenges of successful formalisation

Several other considerations exist taking into account the formalisation roles and responsibilities of stakeholders and cooperatives, the characteristics of informal recyclers, and various success factors to set up a sustainable and successful formalisation framework.

Formalisation roles and responsibilities

Within the process of formalisation, producers and formal e-waste recycling facilities will primarily be responsible for integrating the informal e-waste sector. The type of formalisation depends on the relationship and the potential of the relationship between the sectors (Hinchliffe et al., 2020). Additionally, the formalised system must consider the government or municipal rules, the locations of e-waste collection and processing, the continuous funding of the e-waste management system, and how to control e-waste flow to ensure legality (McCann et al., 2015; Yose, 2014). Both sectors must be able to notice the positive impact of formalisation and the mutual benefits of collaboration. The challenge is to portray this value-added to continue feasible financial operations.

Interface organisations benefit from formalisation as well. Interface organisations such as aggregators, unions, cooperatives, and PROs provide a central point between both sectors, as well as the government and municipalities (Hinchliffe et al., 2020). Interface organisations are, however, not always needed for collaboration between the two e-waste sectors, and can cause additional costs for the formal e-waste sector. However, the problem that the formal e-waste sector then faces is increased effort to interact with the informal e-waste sector. The type of formalisation will, thus, not only depend on the relationship between the sectors, but also on the size, structure, and location of formal e-waste recycling facilities (Hinchliffe et al., 2020).

There are also more general issues with using an interface organisation. E-waste values greatly in size and value. The interface organisation will need a system to assign prices to e-waste of different grades and categories. For some products like circuit boards, grades are based on the number of gold contents. A strong business aspect can help to ensure a competent and effective system is developed and implemented. Another issue is that formal

e-waste recycling facilities only recycle certain components of e-waste. The interface organisation will need to act as a guarantor between the two e-waste sectors to ensure the correct e-waste flows to the correct facilities. Lastly, there is also the issue of developing an interface organisation. Responsibility will either fall to the local government, willing formal e-waste recycling facilities or e-waste institutions. The latter option will be beneficial as formal e-waste recycling facilities and institutions have more knowledge of e-waste activities and a better reputation regarding corruption (Williams et al., 2013).

The involvement of stakeholders and organisations also relates to financial support. The formalisation framework must build on the level of support stakeholders are willing to offer and the needs of the informal e-waste sector. This support can be operational assistance, cooperative registration, infrastructure, equipment access, transport, and electricity. Where funding is not provided, collaboration with various entities for funding and grants is an option.

Care should be taken not to fast-track activities. Organisations should be able to comfortably handle progress and not be left with debt (Muswema et al., 2016). Complete integration is also not necessary. Initiatives that have tried to fully integrate the informal e-waste sector saw a high drop-out rate and a loss of income for informal recyclers (Gerdes & Gunsilius, 2010).

Informal recyclers' characteristics

The attributes of individual informal recyclers will also influence the potential for formalisation. These attributes are motivation, passion, and hard work. Informal recyclers and formal e-waste recycling facilities should realise that formalisation is not a quick and instant solution. Good individual attributes will, thus, be important. Additionally, the interaction of individuals within teams is also important. Individuals must be able to work in teams and not cause unnecessary conflict. The longer individuals are associated with each other before forming a cooperative, the more successful and sustainable formalisation will be. Only forcing individuals together through incentives before knowing each other is dangerous. Natural progression and relationships are needed (Guerrero et al., 2013; Muswema et al., 2016). People who are forced to work together without consensus are a significant reason for formalisation failures (Muswema et al., 2016)

Good administrative and operational considerations – such as record keeping – help with open communication, transparency, and good decision-making (Guerrero et al., 2013; Muswema et al., 2016). Training and mentorship from cooperatives and stakeholders, before and throughout formalisation, affect the understanding of the formalisation and formal e-waste

recycling facilities' business model, how it functions, and the governance (Muswema et al., 2016).

Formalisation success factors

Throughout integration, the objective of striving for a sustainable integration process should focus on increasing the income of the informal e-waste sector, improving its working conditions, and providing long-term perspectives (Gerdes & Gunsilius, 2010). Gunsilius et al. (2011) further identified more success factors to be considered through formalisation:

- Involve the informal e-waste sector or representatives whilst setting up a formalisation plan.
- Improve the social recognition of the informal e-waste sector through awareness campaigns, and partnerships with stakeholders and organisations.
- Provide training programmes to the informal e-waste sector.
- Provide information about the recycling markets and prices.
- Analyse the feasibility of formalisation and new recycling initiatives.
- Establish partnerships with the formal and private sectors to improve the relationship of the informal e-waste sector with the industrial value chain.

Timm et al. (2020) support and add on these success factors:

- Set clear collection and recycling targets for municipalities.
- Provide training programmes for formal e-waste recycling facilities as well as train and integrate the informal e-waste sector.
- Focus on education for political leaders and decision-makers on the importance of the informal e-waste sector and incorporating the informal e-waste sector into the e-waste management system and legislation.
- Set up policy development, implementation, monitoring, and evaluation plans.
- Create initiatives to create awareness and end stigmatisation.
- Guide analysis on the existing informal e-waste sector collection system to gain insight for a successful integration plan and apply this to various contexts.
- Set up dispute resolution mechanisms and guidance for different stakeholders to work together.

DFFF & DSI (2020) also set up principles for integrating the informal sector into the solid waste management system of South Africa. These principles have been adapted to the e-waste management system:

1. Understand – Stakeholders working with the informal e-waste sector should understand:
 - Who the informal e-waste sector is
 - The role and contributions of the informal e-waste sector
 - How the informal e-waste sector collects and salvages e-waste
 - The key challenges the informal e-waste sector faces
 - Why the informal e-waste sector should be respected
 - What informal e-waste sector integration, the plan, and why it is important
2. Commit – All parties must commit to the integration to see success.
3. Engage – Work together and assign a team leader who is responsible for engaging with the informal e-waste sector, meeting with them regularly, and sharing all relevant information.
4. Support – Provide support for the informal e-waste sector to strengthen their capacities and enable full participation in discussions relating to waste management and integration.
5. Facilitate access – Improve e-waste access for the informal e-waste sector by:
 - Allowing them to collect e-waste from the street
 - Arranging for them to collect from landfills in a safe manner where the informal e-waste sector is already collecting and arranging for landfill permits
 - Informing officials, security, law enforcement officials, and residents that they should not harass but work with the informal e-waste sector
6. Provide infrastructure – Access to storage places, ablutions, and clean water.
7. Reverse harm – Prevent and cancel programmes that are negatively affecting the informal e-waste sector.
8. Address true needs – Use a needs assessment tool to identify the true needs of the informal e-waste sector, and their main problems, and build on this to facilitate better working conditions.
9. Recognition, respect, and reimbursement – The role of the informal e-waste sector should be recognised and considered within the e-waste management system and inequalities should be addressed.
10. Value expertise – Organisations should not assume the needs and activities of informal recyclers or the best form of integration.
11. Meaningful engagement – Include the informal e-waste sector as equal partners in decision-making.
12. Build on existing strengths – The informal e-waste sector excels in e-waste collection and manual dismantling.
13. Increased diversion and cost-effectiveness – Integration initiatives support the cost-effective diversion of e-waste from landfills.

14. Evidence-based – For policies to be evidence-based, piloting can provide the necessary evidence, whilst monitoring and evaluation contribute to future advances.
15. Enabling environment – A safe environment should be created at the local, provincial, and national levels focused on improving working conditions, security, income, and compensation.
16. Holistic integration – Successful integration necessitates changing how the informal e-waste sector is seen and being participants in political, economic, social, environmental, and cultural processes.
17. Register – The informal e-waste sector should be able to register without discrimination and incentivise them to be a part of planning and implementing integration.
18. Plan and move forward – Plan with the informal e-waste sector what the best way forward is and initiate the process.

Multicategorical considerations and challenges

Lastly, Guerrero et al. (2013) further explored considerations relating the policy and legislation, economics, institution, social acceptance, and operations. The influence of these factors is summarised in Table 6 and further explained after the Table. These factors have been adapted from (Guerrero et al., 2013) to apply to the South African context.

Table 6: Five factors that influence the e-waste management system adapted from Guerrero et al. (2013)

Categories	Influences	Reference
Policy and legislation	Adequate policies	(Asase et al., 2009; Guerrero et al., 2013)
	Adequate legislation	(Mrayyan & Hamdi, 2006)
	Strong regulations	(Seng et al., 2010)
Economic	Economic instruments	(Chung & Lo, 2008)
	Private sector participation	(Sharholy et al., 2008)
	Lack of resources	
Institutional	Leaders interested in e-waste management	(Guerrero et al., 2013)
	Knowledge of technologies and good practices	
	Leader knowledge about the e-waste management system	
	Knowledge by municipalities	(Chung & Lo, 2008)
	Inadequate management	(Hazra & Goel, 2009)
	Municipal support	(Zurbrügg et al., 2012)
	Authoritative leadership	(Sharholy et al., 2008)
	Skilled labour	(Mrayyan & Hamdi, 2006)
Social acceptance	Coordination and cooperation between service users and provides	(Guerrero et al., 2013)
	Education and awareness campaigns	

	The willingness of citizens to contribute	
	Citizens participating in decision-making	
Operational	Infrastructure and road quality	(Henry et al., 2006)
	Technical skills	(Guerrero et al., 2013; Hazra & Goel, 2009)
	Suitable infrastructure and equipment	(Guerrero et al., 2013)
	Technologies	(Mrayyan & Hamdi, 2006)
	Reliable data	
	Evaluation of environmental impacts	(Asase et al., 2009)

Poor understanding and misinterpretation of *legislation* is a setback for the e-waste management system and is, unfortunately, a reality in South Africa (Dlamini & Simatele, 2016; Godfrey et al., 2016). Poor international, national, and provincial laws hamper the implementation of appropriate strategies. Inadequate governance of existing policies also adds to this. More so, the flooding of legislation makes it difficult for the formal e-waste sector to participate in e-waste recycling and be competitive (Godfrey et al., 2016).

Municipalities generally fail to collect waste due to poor financial management and the use of needed *economic* tools (Guerrero et al., 2013). Poor financial management is seen through poor waste recovery, inadequate funding, and corruption. Not only does this lead to economic decline, but it also influences operational expenses and the ability to complete recycling activities (Godfrey et al., 2016). Operational success depends on active municipal and citizen participation (Guerrero et al., 2013).

Institutional problems include inconsistent collection and services, inadequate collection and handling capacity, and ineffective legislation (Godfrey et al., 2016). Inadequate leadership is most often the biggest institutional factor (Chung & Lo, 2008). Institutional problems also arise due to the lack of trained labour (Godfrey et al., 2016) and available information from recyclers and the public (Seng et al., 2010).

Lastly, *social* factors associate informal recyclers with a low social status which leads to little motivation (Guerrero et al., 2013). Low priority is also given to the work of informal recyclers, which results in limited skilled and trained informal recyclers (Sharholy et al., 2008), and harassment of informal recyclers (Dlamini & Simatele, 2016).

The factors listed in Table 6 are further elaborated in Table 7. Table 7 provides a summary of challenges within these five categories that can prevent formalisation and recommendations that can help overcome these challenges. The responsible parties for these recommendations are also listed (Aparcana, 2017a; Yose, 2014).

Table 7: Five categories that act as formalisation challenges adapted from Aparcana, 2017a; Yose (2014)

Categories	Challenges to formalisation	Recommendations for formalisation (Velis et al., 2012)	Responsible parties
Policy and legislation	Lack of adequate and clear legislation	Favourable legislation with political support and law enforcement	The government
	E-waste legislation falls under hazardous waste	Focus on eco-efficiency and EPR	Electronic producers
Economic	Lack of finances, support from the government, weak fundraising	Expansion of financial basis and incentives	The government
	Consumers are willing to pay for householder refuse collection but not e-waste collection	Households must be willing to pay for both waste collection services	Industry Communities Consumer support
Institutional	Lack of cooperatives, e-waste institutions, and management from local authorities	Formation of cooperatives to organise the informal e-waste sector	The local government
	Environmental protection and economic goals in conflict Roles and responsibilities of organisations confused, a rare collaboration	Stakeholder collaboration, involvement, partnerships, good relationships	The formal e-waste sector
Social acceptance	Lack of education and awareness of the waste management system	Education and awareness campaigns, training	The government
	The social rejection of informal recyclers and general disrespect	Informal recyclers' empowerment, acknowledgement, acceptance, and inclusion Safety practices and environmental health improvement	The formal e-waste sector Consumers
Operational	Lack of infrastructure, trained workforce, management expertise, and record-keeping	Asses existing waste management documents and improve data collection and quality	The government
	All e-waste recyclers require expensive licenses	Asses operational requirements and the improvement thereof Development of inclusive norms and standards for the informal e-waste sector	

The most frequent challenges after formalisation initiatives have been implemented are observed under the legislation, organisational, and economic measures (Aparcana, 2017b). 75% of the case studies experienced challenges with legislation. The legislation adds to the lack of empowerment of the informal e-waste sector and negotiation power. Policies that realise the informal e-waste sectors' potential have been implemented more successfully (Aparcana, 2017b).

50% of case studies experienced challenges with institutional measures. There are conflicts between authorities and cooperatives, mistrust among informal recyclers, and corruption. Lack of transparency during formalisation, lack of legislative clarity, and lack of distribution of roles and responsibilities add to these challenges (Aparcana, 2017b).

Within the economic measures, 45% of case studies experienced challenges. The lack of support makes it very challenging to provide enough incentives for the informal e-waste sector. For sustainability, it is important to look at financial mechanisms, payment schemes, strengthening of business capacities, and diversification of waste services (Aparcana, 2017b; Velis et al., 2012).

The last challenges were experienced with social barriers – 40%, and operational aspects – 30%. Social challenges included a lack of awareness from the formal e-waste sector regarding the importance of the informal e-waste sector, low job satisfaction, and commitment to informal recyclers. Organisational challenges include a lack of skills, reporting volume and quality of data, and the current circumstances of the informal e-waste sector (Aparcana, 2017b).

2.5.5. Attempts to formalise waste picking in South Africa

After looking at case studies on the considerations and challenges of formalisation, further case studies on the attempts at formalisation were explored. There are, however, no case studies specifically on e-waste formalisation in South Africa and very few studies have touched on the formalisation of solid waste management. Even fewer studies have indicated any kind of significant success. The lessons from local formalisation processes are identified and highlighted in this section to prevent future e-waste formalisation failures in South Africa.

Godfrey et al. (2016) conducted a study in South Africa on the integration of the informal sector in solid waste management. Participants included the formal sector, informal sector, and municipalities. Godfrey et al. (2016) collected data during two regional workshops in Johannesburg and Cape Town that explored the views of the informal sector on formalisation.

From this, the formal sector recognised that the informal sector has a key role in waste management. Despite this realisation, due to different views, there is noticeable tension in the approach to formalisation. These different views include various factors. There is, firstly, no clear preferred approach to integrate the sectors – 44% of participants preferred cooperatives being formed while 33% of participants preferred the private sector directly employing informal recyclers. Cooperatives face numerous challenges such as financial sustainability, limited access to the market and recyclables, and lack of infrastructure. The private sector model creates more administration for formal recycling facilities and runs the risk of exploiting the

informal sector. Preferences also differ based on the location and attributes of the waste system in that area (Godfrey et al., 2016).

Participants in this study further motivated that municipalities must take responsibility for supporting the informal sector and source separation (Godfrey et al., 2016). In a developing country, this is difficult if the government is not completely reliable. Municipality participants indicated that they do not have the resources to take on this responsibility, that it is difficult for local government to contract small businesses or the informal sector, and that due to performance uncertainty, integration of the informal sector creates great risk (Godfrey et al., 2016). Nevertheless, participants still supported that municipalities should at least regulate legislation and be responsible for registering and monitoring the informal sector (Godfrey et al., 2016).

Additionally, Timm et al. (2020) completed a study 'Lessons from Informal Recycler Integration Initiatives', focused on integrating informal solid waste recyclers into the municipal waste management system of the City of Johannesburg Metropolitan Municipality and Metsimaholo Local Municipality. This study focused on the integration experiences of informal recyclers, municipal officers, and residents to understand integration within municipalities. Pikitup, the official waste management service provider to Johannesburg, and The Environment and Infrastructure Services Department (EISD), implemented initiatives to try and integrate informal recyclers. These initiatives included informative awareness videos, the distribution of once-off protective equipment and trolleys, and training workshops.

Informal recyclers were critical about the content of the training workshop and commented that they were taught about materials and separation on which they were already highly knowledgeable. Informal recyclers struggled with legislation and business management topics as they did not understand how it applies to them. The content level was too high and dense, with the sessions being more than an hour long. An extensive amount of information was also lost in translation. EISD did not give the workshop facilitators adequate guidance on what content to include or the level at which the workshops should be presented. Overall, the workshops were intimidating and difficult to apply practically (Timm et al., 2020).

A few needs analysis workshops were conducted for informal recyclers. The key issues that emerged were the need for trolleys, payment by cash and not bank deposits, harassment, and the lack of identity cards. A committee was also created for informal recyclers to gather monthly with one representative from each Johannesburg region. These meetings stopped soon after due to limited attendance. There were attempts to register informal recyclers, but officials failed to find informal recyclers to register (Timm et al., 2020).

It was discussed that the limited funding Pikitup and EISD received, should rather very carefully have been distributed. For example, informal recyclers only received one set of clothing that would not last long. Also, providing each cooperative with infrastructure and transport is not as effective as central recycling hubs where informal recyclers can sort and store materials, have access to equipment, health care, and ablutions, and work together (Timm et al., 2020).

Municipal and formal participants highlighted more problems that they faced throughout these initiatives and during the process towards integration (Timm et al., 2020):

- Officials received insufficient support, guidance, and finances. Officials had to rely on their own experiences to come up with strategies and approaches to work with informal recyclers. This led to different understandings of how to work with informal recyclers. This lack of clarity led to disagreements and tension between officials and informal recyclers.
- Municipalities did not realise the existing complexities of the informal sector. Municipalities could also not agree on a definition for integration.
- Officials believed informal recyclers should only be paid for the sale of recyclables and not for the collection of the materials, even though private companies are paid for this.
- The belief that cooperatives are synonymous with integration, even though 91% of cooperatives in South Africa have failed by 2015 (Timm et al., 2020). Officials should not underestimate their responsibility within integration even though cooperatives exist.
- Informal recyclers were not included in any of the municipalities and Pikitup's integration plans, even though they were the main stakeholders affected. This exclusion infuriated wasted pickers who want to be treated equally.

There were also challenges related to cooperatives. Firstly, cooperatives should not only consist of informal recyclers as this causes dependence on guidance from formal recyclers or officials. This is a major challenge for sustainability. Pikitup experienced it in such a way that cooperatives depended too much on them long-term and did nothing when they were not assisted. Further problems arose with contracts between cooperatives and private companies. Even though private companies were motivated to work with cooperatives, no guidance regarding how this relationship would work was given. Contracts did not monitor if informal recyclers were being integrated, and no consequences were applied if they were not.

Contracted informal recyclers also then provided households with collection services but were not allowed to collect recyclables for themselves. This created a worse relationship between informal recyclers and households and left informal recyclers worse off than before (Timm et al., 2020). Informal recyclers believe that they should be able to collect recyclables and be

paid for their collection services. Legal compliant ways should exist for informal recyclers to be paid, fairly and justly. Informal recyclers further believe that the integration process should include their input as a form of showing respect, engaging as equals, and being included in the decision-making process (Timm et al., 2020).

The biggest challenge officials faced was the development of an integration framework. There were too many issues that were not agreed upon. Officials lacked decision-making authority. The integration framework could, thus, not be finalised. There was great legal tension during registration that led to the collapse of the campaign. Legally, non-South Africans could not be registered, which led to conflict points. Furthermore, during workshops and campaigns, informal recyclers lost a whole day of income, which officials did not account for and could not support. The city's disregard for informal recyclers did not help with funding either (Timm et al., 2020).

After the study was completed, the biggest shortcomings were summarised (Timm et al., 2020):

- Policies and strategies are inconsistent and do not provide enough guidance for all the parties involved.
- Officials also had little authority in decision-making.
- Private companies are prioritised over informal recyclers, with the central role of informal recyclers eliminated.
- Pikitup and EISD barely featured the informal sector integration in their objectives which led to insufficient funds, support, training, and planning time.
- An overall lack of communication and agreement.

The biggest wins from this study were that (Timm et al., 2020):

- The City of Johannesburg has been the only municipality in South Africa to implement initiatives committed to supporting informal recyclers.
- In a very limited funding environment, Pikitup and EISD found innovative ways to obtain government funds and industry support.
- Pikitup and EISD managed to shift some of their approaches to meet the demands of informal recyclers.
- Even though the integration was not successful, progress in the right direction was made and demonstrated that it is possible to work collaboratively to form an integration framework.

2.6. Theoretical formalisation summary

The core elements of an informal e-waste formalisation approach that emerged from the literature were taken to create a comprehensive, theoretical, formalisation summary. The steps of this theoretical formalisation summary include:

- Utilising the current channels and stakeholders
- Creating partnerships and relationships for formalisation
- Indicating how an EPR principle is helpful and can be applied
- Stipulating protocols and incentives that are crucial for successful formalisation
- Specifying the monitoring of the formalisation process

The theoretical formalisation summary is displayed in Figure 5. These steps apply to all the stakeholders involved in the formalisation process – the formal and informal e-waste sectors and the government – and should be applied in order. To be able to create partnerships, the existing channels and stakeholders must first be established. Only then after the partnerships are created, EPR can be assessed in terms of the partnerships. The protocols and incentives are then based on the type of partnership and mutual agreement within the partnership. Lastly, monitoring of the whole formalisation process should be set in place. The steps in the theoretical formalisation summary would be able to function independently to a degree. However, it is advised that the flow be followed throughout formalisation to deliver the most successful and sustainable implementation.

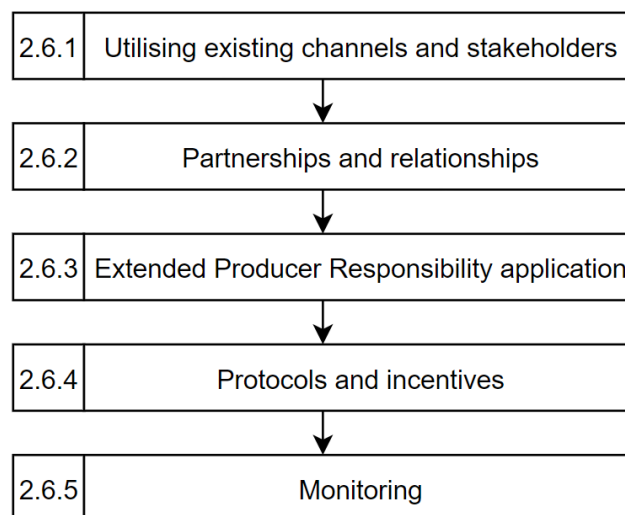


Figure 5: Theoretical formalisation summary based on literature

The summary is used to connect the theoretical concepts of the literature to the data collected and provide guidance to interpret the data collected. The summary highlights key steps in the

formalisation process which further guides the development of the qualitative interviews by highlighting considerations to incorporate for formalisation. Lastly, the summary is incorporated into the recommendations of the study in conjunction with the findings of the study. The five steps of the theoretical formalisation summary will now be unpacked to explain the different considerations and challenges within each step.

2.6.1. Utilising existing channels and stakeholders

Utilising the potential of existing informal collection channels leads to a more comprehensive, consumer-friendly, and inclusive take-back system. By recognising the informal e-waste sector, e-waste collection can more easily be quantified, making record-keeping and assessment of the data much easier and more accurate. This will in turn help with forecasting the e-waste generated, which helps planners and policymakers to develop new management plans (Panwar et al., 2018).

Common purpose and goal

The first step towards formalisation is to coordinate the informal e-waste sector into formal enterprises to upgrade their current recycling methods. Next, the foundation for formalisation must be identified, such as legal frameworks, building capacity, and monitoring (Davis & Garb, 2015).

To use the existing informal channels within formalisation, a joint collection system should be set in place. A joint collection system will overcome many issues of environmental laws, complete the recycling system to be more comprehensive and achieve a higher e-waste recovery rate. Through using an interface organisation, a common collection site can be established to hire informal recyclers for collection (Panwar et al., 2018). Throughout this collection, the same existing e-waste channels will be used. The only difference is that the informal collectors – registered with formal e-waste recycling companies – will collect e-waste from households and consumers and deliver it to the appropriate recycling facilities (Davis & Garb, 2015; Henzler et al., 2018). Formal e-waste recycling facilities then buy the e-waste from informal recyclers with support from cooperatives (Panwar et al., 2018).

Stakeholder analysis

For this joint collection system to work, a thorough analysis of the existing collection and recycling channels and stakeholders needs to be conducted – the quantities, constraints, prices, people, and dynamics (Davis & Garb, 2015; Henzler et al., 2018). Even though statistics regarding the informal e-waste sector are available, little is truly known about informal

networking, how tasks are distributed, and the financial support or buyers of the e-waste (Henzler et al., 2018; Lundgren, 2012). According to (Henzler et al.) 2018, this analysis of the stakeholders should cover all applicable parties of the informal e-waste sector and assess their willingness to formalise (Henzler et al., 2018; Lundgren, 2012).

Analysing the current stakeholders enhances knowledge to understand the different stakeholders. This might seem easy but there are many constraints to obtaining sufficient, accurate data from both sectors. Both sectors would need to be surveyed about their daily activities, dynamics, constraints, and challenges faced (Henzler et al., 2018), such as (Davis & Garb, 2015; MoHUA, 2016):

- The type of waste handled
- The size of each recycling sector
- Where e-waste waste is collected from
- Where work is performed
- Work times and days
- To whom the e-waste is sold
- An estimated daily or weekly income
- Work-experience
- An understanding of the systems and processes
- The policies and legislation applicable to different stakeholders

The size of the informal e-waste sector is especially important to assess the range of informal activities, processes, and work performed, to derive a map of the collection hotspots. If this information is not obtained, key parts of the value chain will be overlooked, incorrect incentives will be devised and implemented policies will not deliver the intended results (Davis & Garb, 2015).

A thorough investigation must be conducted without jeopardising the social and economic benefits communities currently receive (Henzler et al., 2018; Lundgren, 2012). Working through cooperatives, institutions, leaders, or agencies that interact with informal e-waste activities and have a strong standing with the community will be especially helpful in collecting substantive data on ground-level activities. These parties will be vital for creating a sustainable relationship with informal collectors (Henzler et al., 2018). The informal e-waste sector is also less likely to feel threatened if they are questioned by familiar contacts.

Based on the completed analysis, goals, and objectives for the e-waste management system must be determined. These goals can include working towards formalisation through training, supporting the informal e-waste sector by establishing material recovery facilities (MRFs) and using EPR to help lighten the e-waste load (MoHUA, 2016).

Henzler et al. (2018) advised that quantitative targets must not be set and published within external documents, but rather outline a qualitative approach for formalisation. This includes how the informal collectors are integrated into the EPR strategy – either directly or indirectly through cooperatives –, outreach and activation of initiatives, the support offered, the type of incentives offered, and raising awareness (Lundgren, 2012) of sound activities for the informal e-waste sector (Henzler et al., 2018). Internally, however, it is advisable to define quantifiable metrics for monitoring the partnership and ensuring a functional company. These metrics include the number of informal recyclers that are formalised and engaged in EPR activities, and importantly the amount of e-waste, advisably based on the e-waste market volume sourced from the informal e-waste sector (Henzler et al., 2018). Universal collection targets can be set by producers of electronic and electrical products based on discussions with the informal collectors and the amount of e-waste being produced (Panwar et al., 2018).

2.6.2. Partnerships and relationships

After sufficient data has been collected, the correct use of this analysis is crucial. It is important to realise that the integration of the two e-waste sectors is continuous and incremental (Davis & Garb, 2015; Hinchliffe, 2017). If too many changes occur simultaneously, the informal e-waste sector will be overwhelmed and discouraged from formalising. The formalisation will prematurely rely on trust between the two e-waste sectors that cannot be assumed. (Davis & Garb, 2015). The next step in the theoretical formalisation summary is, thus, to create trust-based relationships and determine viable options for partnerships.

Relationship trust building

Developing a good and personal relationship between the two e-waste sectors requires building trust over time. The informal e-waste sector has a long history of exploitation and harassment. The informal e-waste sector has not learned to work with other people and be open to opinions and negotiation (Gerdes & Gunsilius, 2010). Various cooperatives have also disintegrated over time due to inadequate trust between members and external partners. It is, therefore, vital that trust is established for long-term success (Hinchliffe, 2017). A transparent relationship is especially important for the informal e-waste sector as their livelihood depends on the income they acquire from collection and recycling. There is, thus, a need for

mechanisms, such as a binding agreement, to be in place to ensure a trustworthy relationship (Henzler et al., 2018; Hinchliffe et al., 2020). Mediators must communicate the needs of the informal e-waste sector (payment preference, contract type, incentives) and align them with the expectations of the formal e-waste sector (Henzler et al., 2018). Cooperatives are important mediators between the two recycling sectors to keep an open communication channel and convey the needs of the informal e-waste sector to the formal e-waste sector. Cooperatives have high expertise levels in e-waste collection channelisation and provide knowledgeable information and links to the informal e-waste sector (Henzler et al., 2018). It is advisable not to only use powerful collaborators to work with the informal e-waste sector to avoid exploitation (Gerdes & Gunsilius, 2010).

To monitor how the relationship progresses, an agreed-upon baseline for formalisation and e-waste collection must be set (Henzler et al., 2018). This baseline includes e-waste handling, reporting, and collection target metrics that can be measured and monitored (MoHUA, 2016). International e-waste management rules and regulations assist in calculating target metric values (Central Pollution Control Board, 2016; Henzler et al., 2018; Kumar & Singh, 2013).

Partnership agreement

After analysing the existing channels and stakeholders, the type of partnership can be determined, either through interface organisations or directly with formal e-waste recycling facilities. The type of agreement can be oral or written, binding or non-binding (Henzler et al., 2018). There are various arguments for a non-binding agreement. Firstly, trust is a key factor in the formalisation process and acts as a mutually binding regulation. Secondly, contracts can delay or prevent the establishment of partnerships. Thirdly, written agreements are often time-limited and would require regular renegotiation. Agreements should, therefore, provide some flexibility to adapt to changing conditions (Hinchliffe, 2017). Informal recyclers also prefer an open-ended or non-binding agreement, whilst cooperatives (NGOs) are more willing to enter formal, legal-binding contracts (Henzler et al., 2018). A compromise could be made to use contracts to ensure the minimum requirements for formalisation are covered.

In either of the agreements chosen, the financial incentives must be realistic to effectively bridge the price gap between the two recycling sectors. The informal e-waste sector should not be expected to compete at the cost of decent working conditions. Without realistic support from formal e-waste recycling facilities, the current situation will remain unchanged and prevent a successful partnership.

Once a good relationship has been formed with the informal e-waste sector, payment preferences can be discussed, given that realistic targets are met. Every phase of the e-waste management system has different positions and cost structures and should be reflected within the agreement. Payment preference will be based on the partnership and may be different for each case. Other non-financial incentives, such as training, protective clothing, and social benefits, can also be used to increase the attractiveness of a partnership. Regardless of the agreements decided on, the payment system should consider the needs of informal recyclers (Henzler et al., 2018).

Partnership conditions

The partnership must further be tailored specifically to the conditions and value chain structures of South Africa. The partnership must also portray positive impacts and mutual benefits (Hinchliffe et al., 2020). Through analysing the existing channels and stakeholders, the key strengths and risks of both e-waste sectors are identified for utilisation and prevention of harm (Davis & Garb, 2015; Li & Tee, 2012). Building on the strengths of the informal e-waste sector whilst simultaneously diminishing weaknesses can lead to a sustainable partnership and quick and significant improvement of the e-waste management system. Policymakers should also avoid policies that work against the strengths of the informal e-waste sector that will most likely fail (Davis & Garb, 2015).

Hinchliffe et al. (2020) further support this by stating that a partnership between the formal and informal e-waste sectors is co-beneficial. The informal e-waste sector receives various threats from law enforcement, which include harassment, bribery, marginalisation, or being pushed underground. A partnership with the formal e-waste sector can prevent these threats and offer even more benefits. Tangible benefits include security and health care. The greatest benefit is, however, and more constant and reliable income. The formal e-waste sector can in return use the existing informal channels to reach their collection and recycling targets. Long-term, this will also help to lessen cherry-picking from both e-waste sectors (Hinchliffe et al., 2020).

Partnership protocol considerations

Good protocols are needed to ensure that a fair partnership is established. The informal e-waste sector has supplied e-waste to the formal e-waste sector for several years, but there is a lack of transparency from both sectors. Formal e-waste recycling facilities are prone to buy e-waste from informal recyclers for an unfair price and obtain large profits from reselling valuable materials. Good e-waste traceability is the start of a more transparent e-waste management system (McCann et al., 2015).

The design of cooperative protocols is very important and necessitates engagement between relevant stakeholders. In South Africa, there are few, if any, mutually beneficial policies that have originated from consulting the informal e-waste sector. This is a great concern as participation from both e-waste sectors leads to empowerment, increased trust, a more comprehensive e-waste management system, and better quality of environmental management decisions – especially managing e-waste that requires transparent and flexible decision-making (Davis & Garb, 2015).

As mentioned in the previous section, using a joint collection system contains various opportunities. However, the challenge of creating a joint collection system is to establish which party will retain overall control and responsibility for operations. An entity such as an e-waste institution or interface organisation is needed to coordinate the various activities according to the different roles and responsibilities of the stakeholders. This entity is also responsible for ensuring that system regulations are enforced and adhered to. The government can also bear responsibility (Davis & Garb, 2015; Mccann et al., 2015) by creating a legislative environment that ensures regulations are enforced (Mccann et al., 2015).

Caution must, however, be taken in selecting the government as the sole entity for this partnership. Even though the government has the power to enforce regulations and has less potential for conflict of interest, other concerns arise. Corruption is a significant problem within the government, which can lead to funding shortages and livelihoods being ruined. Funding flowing in and out of government can be problematic. The government has proven not to be economically efficient, which adds to further administration. Additionally, it is easier for institutions or interface organisations with comprehensive e-waste knowledge to form partnerships with both e-waste sectors. For this reason, it is also difficult for the government to hold an objective and comprehensive view and consider the well-being of the whole community and environment (Mccann et al., 2015).

The government and local authorities are still important. By encouraging a partnership between the two e-waste sectors, public authorities can enforce existing legal frameworks. A partnership increases the chance of legislation being implemented and enforced successfully. Consumers are then assured that e-waste collectors and recyclers are registered and operating legally. A partnership additionally helps to capitalise on the existing informal collection infrastructure and creates opportunities for monitoring e-waste flow (Hinchliffe et al., 2020).

Partnership considerations

Lastly, there are numerous considerations for a successful and sustainable partnership. A partnership should provide long-term support for the informal e-waste sector. Formalisation is more likely to be successful if entrepreneurial thinking is harnessed. Analytical tools can be used for efficient resource allocation. More so if efficient organisational structures are developed and responsibilities are defined. Additionally, it is emphasised that no approach will apply to every city or scenario. Measures and frameworks must be contextualised to the local conditions. The organisational structure of partnerships should consider the entrepreneurial character of the informal e-waste sector and not enforce policies that conflict with the current system. Diversifying the activities that cooperatives take on can also help with sustainability – from collection to refurbishment (Hinchliffe, 2017).

To increase the potential success of formalisation, the most influential individuals within the informal e-waste sector community should be identified and included in the integration process. Integration of reliable individuals will create much more trust within the informal e-waste sector. If such individuals cannot be found, community organisations should be approached (Hinchliffe, 2017). A partnership should be established with these individuals or organisations. This partnership should then be maintained by assessing the relationship periodically through regular meetings and continuous open communication (MoHUA, 2016).

Lastly, the public should also be recognised as a type of partner. South Africa's e-waste management system cannot function without sufficient e-waste and so, support from the public. The needs and problems of the public are also important. Awareness is vital to induce positive behaviour. Separation at the source can tremendously help with e-waste collection (MoHUA, 2016).

2.6.3. Extended Producer Responsibility application

Once a partnership, with mutually beneficial agreements, has been established between the formal and informal e-waste sectors, a plan to implement EPR can be designed. The government and formal e-waste recycling facilities must consider the informal e-waste sector when implementing EPR schemes. EPR schemes can compromise the role of the informal e-waste sector and thereby compromise thousands of livelihoods. The implementation of EPR in South Africa should, as a result, focus on an integrated service-value chain to recover e-waste. Exclusion can also result in considerable conflict. This design of EPR should, thus, focus on recognition, participation, source separation, safe working conditions, and maintaining inclusivity (Godfrey et al., 2016).

As EPR is a relatively new principle that has been implemented in South Africa, manufacturers and producers are responsible for setting up such plans and fulfilling obligations (Henzler et al., 2018). South Africa has made provision that the EPR schemes can be implemented through the “National Environmental Management: Waste Act (NEMWA) (No. 59 of 2008)”. Voluntary EPR has been implemented for several years, with most organisations that focus on solid waste (Godfrey et al., 2016). Formal e-waste recycling facilities can control their resource supply and unpredictable risk by using EPR to close the material loop in the e-waste value chain. A partnership with the informal e-waste sector and interface organisation is a key piece to implementing an EPR scheme on a large scale (Henzler et al., 2018).

Regardless of the theoretical basis of EPR, the effectiveness of eco-design in developing countries has not been proven, especially with complex waste streams such as e-waste. The benefits of an improved design in terms of cost are yet to be proven in developing countries. (Baldé et al., 2017; Torres et al., 2016). Producers face challenges in accepting responsibility due to the lack of e-waste treatment facilities that comply with international standards and existing infrastructure that increases e-waste collection targets. Government support or market-oriented approaches that use compliant recyclers to state a case is needed to improve the standard of e-waste treatment facilities (Baldé et al., 2017). Additionally, the lack of correct record keeping of electronics entering the market makes it difficult to implement a successful EPR scheme (Panwar et al., 2018).

Challenges also emerge with allocating economic responsibilities along the e-waste management system and financing e-waste activities. Financial contributions differ according to various activities, geography, and selected business models (Torres et al., 2016). EPR can help provide funding for incentives, infrastructure, and grants (DFFF & DSI, 2020; Godfrey, 2021). EPR schemes have seen increased recycling for solid waste by redirecting private sector funding to develop local recycling infrastructure and end-use markets (Godfrey, 2021). With a shift in focus towards e-waste, the same increase in recycling can be seen. Even more so due to the value of e-waste. Cooperatives must be involved in funding allocation decisions. Programmes that then receive funding should be required to collect e-waste, promote formalisation, and abide by the chosen formalisation framework (DFFF & DSI, 2020).

2.6.4. Protocols and incentives

After a partnership is formed and an EPR model is developed, incentive and protocol documents must be created for producers to fulfil EPR recycling obligations. Henzler et al. (2018) clarify that incentives are payment for work based on market value, and protocols include reporting on e-waste collected, health conditions, reliability, and transparency.

The informal e-waste sector is primarily motivated by monetary or non-monetary incentives to sustain their livelihoods. The informal e-waste sector is even willing to deter their health for economic gain. (Aparcana, 2017a; Davis & Garb, 2015; Lundgren, 2012; Wilson et al., 2006). Thus, the correct incentives and protocols to adopt formalisation must be determined.

Incentives

Incentives play an important role in formalisation. The informal e-waste sector should rather be incentivised than punished as motivation to formalise. Punishment and legislation are far less effective as the informal e-waste sector already operates in difficult conditions and has survived outside of the law for several years. Legislation has thus far only caused the informal e-waste sector to operate more illegally. In developing countries, legislation implemented by the government with power struggles, volatile regulations, conflict of interest, and unpredictable enforcement is unwise. The informal e-waste sector will only continue to collect e-waste in a more illegal and untraceable manner (Davis & Garb, 2015).

A key challenge experienced in other developing countries is how to establish the correct incentives to reduce illegal activities and redirect more e-waste to formal e-waste recycling facilities (Chi et al., 2011). Incentives must be based on the cost and activities of the informal e-waste sector and its needs (Henzler et al., 2018). Also, legislative support is needed for improved working conditions and recycling rates in the informal e-waste sector (Chi et al., 2011). Legislative changes are needed to allow the formalisation of the informal e-waste sector (Aparcana, 2017a). The informal e-waste sector is often marginalised or harassed within its day-to-day activities. Public recognition is a necessity for legitimising informal activities and a successful partnership (Wang et al., 2016).

A successful partnership will only be sustainable if both parties receive value-added. The informal e-waste sector requires enough incentives to encourage them to collect sufficient e-waste for formal e-waste recycling facilities (Henzler et al., 2018). Incentives do not only have economic purposes but are used for creating an inclusive channel. Informal recyclers who receive an identity card and uniform are included within an organisation and given proof of legal activities, improved security, protection against harassment and unwanted attention, increased respect, and increased work pride (Lines et al., 2016). Security measures can be even further improved by low-cost measures such as allocating storage and handling areas. This lessens the pressure to quickly dispose of e-waste with the fear of theft or operations being halted due to illegality (Grant, 2019). Collaboration between the two recycling sectors further increases bargaining power with the government, companies, and households (Lines et al., 2016).

Monetary incentives

Monetary incentives are based on the market price of e-waste, influenced by quality and quantity (Hinchliffe et al., 2020; Lundgren, 2012). To prevent paying over the market, incentives should start low and increase with market value (Hinchliffe et al., 2020). Monetary incentives can be calculated according to weight or fixed salaries, paid on a monthly or weekly basis.

As an example, Europe devised a remuneration model that can be used to determine the tariff paid per kilogram of e-waste collected. The tariff increases with the amount of e-waste (Tariff A). This tariff can also consider environmental policies to increase the value of the waste (Tariff C). The tariff can also then consider the quality of the e-waste. E-waste that has been damaged, for example, harmful fluorescent lights, will receive a lower tariff (Tariff B). This model is displayed in Figure 6 (Deubzer, 2011).

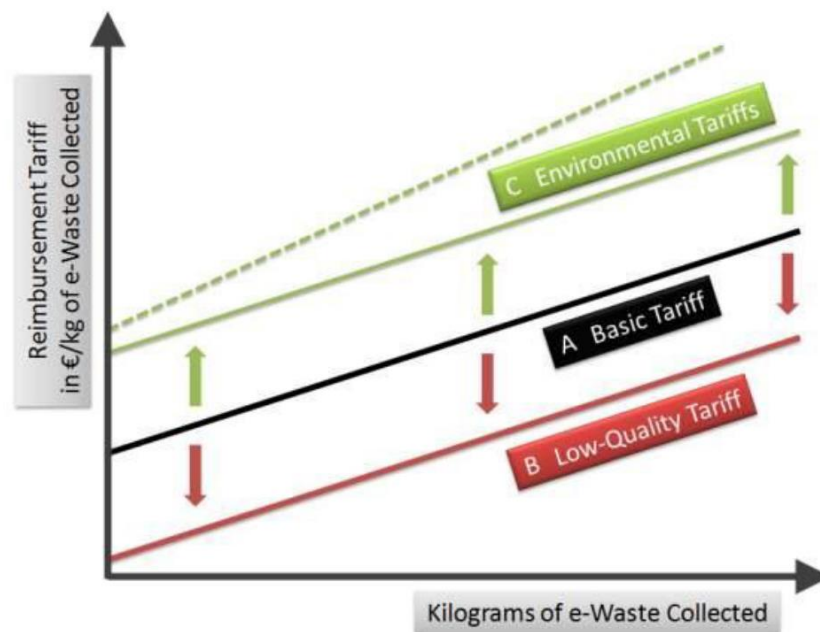


Figure 6: Reimbursement model providing collection incentives

An advanced payment system can help increase motivation for e-waste collection but is, however, only a feasible option with a trust-based relationship (Henzler et al., 2018). Trust must be built through transparency on cost and reporting, information, and awareness-raising campaigns to prevent the exploitation of misunderstandings (Hinchliffe et al., 2020; Lundgren, 2012). Trust must be established even before collection targets are set in place. Prices of e-waste must be decided on together so that both parties are satisfied.

Informal recyclers can then be paid directly into their bank accounts when e-waste is delivered via buy-back centres, recycling facilities, or cooperatives. NGOs can also be contracted to facilitate payments and provide continuous support. Informal recyclers would need to choose their preferred method of payment (DFFF & DSI, 2020).

Non-monetary incentives

Non-monetary incentives add even further value and partly close the price gap (Hinchliffe, 2017). Non-monetary incentives alone are unlikely to be sufficient for formalisation and should be seen as a complementary tool (Henzler et al., 2018; Hinchliffe et al., 2020). Non-monetary incentives include facilitating registration, tax exemptions, access to health care and financial services, protective gear and uniforms, identification documents (IDs), advocacy of workers' rights, skill-building, training on where and how to handle e-waste, transportation of materials with pushcarts, educational facilities for informal recyclers' children, assistance with taxes or legal support, access to various consumers, and awareness creation (Aparcana, 2017a; Henzler et al., 2018; Hinchliffe et al., 2020; Lundgren, 2012; MoHUA, 2016; Wilson et al., 2009; Yose, 2014).

Allowing EPR fund access to the informal e-waste sector is a powerful incentive to formalise. Conditions can be added to these incentives to register, organise, and enforce legislation (McCann et al., 2015). The public also has a part in ensuring a successful formalisation by understanding the importance of the informal e-waste sector. This is the importance of non-monetary incentives and awareness-raising activities (Henzler et al., 2018).

Protocols and regulations

Various regulations and protocols must be included in a partnership to protect both the formal and informal e-waste sectors. Deubzer (2011) highlights the following considerations regarding the setup of protocols and regulations:

1. Regulations must be inclusive and build on existing strengths. Policies should rather enable the informal e-waste sector to formalise than disable its work. The efficiency and diversity of the informal e-waste sector should be considered.
2. Economics, incentives, and institutions must work. Effective plans that address pricing issues must be set in place to address the health and livelihoods of the informal e-waste sector. The formal e-waste sector must consider economics, incentives, and different business models along the e-waste value chain and discuss it with applicable stakeholders.

3. Policies and regulations should also remember the importance of reusable e-waste for the environment and economy.
4. The government and local municipalities should take responsibility for providing financial and regulatory support, as they can also benefit from this. The government should also take responsibility for regulating international laws to prevent illegal e-waste import from developed countries.
5. Better public awareness is needed. Education and information channels need to provide more information on e-waste recycling in general and within the informal e-waste sector to help influence public behaviour.
6. To engage with electronic producers to devise a more inclusive e-waste management model that interacts with all stakeholders.
7. To set up mandatory protocols for recordkeeping of informal recyclers' activities, the amount and value of e-waste collected, collection sites and channels, and the roles and responsibilities of all the stakeholders involved.

Henzler et al. (2018) also state that reporting is a key protocol aspect. Cooperatives and formal e-waste recycling facilities should determine reporting frequencies for e-waste flow and the amount collected, together with the informal e-waste sector. Reporting is a very important and continuous process to be conducted according to e-waste legislation. The Central Pollution Control Board (CPCB) can easily request these records that must be available (Henzler et al., 2018). Protocols further include provisions made for occupational aspects – health and safety standards for the collection, dismantling, and recycling, exclusion of child labour, and transparency and reliability of e-waste activities and costs (Henzler et al., 2018; Lundgren, 2012).

There is further potential to create a database for informal recyclers that can be developed and updated continuously (Dlamini & Simatele, 2016). Registration of informal recyclers can be done through cooperatives and buy-back centres, enabling authorities to collect information on informal recyclers. This information is valuable to indicate the role and importance of the informal e-waste sector (Dlamini & Simatele, 2016). To prevent any unnecessary conflict or miscommunication, focal points of contact between partners must be used. Open communication channels are essential to enable the informal e-waste sector to voice its complaints (Henzler et al., 2018). NGOs can help in forming informal recyclers into cooperatives. These cooperatives can actively create opportunities and improve the lives of informal recyclers (Dlamini & Simatele, 2016). Various stakeholders can commit themselves to empowering informal recyclers – “The Department of Environmental Affairs (DEA), - Environment and Infrastructure Services (EISD), - Economic Development (DED) and buy-

back centres” (Dlamini & Simatele, 2016). A needs analysis workshop is a good opportunity to understand what the informal e-waste sector needs and the issues it experiences (Dlamini & Simatele, 2016).

To ensure sustainability, top-down (policies from the government) and bottom-up (recycling processes and including communities) approaches can be integrated into formalisation (Davis & Garb, 2015). Top-down regulations from the government can enhance bottom-up activities by correctly channelling informal activities. Often e-waste is improperly burned due to the plastic or glass encasing costs that outweigh the valuable materials. Authorities can help reshape the system of incentives to make correct recycling methods beneficial for all stakeholders. These incentives can also be conditioned by laws against burning and dumping (Davis & Garb, 2015).

Municipalities, law enforcement officials, and households must be made aware of these protocols. Standardising protocols makes awareness creation easier. For example, the door-to-door collection is to be completed timely and regularly for a routine to be established. Recycling facilities and cooperatives can also conduct annual consumer surveys to monitor the services received (MoHUA, 2016).

2.6.5. Monitoring

The formalisation process, especially collection targets within partnerships, must then be monitored. Two key success factors to monitor for these partnerships are profit generation and achieving targets (Henzler et al., 2018).

Further activities such as regular reporting, modifying the agreement to fit the purpose, following an implementation schedule, and random periodic audits are needed. A market survey is valuable to understand to volumes of e-waste in the market, its lifecycles, and rising volumes of e-waste (McCann et al., 2015). Monitoring and reporting e-waste flow is almost impossible without the use of digital support. A tracking mechanism can be used to ensure transparency and trace the flow of e-waste (Henzler et al., 2018). Mass-flow tracking can be used to ensure e-waste does not re-enter the e-waste management system to be sold multiple times (Henzler et al., 2018; Hinchliffe et al., 2020). Digital applications also provide opportunities to integrate informal collectors into a formal reporting system (Henzler et al., 2018) and can be used for communication, management of channels, and instant digital payments.

Reporting helps with accountability, non-compliance, data gathering, and analysis (Henzler et al., 2018). Tools such as audits ensure credibility and transparency. Data from the audits can be analysed, documented, and coordinated with applicable parties. Data is the key to the improvement and optimisation (Henzler et al., 2018) of the South African e-waste management system. Overall, digital support helps integrate the informal e-waste sector and learn how to collaborate with them (Henzler et al., 2018).

Lastly, long-term support is crucial. The informal e-waste sectors' livelihoods are at risk if the formal e-waste sector were to withdraw quickly. The formal e-waste sector must, therefore, see these partnerships as long-term investments (Henzler et al., 2018).

2.7. Chapter summary

The literature review started by creating an image of the current e-waste management system. This is the flow of e-waste – consumption, collection, material recovery, and disposal. Within these phases, there are three comprehensive stakeholders – the government, the formal e-waste sector, and the informal e-waste sector. The roles and responsibilities of these stakeholders were also touched on. Further in-depth discussion and comparison were done for the formal and informal e-waste sectors to understand the different activities that take place within each sector.

More context was created by comparing developed and developing countries to show what type of initiatives can successfully be implemented in South Africa as a developing country. One significant success factor of developed countries is adequate legislation and enforcement thereof. Thus, the legislative development for e-waste in South Africa and the existing gap was explored. The need for e-waste legislation that specifically considers the informal e-waste sector was addressed. Successful international regulatory frameworks were explored. Lastly, the challenges to developing this e-waste legislation were considered.

The majority of the literature study sections focused exclusively on the informal e-waste sector. The reason why the informal e-waste sector exists revealed factors such as the economic value of e-waste, industrial interdependence, and socioeconomic conditions. The challenges and opportunities of the informal e-waste sector touched on several factors such as safety and health impacts, social acceptance, and efficiency of the informal e-waste sector. More in-depth reasons for the importance of the informal e-waste sector were looked at.

The potential for the formalisation of the informal e-waste sector was studied. The initiative of formalisation was considered within the context of South Africa. These key success factors of formalisation were considered, as well as the challenges that all the stakeholders in the e-

waste management system can face. These challenges were also considered according to legislative, economic, institutional, social, and organisational measures.

Three main approaches to formalisation – cooperatives, MSEs or CBOs, and formal workers – were then investigated, together with the type of incentive models that will be needed. These three formalisation approaches have been implemented internationally and the key applicable learnings from these case studies have been tabulated.

Lastly, the theoretical formalisation summary was developed to summarise the key formalisation factors discovered in the literature. The theoretical formalisation summary looked at utilising existing channels and stakeholders, relationships and partnerships between the two e-waste sectors, the application of EPR, protocols and incentives to drive formalisation, and monitoring of the overall formalisation process. The theoretical formalisation summary is used in the following chapters to interpret the collected data, assess the potential for formalising the informal e-waste sector, and provide recommendations that could inform future work that considers the perceptions of the informal e-waste sector.

2.8. Synthesis of the research topic

The e-waste recycling management system of South Africa is generally not well-covered in the literature and research gaps emerge. However, the rationale behind the research does not only originate from the research gaps found in the literature but also from the need for formal e-waste recycling facilities to obtain and collect more e-waste. Consequently, the research topic is inspired by related international studies, gaps in the South African e-waste management system, and the unutilised potential of the informal e-waste sector. The purpose of the literature review is to create the context for this study. This context provides a comprehensive and in-depth understanding of the current e-waste management system.

This section aims to bring these ideas together into a conceptual framework which will guide this study. A framework is proposed that shows the interrelationship between different theoretical elements and places a boundary around the study in terms of scope. This framework, presented in Figure 7, highlights the five main points to explore the potential of formalisation within this study. It further identifies the critical relationship between the current activities, challenges, and opportunities of the e-waste management system that affects the potential for formalisation.

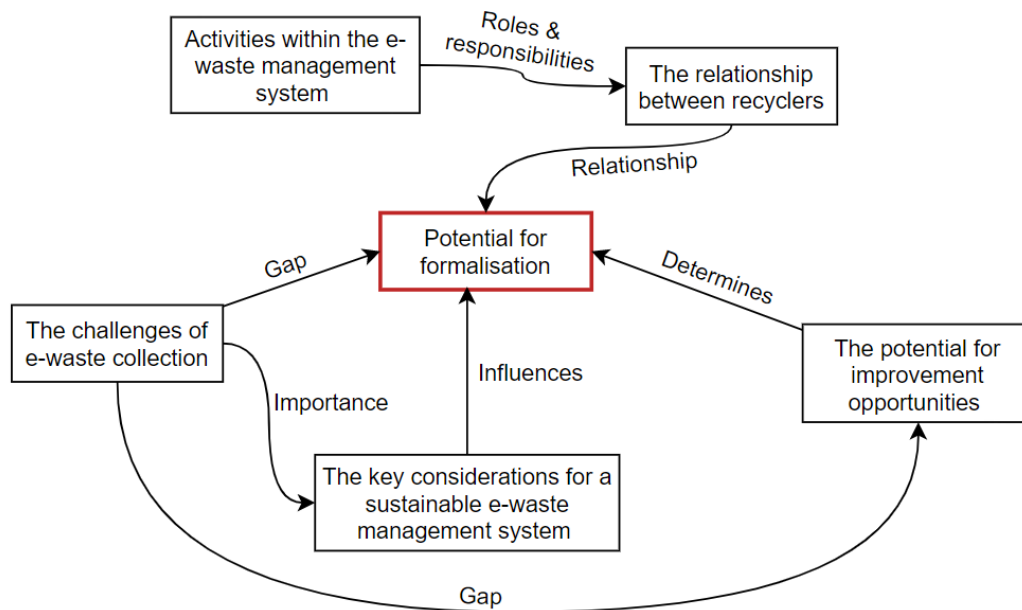


Figure 7: Conceptual framework of theoretical concepts

Although all the factor influences each other and the potential for formalisation in some way, the key connections are indicated. The activities within the e-waste management system influence the roles and responsibilities of the two e-waste sectors. This in turn also affects the relationship between the two e-waste sectors. The relationship status between the two e-waste sectors is an essential part of the formalisation process. Further, the challenges of e-waste collection emphasize the gaps within the current e-waste management system and why formalisation is needed. The challenges also link to potential improvement opportunities that can overcome these gaps and are important to consider for a sustainable e-waste management system. The key considerations for a sustainable e-waste management system influence the potential for formalisation. Similarly, the potential for improvement opportunities is one of the factors that determines the potential for formalisation.

3. Research methodology

The methodology guides the overall structure of the study, determined by the research questions. To achieve the objectives that originated from the research questions, a structured approach is followed. The research design is first explained and touches on the logic behind the study, as well as the chosen data collection method. The research context then gives a more comprehensive view of the study, including the research subject, time and place, and audience. The methodology further explores the different approaches available for data collection and the most suitable options for this study, while the method includes a detailed explanation of the data collection, analysis, and presentation. Lastly, the concepts of validity and reliability, ethical considerations, and an overall summary are given.

3.1. Research design

The research design is the strategic plan to answer the research questions (Oshagbemi, 2017). The purpose is to understand the current situation of the informal e-waste sector, the connection and relationship with the formal e-waste sector, and how the current potential of the informal e-waste sector can be utilised.

This study follows the four key elements for a successful study design; 1) Epistemology; 2) Theoretical perspective; 4) Methodology; and 5) Method (Crotty, 2020). *Epistemology* relates to the nature of knowledge and how it is obtained. It is believed that the knowledge in this study is based on experiences, subjective, and new.

The *epistemological approach* follows a subjective position that requires involvement between the researcher and participants for the data collection. The study further supports that human behaviour is not determined by pre-empted rules and that the responses are determined by their free initiative produced from their perspective and environment (Crotty, 2020).

Theoretical perspective provides context for the study and proves the logic for the choice of methodology and method. This study believes that human behaviour is not determined by pre-empted rules and that the responses are determined by their free initiative produced from their perspective and environment. Participants act voluntarily. Therefore, a *theoretical perspective of interpretivism* is used which values the difference in participant responses to obtain a range of views. Accordingly, the *methodology* and *method* for this study need to follow an idiographic approach that values subjective experiences and responses (Crotty, 2020).

An interpretive approach (Cohen et al., 2011) is chosen for rich data collection analysis of subject responses. For this study, a qualitative approach is chosen as there is a lack of raw data based on experience available in the e-waste management recycling system. A qualitative approach is also deemed best for rich data collection, following the mindset explained by Crotty (2020). A qualitative approach is ideal for analysing open-ended questions using subjective methods. This allows for exploring numerous ideas and gaining insight into each question. Additionally, qualitative research progresses and expands from the opening to the end stages.

In summary, a qualitative research approach based on a subjectivist position is needed to explore the roles and responsibilities of both the formal and informal e-waste sectors and their existing relationship. This also includes current challenges and future opportunities between the two e-waste sectors. Together with literature, themes, and determinants that arise from the data, qualitative analysis is the appropriate strategy to answer the research questions.

3.2. Research context

The study takes place within the e-waste management system of South Africa but refers to relevant local and international research with an applicable timeframe. This study focuses on informal e-waste collection and aims to identify the key considerations for formalising the informal e-waste sector by eliciting the perceptions and experiences of the formal e-waste sector.

Data was not collected from the informal e-waste sector directly as the ethics clearance process found that the risks to the researcher and the institution outweighed the benefits. It is, however, important and valuable to obtain information from the formal e-waste sector on their perception and experiences of the informal e-waste sector. This is because the informal e-waste sector collects more than 50% of the e-waste in South Africa and can be an asset to formal e-waste recycling facilities. This will lead to more economic growth and less detrimental environmental activities. This research will also help to understand e-waste collection and recycling, to help create a more transparent e-waste management system.

3.3. Methodology

As an introduction to the steps followed for the study, a summary is provided in Figure 8 which is elaborated on in the following sections. The literature review is used as a foundation for the preliminary methodology and development of the data collection instrument. The literature review also feeds into the content and thematic analysis and is used for comparison of the data collected. Similarities found within the comparisons enable existing themes to be

emphasised while the differences are used to fill literature gaps. The literature review is, therefore, useful for the interpretation and discussion of the results and analysis. The qualitative interview is used from steps three to six as the selected tool for data collection. The data collected is then used during analysis and processing, and interpretation and discussion.

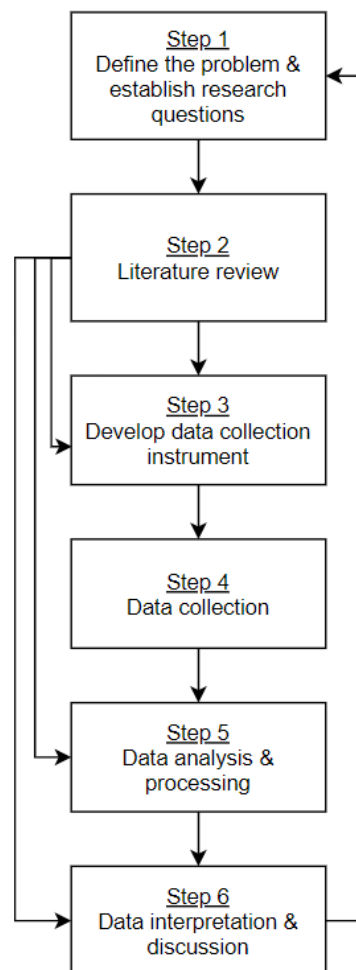


Figure 8: Overview of the research method design

The first step in the overview of the research method is to define the problem and establish research questions. This step is a preliminary methodology developed to enable the researcher to select and develop the data collection instrument. During the first two steps of the study, a literature review is used to obtain a comprehensive view of informal e-waste recycling and the e-waste management system. Through this, the knowledge that the formal and informal e-waste sectors have about e-waste activities and how they use this knowledge is gained. The two e-waste sectors are then compared to identify their main characteristics and differences. This is useful to determine their roles within the e-waste management system. The e-waste context within developing and developed countries is also researched. Thorough research on local and international schemes is conducted to gain insight into the identified problem South Africa faces.

After the literature review, step three is the development of the data collection tool. Very few studies focus on the willingness of the formal e-waste sector to be a part of the formalisation process. Therefore, qualitative interviews are suitable for this study so that participants can provide different, open-ended views. The methodology of this study allows for subjective perceptions and experiences.

Step four is data collection. Primary data collection is used to collect raw data. Primary data refers to qualitative interviews conducted. These interviews give more insight into the perceptions and experiences of the formal e-waste sector, as well as their understanding of the roles and responsibilities of the informal e-waste sector.

Steps five and six are then completed – data analysis and processing, and the interpretation and discussion of this analysis, respectively. This analysis is done through content and thematic analysis.

3.3.1. Data collection

The steps followed within the research method further link to the research questions and objectives of the study. Step four, data collection, specifically speaks to how the objectives are planned to be achieved. This literature review highlights key aspects of the research topic by drawing on relevant e-waste recycling literature that illustrates the importance of the informal e-waste sector and elaborates on how the potential can be utilised. The data collection then further offers new perspectives on the e-waste management system. This section aims to connect theoretical concepts of the literature and data collected to the research questions and objectives of this study.

Research question 1: What is the current state of the formal and informal e-waste sectors in South Africa?

Objective 1: To identify key stakeholders in the e-waste management system and define their roles, responsibilities, and relationships.

The current e-waste management system is explored through literature to give an overview of current e-waste flow and activities taking place, as well as the roles and responsibilities of stakeholders within the e-waste management system. A sector comparison is then used to understand the differences and similarities between the formal and informal e-waste sectors.

The interviews are further used to determine, from the perceptions and experience of the formal e-waste sector, who makes up the informal e-waste sector and which roles and responsibilities it takes on. The role and responsibilities of the formal e-waste sector are also discussed.

Research question 2: *What is the potential for formalising the informal e-waste sector in South Africa?*

Objective 2: To identify the challenges that prevent an integrated e-waste management system.

The second objective is explored through the literature on the challenges and benefits of the informal e-waste sector, as well as the challenges of formalisation. Objective two relates to legislative development, formalisation approaches, and general considerations.

The interviews further include various questions to identify practical challenges that the formal e-waste sector experiences. What works and does not work is also discussed in the context of the practical challenges.

Objective 3: To identify key considerations for an integrated e-waste management system.

The sector comparison from objective 1 links to the potential for formalisation. By understanding the key characteristics and differences between the two e-waste sectors, the unique potential of each e-waste sector that can be utilised to improve the e-waste management system emerges. Opportunities also arise from plans to overcome formalisation challenges and solid waste management (SWM) attempts to formalisation.

From objective 2, objective 3 further explores the considerations and approaches to formalisation, and how key elements from international countries can be applied to South Africa. Through literature, objective 3 considers the contributions of the informal e-waste sector, the challenges and opportunities it currently faces, and how this can be used to be mutually beneficial.

The interview questions and findings highlight possible opportunities to overcome existing challenges within the e-waste management system. The topic of formalisation is also explored. The interview questions are asked in such a way as to understand the willingness of the formal e-waste sectors to be a part of the formalisation process.

Objective 4: To understand how the formal and informal e-waste sectors could be integrated, and what benefits and opportunities could be realised from this.

Objective 4 links to the current e-waste management system and sector comparison. An understanding is needed to identify how these activities and stakeholders can be utilised and integrated. Objective 4 then builds on the opportunities and potential for formalisation. The literature provides a foundation to understand the two e-waste sectors and their relationship, with further understanding provided through the interviews conducted.

Lastly, the interview questions build on the previous questions about the challenges and possible opportunities for the e-waste management system. The interview participants discuss their perception of potential benefits from formalisation, as well as considerations for the process of formalisation.

3.4. Method

The method goes into more detail to explain the data collection that took place. The development of the data collection tool, the data collection process, data handling, and data analysis are also discussed.

3.4.1. Qualitative interview development

Qualitative interviews can be approached in two ways regarding the collection and interpretation of data. The first is a common-sense hypothetico-inductivist model that gathers all relevant information to identify what theory they might suggest. The second is an anti-common-sense hypothetico-deductivist model that looks at the theory of the topic to determine what information is relevant to the study (Wengraf, 2001). The latter model was followed in this study.

Thorough planning for the interviews was needed to extract the full potential from the process. Wengraf (2001) suggests following the framework displayed in Figure 9 to prepare a semi-structured or heavily structured interview, based on the need for the study. The research purpose (RP) and central research question (CRQ) was predetermined by the study. The theory questions (TQ) then relate to questions that can fill gaps identified in the literature and can aid in answering the CRQ. Lastly, the informant questions (IQ) are sub-questions that support the TQ.

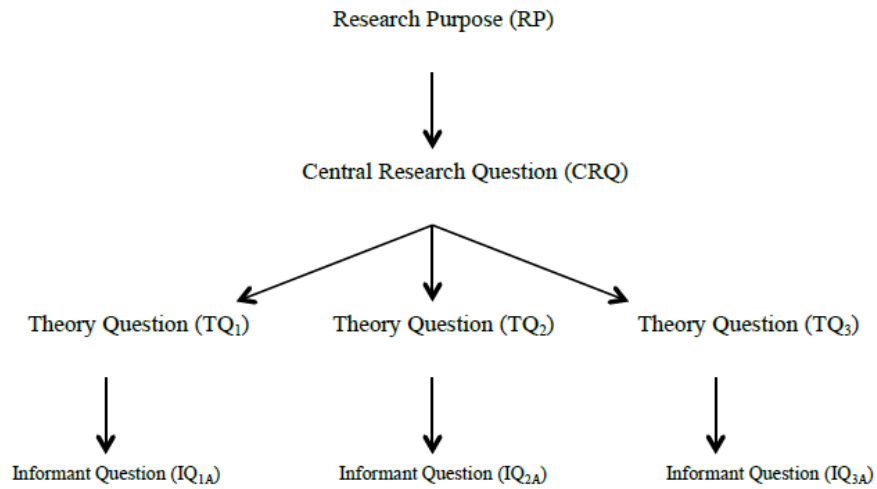


Figure 9: A framework for obtaining interview questions stemming from the research purpose extracted from Wengraf (2001)

The guidelines of Figure 9 were followed to develop an interview question framework, as presented in Table 8. The interview questions were derived based on the research questions **(1.4 Research questions and objectives)**. These questions were formulated in a way to obtain new and valuable information to progress the e-waste management system. The interview protocol is shown in **APPENDIX D D**. The participants were asked a series of open-ended questions (Lakhan, 2015) based on a conceptual framework that emerged from the literature study in section **2.8 Synthesis of the research topic**.

As displayed in Table 8, the interview questions are divided into two categories – formal and informal e-waste sector questions. The formal e-waste sector questions were asked to participants to obtain information about their perceptions and experiences. The informal e-waste sector questions were asked to the same participants to obtain information about their understanding of the role that the informal e-waste sector plays, their perception of how formalisation could work, and what resistance could be expected. Before the informal e-waste sector questions were asked, the participants were also made aware of this purpose.

Table 8: The interview framework stemming from the research purpose and questions of the study

Research Purpose									
This study aims to understand the current circumstances of the informal e-waste sector and its relationship with the formal e-waste sector									
Central Research Questions									
What is the current state of the formal and informal e-waste sectors in South Africa?						How can the informal e-waste sectors potentially be utilised to improve the e-waste management system of South Africa?			
Informant Questions (To formal e-waste recycling facilities)									
Are there any barriers or difficulties that you face when collecting e-waste, for example, any issues or risks around collecting and working with e-waste – safety or health-related? If so, care to elaborate?		Are there any impacts of legislation to register and handle e-waste properly on your business (make it difficult or costly to handle e-waste)?		Have you interacted with informal recyclers? If yes, how often do you interact with the informal e-waste sector and what has your experience been?		What potential do you see in forming a partnership with the informal e-waste sector?	What are the barriers or potential issues of working with the informal e-waste sector?	What do you believe are key things to consider when working with the informal e-waste sector?	What advice do you have for the potential formalisation of the informal collection of e-waste (how do you think the formalisation could work)?
Informant Questions (To formal e-waste recycling facilities on their understanding of the informal e-waste sector)									
How do informal recyclers collect their e-waste and how much do they collect?	Where are the general places/people that informal recyclers collect e-waste from?	Who are the types of people informal recyclers sell e-waste to?	What prices do informal recyclers get for the e-waste or metals sold? Is this enough to make a living on?	Do informal recyclers feel unsafe or face issues when collecting the e-waste?	How big is their collection community?	Is there significant competition between formal and informal collectors?	What do you think can improve the work circumstances of informal recyclers?	Do you think informal recyclers are cautious about change?	Do you think informal recyclers will consider working with formal recycling companies and collecting e-waste for them if this leads to better circumstances?

3.4.2. Population and sampling

The chosen population size and sampling methods are important for the physical data collection of the interviews. Sampling is used to portray a larger group or population that cannot all be contacted.

3.4.2.1. Population

Even though the literature focuses on the whole of South Africa, for the data collection, more populated and developed recycling areas were targeted to recruit interview participants. This is Gauteng, Durban, and the Western Cape. 55% of e-waste recycling in South Africa takes place in Gauteng (Infrastructure News, 2022), whilst the other two provinces are the next biggest contributors to e-waste recycling.

Further, inclusion criteria were developed to recruit interview participants. Participants had to:

- Be a part of the formal e-waste sector
- Be an owner or employee of or at an e-waste company of any size that is involved in the e-waste management system
- Be involved in any activities from e-waste collection to recycling or a part of an institution that works towards the improvement of e-waste management in South Africa
- Be involved with different stakeholders such as consumers, recyclers, or similar employees from other formal e-waste recycling facilities

Similarly, exclusion criteria were developed. Participants were excluded that:

- Worked in the e-waste industry for less than a year with no prior e-waste involvement
- Work within the e-waste industry but only a part of the administrative process, i.e., would not be able to provide valuable information about e-waste activities and stakeholders

3.4.2.2. Sampling

To ensure sampling is done correctly, the correct sampling technique and size are needed for accurate and reliable data.

Sampling technique and size

The study sample size was based on non-probability sampling using the set the inclusion criteria mentioned in the previous section. The non-probability sampling techniques included convenience sampling and snowball sampling (McCombes, 2022). Convenience sampling was used to gather data from the most accessible sources (McCombes, 2022) and snowball sampling

(McCombes, 2022) was used to reach more interview participants. During the interviews, more contacts were obtained to recruit for additional interviews.

For a qualitative study that includes limitations within the data collection, it was difficult to ensure that saturation would be reached. Therefore, purposive sampling was important to rely on the researcher's judgment in choosing the sampling size and which participants to include in the interviews (McCombes, 2022). Contact with the formal e-waste sector was a viable sampling option for data collection. The number of interviews the researcher estimated was 10-20 (Creswell & Creswell, 2018) to gather enough raw data for thorough analysis and saturation to be reached.

3.4.3. Recruitment of participants

Once qualitative interviews were chosen, participants were identified by searching online for formal e-waste recycling facilities and institutions. The company websites were compared to the developed inclusion and exclusion criteria. The contact information of the selected facilities was obtained through the websites. The e-waste recycling facilities and institutions were contacted by email and telephone. Once the participants agreed to be a part of the interview process, the interviews were scheduled for a specific date and time. Simultaneously, the interview questions were sent to the participants via email before the interview for preparation.

In total, a combination of 50 formal e-waste recycling facilities and institutions were contacted. Out of everyone contacted, 12 participants were willing to be interviewed – 11 from e-waste recycling facilities and one from an e-waste institution. Participants from the formal e-waste recycling facilities were either the owners or employees of the company and had been in the e-waste industry for more than a year, with a history of being involved in e-waste activities. These participants were either in charge of e-waste operations or had extensive knowledge about e-waste operations. Additionally, one participant worked at an e-waste institution that helped develop initiatives and host conferences aimed towards the improvement of the e-waste management system.

The interviews were conducted virtually and in person. Virtual data collection included a combination of telephonic, email, or video-conference platforms, based on the preference of the participant. One interview was conducted in person, four interviews were conducted via a video conference platform, and three were conducted telephonically. Another four participants did not have time to schedule interviews and completed the interview questions, of which three allowed follow-up questions through email and telephone. The interview recruitment process is displayed in Figure 10.

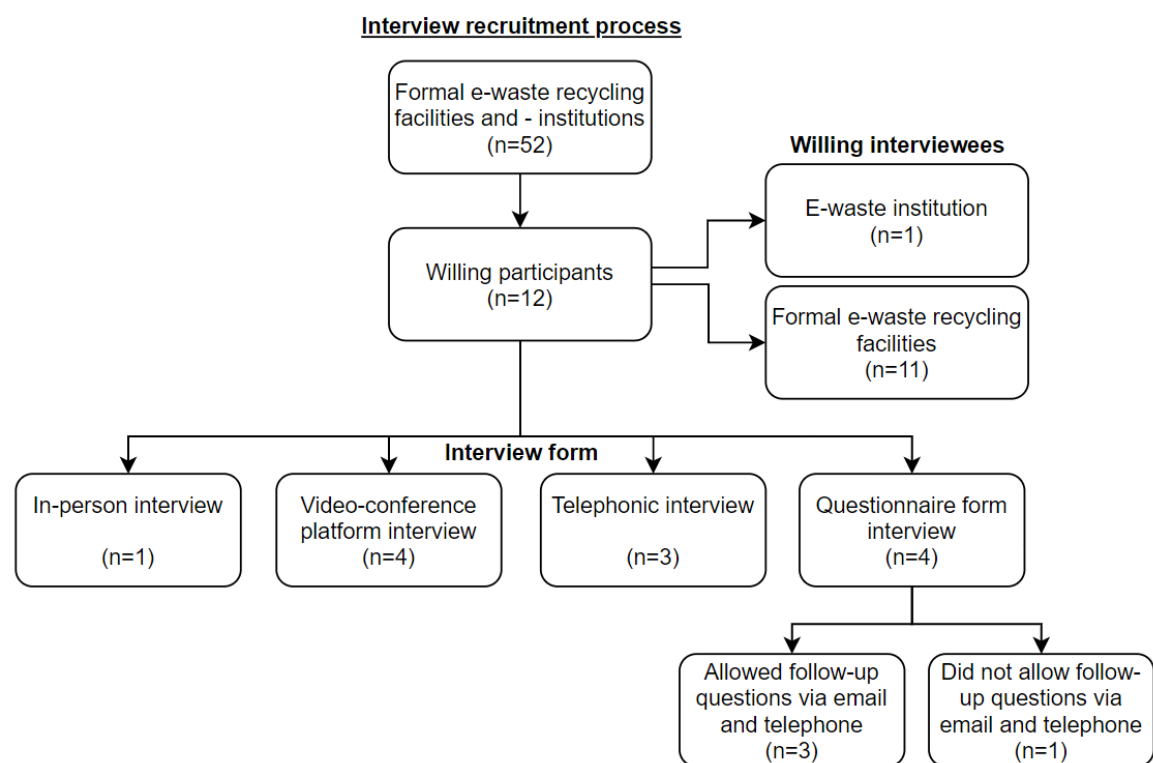


Figure 10: Interview recruitment process

During the interview recruitment process, the background and importance of the study were discussed with each participant, through email and over the phone. Participants were also informed that the researcher is a registered student at a University and that ethics clearance had been obtained. No participants were given monetary or non-monetary incentives to partake in the interview process.

3.4.4. Data collection process

The data collection process could then commence once the interviews were scheduled. Preparation was important to ensure that all the participants understood the purpose of the interviews. The interviews were conducted individually to prevent any influence from other participants in order for different responses to be investigated and understood separately.

The interviews were conducted in a semi-structured way to obtain rich, unaffected, and open-ended information from participants. A semi-structured interview was beneficial to explore deeper issues within the e-waste management system. Follow-up questions were, therefore, not set up before the interviews were conducted, but were asked during the interviews where applicable.

The platforms through which the interviews were conducted are explained in the previous section. The interviews were digitally recorded, and notes were taken during the interviews to later be transcribed. After each interview, the main ideas of the interview were captured with a summary.

3.4.5. Data handling

The data collected from the interviews are kept for the whole length of the study and a further five years. The data is stored by the researcher and the supervisor of the study on an external and online drive. The data folders on both locations are password-protected. For confidentiality and anonymity purposes, the data do not reveal the identities of participants. As explained in the next section, the interviews were coded to remove the identities of the participants. Ethical considerations crucial for the data collection and handling are explained under **3.6 Ethical considerations**.

3.4.6. Data analysis

After the raw data was collected, thematic and content analysis was useful to identify themes within the data. According to Rosala (2019), thematic analysis is “a systematic method of breaking down and organising rich data from qualitative research by tagging individual observations and quotations with appropriate codes, to facilitate the discovery of significant themes”. Content analysis groups data into categories according to themes, words, sentences, or phrases. The content can then be assigned and analysed with the relevant category. One of the approaches used in content analysis is relational analysis (Birmingham & Wilkinson, 2003), which considers relationships between words or phrases whereby themes and meanings are identified (Birmingham & Wilkinson, 2003).

Once the data was collected these two methods of analysis were applied. Ideas and evidence were grouped throughout the analysis with identifying codes that emerged. These codes were compared across all the interviews to develop themes and build a logical argument. The insights obtained from the data were then used as snowball sampling for further literature – initiating further research on what was discovered. Comparisons with relevant literature were also used for interpretation and discussion.

Each interview was analysed individually – reading through the transcripts and notes, as well as listening to the recordings. Ideas were coded with different colours and phrases. To provide an even richer overview of each interview, key sayings were quoted directly with the use of recordings. The ideas and codes were also expanded into sub-ideas.

To help with comparing the emerging codes, the data was tabulated, which can be seen in **APPENDIX E** and **appendix f**. The informant questions were provided in separate rows with the interview answers compared in each column. Manual and computer-facilitated techniques were used for the analysis. The interview answers were printed out in table form to identify the main codes. These codes were then grouped in different columns in Excel. The final themes that

expanded into different sub-themes, emerged from these comparable codes. Lastly, these themes and sub-themes were organised in a thematic map (Figure 12 under **4.5 Introduction to the themes**) to show the relationships between them to facilitate the process of discussing the data logically.

3.5. Validity and reliability

The researcher intended to understand the e-waste management system and how the potential of the informal e-waste sector can be utilised to improve the system. The value of this study topic is proved by the literature. Validity is addressed through the research design, which includes the data collection and analysis, as well as how the findings are interpreted and presented (Cohen et al., 2011). To answer the research questions, the data was sourced from the formal e-waste sector, based on the inclusion and exclusion criteria, using qualitative interviews. The inclusion and exclusion criteria ensured that data were only collected from experienced participants actively involved in the e-waste industry.

The knowledge obtained through the literature review was used to set up a conceptual framework of theoretical concepts to guide the rest of the study. The research method is, therefore, based on previously completed work. This framework was used to set up the questions for the qualitative interviews. An interview protocol for this study was then set up. This protocol also included discussing the interviews with the researcher's supervisor.

To address the credibility of the findings, every perception and experience was captured, with the coded data based on themes, evidence and rich descriptions used to support claims. Rich descriptions address external validity by providing readers with sufficient detail to determine in which context reuse of the data is possible (Cohen et al., 2011). Unsupported generalisations (Cohen et al., 2011) were also avoided. Surprising evidence was investigated, and rival explanations were considered during the interpretation of the data with reference to literature (Cohen et al., 2011) to mitigate bias from the researcher. Saturation was reached through the interview process as multiple interview questions received the same or similar answers with no new themes emerging.

It is important to acknowledge that the perceptions and experiences of the participants, as well as the interpretation of the researcher, can introduce bias into the findings, affecting the validity of the study (Cohen et al., 2011). To mitigate the bias and prevent using preconceived opinions or conceptions (Cohen et al., 2011) several techniques were used; 1) making extensive reference to theory (Cohen et al., 2011), 2) using peer examination (Creswell, 2009) to contest interpretations and raise additional alternative views (Merriam, 2009), 3) constant examination of rival explanations (Cohen et al., 2011), and 4) adequate engagement with data (Creswell, 2009).

3.6. Ethical considerations

This study involved human participants and potential risk for the researcher if the necessary precautions were not taken. Therefore, the necessary ethics training and appropriate ethical clearance were completed. A low-risk clearance was received with an ethics number of NWU-05505-22-A1. No in-person contact with informal recyclers was allowed for the researcher by the ethics committee and as a result, data was only collected from the formal e-waste sector.

3.6.1. Process of obtaining informed consent

This study adhered to all the required ethical regulations. No confidential information was used during this study. Consent was given by all participants to participate in the interviews and for the data obtained from the interviews to be used for the study. Participants were informed of the purpose of the data collection and the context of the questions. Before the interviews were conducted, it was indicated that the participants did not have to answer any questions they felt uncomfortable with. Every step of the interview was voluntary and at any point could participants withdraw from the process. Additionally, if consent was given, the interviews were recorded for accurate record keeping.

3.6.2. Anonymity

Even though identifying information was obtained during the recruitment and interview process, all data was linked to a number and no identifying information was linked to specific data. Furthermore, no identifiable information about participants is made known in this study. Participants who indicated that they would like to receive the results of the data collection process were informed that they could contact the researcher for this information.

3.6.3. Confidentiality

No non-disclosure agreement was needed as no confidential information was collected or shared. All collected data was saved on the personal computer and online drive of the researcher and their supervisor. The devices on which the data is stored are password-protected to prevent unauthorised parties from obtaining the data.

3.6.4. Risk-benefit analysis

The risks and benefits for participants and organisations must be assessed during a study where data collection takes place. The risks and benefits for the formal and informal e-waste sectors, as well as the researcher, are considered.

3.6.4.1. Risks and precautions

The formal e-waste sector did not face any risks during interviews as they participated voluntarily, and their personal information was kept anonymous.

There are indirect risks included in the informal e-waste sector. It risks facing exposure to illegal activities that are taking place, which may result in economic, social, and legislative changes. The study, however, focuses on improving the e-waste management system and, consequently, decreasing illegal activities that pose a danger to society. Thus, all findings were included in this study as withholding sensitive information can lead to even worse future results – for society and the economy.

3.6.4.2. Benefits

The benefits were considered in terms of all the parties and South Africa as a whole. The data collected will provide deeper insight into understanding the e-waste management system and activities that take place. It will also provide a different perspective than only conducting desktop research. This insight will lead to the progression of the e-waste management system, possible formalisation, and improvement of economic, social, physical, and psychological conditions. Not only will the South African e-waste management system be benefitted but both e-waste sectors.

3.7. Chapter summary

The methodology first introduces the study design and context in which this study took place, as well as the scope that was explored. The qualitative interview development, data collection process, - handling, and - analysis sections explored the data collection tool – qualitative interviews – and development thereof, and how the collected data was handled and analysed to address the research questions. From there, the decision was made regarding the population and sampling size, and the type of sampling and sourcing techniques used to collect data. The inclusion and exclusion criteria for selecting participants were also discussed in this section. The recruitment of participants section looked at the recruitment process.

The validity and reliability section further addressed how the study and the data collected were evaluated by the researcher. Lastly, the ethical considerations section includes the process of obtaining informed consent, establishing how the anonymity of participants and confidentiality of information is kept private, and the risk-benefit analysis for participants and South Africa.

The following chapters are the product of the applied methodology. During these chapters, the research questions and objectives will be linked to corresponding results and analysis.

4. Findings

To understand the e-waste management system of South Africa, a view from stakeholders within the system is required. This study considered the perceptions and experiences of the formal e-waste sector. The qualitative interview questions were developed to explore the activities within the e-waste management system, the relationship between the two e-waste sectors, the challenges of e-waste collection, the potential for improvement opportunities and formalisation, and key considerations for a sustainable e-waste management system. This chapter starts with an overview of the interviewed participants, followed by an introduction to the findings. More insight is then given into the activities of the informal e-waste sector, based on the data collected. Lastly, the themes and sub-themes are explained. Each section is named according to the recurring themes and sub-themes identified from the data collected.

4.2. Overview of the interviewed stakeholders

The interviewed participants were from the formal e-waste sector and ranged from employees to owners. The experience of the interviewed participants ranges from one to more than 15 years of experience in the e-waste industry.

The processes, activities, sizes, and roles of the companies that the participants come from differ. The services offered by the companies range from free to paid collection of e-waste, manual to automated dismantling, recycling e-waste internally to exporting, and no interaction to continuous interaction with the informal e-waste sector. Some of these facilities interact with over 700 informal collectors daily. Smaller recycling facilities tend to have a more personal connection with informal recyclers while bigger facilities work through middlemen. Smaller e-waste recycling facilities depend more on e-waste from informal recyclers than bigger facilities. The profile details of these participants can be found in under **APPENDIX C**.

Fifty formal e-waste recycling facilities and institutions were contacted to participate in the interviews for this study. After little response was received through email, all the companies that did not respond were phoned. After the telephone interaction, twelve participants were willing to be interviewed. Of the thirty-eight unwilling participants, approximately half did not have time to be interviewed. The rest did not want to be interviewed to discuss company activities or informal e-waste sector activities.

The interview questions were sent to the participants before the scheduled interviews. Each interview also began by reaffirming to the participants that the purpose of the interview was to gather information on their perceptions and experiences. The majority of the participants

welcomed being able to voice their insights and were open to staying in touch and answering any further questions after the interview was completed.

4.3. Introduction to the findings

As discussed in Chapter 3, printouts of the interview answers and an Excel spreadsheet of the information categories were used during the data analysis. Extraction of the information can be found in **APPENDIX E**.

Quotations from the interviews are used to support the findings and referenced back to the originating participant, i.e. P1 representing participant 1. Only the analysed data collected from the interviews are presented, without discussion from the researcher. Thus, all the explanations within this chapter are only the views and information collected from the participants.

The chapter further provides an overview of the informal e-waste sector activities based on the perceptions of the formal e-waste recycling facilities. These perceptions are based on the experience of either working directly for the informal e-waste sector or middlemen, such as community committees. Thereafter the identified themes from the data collection are discussed.

4.4. Overview of the informal e-waste sector

The overview of the informal e-waste sector explains the who, what, and how questions regarding the informal e-waste sector, e-waste collection, and activities. The overview further explores the collection activities and income of the informal e-waste sector, collection challenges that the informal e-waste sector faces, and the perception of the interview participants on whether the informal e-waste sector would be willing to formalise.

4.4.1. Collection activities and income

The informal e-waste sector is commonplace in South Africa – with e-waste collection, dismantling, and recycling. Five of the participants noted that the informal e-waste sector is extensive and ranges from 90 000 to 120 000 informal recyclers in South Africa, highlighting the potential for e-waste collection through formalisation. Informal recyclers typically live in informal settlements in and around cities and urban areas and travel great distances to collect the waste.

It was noted by most participants that informal recyclers travel from house to house, street to street with their trolleys and carts to collect e-waste, either directly from households or from street bins. Informal recyclers also visit landfills, rural communities, shopping centres, and a mixed batch of collection points. Informal recyclers collect waste from households in communities, especially on days on which waste is put out on the streets for municipal collection. It was indicated that the

informal e-waste sector can collect a significant amount of e-waste daily. P4 indicated that in a small area, Mitchell's Plain, only a few informal recyclers provide 300-400 kg of e-waste per week. P2 added to this by saying that each informal recycler they buy from brings in about 35-70 kg of e-waste per week. Some of the more invested informal recyclers individually bring 50-500 kg of e-waste a week. P1 stated that *“The amount they collect individually is based on their motivation to work.”*

P2 further indicated that informal recyclers bring in much more e-waste from households than formal collectors can. The reason given for this is that the informal e-waste sector is more extensive and flexible to collect daily, and extremely motivated as their livelihoods depend on it. These numbers are, however, estimated values due to a lack of record-keeping from both recycling sectors.

All the participants mentioned that after collection, informal recyclers sell their e-waste either to formal buy-back centres, other informal recyclers with buy-back centres, formal e-waste recycling facilities, second-hand sellers, or scrapyards. It is the participants' perception that the informal e-waste sector is motivated by cost and will sell to anyone who can offer them the most money. The flow of e-waste between the stakeholders in the e-waste management system is displayed in Figure 11.

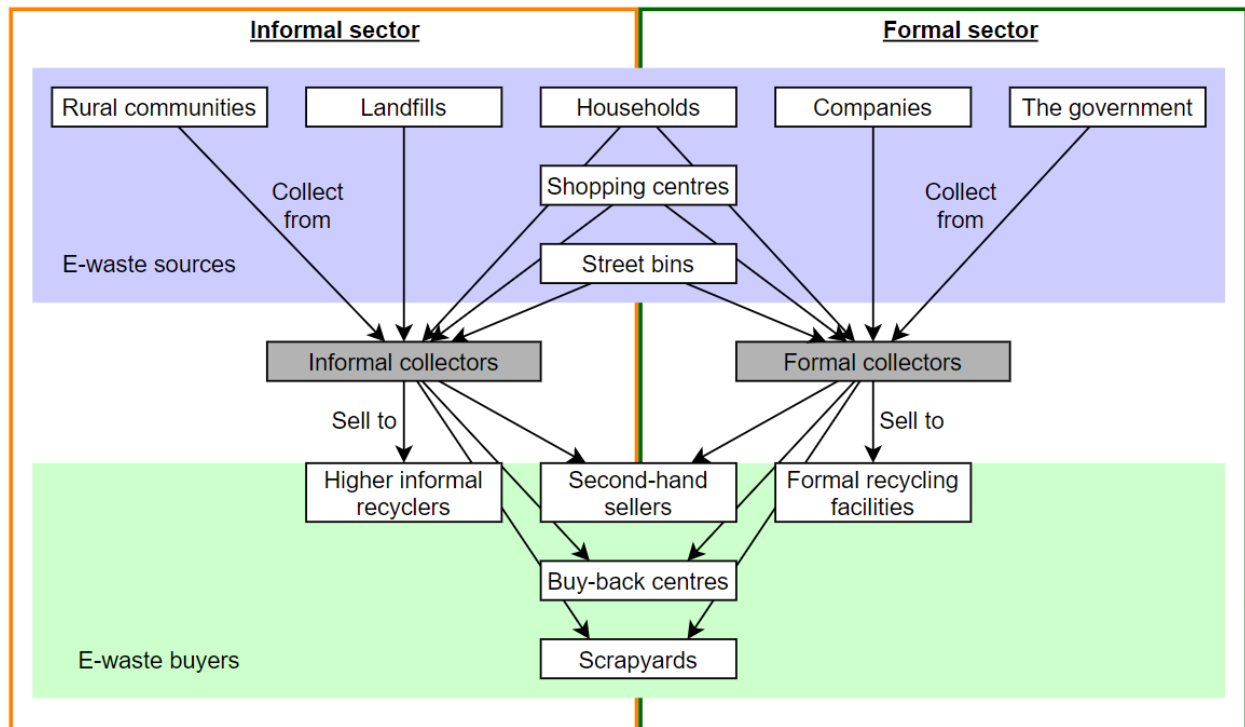


Figure 11: Stakeholders involved in e-waste flow in the South African e-waste management system

The prices informal recyclers receive for their e-waste differ based on the amount of e-waste collected, as well as the type of e-waste. The range of e-waste component prices was estimated by the participants and is displayed in Table 9.

Table 9: E-waste categories and buy-back prices

Price (R/kg)	E-waste categories	Participant
0.50	Low plastics	P3
3	High plastics	P11
0.60	Printers	P8
0.60 - 1.50	Stripped and cleaned ferrous metals	P8
1.50	General e-waste	P3
6-10	Stripped and cleaned non-ferrous metals	P8
10	Complete hard drives	P3
13	Low-grade PCs	P3
120 - 190	Circuit boards	P4
250	Hard drive boards and cell phone boards	P3
250	Silver	P3
525	Gold	P3
1000	Ceramic	P3
2000	Double-sided ceramic CPUs	P3

P1 stated that on average, informal recyclers live off minimum wage, which is about R4 500 per month, for a 45-hour work week and asked the question, *“Can we live off this money?”*. The participant further stated that informal recyclers endure these difficult work conditions to be able to support their families.

P6 agrees with P1 and states that it is the participant’s understanding that informal recyclers work for little money which makes it difficult to create sustainable living conditions. P6 had the following to say about the income of the informal e-waste sector; *“They work for an ‘appel en `n ui”* (P6), which translates to working for next to nothing. In the same way, P9 thinks that informal recyclers do not receive enough money to make a decent living.

In contrast, P3 noted that motivated informal recyclers can make a decent living from e-waste collection. P3 worked with an informal recycler that only received around R550 per week for e-waste sold. After P3 educated the informal recycler on the value of the types of e-waste and how to safely dismantle products to receive more value for components, the informal recycler made around R271 000 for that year (2015), which averages to R5 200 a week. P11 also stated that the income of informal recyclers can lead to sustainable income.

4.4.2. Collection challenges

During the interviews, the participants also spoke about the challenges that the informal e-waste sector faces. The informal e-waste sector is exposed to unsafe working conditions and harassment from authorities when collecting e-waste. Even if the informal e-waste sector is only collecting and selling e-waste to provide for their families, this is not the perceived image that many stakeholders in the formal e-waste sector have. One participant stated the following about people that informal recyclers try to collect from:

“Some people will make it difficult when they (informal recyclers) are collecting because they will say they (informal recyclers) are collecting to sell and buy drugs, even though they are trying to provide for their families.” (P12)

Another collection challenge that arose during the interviews was competition between the two e-waste sectors. The entire industry is vertically stacked, as illustrated in Figure 11. Vertical stacking implies that the formal and informal e-waste sectors compete for the same raw materials. P1 stated that informal recyclers travel between 10-20 km a day to collect materials, while P3 stated it can be up to 35km a day. This distance emphasizes the loss of time and effort that can be decreased if the two e-waste sectors work together.

The competition between the two e-waste sectors also exposes informal recyclers to the risk of theft and gives them a reason to feel unsafe. P2 states, *“They have 100% risk of theft.”* E-waste is very valuable and difficult to trace, which leads to even more risk. Additionally, the informal e-waste sector does not have a place to store e-waste and needs to sell it daily to reduce risk.

Lastly, it is the concern of some of the participants that the context in which the informal e-waste sector operates can lead to unsafe working practices. This concern makes it difficult for formal e-waste recycling facilities to interact with the informal e-waste sector. During these findings, social issues regarding the informal e-waste sector arose. Investigating or addressing social factors is not the focus of this study but rather the integration of the two recycling sectors. These social issues should, thus, be explored in more depth in future studies.

4.4.3. (Un)Willingness to formalise

Throughout the interviews, the participants touched on their perception of whether the informal e-waste sector would be willing to formalise. Various participants were under the impression that most of the informal e-waste sector would formalise if it meant better working conditions and living standards.

“Probably 80% of the informal e-waste sector would be willing to formalise. At the end of the day, the person that wants to grow, will.” (P1)

P11 said the following when asked about possible opportunities for the informal e-waste sector; *“An increase in productivity and recycling targets achieved. A positive outcome and job satisfaction.” (P11)*

A few, participants did, however, also touch on factors that could lead to a potential unwillingness to formalise. P1 stated that the willingness to change is paired with factors such as the degree of operational knowledge and a transparent e-waste industry. Operational knowledge refers to the training on e-waste recycling practices, the teaching of basic legislative guidelines that the informal e-waste sector must follow to work legally, and to knowledge of what is acceptable and unacceptable within formal parameters. To this P1 mentioned, *“We can share operational knowledge if they are really willing to change.”* Transparency includes but is not limited to open communication, transparent activities, and inclusive decision-making.

It is, further, the perception of some participants that there will always be individuals who are resistant to change, that some informal recyclers may not want to be controlled, and that the fear of losing income could add to the potential unwillingness to formalise.

4.5. Introduction to the themes

Seven main themes were identified, with nineteen sub-themes, as displayed in Table 10. Table 10 provides a summarised view of all the themes and sub-themes while Figure 10 is used to explain the links and logic between the themes.

Table 10: Interview themes and sub-themes

Themes	Sub-themes
Theme 1: Formal collection trade-offs	Transport cost versus value
	Collection encounters
Theme 2: Overcoming formal e-waste sector gaps	Informal e-waste sector collection
	Informal sector e-waste sourcing
	Manual e-waste dismantling
Theme 3: E-waste legislative development	Costly and time-consuming legislation
	Lack of government support and legal implementation
	Government control over Extended Producer Responsibility
Theme 4: Lack of e-waste awareness from different stakeholders	Lack of awareness and education
	Informal e-waste sector training
Theme 5: Formal recycling facility concerns	Constraints leading to an unwillingness to formalise

	Reputational risk
Theme 6: Reflection on social factors	Perceived image
	Mutual respect
	Community engagement
Theme 7: Formalisation requirements and success factors	Structured approach
	Supporting links
	Requirements to accept informal e-waste
	Incentives

Figure 12 displays the thematic map of the themes and sub-themes that were used to guide the analysis and presentation of the findings. The thematic map builds the themes around the focus of the study as is shown by a linking line. The thought process around how themes link to each other is shown by arrow lines. As an example, *formal e-waste recycling facility concerns* speak to the concerns of the participants. The question attached to this theme is then if these concerns can be addressed through awareness and education. This theme then logically links to another theme, *stakeholder awareness*, that emerged from the data. These two themes are, therefore, discussed after one another in the explanations to come. Similarly, the other themes have thoughts of the researcher linked to them that also assist in the discussion of the findings.

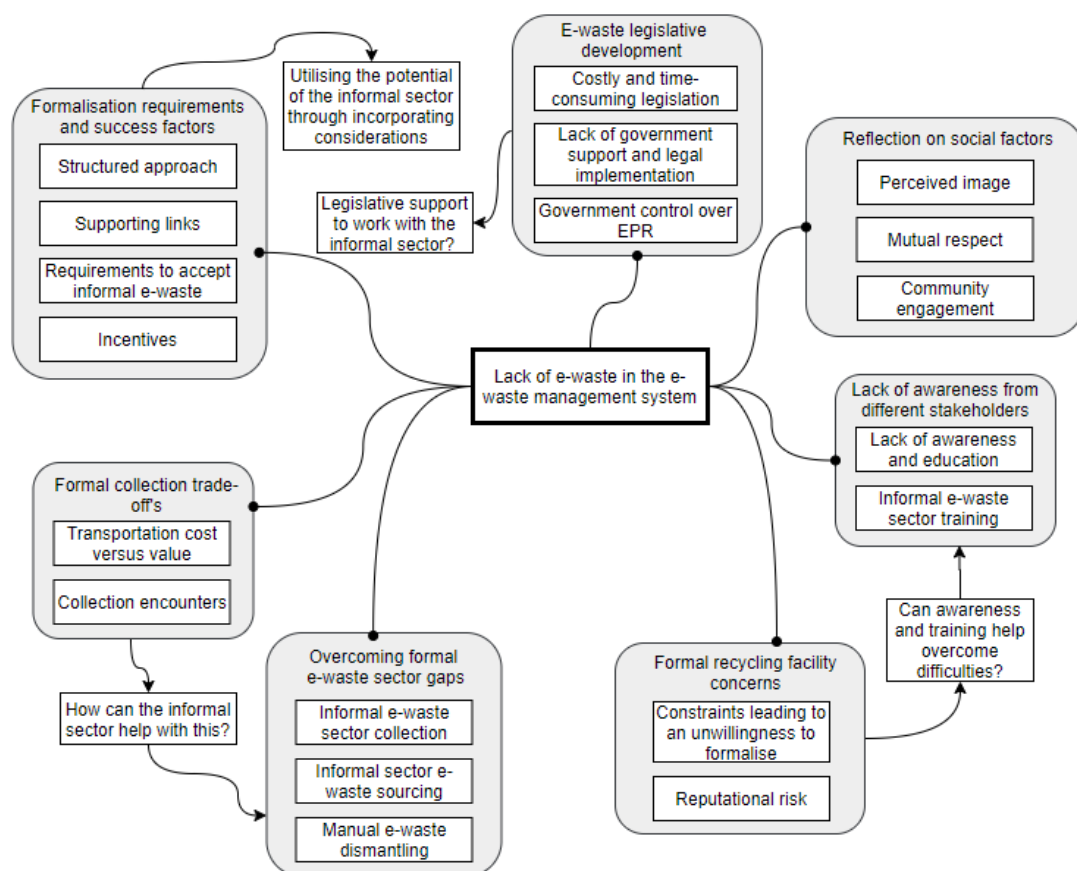


Figure 12: Formal e-waste sector interview thematic map

4.6. Theme 1: Formal collection trade-offs

This theme covers the formal e-waste sector's collection challenges through transport cost versus value and challenges faced with collection encounters. Essentially, the cost of collection is higher than the value of the e-waste and various challenges that the formal e-waste sector faces when collecting e-waste. How this relates to the informal e-waste sector is explored in Theme 2.

4.6.1. Transport cost versus value

With the majority of formal e-waste recycling facilities, the transport cost to collect e-waste is more than the trade value of the material. Most clients that request e-waste collection only have a few devices to dispose of which makes it difficult to collect feasibly; *"The cost of transport alone is detrimental."* (P1). Before any e-waste can be collected, formal e-waste recycling facilities need to determine if the value of the materials is feasible.

Additionally, once the e-waste is collected, the dismantling and disposal of the e-waste are the responsibility of the formal e-waste recycling facilities. Manual dismantling of low-value materials is then an additional cost that is often unfeasible.

"The main problem for us, as a company, is that this material, of which has no value, lands up at our facilities and it costs us money to discard safely, with no revenue in return." (P8)

4.6.2. Collection encounters

A significant challenge the participants mentioned was the safety risks of collecting e-waste. Due to e-waste being valuable, the collection thereof is often paired with the risk of theft. P2 mentions that *"there will never not be any threats with valuable materials."* Various companies have had to employ security escorts for the trucks, have security employees ride along in the truck, or install close-circuit television (CCTV).

Another challenge that formal e-waste recycling facilities face during e-waste collection is harassment from law enforcement. Not all law enforcement officials are educated on e-waste collection legislation and the required licensing to transport e-waste. This has caused problems with some formal e-waste recycling facilities. E-waste transport vehicles are often stopped because e-waste is still classified as hazardous.

"There is a lack of knowledge from police. They stop our vehicles and want to confiscate all the e-waste. We cannot argue with a cop (police) that has authority." (P3)

This makes it very difficult for formal e-waste recycling facilities to collect e-waste. P3 further states that policymakers also lack practical knowledge of the current e-waste activities that are

taking place which they suggested can result in ineffective and impractical legislation. Informal recyclers also make it difficult for formal e-waste recycling facilities to collect large volumes of e-waste from households because the e-waste is already collected before they have the opportunity.

4.7. Theme 2: Overcoming formal e-waste sector gaps

As discussed in Theme 1, formal e-waste recycling facilities face challenges with transportation costs and harassment from officials. Additionally, it is not feasible for formal e-waste recycling facilities to completely dismantle e-waste manually. Theme 2 looks at the potential link that informal collectors can create to collect e-waste from households, the current e-waste buy-back relationship between formal e-waste recycling facilities and the informal e-waste sector, and how the informal e-waste sector can bridge the gap of manual dismantling.

4.7.1. Informal e-waste sector collection

This sub-theme explores the potential of the informal e-waste sector to become the e-waste collection link between households and formal e-waste recycling facilities. The participants were asked what potential they see in forming a partnership with the informal e-waste sector and the opportunities of working with the informal e-waste sector. The majority of the participants could easily identify opportunities for working with the informal e-waste sector.

Throughout the interviews, it was evident that smaller e-waste recycling facilities were influenced more by informal collection. This is because bigger e-waste recycling facilities rely on large companies and contracts for their e-waste, whilst smaller e-waste recycling facilities depend on households or the e-waste that informal recyclers bring in. This is where the potential of working with the informal e-waste sector arises. Various participants mentioned that households have unfeasible collection requests for only a few electronic devices. The informal e-waste sector can potentially be this link to collect smaller quantities of e-waste from households.

“We should build on what exists. If we can work with informal recyclers that help restore and dismantle appliances that will be good. We can see that people will be asking for that. People just want someone to take the e-waste off their hands.” (P7)

P8’s company uses a two-bag system to collect e-waste. With this, households are provided with two recycling bags in which e-waste can be placed. One bag is taken out on a specific day and is collected by the company. When the second bag is collected the following week, the empty bag of the previous week is returned. Unfortunately, the informal e-waste sector cherry-picks from these bags and makes it difficult for the initiative to be sustainable. P8 noted that potential here

originates, with a basis of trust and contractual agreement, that the informal e-waste sector collects and transports the bags and delivers them to the applicable e-waste recycling facilities.

4.7.2. Informal sector e-waste sourcing

Due to the potential e-waste collection link that the informal e-waste sector can form, the sub-theme of informal sector e-waste sourcing emerges which focuses on the volume of e-waste that the informal e-waste sector brings in for formal e-waste recycling facilities. The participants explained their level of contact with the informal e-waste sector in terms of e-waste buy-back. Only a minority of the recycling facilities that participated in the interviews indicated that they do not accept e-waste from the informal e-waste sector. Smaller recycling facilities are especially open to buying e-waste from informal recyclers.

“A lot of formal e-waste recycling facilities depend on the e-waste that the informal e-waste sector brings in. The informal e-waste sector contributes a lot towards the collection of e-waste.” (P9)

The informal e-waste sector brings in a range of e-waste products and already has access to a range of formal recyclers who are willing to buy the e-waste. Smaller e-waste recycling facilities also act as a bridge between the informal e-waste sector and larger e-waste recycling facilities by selling bigger and more feasible quantities of e-waste that informal recyclers are unable to do. In this way, for both smaller and larger recycling facilities, collection and recycling targets can more easily be met.

4.7.3. Manual e-waste dismantling

Manual dismantling and recycling limit the amount of e-waste that e-waste recycling facilities can process per day. Due to this limitation, some larger e-waste recycling facilities have moved from manual dismantling to automated technology.

“A few years back we had about 30 people that stripped the materials but now we have technology that can strip the e-waste up to a point that is still cost-effective for us.” (P5)

Smaller recycling facilities, however, do not collect enough e-waste to fully utilise automated machines and are limited to manual dismantling. Some of the formal e-waste recycling facilities already work with informal recyclers who correctly and manually dismantle e-waste with the training they receive at the facilities.

“We can recycle materials up to a point. We give these materials to the informal e-waste sector for free and they dismantle them further manually and sell it back to us. Different roles and responsibilities. It works quite well.” (P5)

4.8. Theme 3: E-waste legislative development

E-waste recycling facilities must adhere to various laws from collection to disposal. The participants were asked about the impact of legislation on their companies and if there are any aspects of legislation that need improvement. Theme 3 looks at the monetary and time-consuming implications of e-waste legislation, the lack of government support and implementation of legislation, and government control over various laws.

4.8.1. Costly and time-consuming legislation

An overarching theme that emerged throughout all the interviews was that the registration and legislation processes, that formal e-waste recycling facilities need to follow, are costly and time-consuming. The cost and time requirements of registration and legislation processes are based on the volumes of e-waste that formal e-waste recycling facilities work with. Smaller recycling facilities have fewer administrative requirements to obtain licensing. Besides adhering to local rules and regulations, the only required costly certification that one of the smaller companies' participants mentioned is ISO9001.

"The only costly certification we are busy with is ISO9001. Other ISO's will benefit us as well, but it is very costly." (P2)

Bigger recycling facilities, however, must adhere to more legislative requirements. A few of the participants emphasised this by stating that their companies must be registered under the local municipality or applicable e-waste governing body. This implies that companies with various branches in different provinces need to undergo different registration processes for each branch. Many of these accreditations must also be renewed annually. One participant noted that the process of becoming a member of the Institute of Waste Management of Southern Africa (IWMSA) is extremely time-consuming.

"To get our IWMSA memberships, the company waited to get the certificate to fully operate after 6 years from its registration date." (P11)

Not only is registration more time-consuming for bigger recycling facilities, but also more expensive. Companies that process more than 20 tonnes of e-waste per month need to apply for an additional e-waste management license. One participant shared that they have a yearly compliance expense of R200 million. This is because the e-waste legislation of South Africa is still designed for a linear economy and solid waste materials. The legislation does not benefit companies that try to refurbish and re-use e-waste instead of only disposing thereof.

“The definition of e-waste is still wrong. It makes it difficult to collect e-waste under hazardous legislation – and it will probably take about 30 years to fully change the legislation.” (P3)

Various participants mentioned laws that their companies must adhere to. These laws apply to both small and large formal e-waste recycling facilities but to different degrees. The laws mentioned are displayed in Table 11, indicating if the laws apply to small and big formal e-waste recycling facilities.

Table 11: Law and license requirements for formal e-waste recycling facilities

Law or license	Description	Small operation	Large operation
The National Environment Management Waste Act (NEMWA)	License for handling e-waste	Optional	Mandatory
The Second-hand Goods Act	To record that stolen devices are not bought, recycling facilities must obtain a copy of the informal recycler's identity document or passport, a photo of the informal recycler, a contact number, a possible address, a proof of invoice, and the serial number of the device bought	Mandatory Supporting links	Mandatory
License for transport	Obtained from the Department of Agriculture and Rural Development	Mandatory Requirements to accept informal e-waste	Mandatory
The Environmental and Health and Safety laws	General bylaws for each region to ensure recycling facilities are compliant and certified	Mandatory	Mandatory
The International Organisation of Standardisation (ISO):			
9001	Quality management systems	Mandatory	Mandatory
14001	Environmental	Optional	Mandatory
27001	Cybersecurity	Optional	Mandatory
54001	New occupational health and safety	Optional	Mandatory
The Protection of Personal Information (POPI) Act	Protection of personal information	Mandatory	Mandatory

P3 stated that if formal e-waste recycling facilities operate with more than 500kg of e-waste per day, a NEMWA license is needed. P3 describes the process to obtain a NEMWA and transport license as; *“A complete mess.”*

Similar to the second-hand goods act, only one of the participants mentioned that they use a certificate of origin. This means that the company can only buy e-waste back from sources that have a certificate of origin that validates the origin of the electronic device. This ensures that stolen devices are not bought.

“We have said no to a lot of work because of this (requesting a certificate of origin). The law stipulates to determine where e-waste comes from and not to have illegal e-waste but 99% of companies do not adhere to this.” (P5)

The argument exists, though, that companies only need to determine that e-waste bought is not stolen property. Thus, companies that do not request a certificate of origin have different ways to determine if e-waste is stolen, such as scanning the serial codes of the devices. Also, disposal bins placed at recycling facilities and shopping centres are un-incentivised ways to collect e-waste without a certificate of origin. It is unlikely that consumers or informal recyclers would dispose of stolen e-waste in one of these bins as there are no incentives received.

4.8.2. Lack of government support and legal implementation

In addition to legislation being costly and time-consuming, some of the participants have the perception that the existing legislation is not serving the intended purpose.

“Legislation is only good on paper. Registered companies are being punished for listening to the law while other recyclers do what they want and get away with it. Legislation for registration and disposal only costs money and takes a lot of time.” (P6)

The same participants also stated that the current recycling legislation is *“only trying to take responsibility away from the government” (P6)*. With new legislation such as EPR being established, responsibility is shifted towards producers and recycling facilities. In this way, it is the view of some of the participants that the government is shifting responsibility away from themselves and onto other stakeholders. A few of the participants (P3, P6, P11) already feel like they carry the most responsibility and do not have a positive attitude towards the government.

Various participants (P1, P2, P3, P4, P7, P11) are willing to work with the informal e-waste sector, but they do not have the support or funds to start this partnership on their own. P6 and P8 also mentioned that they might be willing to work with the informal e-waste sector if the police relationship improves. Currently, some of the formal e-waste recycling facilities are being

harassed by police for buying e-waste from the informal e-waste sector. Both e-waste sectors, therefore, need support from the government, not only through funding but also through legislative implementation, monitoring, and initiative engagement, as can be seen in the following statements from participants.

“The private sector alone cannot change South Africa's problem. A lot more focus on the government is needed.” (P1)

“I am here to employ people but need big support from bigger companies and government.” (P6)

“How can we do right if the government does not? What example do we have to follow? Waste to landfill target is not achieved at all – it is miserably failed. The government does not want to take responsibility and therefore the responsibility falls on the private sector. The focus of the government is on the wrong things – micro things. The government does not invest in progress, they only invest in legislation that makes things harder for the public and companies. Legislation is only for show – only to protect the government.” (P6) The morale and trust that the formal e-waste sectors have in the government are low. This is further supported by the lack of legislative monitoring from the government. As an example, one participant from a smaller formal e-waste recycling facility mentioned that they often do work for larger formal e-waste recycling facilities. Within this process, they need to provide proof of licensing and registration papers. It has then happened that the larger facilities do not appoint the smaller facility, but only use their registration papers for government tenders, with no repercussions.

“A lot of big and corporate companies only want to see your papers to use for themselves. They have used my e-waste papers to collect e-waste from other companies or hire cheaper companies to do the work. Corporate businesses should adhere to regulations and the needed certifications as well. Big organisations also have to realise they need to be compliant and are not able to do what they want.” (P6)

“How can they prove that they have the correct paperwork – who evaluates this? Corporate companies think that small companies cannot manage a big e-waste load and exploits small companies to their advantage.” (P6)

Due to the lack of legislative monitoring, there are formal e-waste recycling facilities that do not obey laws. Several of the participants are negative about this as it makes it difficult to compete with uncompliant e-waste recycling facilities. Not only does this decrease the morale and trust in the government but makes participants feel powerless.

Even though most participants share the same opinion, they simultaneously still believe that legislation has value. P8 supports this by saying *“legislation is always good, but the policing thereof is the problem.”*

4.8.3. Government control over Extended Producer Responsibility

The lack of trust in the government carries over to the government's control over extended producer responsibility (EPR) initiatives and funding. Participants raised EPR as one of the legal factors that affect their activities. It is the view of some of the participants that the government is too easily bribed and will use these initiatives to benefit themselves, thereby disadvantaging the e-waste sector.

One of the participants also stated that the government cannot be in control of EPR initiatives because funding cannot specifically be allocated for EPR. If the funding is in government possession, according to law, it automatically opens up to any other public projects and initiatives. Also, the funding allocated for EPR is based on claims for each year and is then kept at a fixed value. Thus, if the needed funding for one year is much higher than the previous year, the funding cannot be increased.

Another participant stated, *“EPR is a very good system if managed correctly, unfortunately, it is not yet in SA. However, if it does eventually come to South Africa, it will put most of the informal collectors out of business.”* (P10)

P3 explained that if EPR is successfully implemented in a country like Switzerland, all the responsibility of ensuring e-waste is collected and disposed of is on electronic producers and consumers. Producers then need to ensure that there are available channels for consumers to safely dispose of e-waste. The responsibility then also falls on the consumers to ensure that they are using these channels. Therefore, it is the opinion of this participant that the role of the informal e-waste sector could be endangered if EPR was introduced.

Producer Responsibility Organisations (PROs) are incorporated to support producers throughout EPR. According to P3, PROs in South Africa are the E-waste Association of South Africa (eWASA), Electronic Recycling Associations (ERA), and Resource Recovery and Electrical Energy (R2E2). PROs receive funding available within the e-waste management system to support initiatives. The percentage funding of everything received must then be allocated according to the following criteria:

- 43-45% enterprise development and job creations
- 25% recyclers

- 10% PROs management
- 10% research and design
- 7% awareness creation
- 3-5% education

EPR initiatives aim to set up an e-waste collection network through PROs. P3 noted that the success of this collection network initiative will rely on how well the plan is constructed and implemented.

“The problem is that it takes the control away of companies that are successful in what they do. It can be a good idea with a lot of thought. Alternatively, why change a plan if it already works without additional funding?” (P3)

P3 mentioned additional concerns that may arise for formal e-waste recycling facilities being registered with PROs:

- Formal e-waste recycling facilities cannot claim funds
- Administration for claiming creates an enormous bottleneck that makes operations unsustainable
- Miscommunication between recycling facilities, producers, and PROs on how to claim and who should claim
- Middlemen make money whilst producers or consumers have to pay more

4.9. Theme 4: Lack of e-waste awareness from different stakeholders

Throughout the interviews, stakeholder awareness was a recurring barrier that was mentioned. Some of the previous themes have touched on the lack of knowledge whereas Theme 4 further looks at the lack of awareness from different stakeholders and awareness creation through education and training.

4.9.1. Lack of awareness and education

The majority of participants highlighted that the lack of knowledge and awareness from all stakeholders on e-waste collection and recycling is a problem in South Africa. This is also a common theme that was noted throughout the literature. Knowledge refers to the education and “know-how” of e-waste recycling, while awareness only refers to being aware that e-waste is potentially harmful and must be discarded and recycled differently.

“The biggest thing about South Africa’s failure is that people are not educated.” (P1)

“Education is so important.” (P3)

This lack of awareness also extends to consumers and companies. Participants implied that many consumers and companies are unsure of what e-waste can be recycled or how to dispose of e-waste, supported by the following statements:

“Most companies and people are unsure of where to take their e-waste – where to dispose or how to recycle.” (P4)

“There are a lot of people and companies that do not know what to do with their e-waste.” (P7)

It was also suggested that consumers are not aware of the time and money that goes into the collection and recycling of e-waste, as *“they do not see what happens behind the screen” (P5)*. Participants further suggested that there is a need for continuous awareness creation to educate consumers and the informal e-waste sector on the value of e-waste, the processes of collection and recycling, and what can be recycled.

“We need to communicate with the informal e-waste sector and consumers on the value of e-waste, the processes and what goes into it, and why you can or cannot recycle. Consumers cannot understand that they have to pay for collection which creates complexity” (P5)

Some of the participants stated that universities and higher institutions are needed to create this constant awareness as they can reach greater platforms of communication and influence. A recycling lifestyle must be shaped.

“We need academia to highlight these issues.” (P3)

“People need to know the values – awareness and education.” (P5)

“Awareness needs attention! People tend to care even less now than years back. People and companies need to focus on the values and the reason for recycling and not only money – there should not be a crisis first for people to realise how serious the situation is – then it is too late.” (P5)

4.9.2. Informal e-waste sector training

Similar to the need for awareness and education, training is a key factor identified by participants for formalisation. For example, to overcome the mentioned manual processing gap, the partnership with the informal e-waste sector must be handled correctly and the dismantling activities of the informal e-waste sector must be legal.

Various participants spoke about a need for training that should be a core part of integrating the informal e-waste sector into formal activities. A few participants indicated that it is important to remember, that based on their experience, the whole informal e-waste sector is not fully educated. Therefore, the training must be based on the informal e-waste sector's background and understanding. This is to ensure that the training is conveyed at an appropriate level.

One of the participants specifically mentioned that they would want to become a training facility and, in the process, set up a Sector Education and Training Authorities (SETA) approved programme. Another participant also expressed their willingness to provide training for the informal e-waste sector.

"It would be nice the interact with the informal e-waste sector and teach them how e-waste management works, the regulations behind it, various fractions, how to manage waste streams better, and health hazards." (P2)

"We want to help them, but they have to be willing to learn as well. Train them, licensing, what they need to collect, how to collect, what to do, etc." (P4)

These recycling facilities have the goal of providing these potential employees with appliance repair training that is accredited in South Africa's critical skills list. There is, however, still a lack of support and services for this specific need.

"There is no registered and formal training available for the informal e-waste sector to learn everything on recycling they need to know, like a basic course that matric is not needed for. Existing courses are very high-level. We need an appliance repair course that is only a three-month course." (P7)

The purpose of training is to ensure that the formal and informal e-waste sectors are prepared for and equipped with the needed knowledge to handle formalisation so that it can be sustainable.

"Putting people in a position without training or education is setting them up for failure." (P3)

4.10. Theme 5: Formal recycling facility concerns

Based on the perceptions of the participants, there is potential to integrate the informal e-waste sector into the activities of formal e-waste recycling facilities. There are, however, constraints that feed into the unwillingness to formalise. Theme 5 looks at the constraints leading to an unwillingness to work with the informal e-waste sector and the potential reputation risk for formal e-waste recycling facilities.

4.10.1. Constraints leading to an unwillingness to formalise

Additional considerations that the participants mentioned throughout the interviews add to the formal e-waste sectors' concerns and unwillingness to consider the full potential of formalisation. A general concern is that the volume that individual informal recyclers bring to formal e-waste recycling facilities per visit is not feasible, meaning recycling facilities prefer to buy back larger volumes of e-waste per visit. It is also the experience of some participants that informal recyclers tend to cherry-pick and only sell low-value e-waste. The condition in which e-waste is received also does not always meet the required quality standards.

"Our company specifically only want small, personal e-waste in very good condition, and they cannot always ensure that." (P4)

"Items such as batteries, capacitors and screens need to be handled with care as these items need to be recycled in an environmentally friendly manner and if they are damaged when collecting this will not be possible." (P5)

Another concern is the origin of e-waste. One of the participants mentioned that some recyclers within the informal e-waste sector are driven to steal e-waste to sustain their livelihoods. The refusal from formal e-waste recycling facilities to buy stolen e-waste then creates tension and trouble in the relationship between the two e-waste sectors. The participant further mentioned that there are risks associated with buying e-waste. The informal e-waste sector cannot always prove that the e-waste is not stolen and is sometimes not willing or able to provide any proof of documentation.

"They need to have the accreditations as informal recyclers which is difficult for them to get." (P12)

"We do not know what is from a criminal of the legitimate source." (P2)

"It is difficult because they do not want to tell you where they got the e-waste. They only want to know how much they can get. Especially if it is copper. We need the details. If the informal e-waste sector does not have IDs (identity documents) or documents, we do not take e-waste from them. We need to protect ourselves and stay compliant. We need their details and where they collect e-waste from." (P4)

"We need to sign a document for a certificate of origin. We need to know that the device or components are not illegal or able to be traced because we will take responsibility for it. Paperwork is very important for us. We do not allow people just to come to drop off waste without documentation." (P5)

Formal e-waste recycling facilities can face consequences if any stolen e-waste is bought. Together with having to be able to provide documentation, any company that buys back e-waste must store the e-waste for seven days. If any electronic devices are reported stolen, law enforcement officials can then visit scrapyards, buy-back centres, or formal e-waste recycling facilities to search for the stolen devices by scanning the serial codes. Law enforcement officials are then legally allowed to take back the devices, causing formal e-waste recycling facilities to lose money.

“Informal collectors come to try and sell e-waste to us, but we do not want their e-waste. The police are on our case and look through our e-waste because the informal collectors steal electronic and electrical products.” (P6)

“There is often municipality equipment theft. This makes any scrap yard to be targeted by the authorities.” (P9)

Furthermore, it is the perception of some participants that the informal e-waste sector is unreliable and untrustworthy. The concern arises then that formal e-waste recycling facilities would have to take responsibility for the actions of the informal e-waste sector. Another concern with this is that households will not easily trust the informal e-waste sector.

“There will be backlash from communities if the informal e-waste sector comes knocking on their door.” (P8)

“We stopped working with the informal e-waste sector because they only bring e-waste when they need money. They were not reliable. They also expect too much which created more administration and work than the value we received.” (P5)

“They are very untrustworthy relationships and have little awareness. There is a feeling of my company doing all the work and the informal e-waste sector just benefitting from this. This would have to change. The informal recyclers become my responsibility if they work for me. The informal recyclers cause violence and chaos – very untrustworthy – illegal.” (P6)

Lastly, one of the participants mentioned that it is difficult to know all the locations where informal recyclers collect e-waste. While the spread-out system of the informal e-waste sector provides more flexibility and quick e-waste collection from large areas, it creates uncertainty.

“It is difficult because the informal e-waste sector is complex, very spread out, and they have their own processes that they follow.” (P4)

In contrast, one participant emphasised that e-waste will always have its safety risks but that the informal e-waste sector is not always to blame. They indicated that informal recyclers often have to provide for families or are living in conditions that they were born into. There is significant potential in working with the informal e-waste sector in the challenges that can be overcome.

“There are definitely negative things about the informal e-waste sector, but we also need to look at whether it is always their fault?” (P1)

4.10.2. Reputational risk

The concern of taking responsibility for the informal e-waste sector links to the reputational risk of formal e-waste recycling facilities. For the informal e-waste sector to legally collect e-waste, the needed licensing or proof of permission would need to be obtained. The participants raised concerns regarding this.

“The problem is, for example, if they transport the materials, they are not registered or certified. People will say the collection is done for our company. This causes risk to the image and reputation of our company. An accident we or they have, has a direct impact on the environment.” (P3)

“If we take responsibility for them it is our name so we would need to carefully analyse if the person can work for us. We cannot just give licenses out with our name; they might use it for personal gain.” (P8)

“The informal recyclers need to understand that if they work for me, they become my responsibility and would have to listen.” (P6)

“The informal e-waste sector would have to take it as a business, not as just hustle of the day.” (P9)

One participant mentioned, that even if the informal e-waste sector is willing to formalise, if formal e-waste recycling facilities are not able to deliver on what is promised through partnerships, problems will arise.

“They would consider formalisation, but it is difficult for the formal e-waste sector to promise this. If formal facilities do not live up to their promises it can lead to legal problems – a bit of a risk to open yourself up. If they also do not work according to the set-out rules of engagement it opens up risk for formal facilities. It will have to be handled well or else formal facilities’ reputations can be tarnished.” (P2)

4.11. Theme 6: Reflection on social factors

During the interviews, some of the participants self-reflect on the importance of understanding the social context of informal recyclers for formalisation to be achieved. Theme 6 looks at this through the perceived image of the informal e-waste sector, mutual respect, and community engagement.

4.11.1. Perceived image

This theme focuses on how the informal e-waste sector is viewed and then treated accordingly. One participant pointed out that while the informal e-waste sector might have some negative aspects, this does not only apply to all informal recyclers.

“People only tend to see the negative of the informal sector – either they are entitled, steal, strike – things that are probably true to a degree. The thing is, there are people like this in the corporate world too. Then we have to realise some of them don’t care – but even educated and high-income people act like that. We cannot always blame the informal e-waste sector and the government. What are we doing to bring changes?” (P1)

“We are not going to fix the world by only looking at the negative. Stop complaining and see the positive and see how we can help to change the negative” (P1)

Another participant mentioned that the informal e-waste sector does not only want to be associated with the waste they collect. The work that the informal e-waste sector does contributes to e-waste collection and diverts e-waste away from landfills.

“People really see waste recyclers bottom feeders.” (P5)

“Their work is not all waste. They want to be recognised, not seen as waste. Take away the stigma. They want to be seen as essential. Bring sexy back” (P4)

4.11.2. Mutual respect

One of the biggest reasons for conflict and misunderstanding between the two e-waste sectors is different mindsets and views. These differences originate from different backgrounds. Various participants pointed this out.

One of the participants mentioned that due to their different backgrounds, the way people think will be different. P1 stated that the formal e-waste sector cannot expect the informal e-waste sector to function on the same level if treated at a lower level. Thus, if the informal e-waste sector is treated with no respect or as if it does not have knowledge and experience, a higher level of

performance cannot be expected. There cannot be a disconnect between set expectations and conduct.

“The problem is with some people in the corporate world – they want everyone to operate at the same level. The informal e-waste sector might not even have been to school. Regardless of the background – respect. A lot of people just want time invested into them. To show that you are willing to sacrifice the most valuable thing to improve their lives. At the end of the day, it’s just about respect” (P1)

“We should not see them as low class.” (P1)

“The informal e-waste sector works for a minimum wage we cannot expect them to think and do the way we do that lives comfortably to a sense. They work very hard in bad working conditions out of desperation and do not see the consequences of their actions. We can’t always blame other people.” (P1)

P1 further emphasised that formal e-waste recycling facilities must be willing to offer up time and effort to work with the informal e-waste sector if they expect the same level of functionality. Every success story must have a beginning.

“We need to know some people want freebies and we should deal with it. Be humble and realise it will take some effort.” (P1)

“We are not going to change to world or even just South Africa by not being willing to invest in the people. Jesus said, love people as I love you, regardless of what type of person they are, and if you have respect for the individual you will understand that if they are not well educated you need to be patient and willing to invest time to help them to understand. Sometimes they just lack understanding.” (P1)

“Give someone money, he will just spend it the next day. It’s like teaching a man to fish. If you can share knowledge that they can use that, and it will help them. It is worth a lot more.” (P1)

4.11.3. Community engagement

To change the perceived image of the informal e-waste sector, trust must be built. One participant mentioned that they are willing to work with the informal e-waste sector and that they already try to build trust. It is important to embrace a different attitude when working with the informal e-waste sector. To build a good and sustainable relationship, the foundation of the relationship cannot only be focused on monetary incentives or individual gain.

"We should not always expect something in return. It is not always a case of helping them to help myself." (P1)

P1 further stated that one of their branches is situated right next to an informal settlement. This creates the opportunity to support small businesses and help where needed. This formal recycling facility helps the informal e-waste sector through a community committee that already exists in the informal settlement.

"There is definitely potential to work together and we try to do this already." (P1)

"We really try and help them by either employing them or donating food and blankets. We try and show we do not want to abuse them and really care. We deal with the community committee and speak with them. We try and get them into groups to get their waste into a central area and then help with transport. So far, they are very glad and appreciative of our help, so we are in a good relationship with them." (P1)

More participants mentioned that they would be willing to work with the informal e-waste sector, as they are smaller than solid waste management, which makes it easier to form a relationship.

"We do not have a problem with them." (P7)

"It would be a lot easier to actually work with the informal e-waste sector. I would like to work with them. I think they do a remarkable job it just needs to be more structured." (P4)

"About 80% of the people we buy from is from the informal e-waste sector." (P1)

"New legislation is calling for integration. I support it fully. About 90% of our client base is the informal e-waste sector so we get a lot of e-waste in from them as well" (P3)

One participant also mentioned that they have running water and sanitation facilities on site for the informal e-waste sector to use. Two more participants mentioned that they are part of initiatives to collect e-waste from schools and shopping centres and would be willing to support more of these initiatives.

4.12. Theme 7: Formalisation requirements and success factors

The concerns of the participants were discussed throughout the previous themes. Theme 7 further explores the key operational considerations for working with the informal e-waste sector. These considerations cover the use of a structured approach for formalisation, the need for a support system and supporting links, requirements, and incentives needed for formalisation.

4.12.1. Structured approach

When asked about the key considerations for potential formalisation, the participants highlighted that structure is needed. Currently, the informal e-waste sector is too unreliable and unorganised for the formal e-waste sector to work with. The formalisation process and continuous working operations and logistics must be thoroughly planned out in a structured manner that still allows for flexibility.

“I think they do a remarkable job it just needs to be more structured. We need to create opportunity for the informal e-waste sector that is very structured” (P4)

“We have to create an enabling regulatory framework that enables both the formal e-waste sector that is well established to interact and engage with the informal e-waste sector that has no knowledge about compliance, and the framework must be very flexible. The moment the framework is rigid, the first issue will throw out the framework – the informal e-waste sector will leave.” (P3)

A question that arose from one participant is how the regulation and distribution of e-waste between the formal e-waste recycling facilities will work. Another participant also spoke about this and mentioned that various factors influence this decision – the size and number of the formal and informal e-waste sectors apart from the integration, the area in which e-waste is collected, and the existing systems already in place. The informal e-waste sector already has a collection system and an internal code for where it can collect e-waste and how the materials are divided among themselves. The formalisation process must build on the already existing informal e-waste sector collection system.

“They have a code between themselves. Usually the informal e-waste sector divides regions up and sticks their area. They respect each other. They are extremely prideful to provide for their families.” (P3)

“The informal e-waste sector is actually well-organised. They have a site close by where they sort materials and divide among each other. They are self-organised.” (P7)

It was further advised that the formalisation approach must be handled well to protect the reputation of formal e-waste recycling facilities. The approach must also not be too complex and inflexible as this will not motivate the informal e-waste sector to integrate into the process.

“Formalisation will have to be handled well or else formal facilities’ reputations can be tarnished. Start with a formalised approach – training and giving authority when certified and licensed.” (P2)

“Potential but the formalisation would have to be simple. Do not reinvent the wheel. Do not over-engineer the solution. It must be able to include all the factors for a successful e-waste management system without making it too complex. The informal e-waste sector will just go to the next person if selling their products are too difficult. Formalisation will work but it has to be more flexible. We cannot implement a developed country approach in a country that struggles with water, housing, and job creation” (P3)

It was further mentioned that most of the informal e-waste sector is not formally educated and might not understand detailed explanations. Formal plans need to be properly communicated and aligned with the target audience to enable effective change management

“We then have to know how to handle people and how to communicate with them.” (P1)

“Make it very simple in terms of telling them what they need to do and what you want from them.” (P3)

P3 further commented that all stakeholders will need to see the benefits of formalisation, especially the informal e-waste sector.

“We need to explain why formalisation will benefit them. If formality comes with a cost, they will not buy into it. Need to give enough incentives to want to be a part of formalisation.” (P3)

“Depends on how it is packaged and conveyed. No one likes to change so they need to see the benefits it holds for them.” (P4)

4.12.2. Supporting links

To progress towards formalisation, some of the participants stated that they will need support that can be hands-on to work with the informal e-waste sector. The formal e-waste recycling facilities cannot conduct business and simultaneously regulate the informal e-waste sector.

“We do not have the same buy-back power as big recycling companies so it will be difficult to deal with the informal e-waste sector ourselves.” (P2)

“There are different informal collectors. Small collectors that sell to middlemen. Middlemen buy from many collectors and sell to medium size recycling facilities. And then large facilities that only buy from medium size facilities. They do not want to deal with people that only bring in less than 500kg of materials at once. We do not want to deal with hundreds of collectors that bring material – it causes congestion. A middleman or community committee is much easier to buy from.” (P1)

One participant mentioned that PROs can help link the two e-waste sectors but that community committees like the African Reclaimers Organisation (ARO) are crucial because they have more ground-floor experience and interactions with the informal e-waste sector. This participant explained the following regarding PROs and community committees:

“PROs are the middlemen between producers and the government. We can incorporate these into formal facilities through these associations to provide better training from a to z. It brings more opportunities for funding. But eWASA won’t know who the informal recyclers are because they work for an academic foundation. The idea may be that PROs are going to level the playing field, but PROs will drive the informal e-waste sector underground if policies are too strict.” (P3)

“We need to use companies such as SAWA and Arrow Recovery Group to speak to the informal e-waste sector that has 90 000 – 120 000 members. They understand the people’s needs much better. We need to engage with them directly. Every scenario is different. First, we have to look at the scenario and facts and then only make informed decisions. The framework must be based on facts and challenges experienced on the ground level. ‘What does the informal e-waste sector face on a daily basis?’” (P3)

Based on case studies findings in the literature review, a follow-up question was asked by the researcher regarding the possibility of using NGOs as cooperatives. P3 noted that NGOs can work but that all the decision-making and processes would have to be very transparent. There would have to be various levels of stakeholders – recyclers, refurbishers, industry, and academia – on the board to oversee financial decisions. This in itself creates a bottleneck for quick and effective fund claims.

4.12.3. Requirements to accept informal e-waste

To comply with legal requirements, the informal e-waste sector must have a personal identity document driver’s license, or documentation such as proof of e-waste origin. This ensures that formal e-waste recycling facilities have the correct details when audited. Participants mentioned that another requirement for formalisation includes a process for the informal e-waste sector to obtain the correct documentation.

“We cannot overlook that – the informal e-waste sector needs to be registered and licensed.” (P3)

“They need to be documented to ensure that they have traceability. Cradle to the grave is important. We want to know where stuff is coming from. If we need to audit you want to be able to trace products. Not motivate stealing and cherry-picking. Formalisation must find a way to ensure the vendor onboarding process. This is audits through ID, NDA documents, POA, legally

binding documents that control morals, and ethical conduct. This will give a lot of formal companies more peace of mind – without making them give up their sources that are legally obtained. Just to ensure materials coming in are not stolen. Being able to capture everything.” (P2)

“They may not have the correct certification, but they can operate at an elevated level with formal e-waste recycling facilities. Collectors with vehicles have much more accountability and traceability.” (P2)

“They need to have a proven track record that can audit their activities. Good monitoring – due diligence and making sure working with the informal e-waste sector is feasible.” (P2)

“If you can implement a better paper-trail system where the informal e-waste sector can supply a Certificate of Origin, bigger Companies can purchase from the informal e-waste sector.” (P5)

P3 noted that support for the informal e-waste sector to transition into a more compliant environment will also be needed. The transition into an extremely compliant sector will need to be handled with much planning and careful consideration to ensure the transition is as easy as possible.

“Compliances make it much more difficult. There is such a big difference between the compliances set in place by the government for big companies versus the informal e-waste sector. Super compliance versus nothing.” (P3)

4.12.4. Incentives

Based on the interviews, the consequent benefits of formalisation for the informal e-waste sector are primarily monetary incentives with non-monetary incentives second. Two participants did, however, mention, that monetary incentives, in the form of buying back e-waste, will require adequate cash flow at the recycling facilities, which poses a risk. One participant mentioned that looking at the possibilities of cashless transactions is necessary.

“You must always have enough cash which can be challenging. We need good security measures to minimize theft” (P8)

Various non-monetary incentive requirements mentioned throughout the interviews include better work circumstances, sanitary facilities, personal protective equipment (PPE), and secure storage. The informal e-waste sector faces problems with harassment and theft when collecting and dismantling e-waste. Providing the informal e-waste sector with certified sites where e-waste can be dismantled and stored can be an important motivation for formalisation.

“It is vitally important to first collect and then transport. We need a specific site that is certified and licensed so that the informal e-waste sector can dismantle e-waste into plastics and metals there and sell that. Then they get more for it than transporting it. It is much cheaper to transport very valuable materials that are already dismantled. Transport efficiency.” (P3)

“If they can have decent facilities where they can strip their material would make their lives better and keep the environment clean as well.” (P8)

“They also need incentives in other parts of the value chain – not just money. Storage can be a good non-financial incentive.” (P4)

P4 also mentioned that the integration can work based on a reward system. Thus, based on the attitude and commitment of individual informal recyclers, more incentives can be received.

4.13. Chapter summary

The data collected during the interviews provided insight into the perceptions and experiences of the formal e-waste sector regarding the current informal e-waste sector activities. Thereafter, the analysis of the collected data delivered categories that were broken down into seven main themes, each with individual sub-themes. The seven themes reported on were; 1) Formal collection trade-offs; 2) Overcoming formal e-waste sector gaps; 3) E-waste legislative development; 4) Lack of e-waste awareness from different stakeholders; 5) Formal e-waste recycling facilities concerns; 6) Reflection of social factors; and 7) Formalisation requirements and success factors.

These themes provided insight into the challenges that the formal e-waste sector faces, their key concerns and considerations for formalisation, and their potential willingness to be a part of the formalisation process. Building on the analysis and reporting of the themes, the next chapter goes into the discussion of the themes. Throughout the discussion, reference is made to literature based on similarities and differences found throughout the data analysis.

5. Discussion

This study aimed to emphasize the importance of the informal e-waste sector and explore the benefits of utilising its potential throughout the literature review. Furthermore, the aim of the study was to understand the formal e-waste sectors' perception of the relationship between the two e-waste sectors, as well as the formal e-waste sectors' willingness and considerations to be a part of the formalisation process. The study achieved this by eliciting the perceptions of the formal e-waste sector and framing these perceptions concerning the potential for formalisation. The findings reveal that the informal e-waste sector is a significant part of the e-waste management system and cannot be ignored. The findings further reveal that there is a potential willingness from the formal e-waste sector to be a part of the formalisation process.

The originality of this study lies in the unique perspectives obtained from the formal e-waste sector that provide a rich description of the intricate and complex relationships between different stakeholders in the e-waste value chain and the considerations for formalisation. The findings and recommendations are suitably broad to facilitate further conversations about improving the e-waste management system in developing countries and developing a formalisation framework for South Africa. The previous chapters have detailed the findings from the formal e-waste sector interviews. The findings were organised in a thematic map to create links between the emerging themes and to explain how these themes integrate. The link between these themes and the objectives is shown in Figure 13 at the start of the discussion.

The themes are discussed in this chapter to provide insight based on the literature and the interview findings. The discussion is divided into two sections – theme relationship and theme discussion. The theme relationship section considers the links between the different themes and sub-themes, and how they address the objectives (found in **1.4 Research questions and objectives**) of the study. The theme discussion section then unveils the input of the researcher regarding the themes, based on the findings of the interviews.

5.2. Theme relationship

The relationships between the themes are explained in the following section. The seven themes and nineteen sub-theme connections to one another are displayed in Figure 13 and explained accordingly. The objectives, referred to as “OB” in Figure 13, that are addressed by the specific themes are also displayed.

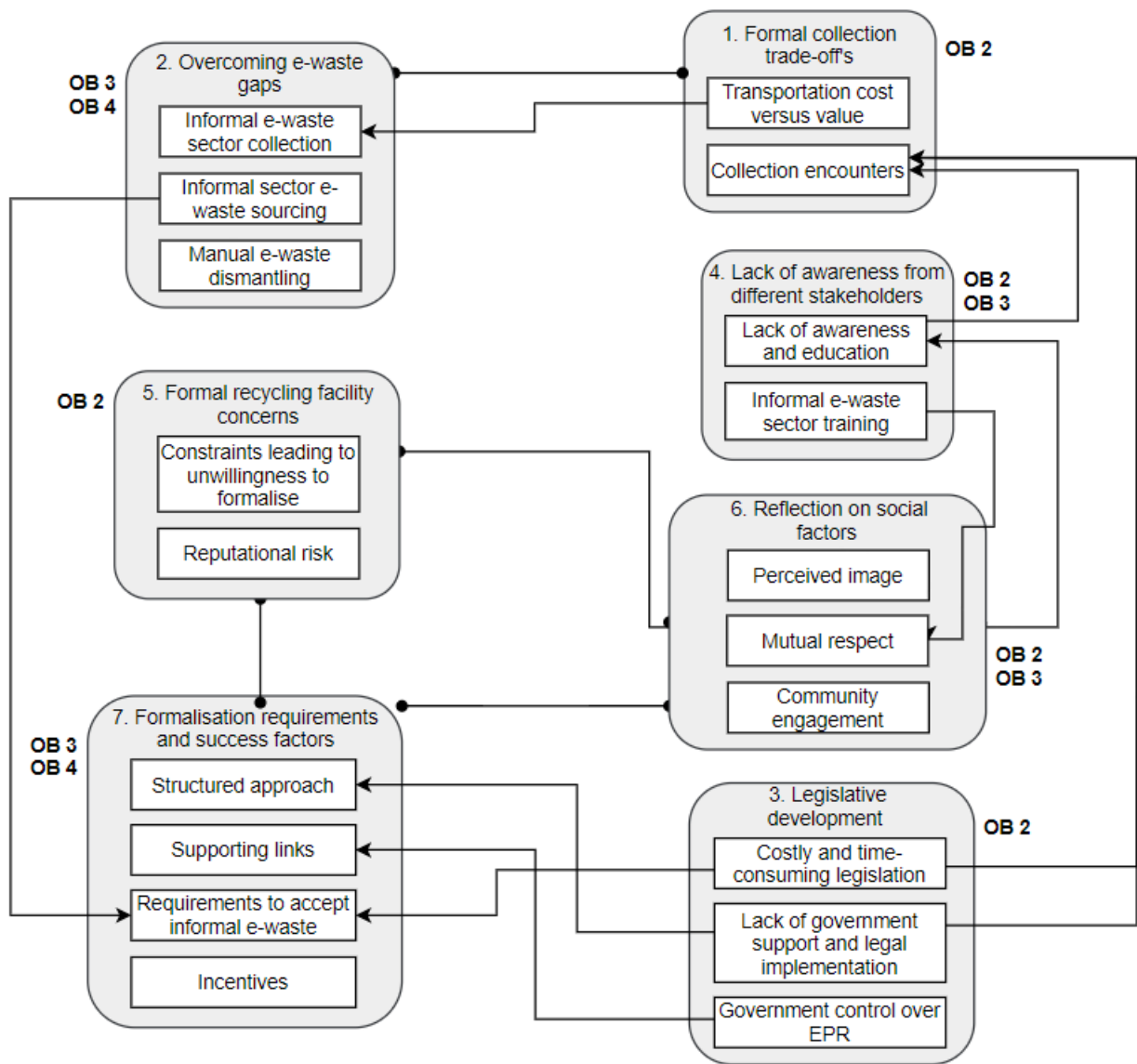


Figure 13: Key findings concerning the thematic map of the study

Firstly, the *formal collection trade-offs* partially address objective 2 (to identify the challenges that prevent an integrated e-waste management system) by exploring the challenges that formal e-waste recycling facilities experience during e-waste collection. The *formal collection trade-offs* further highlight the transportation cost versus the value of collecting e-waste from consumers. Paired with this are collection risks and challenges. Due to high transportation costs, the link is made to the *informal e-waste sector collection* sub-theme as the informal e-waste sector has the potential to act as a less expensive collection solution. The whole *formal collection trade-offs* theme connects to *overcoming e-waste gaps* as formal e-waste recycling facilities currently face collection challenges that the informal e-waste sector has the potential the overcome.

Overcoming e-waste gaps helps address objectives 3 (to identify key considerations for an integrated e-waste management system) and 4 (to understand how the formal and informal e-

waste sectors could be integrated, and what benefits and opportunities could be realised from this). This theme addresses these objectives by identifying the opportunity and benefits of utilising the informal e-waste sector for e-waste collection and filling gaps that formal e-waste recycling facilities have – the volume of e-waste collected, and manual dismantling of the e-waste collected. The sub-theme *informal sector e-waste sourcing* is linked to *requirements to accept informal e-waste*. The formal e-waste recycling facilities interviewed specified certain requirements that are needed when accepting e-waste from external sources to ensure transparency and honesty.

Objective 2 is then further addressed by the theme *formal recycling facility concerns*. This theme explores the constraints that lead to the unwillingness of formalisation from the formal e-waste sector and considerations for the reputation of the formal e-waste sector to work with the informal e-waste sector. *Formal recycling facility concerns* are then also linked to the theme *reflection on social factors*. The *reflection on social factors* of the informal e-waste sector greatly influences all the sub-themes under *formal recycling facility concerns*.

Objectives 2 and 3 are partially addressed through *lack of awareness from different stakeholders*. The sub-theme *lack of awareness and education* provides an understanding of the challenges that prevent an integrated e-waste management system, whilst the *informal e-waste sector training* sub-theme explores the opportunities and key considerations to form this integrated e-waste management system. *Informal e-waste sector training* then links to the sub-theme *mutual respect* under the theme *reflection on social factors* as this looks at the background of the informal e-waste sector that is crucial when setting up training and education programmes.

Objectives 2 and 3 are then also addressed by *reflection on social factors*. *Mutual respect*, *perceived image*, and *community engagement* between the two e-waste sectors consider challenges that prevent an integrated e-waste management system. The sub-themes, however, also reflect on the opportunities that arise from these challenges and the considerations to overcome the challenges. *Reflection on social factors* of the informal e-waste sector links to some of the *formal recycling facility concerns* for formalisation. All the sub-themes under *reflection on social factors* are linked to the *lack of awareness from different stakeholder*. The lack of awareness regarding the informal e-waste sector and its background causes stakeholders to have a skewed perceived image, which also causes strain on the relationship between the two e-waste sectors. *Reflection on social factors* is then lastly linked to *formalisation requirements and success factors* as it is vital to consider the social aspects and background of the informal e-waste sector to create a sustainable formalisation framework.

Objective 2 is lastly addressed by *legislative development*. The sub-themes *costly and time-consuming legislation* and *lack of government support and legal implementation* also influence

the *collection encounters* of e-waste as the current legislation still classifies e-waste under hazardous materials. The sub-theme *costly and time-consuming legislation* then further influences the sub-theme *requirements to accept informal e-waste*. *Lack of government support and legal implementation* are crucial factors to consider when setting up the *structured approach* for formalisation in South Africa. The support and implementation from the government will influence the roles and responsibilities of all the stakeholders in the e-waste management system. Lastly, *government control over EPR* affects the *supporting links* that are chosen for formalisation due to the degree of control from the government.

Formalisation requirements and success factors lastly address objectives 3 and 4 as this theme considers various opportunities and key considerations for formalisation and then indirectly the benefits that can be realised from successful and sustainable formalisation. The considerations are explored throughout the sub-themes. This theme as a whole links to *formal recycling facility concerns* and *reflection on social factors*.

5.3. Theme discussion

The themes are discussed based on their connections to one another. *Formal collection trade-offs* and *overcoming e-waste gaps* are discussed together. Both these themes look at the cost of formal e-waste collection and the unsustainable competition between the two e-waste sectors, as well as how to overcome the current challenges. *Legislative development* is discussed thereafter and touches on the outdated e-waste legislation that should be constructed specifically around e-waste and the informal e-waste sector. *Stakeholder awareness* and *reflection on social factors* are also discussed together. These two themes discuss the current lack of awareness of e-waste recycling from various stakeholders and how this lack of awareness influences the perceived image informal e-waste sector. Lastly, *formal recycling facility concerns* and *formalisation requirements and success factors* are discussed separately. The former states that the concerns of formal e-waste recycling facilities would need to be addressed for formalisation. The latter then adds to this by discussing specific formalisation requirements that can help formalisation to be successful and sustainable.

5.3.1. Formal collection trade-offs & overcoming formal e-waste sector gaps

The cost of formal e-waste collection is detrimental, as supported by (McCann et al., 2015), especially for smaller formal e-waste recycling facilities that collect small volumes of e-waste at a time. The informal e-waste collectors also make it difficult for formal e-waste recycling facilities to collect large amounts of e-waste from households (Mihai et al., 2019) as the e-waste is collected before recycling facilities have the opportunity. Additionally, once the e-waste is collected, the dismantling and disposal of the devices are the responsibility of the formal e-waste recycling

facilities. Manual dismantling of low-value materials is then an additional cost that is often unfeasible for formal e-waste recycling facilities.

The collection and recycling competition between the two e-waste sectors is not sustainable, as echoed through literature (Davis & Garb, 2015; Hougaard, 2021). The two e-waste sectors need to work together to save resources and utilise each other's potential. There is, thus, a need to bridge the gap between e-waste collection cost and trade value by overcoming the current competition between the two e-waste sectors. The informal e-waste sector can bridge this gap (Aparcana, 2017b; Dlamini, 2016; Godfrey, 2021; Panwar et al., 2018). Working with the informal e-waste sector also creates room for negotiation to determine which activities in the e-waste management system should be managed by the different e-waste sectors. The process of e-waste collection and recycling can potentially be sustainable if the informal e-waste sector only collects e-waste and safely helps with dismantling (Raghupathy et al., 2010). The formal e-waste recycling facilities have more specialised equipment and methods to extract the most value from e-waste that can be taught to the informal e-waste sector. Even though the informal e-waste sector is not employed by formal e-waste recycling facilities, there is a form of a mutually beneficial partnership. In this way, the informal e-waste sector receives incentives for the e-waste collected and the labour of dismantling electronic devices, without negatively affecting the environment or creating health risks. It is important to remember that manual versus automotive dismantling is only one aspect of formalisation where larger and smaller recycling facilities should be approached differently, based on facts, needs, and ground-level experience.

There are, however, collection risks and challenges to consider when working with the informal e-waste sector. These risks and challenges are also explained throughout the literature (IFC, 2015; Kumar et al., 2017; Vijarania et al., 2017). It is the perception from some of the interviewed participants that the informal e-waste sector does not always follow the correct legislation to collect or work with e-waste. The informal e-waste sector is, therefore, often harassed by law enforcement officials. This places strain on the relationship between the two e-waste sectors and influences the volume of e-waste that the informal e-waste sector can collect. To minimise harassment from law enforcement officials, the informal e-waste sector must be able to provide a form of documentation or proof that collection is being done on behalf of formal e-waste recycling facilities. For this, trust between the two e-waste sectors is crucial (Hinchliffe, 2017).

The informal e-waste sector also faces risks of traffic or accidents when transporting e-waste along busy highways (Dlamini, 2016; Gunsilius, 2011; Yose, 2014). It is the understanding of the interviewed participants that most informal recyclers will continue these risky activities, even if these activities do not adhere to the correct legislation, due to their level of income.

Another collection risk is theft. Some interviewed participants indicated that there can be a perception that informal recyclers steal e-waste. An additional concern is that informal recyclers cherry-pick whilst collecting e-waste to sell to formal e-waste recycling facilities, as mentioned in the literature (Hinchliffe et al., 2020). If the gap between the two e-waste sectors can be narrowed by forming a trust-based relationship and working together, the probability of theft can be decreased.

In summary, the findings from the interviews provide additional information on the challenges that the formal e-waste sector faces when collecting e-waste and how the informal e-waste sector can help overcome these challenges. Insights are also given on how the relationship between the two e-waste sectors can potentially function sustainably. Collection risks for the informal e-waste sector are further highlighted, with input on how these risks can be mitigated.

5.3.2. E-waste legislative development

Legislative development has a significant impact on e-waste collection, as supported by (Gerdes & Gunsilius, 2010; Grant, 2019; Sadan, 2019). Currently, legislation is outdated, inadequate, and does not support the formal e-waste sector (Mmereki et al., 2016). The needed law enforcement clearance and e-waste transport licenses are time-consuming and can take anywhere from four weeks to obtain. E-waste transport licensing is a key consideration to keep in mind to working with the informal e-waste sector. As with e-waste collection, the correct documentation is needed.

Inclusive legislative changes, that incorporate the informal e-waste sector, are another approach to minimise the previously mentioned collection challenges. It is critical to remember that the informal e-waste sector will not disappear just because of legislation. Strict legislation with disregard for the informal e-waste sector might cause the informal e-waste sector to go underground, exacerbating many of the challenges that are already experienced, also stated by Patil & Ramakrishna (2020).

Supporting legislation that considers e-waste in its recycling category is another step towards progressing the e-waste management system. The legislation must also be successfully and continuously adapted and implemented. The findings of this study support that effective implementation is needed (Ilyassova et al., 2021) and add that legislation must be able to function long-term, on a practical level. Legislation should not only be based on a theoretical type of industry. This type of legislation development comes from a lack of know-how and awareness from policymakers.

Ineffective legislation only harms compliant formal e-waste recycling facilities. The government must factor this into legislative development – legislation must be implemented more efficiently and effectively, and compliant companies must benefit from compliance.

The findings of the study also gave new insight to the state that the legislation setup must consider the government's control over EPRs and PROs. How EPR is implemented and integrated into the South African e-waste legislation will impact the degree of influence informal e-waste sector. The policymakers of South Africa must determine how legislation is developed regarding EPR. This development must consider the trade-off between increased e-waste collection and recycling only from formal e-waste recycling facilities versus the potential loss of thousands of job opportunities for the informal e-waste sector. Legislation should, therefore, be developed so that the informal e-waste sector is incorporated into EPR initiatives and looks towards potential formalisation. The collection channels that producers need to set up according to EPR can incorporate the informal e-waste sector.

In summary, the findings build on the literature by giving current examples of inadequate e-waste legislation. The findings emphasize that e-waste legislation must consider the informal e-waste sector. Furthermore, new insight into the government's control over EPR and PROs is provided.

5.3.3. Stakeholder awareness & reflection on social factors

The lack of stakeholder awareness and education on e-waste leads to a misconception of the informal e-waste sector and its role in the e-waste management system. Insufficient knowledge is also seen through stakeholders who do not know how part of the e-waste management system. It can further lead to an unwillingness to formalise from both e-waste sectors. Conflict arises between the e-waste sectors due to misunderstandings. Awareness of the activities from both e-waste sectors is needed to understand both roles and how these roles can complement one another. Education can also help motivate the two e-waste sectors to understand why formalisation is important.

It is suggested that consumers also do not understand the full complexity of e-waste recycling. Awareness from consumers will help change how the informal e-waste sector is perceived. Mutual respect from the formal e-waste sector and community will influence how the informal e-waste sector experiences work and its willingness to be a part of formalisation. E-waste education can help consumers obtain the necessary knowledge to safely dispose of their e-waste correctly. Consumers are then more likely to understand that, through formalisation, the informal e-waste sector can be a collection link for households.

The need for continuous awareness creation for all stakeholders is echoed throughout the study's findings and literature (Guerrero et al., 2013; Gunsilius et al., 2011; MoHUA, 2016; Timm et al., 2020; Wath et al., 2010; Yose, 2014), as well as a need for educating and training the informal e-waste sector (Ambrosi, 2018; Lundgren, 2012). The lack of training in the informal e-waste sector leads to wrong dismantling and disposal methods, as well as a misconception of the value of e-waste. Training should be an integrated part of the medium to the long-term growth strategy of formal e-waste recycling facilities. This does not only require support from the formal e-waste sector but the government as well. There is a need to create a recycling lifestyle – starting at a very young age. A few of the interviewed participants mentioned that they would be willing to create and support these awareness and training opportunities if support is provided. One participant also mentioned that they are working with community committees and supporting the informal e-waste sector. Therefore, if this type of relationship can be developed throughout the whole e-waste management system, it can be mutually beneficial.

In summary, the findings of the study additionally emphasize that a lack of e-waste awareness and knowledge leads to an incorrect perceived image between the two e-waste sectors, and essentially, an unwillingness to formalise. The study also highlights that there are formal e-waste recycling facilities that would be willing to support awareness and training programmes.

5.3.4. Formal recycling facility concerns

The formal recycling facility concerns would need to be addressed for formalisation to be able to be realised. The interviewed participants mentioned that it is their perception that some of the informal recyclers would not be willing to commit to formalisation. This, however, could also be true for the formal e-waste sector. As echoed in the literature (DFFF & DSI, 2020), commitment from each e-waste sector is needed to form a relationship and formalisation partnership. Mutual awareness creation and education of each sector is a good first step towards overcoming the concern of lack of commitment. A formal and documented commitment (Henzler et al., 2018) towards formalisation is another step to ensure both sectors are held accountable.

Trust between the two e-waste sectors will help overcome more concerns – lack of documentation and structure from the informal e-waste sector, theft, and e-waste origin – that lead to unwillingness to commit. Based on the answers from the interviewed participants, if the informal e-waste sector tries to sell stolen e-waste, the two e-waste sectors will not be able to work together. These concerns can be addressed by a good relationship and mutually beneficial agreement between the two e-waste sectors. The attitude of the informal e-waste sector is an important consideration to ensure formalisation success. It is, therefore, crucial to use what is

most important to the informal e-waste sector as motivation for formalisation. A structured, fact-based approach towards formalisation would also be of help.

Another concern was the small amounts of e-waste that individual informal recyclers try to sell to formal e-waste recycling facilities daily. The volume of e-waste can, however, be regulated by cooperatives that can store e-waste until the volume is sufficient for larger recycling facilities.

Lastly, it is crucial to remember that the participants emphasized that the reputation of the formal e-waste recycling facilities must not regress, or else formalisation will not be worth it for the formal e-waste sector. Thus, formal e-waste recycling facilities will not be able to adhere to promises of formalisation if these promises lead to regression in reputation and perceived image.

In summary, this whole section provides new information about current concerns the formal e-waste sector has regarding formalisation. These concerns are key considerations to integrate into a formalisation framework and can potentially be addressed by good relationships, mutually beneficial agreements, and a structured, fact-based formalisation approach.

5.3.5. Formalisation requirements and success factors

Stakeholder engagement is very important for a big change like formalisation within the e-waste management system. The formal e-waste sector has not been approached regarding this topic and this was evident from the interviews. Some of the participants noted that before the interview, they had not thought of the informal e-waste sector as a potential partner to their companies. It was, therefore, initially difficult for them to answer questions about the potential for formalisation or key considerations to formalisation, as they have not put much thought into it. After participants were encouraged to think about the possibilities, most participants admitted to seeing the opportunities that working with the informal e-sector presents although several concerns were expressed. This realisation encourages the potential for formalisation. By making the formal e-waste sector aware of the possibility for formalisation, the input and buy-in from stakeholders will increase, initiating the process of setting up a formal formalisation framework.

Considerations from all the previous themes, as well as an understanding of the mentioned requirements and success factors, are crucial to building a sustainable formalisation framework for the e-waste management system of South Africa. The interviewed participants mentioned certain factors throughout the interviews – reputation, requirements to accept e-waste, supporting links, and the structure of the informal e-waste sector – that will determine whether formal e-waste recycling facilities would consider formalisation. Within these factors, there are various smaller considerations.

The chosen formalisation process and support system must, therefore, not merely be based on previously chosen systems or what has been implemented internationally, but on the current infrastructure of South Africa and the context in which the system can function. In the same way, this applies to incentives. The type of incentive system must be based on literature, ground-level feedback from the formal and informal e-waste sectors, and sustainability considerations.

An important consideration for formal e-waste recycling facilities is how organised the informal e-waste sector will be within the formalisation framework that is set up. 92% of cooperatives have failed to organise informal recyclers, with the informal e-waste sector returning to landfills or operating independently (Grant, 2019). The current study's findings provide new insight and state that a controlled and organised system is needed that does not limit the abilities of the informal e-waste sector. There is various formalisation approaches to consider that should be selected based on the need of the community. Based on the input from one participant, an example of an e-waste collection system that can be implemented is a two-bag system where households place their e-waste outside in bags provided specifically for e-waste. A scheduled collection system can be devised for households to put out their e-waste or sell directly to the informal e-waste sector. Central drop-off points can also be predetermined. In this way, households and informal recyclers work through cooperatives or formal e-waste recycling facilities to collect e-waste.

In summary, setting up an applicable and complete formalisation framework for South Africa requires more in-depth ground-level experiences and understanding. Various levels of control are also needed to help set up and monitor this formalisation framework. Input is, thus, needed from law enforcement, formal e-waste recycling facilities, formal e-waste institutions, and informal e-waste sector committee communities.

5.4. Limitations

During the study, the researcher was faced with limitations. The research on e-waste recycling in South Africa is limited. For this reason, various literature sources outside of South Africa were used in the literature review. This meant that not all the literature sources apply directly to a developing country. There is also a lack of e-waste statistics for South Africa which meant that not all the statistics referenced were updated in the last two years. The researcher further acknowledges that the interview participants provide a biased perspective as their answers are only based on perceptions and experiences of the informal e-waste sector.

5.5. Research novelty and impact

This study makes a significant contribution towards the improvement of the e-waste management system of South Africa. It provides a holistic view of the mindset of the formal e-waste sector. It represents the potential and key considerations for formalisation, based on the perceptions and experiences of the formal e-waste sector and literature.

This study makes use of interviews to obtain unique perspectives from formal e-waste recycling facilities. This illuminates the relationship between the two e-waste sectors and exposes the potential for formalisation from more than one participant. The study, therefore, provides a valuable methodology that can be used in different contexts of data collection, to understand the complexity of different perspectives and relationships.

Although the study corroborates and highlights many findings in the e-waste literature, it provides additional insight into e-waste recycling activities, the mindset of key stakeholders, and the complexities and considerations of the e-waste management system. The insight is particularly interesting because of the range of the formal e-waste recycling facilities' size and level of knowledge on e-waste. The different views and reasonings highlight various factors that play a role in the formalisation process and the success of South Africa's e-waste management system.

The findings of this study can be used to guide future researchers to build on these themes, transform them, and apply them in future research. E-waste institutions, recycling companies, and the South African government can use this research for further e-waste management development, planning, and implementation to improve the current circumstances of e-waste recycling. Through bettering the e-waste management system, society and the environment is benefitted.

6. Conclusion and Recommendations

In the final chapter, reference is made back to the aim of the study – using the findings to provide recommendations for future work if a formalisation approach for an integrated e-waste management system is considered in future. Recommendations on further steps for the e-waste management system are suggested. The study concludes by reflecting on opportunities for further research inspired by this study.

6.2. Conclusion

The conclusion refers back to the proposed research questions in Chapter 1 (**1.4 Research questions and objectives**). The research questions are explained through their related objectives and followed by a final summary. The conclusions related to the two research questions for the study are as follows:

Research question 1: *What is the current state of the formal and informal e-waste sectors in South Africa?*

Objective 1: *To identify who makes up the formal and informal e-waste sectors and define their specific roles, responsibilities, and relationships.*

The government and both e-waste sectors hold crucial roles and responsibilities in the e-waste management system. The government controls e-waste imports, refineries, municipal landfills, and hazardous waste facilities. The government is also responsible for setting up e-waste legislation and the implementation and monitoring thereof. The formal e-waste sector includes manufacturers, retailers, recycling companies, and private initiatives. The formal e-waste sector takes responsibility for facilitating the repair, reuse, disassembly, and recycling of electronic devices legally. Lastly, the informal e-waste sector classifies as any recycler not supported or financed by authorities or companies. The informal e-waste sector is involved in the second-hand market, collecting e-waste from households and landfills, engaging with scrap dealers and recyclers, and performing manual dismantling. The detailed explanation of each of these stakeholders is explained in **APPENDIX C**.

Although these sectors overlap, each sector is uniquely situated to effectively control and carry out individual activities within its environment. Derived from the interviews and the perceptions of the formal e-waste sector, there are simultaneously stable and difficult relationships between the two e-waste sectors. There are existing informal communities that are supported by formal e-waste recycling facilities. There are also, however, informal recyclers and formal e-waste

recycling facilities that do not want to work together. The relationship between the two e-waste sectors is greatly based on awareness, education, and trust.

Research question 1 summary:

A divide, on various levels, between the formal and informal e-waste sectors is seen in access to education and training, sustainable income versus minimum income, and super-compliance in e-waste recycling versus no obedience to legislation. There is also a difference between smaller and larger recycling facilities regarding the volume of e-waste collected, where e-waste is collected from, and the stakeholders worked with. The smaller companies tend to work with the informal e-waste sector more easily and some are even dependent on the e-waste collected by informal recyclers.

The formal and informal e-waste sectors also compete against each other. This lack of cooperation wastes resources and is counter-productive to optimally collect e-waste. There is potential to remove this waste from the e-waste management system but a trustworthy partnership between the two e-waste sectors must be formed.

Research question 2: What is the potential for formalising the informal e-waste sector in South Africa?

Objective 2: *To identify the challenges that prevent an integrated e-waste management system.*

Various challenges that prevent an integrated waste management system are mentioned throughout the study. A lack of e-waste awareness from all stakeholders creates a misunderstanding between the stakeholders. Consumers are also not aware that e-waste is a problem and must be recycled separately from solid waste. Insufficient training and education from the informal e-waste sector leads to incorrect methods of recycling, which poses a threat to communities and the environment. Another challenge is the distrust between the two e-waste sectors, stemming from a lack of awareness. The two e-waste sectors continue to compete against each other and consequently, waste resources. The formal e-waste sector receives insufficient support from the government on different levels – financial, legislative development, and infrastructure improvement. A significant challenge is then also the complexity of setting up a sustainable formalisation framework to the satisfaction of all stakeholders. A formalisation framework considers numerous aspects of the e-waste management system and decision-making is dependent on the context of South Africa. Within this, the needs of the various stakeholders must also be considered.

Objective 3: *To identify key considerations for an integrated e-waste management system.*

The literature highlights numerous considerations for working with the informal e-waste sector and formalisation. The interviews build on this. Considerations explore the background and perceived image of the informal e-waste sector and mutual respect that requires an understanding of the work and responsibilities that both e-waste sectors contribute. Considerations also touch on the need for a structured formalisation approach set up by multiple stakeholders within the e-waste management system. With this, a formalisation support system is needed to monitor the formalisation process and offer guidance and support to all stakeholders. The last consideration is the requirements for accepting informal e-waste and the incentives needed for the informal e-waste sector to formalise. Incentives are determined within the formalisation approach, based on the needs of the informal e-waste sector and can range from protective wear and transportation equipment to training courses.

Objective 4: *To understand how the two e-waste sectors could be integrated, and what benefits (non-monetary incentives) and opportunities (increased income and work progress) could be realised from this.*

Through literature, a theoretical formalisation summary was devised as a guide for the interpretation of the data in this study. This theoretical formalisation summary reviews key steps in the formalisation process that can be developed to integrate the two e-waste sectors. The interviews add to this by highlighting considerations to incorporate for formalisation. The literature and interviews also emphasize the mutual benefits and opportunities of working together. For the informal e-waste sector, this includes better and more stable working conditions by working with protective gear, better equipment and not being exposed to harmful dismantling and recycling methods, as well as monetary incentives that investigate strategies for sustainable remuneration. For the formal e-waste sector, this includes higher volumes of e-waste collected through the informal e-waste sector and production gaps that can be filled by the informal e-waste sector. Working with the informal e-waste sector also includes opportunities for the formal e-waste sector such as creating a collection link, providing more collection flexibility (due to size, inexpensive methods of travelling, and motivation), and overcoming the manual dismantling gap.

Research question 2 summary:

Throughout the literature, the unique characteristics and benefits of the informal e-waste sector are emphasized. The themes discussed in the study highlight how the two e-waste sectors can work together to improve the e-waste management system of South Africa. The informal e-waste sector can be used in partnership to overcome the shortcomings formal e-waste recycling facilities face by being able to collect e-waste from sources that are not cost-efficient for the formal e-waste

sector and overcoming manual dismantling gaps. The potential of the informal e-waste sector can be further utilised by creating opportunities for training and awareness education. In this way, the informal e-waste sector can be educated about the exact needs of formal e-waste recycling facilities. Challenges of working with the informal e-waste sector and difficulties of formalisation can be overcome with the correct approaches and planning. With support from interface organisations, community committees, and the government (especially in legislation), a sustainable formalisation framework applicable to South Africa can be developed.

Ultimately, this study was able to answer the two central research questions posed. The findings of this study emphasised numerous critical and noteworthy observations. Firstly, there are three main stakeholders within the e-waste management system, each with unique roles and responsibilities to fulfil. Secondly, the potential for formalisation and willingness from the formal e-waste sector to be a part of the formalisation process exists, with certain concerns and success factors that need to be addressed. Finally, the formalisation process is incremental and continuous and needs to be adaptable and flexible. All these observations are vital as they stipulate sustainable success factors for formalisation.

6.3. Recommendations

The findings show that there is potential and willingness for formalisation but that various concerns need to be addressed for a sustainable and successful formalisation process. The recommendations build on these findings.

Before the formalisation process can be approached, awareness creation around e-waste and formalisation is imperative. Awareness will not only clarify the roles and responsibilities of the two e-waste sectors but also foster the recognition that formalisation is a potential method to enhance e-waste collection and recycling, thereby improving South Africa's e-waste management system.

The order in which the formalisation process is implemented is important. It is proposed that the transition into formalisation begins with direct ground-level input from the informal e-waste sector. A similar approach to this study can be followed, with a focus on the informal e-waste sector. There is a need to understand informal e-waste sector activities first-hand. This would require working with the informal e-waste sector directly. This could, also, however, be done through community committees that work with the informal e-waste sector and act as advocates.

Next, it must be determined how the activities of the formal and informal e-waste sectors can be integrated on a sustainable level and which sector should be responsible for certain roles. Literature has touched on the roles and responsibilities of stakeholders (Deubzer, 2011; Finlay & Liechti, 2008; Lydall et al., 2017; Mihai, 2019; Williams et al., 2013; Wilson et al., 2009), but how

these roles are integrated into the formalisation process is important. Both e-waste sector's activities need to be completely understood for successful integration.

It is then advised that the five-step theoretical formalisation summary, as provided in the last chapter of the literature review, be expanded into a formalisation framework for South Africa, incorporating the considerations and concerns from this study and the ground-level input received from the informal e-waste sector. It is crucial that the perceptions and experiences of both e-waste sectors must be considered. This formalisation framework can then explicitly be applied to South Africa to guide the formalisation process and be relevant to similar developing countries. A committee of various levels of stakeholders must be incorporated for planning and setting up the formalisation framework. This committee is also needed for transparency and accountability. Based on the findings, it is crucial that the formalisation framework:

- Be flexible and adaptable
- Be easy to understand
- Be planned out in steps to be easy to implement
- Be able to utilise the existing resources from both e-waste sectors to prevent duplicate work

The formalisation framework should then undergo a thorough validity and reliability process by contacting e-waste institutions and experts, locally and internationally, and incorporating the applicable feedback. Various developed countries such as Switzerland have e-waste organisations set out to help developing countries that should especially be contacted.

Once the formalisation framework is developed and has undergone the needed validity and reliability process, it must be implemented incrementally (Davis & Garb, 2015; Hinchliffe, 2017). It is recommended that a certain location be chosen for piloting. Gauteng is the first best option as most resources are available for its e-waste management system. The implementation must not be rushed. The pace at which steps are implemented must be monitored and controlled based on the abilities of both e-waste sectors. During the implementation, success can be measured based on initial goals to ensure progress (MoHUA, 2016). The progress can also be monitored the determine if adaption and changes are needed (Henzler et al., 2018).

In conclusion, the recommendations suggest that a strategic and thoroughly mapped out, sustainable formalisation framework be set up together by various stakeholders, to act as a step-for-step guide to integrate the informal e-waste sector into the formal e-waste management system.

6.4. Suggestions for further research

The e-waste management system of South Africa has numerous considerations, stakeholders, and activities that integrate to form the system. This study focuses on the informal e-waste sector and the potential for formalisation. Various factors will influence formalisation that can be explored further. A list of future topics is listed that can be integrated and added to this study:

- Perform a study on the informal e-waste sector to understand their willingness and concerns regarding formalisation
- Identify and expand on initiatives that can be used to incorporate the informal e-waste sector into projects such as workshops and meetings as the first step towards formalisation
- Determine the deep social aspects and crucial social factors of the two e-waste sectors working together.
- Analyse the circumstances and economic model of South Africa to identify which formalisation approach and buy-back methods are the most suitable
- Assess the trade value of the range of e-waste in South Africa to determine buy-back prices within formalisation and the sustainability connected to the value of the e-waste
- Set up a step-by-step formalisation framework that incorporates the input of all applicable stakeholders within the e-waste management system and validate this framework Explore further options on how to set up a record-keeping system that can be implemented within the informal e-waste sector
- Compare solid waste legislation and e-waste legislation to identify which laws can be amended and applied to the e-waste management system and assess the effectiveness of e-waste legislation
- Set up an e-waste recycling regulatory framework
- Explore consumer behaviour to assess the perceived image that consumers have of the informal e-waste sector and the potential barriers of consumers to support the formalisation
- Determine how the formal and informal e-waste sectors can be integrated into a reverse logistics model to deliver an optimal and flexible route collection system.

REFERENCES

- Ambrosi, V. M. (2018). Successful electronic waste management initiatives. *ITU Publications*.
- Aparcana, S. (2017a). Approaches to formalization of the informal waste sector into municipal solid waste management systems in low- and middle-income countries: Review of barriers and success factors. *Waste Management*, 61, 593–607. <https://doi.org/10.1016/j.wasman.2016.12.028>
- Aparcana, S. (2017b). Barriers and Success Factors of Approaches To Formalization of the Informal Waste Sector in Developing Countries: A Review. *Sixteenth International Waste Management and Landfill Symposium*, 1–19.
- Aparcana, S., & Salhofer, S. (2013). Development of a social impact assessment methodology for recycling systems in low-income countries. *SOCIETAL LIFE CYCLE ASSESSMENT*, 18, 1106–1115. <https://doi.org/10.1007/s11367-013-0546-8>
- Arora, R., & GTZ_ASEM. (2008). *Best Practices for E-waste Management in Developing Nations*.
- Asase, M., Yanful, E. K., Mensah, M., Stanford, J., & Amponsah, S. (2009). Comparison of municipal solid waste management systems in Canada and Ghana: A case study of the cities of London, Ontario, and Kumasi, Ghana. *Waste Management*, 29(10), 2779–2786. <https://doi.org/10.1016/j.wasman.2009.06.019>
- Baldé, C. P., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2017). *The Global E-waste Monitor - 2017* (Nations United University (UNU) & International Telecommunication Union (ITU) International Solid Waste Association (ISWA) (eds.)).
- Baud, I., Grafakos, S., Hordijk, M., & Post, J. (2001). *Quality of Life and Alliances in Solid Waste Management*. 18(1), 3–12.
- Bennagen, M. E. C., Nepomuceno, G., & Covar, R. (2002). *Solid Waste Segregation and Recycling in Metro Manila: Household Attitudes and Behavior*.
- Birmingham, P., & Wilkinson, D. (2003). *Using Research Instruments: A Guide for Researchers* (1st ed.). Taylor & Francis.
- Casanova, L., Dias, S., Gupta, S. K., Simpson, M. H., Sinnott, P. M., Soos, R., & Whiteman, A. (2009). *Solid Waste Management in the World's Cities*. UN-HABITAT.
- Central Pollution Control Board. (2016). *Implementation guidelines for E-Waste (Management)*

- Rules. In *HWM Division, CPCB* (p. 35).
http://cpcb.nic.in/upload/Latest/Latest_135_GUIDELINES-E-WASTE_RULES_2016.pdf
- Chaudhary, K., & Vrat, P. (2018). Case study analysis of e-waste management systems in Germany, Switzerland, Japan and India: A RADAR chart approach. *Benchmarking*, 25(9), 3519–3540. <https://doi.org/10.1108/BIJ-07-2017-0168>
- Chi, X., Streicher-Porte, M., Wang, M. Y. L., & Reuter, M. A. (2011). Informal electronic waste recycling: A sector review with special focus on China. *Waste Management*, 31(4), 731–742. <https://doi.org/10.1016/j.wasman.2010.11.006>
- Chikarmane, P. (2012). Integrating Waste Pickers into Municipal Solid Waste Management in Pune, India. *Women in Informal Employment: Globalizing and Organizing (WIEGO)*, 1–12.
- Chung, S.-W., & Murakami-Suzuki, R. (2008). A Comparative Study of E-waste Recycling Systems in Japan, Korea and Taiwan from the EPR Perspective: Implications for Developing Countries. *Institute of Developing Economies - Japan External Trade Organization (IDE-JETRO)*, 30, 125–145. <https://www.ide.go.jp/English/Publish/Reports/Spot/30.html>
- Chung, S. S., & Lo, C. W. H. (2008). Local waste management constraints and waste administrators in China. *Waste Management*, 28(2), 272–281. <https://doi.org/10.1016/j.wasman.2006.11.013>
- Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education* (7th ed.). Routledge. <https://doi.org/https://doi.org/10.4324/9780203720967>
- Creswell, J. W. (2009). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. In *SAGE Publication, Inc.* (3rd ed.). SAGE Publications.
- Creswell, J. W., & Creswell, J. D. (2018). Mixed Methods Procedures. In *Research Defign: Qualitative, Quantitative, and Mixed M ethods Approaches*.
- Crotty, M. (2020). *Foundation of Social Research* (1st ed.). Taylor and Francis. <https://www.perlego.com/book/1705175/foundations-of-social-research-pdf>
- Davis, J. M., & Garb, Y. (2015). A model for partnering with the informal e-waste industry: Rationale, principles and a case study. *Resources, Conservation and Recycling*, 105(December), 73–83. <https://doi.org/10.1016/j.resconrec.2015.08.001>
- DEA. (2011). National Waste Management Strategy. In *Waste Management*. https://www.environment.gov.za/sites/default/files/docs/nationalwaste_management_strate

- DEA. (2015). *The Waste Pickers Workshop Report*.
- Deubzer, O. (2011). *E-waste Management in Germany 20* (Issue July). United Nations University.
- DFFF, & DSI. (2020). *Waste Picker Integration Guideline for South Africa: Building the Recycling Economy and Improving Livelihoods through Integration of the Informal Sector*.
- Diaz, L. F., Eggerth, L. L., & Savage, G. M. (2007). *Management of Solid Wastes in Developing Countries* (IWWG Task Group on Waste Management in Developing Countries (ed.)). CISA.
- Dlamini, S. Q. (2016). *Solid waste management in South Africa: Exploring the role of the informal sector in solid waste recycling in Johannesburg*. University of Witwatersrand.
- Dlamini, S. Q., & Simatele, M. (2016). *Unrecognised informal solid waste recycling in an emerging African megacity: a study of Johannesburg, South Africa*. <https://doi.org/10.2495/WM160021>
- Finlay, A., & Liechti, D. (2008). e-Waste Assessment South Africa. *EWaste Association of South Africa (EWASA)*, 1–76. http://ewasteguide.info/files/Widmer_2005_Empa.pdf
- Gerdes, P., & Gunsilius, E. (2010). The Waste Experts: Enabling Conditions for Informal Sector Integration in Solid Waste Management. *Partners for Recycling Management*, 1–32.
- Godfrey, L. (2021). Quantifying economic activity in the informal recycling sector in South Africa. *South African Journal of Science*, 117(9–10), 1–7. <https://doi.org/10.17159/SAJS.2021/8921>
- Godfrey, L., Strydom, W., & Phukubye, R. (2016). Integrating the Informal Sector Into the South African Waste and Recycling Economy in the Context of Extended Producer Responsibility. *CSIR*, 1–6. https://www.csir.co.za/sites/default/files/Documents/Policy_Brief_Informal_Sector_CSIR_final.pdf
- Grant, R. (2019). E-waste challenges in Cape Town: Opportunity for the green economy? *Urbani Izziv*, 30(February), 5–23. <https://doi.org/10.5379/urbani-izziv-en-2019-30-supplement-001>
- Grant, R., & Oteng-Ababio, M. (2021). Formalising E-waste in Ghana: An emerging landscape of fragmentation and enduring barriers. *Development Southern Africa*, 38(1), 73–86. <https://doi.org/10.1080/0376835X.2020.1823822>
- Grosen, J. (2012). Green Growth in Practice Lessons Learnt from promoting Eco-Enterprises in Honduras and Guatemala under Danida's. *Development Associate ApS*.

- Guerrero, L. A., Maas, G., & Hogland, W. (2013). Solid waste management challenges for cities in developing countries. *Waste Management*, 33(1), 220–232. <https://doi.org/10.1016/j.wasman.2012.09.008>
- Gunsilius, E. (2011). The informal sector in SWM – economic arguments and political framework for its integration. *Proceedings International Conference Sardinia 2011, Thirteenth International Waste Management and Landfill Symposium*, 7.
- Gunsilius, E., Spies, S., Garcia-Cortez, S., Medina, M., Dias, S., Scheinberg, A., Sabry, W., Abdel-Ady, N., Florisbela dos Santos, A. L., & Ruiz, S. (2011). Recovering resources, creating opportunities: Integrating the informal sector into solid waste management. In S. G.-C. Ellen Gunsilius, Sandra Spies (Ed.), *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*. [http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Recovering+resources+C
reating+opportunities.+Integrating+the+informal+sector+into+Solid+Waste+Managment#0
%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Recovering+Resour
ces+C](http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Recovering+resources+Creating+opportunities.+Integrating+the+informal+sector+into+Solid+Waste+Management#0%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Recovering+Resources+C)
- Gutberlet, J. (2011). Waste to Energy, Wasting Resources and Livelihoods. In *Integrated Waste Management* (Vol. 1).
- Hazra, T., & Goel, S. (2009). Solid waste management in Kolkata, India: practices and challenges. *Waste Management (New York, N.Y.)*, 29(1), 470–478. <https://doi.org/10.1016/j.wasman.2008.01.023>
- Henry, R. K., Yongsheng, Z., & Jun, D. (2006). Municipal solid waste management challenges in developing countries--Kenyan case study. *Waste Management (New York, N.Y.)*, 26(1), 92–100. <https://doi.org/10.1016/j.wasman.2005.03.007>
- Henzler, M., Eisinger, F., & Hemkhaus, M. (2018). *Creating Successful Formal-informal Partnerships in the Indian E-waste Sector*. 1–20.
- Herat, S. (2021). E-Waste Management in Asia Pacific Region: Review of Issues, Challenges and Solutions. *Nature Environment and Pollution Technology*, 20(1), 45–53. <https://doi.org/https://doi.org/10.46488/NEPT.2021.v20i01.005>
- Hetz, K., & Lemke, A. (2011). The Informal Recycling Market in Ormoc City, Philippines: Evaluation of Options to Enhance Resources Recovery and to Reduce GHG Emissions. *Wiego*.

Hinchliffe, D. (2017). *Building the Link: Leveraging Formal-Informal Partnerships in the Indian E-Waste Sector*.

Hinchliffe, D., Gunsilius, E., Wagner, M., Hemkhaus, M., Batteiger, A., Rabbow, E., Cheng, C., & Ott, D. (2020). *Partnerships between the informal and the formal sector for sustainable e-waste management*. April.

Hougaard, O. (2021). *Constructing an E-waste Management Framework to Improve E-waste Recycling in South Africa* (Issue November). The North-West University.

IFC. (2015). *Utility-Scale Solar Photovoltaic Power Plants*. 35–39.

Ilankoon, I. M. S. K., Ghorbani, Y., Chong, M. N., Herath, G., Moyo, T., & Petersen, J. (2018). E-waste in the international context – A review of trade flows, regulations, hazards, waste management strategies and technologies for value recovery. In *Waste Management* (Vol. 82, pp. 258–275). <https://doi.org/10.1016/j.wasman.2018.10.018>

ILO-IPEC. (2004). Addressing the Exploitation of Children in Scavenging (Waste Picking): A Thematic Evaluation of Action on Child Labour. *International Labour Organisation (ILO)*. <http://www.bvsde.paho.org/bvsacd/cd27/scavenging.pdf>

Ilyassova, G., Nukusheva, A., Arenova, L., Karzhassova, G., & Akimzhanova, M. (2021). Prospects of legal regulation in the field of electronic waste management in the context of a circular economy. *International Environmental Agreements: Politics, Law and Economics*, 21(3), 367–388. <https://doi.org/10.1007/s10784-020-09514-3>

Inclusive Innovations. (2017). *Business Models for Integrated Waste Management*. 1–21. [https://www.innovationpolicyplatform.org/system/files/4 Integrated Waste Manangement_Apr6.pdf](https://www.innovationpolicyplatform.org/system/files/4_Integrated_Waste_Management_Apr6.pdf)

ITU. (2018). *Successful Electronics Waste Management Initiatives*. <https://www.itu.int/en/ITU-D/Climate-Change/Documents/2018/Successful-electronic-waste-management-initiatives.pdf>

Jaiswal, A., Samuel, C., Patel, B. S., & Kumar, M. (2015). Go green with WEEE: Eco-friendly approach for handling e-waste. *Procedia Computer Science*, 46(Icict 2014), 1317–1324. <https://doi.org/10.1016/j.procs.2015.01.059>

Kumar, A., Holuszko, M., & Espinosa, D. C. R. (2017). E-waste: An overview on generation, collection, legislation and recycling practices. In *Resources, Conservation and Recycling* (Vol. 122, pp. 32–42). <https://doi.org/10.1016/j.resconrec.2017.01.018>

- Kumar, U., & Singh, D. (2013). E-Waste Management through Regulations. *International Journal of Engineering Inventions*, 3(2), 6–14. www.ijejournal.com
- Kuria, D., & Muasya, R. (2010). Mapping of Waste Pickers and Organizations Supporting Waste Pickers in Kenya. *Women in Informal Employment: Globalizing and Organizing (WIEGO)*. https://www.wiego.org/sites/default/files/publications/files/Kuria_Muasya_Mapping_WP_Kenya.pdf
- Lakhan, C. (2015). *A critical review of Ontario's Blue Box program: Identifying and testing best practices in printed paper and packaging recycling*. <https://scholars.wlu.ca/etd/1785/>
- Li, R. C., & Tee, T. J. C. (2012). A Reverse Logistics Model For Recovery Options Of E-waste Considering the Integration of the Formal and Informal Waste Sectors. *Procedia - Social and Behavioral Sciences*, 40, 788–816. <https://doi.org/10.1016/j.sbspro.2012.03.266>
- Lines, K., Garside, B., Sinha, S., & Fedorenko, I. (2016). *Clean and inclusive? Recycling e-waste in China and India* (Issue March). About the authors Kate Lines, independent researcher and consultant. KatherineLines@gmail.com Ben Garside, senior researcher, IIED. Ben.Garside@iied.org Satish Sinha, associate director, Toxics Link Irina Fedorenko, DPhil candidate, Oxford University Prod. www.iied.org
- Lu, C., Zhang, L., Zhong, Y., Ren, W., Tobias, M., Mu, Z., Ma, Z., Geng, Y., & Xue, B. (2015). An overview of e-waste management in China. *Journal of Material Cycles and Waste Management*, 17(1), 1–12. <https://doi.org/10.1007/s10163-014-0256-8>
- Lucier, C. A., & Gareau, B. J. (2019). Electronic Waste Recycling and Disposal: An Overview. *IntechOpen*. <http://www.intechopen.com/books/trends-in-telecommunications-technologies/gps-total-electron-content-tec-prediction-at-ionosphere-layer-over-the-equatorial-region%0AInTec>
- Lundgren, K. (2012). The global impact of e-waste: Addressing the challenge. In *International Labour Office*.
- Lydall, M., Nyanjowa, W., & James, Y. (2017). Mapping South Africa's Waste Electrical and Electronic Equipment (WEEE) Dismantling, Pre-Processing and Processing Technology Landscape - Waste Research Development and Innovation Roadmap Research Report. *Futurespot.Co.Za*, March, 1–91. http://futurespot.co.za/pdfs/weee_technology_landscape_assessment_report.pdf%0Ahttp://www.wasteroadmap.co.za/download/weee_technology_landscape_assessment_report.pdf

- McAllister, L. (2013). *The Human and Environmental Effects of E-Waste*.
<http://www.prb.org/Publications/Articles/2013/e-waste.aspx>
- Mccann, D., Wittmann, A., Europe, E., & WEEE Help. (2015). E-waste Prevention, Take-back System Design and Policy Approaches. *Step Green Paper Series*.
- McCombes, S. (2022). *Sampling Methods |Types, Techniques & Examples*. Scribbr.
<https://www.scribbr.com/methodology/sampling-methods/>
- Medina, M. (2000). Scavenger cooperatives in Asia and Latin America. *Resource Conservation and Recycling*, 31, 51–69.
- Medina, M. (2008, October). The informal recycling sector in developing countries: Organizing waste pickers to enhance their impact. *Gridlines*, 44.
<https://openknowledge.worldbank.org/handle/10986/10586>
- Merriam, S. B. (2009). *Qualitative Research: A Guide to Design and Implementation* (3rd ed.). Jossey-Bass.
- Mihai, F. (2019). Electronic waste management in Romania: Pathways for sustainable practices. *Handbook of Electronic Waste Management: International Best Practices and Case Studies*, 533–551. <https://doi.org/10.1016/B978-0-12-817030-4.00024-3>
- Mihai, F., Gnoni, M., & Meidiana, C. (2019). *Waste Electrical and Electronic Equipment (WEEE): Flows, Quantities, and Management — A Global Scenario* (M. N. V. Prasad, M. Vithanage, Technology Electronic Waste Management and Treatment, & Butterworth-Heineman (eds.)). Elsevier Inc. <https://doi.org/https://doi.org/10.1016/B978-0-12-816190-6.00001-7>
- Mmereki, D., Li, B., Baldwin, A., & Hong, L. (2016). The Generation, Composition, Collection, Treatment and Disposal System, and Impact of E-Waste. *Intech*, 32, 137–144.
<https://www.intechopen.com/books/advanced-biometric-technologies/liveness-detection-in-biometrics>
- Mohanty, S., Vermeersch, E., Hintsa, J., Di Cortemiglia, V. L., & Liddane, M. (2015). Weaknesses in European e-waste management. *Blecker, Thorsten Kersten, Wolfgang Ringle, Christian M. (Ed.): Operational Excellence in Logistics and Supply Chains: Optimization Methods, Data-Driven Approaches and Security Insights. Proceedings of the Hamburg International Conference of Logistics (HI*, 22, 535–561. <https://www.econstor.eu/handle/10419/209298>
- MoHUA. (2016). *An Inclusive Swachh Bharat through the Integration of the Informal Recycling Sector: A Step by Step Guide*. Ministry of Housing and Urban Affairs, Government of India.

- Morris, A., & Metternicht, G. (2016). Assessing effectiveness of WEEE management policy in Australia. *Journal of Environmental Management*, 181, 218–230. <https://doi.org/10.1016/j.jenvman.2016.06.013>
- Mrayyan, B., & Hamdi, M. R. (2006). Management approaches to integrated solid waste in industrialized zones in Jordan: a case of Zarqa City. *Waste Management (New York, N.Y.)*, 26(2), 195–205. <https://doi.org/10.1016/j.wasman.2005.06.008>
- Muswema, A., Oelofse, S. H. H., & CSIR. (2016). Implementing small, and medium enterprises (SME) waste and recycling programmes. *Proceedings of the 23rd WasteCon Conference*. <https://researchspace.csir.co.za/dspace/handle/10204/8983>
- Mwanzia, P., Kimani, S. N., & Stevens, L. (2013). Integrated solid waste management: Decentralised service delivery case study of Nakuru municipality, Kenya. *36th WEDC International Conference*, 1–6.
- Nagajothi, P., & Kala, D. (2015). Electronic Waste Management: A Review. *International Journal of Applied Engineering Research*, 10(68).
- Neilsin, C. (2010). *E-Waste Management in the Philippines: An Assessment*. Monash University.
- Oxford, T. (2022). *The war on waste pickers*. Univesity of Witwatersrand. <https://www.wits.ac.za/curiosity/stories/the-war-on-waste-pickers.html>
- Panwar, M., Ahmed, S., & Sharma, A. (2018). Bridging the gaps between the formal and informal e-waste managemnet in India with EPR. *International Journal of Development Research*, 08(01), 18501–18506. <http://www.journalijdr.com>
- Patil, R. A., & Ramakrishna, S. (2020). A comprehensive analysis of e-waste legislation worldwide. *Environmental Science and Pollution Research*, 27(13), 14412–14431. <https://doi.org/10.1007/s11356-020-07992-1>
- Paul, J. G., Arce-Jaque, J., Ravena, N., & Villamor, S. P. (2012). Integration of the informal sector into municipal solid waste management in the Philippines - What does it need? *Waste Management*, 2018–2028. <https://doi.org/10.1016/j.wasman.2012.05.026>
- Periathamby, A., & Tanaka, M. (2014). *Municipal Solid Waste Management in Asia and the Pacific Islands: Challenges and Strategic Solutions*. Springer Singapore. <https://doi.org/10.1007/978-981-4451-73-4>
- Raghupathy, L., Krüger, C., Chaturvedi, A., Arora, R., & Henzler, M. (2010). E-waste recycling in

- India – Bridging the gap between the informal and formal sector. *ISWA Conference Proceedings*, 10.
- Ramchurjee, N. A., & Ramchurjee, C. E. (2016). *Are we experiencing an E-Waste Tsunami? E-Waste Management in Mysore, India*. University of Mysore.
- Rosala, M. (2019). *How to Analyze Qualitative Data from UX Research: Thematic Analysis*. Nielsen N. <https://www.nngroup.com/articles/thematic-analysis/>
- Sadan, Z. (2019). *Exploring the potential for local end processing of e-waste in South Africa. January*. <https://doi.org/10.5379/urbani-izziv-en-2019-30-supplement-001>
- Salhofer, S., Kopacek, B., & Gericke, M. (2017). Developing a Roadmap for E-Waste Management in South Africa. *Sixteenth International Waste Management and Landfill Symposium, October*, 10.
- SAWIC. (2015). *South African Waste Information Centre, Tonnage Reports*.
- Scheinberg, A., Wilson, D. C., & Rodic, L. (2010). *Solid Waste Management in the World's Cities - Water and Sanitation in the World's Cities*. Earthscan Publications for and on behalf of the United Nations Human Settlements Programme UN-HABITAT.
- Seng, B., Kaneko, H., Hirayama, K., & Katayama-Hirayama, K. (2010). Municipal solid waste management in Phnom Penh, capital city of Cambodia. *Waste Management & Research*, 29(5), 491–500. <https://doi.org/10.1177/0734242X10380994>
- Sharholly, M., Ahmad, K., Mahmood, G., & Trivedi, R. C. (2008). Municipal solid waste management in Indian cities - A review. *Waste Management*, 28(2), 459–467. <https://doi.org/10.1016/j.wasman.2007.02.008>
- Shevchenko, T., Saidani, M., Danko, Y., Golysheva, I., Chovancová, J., & Vavrek, R. (2021). Towards a smart E-waste system utilizing supply chain participants and interactive online maps. *Recycling*, 6(1), 1–14. <https://doi.org/10.3390/recycling6010008>
- Shittu, O. S., Williams, I. D., & Shaw, P. J. (2021). Global E-waste management: Can WEEE make a difference? A review of e-waste trends, legislation, contemporary issues and future challenges. *Waste Management*, 120, 549–563. <https://doi.org/10.1016/j.wasman.2020.10.016>
- StEP, Mccann, D., & Wittmann, A. (2015). E-waste prevention, Take-back System Design and Policy Approaches. *Step*, 6579(February). <http://www.step-initiative.org/?file=files/step->

- SWAPP. (2006). Economic Aspects of informal sector activities in Solid Waste Management. *Solid Waste Management Association of the Philippines (SWAPP)*, 79.
- Tadesse, T., Ruijs, A., & Hagos, F. (2008). Household waste disposal in Mekelle city, Northern Ethiopia. *Waste Management (New York, N.Y.)*, 28(10), 2003–2012. <https://doi.org/10.1016/j.wasman.2007.08.015>
- Terraza, H., & Sturzenegger, G. (2010). Dinámicas de Organización de los Recicladores Informales Tres casos de estudio en América Latina. *Banco Interamericanon de Desarrollo*, 117.
- Thakur, P., & Kumar, S. (2021). Evaluation of e-waste status, management strategies, and legislations. *International Journal of Environmental Science and Technology*, 0123456789. <https://doi.org/10.1007/s13762-021-03383-2>
- Timm, M., Chidzungu, S., Dladla, T., Kadyamadare, N., Maema, G., Mahlase, K., Mokobane; A, M., Molefe, K., Ndlovu, L., Ntuli, Z., Phakoe, K., Pholoto, L., Sekhwela, M., & And, S. (2020). *Lessons from Waste Picker Integration Initiatives: Development of Evidence Based Guidelines to Integrate Waste Pickers into South African Municipal Waste Management Systems*.
- Torres, D., Guzmán, S., Kuehr, R., Magalini, F., Devia, L., Cueva, A., Herbeck, E., Kern, M., Rovira, S., Drisse, M.-N. B., Soares da Silva, A., Pascale, A., Laborde, A., Kitsara, I., Godoi, G. C. D. S., & Basiniani, I. R. (2016). Sustainable management of waste electrical and electronic equipment in Latin America. *ITUPublications*, 1–66. https://www.unclearn.org/sites/default/files/inventory/integrated_weee_management_and_disposal-395429-normal-e.pdf
- Velis, C. A., Wilson, D. C., Rocca, O., Smith, S. R., Mavropoulos, A., & Cheeseman, C. R. (2012). An analytical framework and tool ('InteRa') for integrating the informal recycling sector in waste and resource management systems in developing countries. *Waste Management and Research*, 30, 43–66. <https://doi.org/10.1177/0734242X12454934>
- Vijarania, M., Gupta, S., & Gambhir, A. (2017). Challenges and strategies for E-waste management in developing countries. *IJ Sci. Eng.*, 2(9), 64–68. http://oaijse.com/VolumeArticles/FullTextPDF/79_OAIJSE_CHALLENGES_AND_STRATEGIES_FOR_E-WASTE_MANAGEMENT_IN_DEVELOPING_COUNTRIES_13.pdf

- Viljoen, J. M. M., Schenck, C. J., Volschenk, L., Blaauw, P. F., & Grobler, L. (2021). Household Waste Management Practices and Challenges in a Rural Remote Town in the Hantam Municipality in the Northern Cape, South Africa. In *Sustainability* (Vol. 13, Issue 11). <https://doi.org/10.3390/su13115903>
- Wang, F., & Huisman, J. (2010). Formalisation of E-Waste Collection and Recycling in China. *Proceedings of CARE Innovation Conference*, 1–3. <http://www.transwaste.eu/file/001440.pdf>
- Wang, Z., Guo, D., & Wang, X. (2016). Determinants of residents' e-waste recycling behaviour intentions: Evidence from China. *Journal of Cleaner Production*, 137(February 2009), 850–860. <https://doi.org/10.1016/j.jclepro.2016.07.155>
- Wath, S. B., Vaidya, A. N., Dutt, P. S., & Chakrabarti, T. (2010). A roadmap for development of sustainable E-waste management system in India. In *Science of the Total Environment* (Vol. 409, Issue 1, pp. 19–32). <https://doi.org/10.1016/j.scitotenv.2010.09.030>
- Wengraf, T. (2001). *Qualitative Research Interviewing* (1st ed.). SAGE Publications. <https://www.perlego.com/book/861934/qualitative-research-interviewing-pdf>
- Widmer, R., Schluep, M., & Denzler, S. (2008). The Swiss Global E-Waste Programme. *Proceedings of the 19th Waste Management Conference of the IWMSA (WasteCon2008), October*, 459–476.
- WIEGO. (2009). Refusing to be Cast Aside: Waste Pickers Organising Around the World. *Women in Informal Employment: Globalizing and Organizing (WIEGO)*.
- WIEGO. (2020). *Waste Integration in South Africa (WISA)*. Women in Informal Employment: Globalizing and Organizing. <https://www.wiego.org/waste-integration-south-africa-wisa#:~:text=Strengthening the Role of Informal,sorting and selling recyclable discards>.
- Williams, E., Kahhat, R., Bengtsson, M., Hayashi, S., Hotta, Y., & Totoki, Y. (2013). Linking Informal and Formal Electronics Recycling via an Interface Organization. *Challenges*, 4(2), 136–153. <https://doi.org/10.3390/challe4020136>
- Wilson, D. C., Araba, A. O., Chinwah, K., & Cheeseman, C. R. (2009). Building recycling rates through the informal sector. *Waste Management*, 29(2), 629–635. <https://doi.org/10.1016/j.wasman.2008.06.016>
- Wilson, D. C., Velis, C., & Cheeseman, C. (2006). Role of informal sector recycling in waste management in developing countries. *Habitat International*, 30(4), 797–808.

<https://doi.org/10.1016/j.habitatint.2005.09.005>

- Yadav, S. S. K., & Bandyopadhyay, A. (2015). The E-Waste Legislation and Contemporary Sustainability Issues in India: A Critical Analysis. *Asia Pacific Journal of Management Reserach and Innovation*, 11, 245–250.
- Yates, J. S., & Gutberlet, J. (2011). Enhancing Livelihoods and the Urban Environment: The Local Political Framework for Integrated Organic Waste Management in Diadema, Brazil. *The Journal of Development Studies*, 47(4), 639–656.
- Yose, B. (2014). Formalisation of E-Waste Recycling : Making it a Reality. *Proceedings of the 20th WasteCon Conference 6-10 October 2014. Somerset West, Cape Town, October*, 576–586.
- Yu, J., Williams, E., Ju, M., & Shao, C. (2010). Managing e-waste in China: Policies, pilot projects and alternative approaches. *Resources, Conservation and Recycling*, 54(11), 991–999. <https://doi.org/10.1016/j.resconrec.2010.02.006>
- Zurbrügg, C., Gfrerer, M., Ashadi, H., Brenner, W., & Küper, D. (2012). Determinants of sustainability in solid waste management--the Gianyar Waste Recovery Project in Indonesia. *Waste Management (New York, N.Y.)*, 32(11), 2126–2133. <https://doi.org/10.1016/j.wasman.2012.01.011>

APPENDIX A – E-WASTE CATEGORIES

Notes:

The e-waste categories and examples are seen in Table 11.

Table 12: E-waste categories and examples adapted from Deubzer (2011) and Neilsin (2010)

Categories	Examples
Information and Communications Technology (ICT) is an office equipment	Laptops, mobile phones, fax machines, printers, photocopiers, etc.
Consumer electronics and entertainment	Televisions, DVD/VCR/CD players, radios, train sets, slot machines, ticket equipment Battery-powered toys, treadmills, massagers, etc.
Small household appliances	Coffee machines, vacuum cleaners, toasters, irons, sandwich machines, etc.
Large household appliances	Washing machine, refrigerator, freezer, tumble dryer, air conditioner, etc.
Lighting equipment	LED and fluorescent lamps, and tubes
Electronic and electrical tools	Sewing machine, lawnmower, stationary tools, drills, electric saws, electric welding equipment, grinders, etc.
Healthcare equipment and medical devices	Defibrillators, hearing aids, pacemakers, etc.
Security, monitoring, and control instruments	Surveillance and control equipment, security cameras, etc.

APPENDIX B – INFORMAL E-WASTE RECYCLING TECHNIQUES

Notes:

Informal e-waste recycling, which often relates to illegal and incorrect recycling, has many negative impacts on the environment and society. Electronic devices contain components with toxic elements such as lead, mercury, arsenic, and cadmium. Incorrect disposal through open burning, incineration, smashing of electronics, and acid leaching, releases dangerous toxins (Finlay & Liechti, 2008; Ramchurjee & Ramchurjee, 2016; Sadan, 2019). More harmful effects are air, water, and land pollution that can lead to pulmonary and cardiovascular disease, cancer, and birth defects (Grant, 2019; Mmereki et al., 2016; Torres et al., 2016). These informal recycling techniques and concerns are shown in Table 12 (Williams et al., 2013).

Table 13: Informal recycling techniques and environmental impact

Recycling Technique	Informal Process	Environmental Impact
Chip removal	Heating circuit boards Manual chip extraction	Lead and other emissions
Circuit board gold and copper recovery	Hydrometallurgical processing using acids and cyanide	Leached metal and chemical emissions
Wire copper recovery	Open burning of wires	Release of pollutants – dioxins, furans, etc.
Cathode Ray Tube recovery	Manual tube separation	Lead exposure
Residual waste disposal	The build-up in open landfills	Leached metals, pollutants, and flame retardants caused by landfill fires

APPENDIX C – PROFILES OF THE INTERVIEWED PARTICIPANTS

Notes:

All the participants were from the formal e-waste sector. All participants were either employees or owners of e-waste recycling facilities, except for P3 who is an employee of an e-waste institution. Small companies for this study are classified as companies that have only one existing branch with less than 20 employees. Medium companies have either between one to three branches with each branch having between 20 and 50 employees. Large companies then have more than three branches with an average of more than 50 employees per branch. The profiles of the formal e-waste recycling facilities are displayed in Table 13.

Table 14: Profiles of the interviewed participants

Participant	Location	Company size	Main activities	Informal interaction
P1	Gauteng	Large, 700+ clients nationally.	Separate waste on site. Process further, export, or sell.	Many interactions with community committees and helping the informal e-waste sector.
P2	KwaZulu Natal	Medium	Refurbish e-waste, reuse, and sell.	Some interaction with the informal e-waste sector.
P3	Gauteng	Large, one of the most certified companies in the recycling space	IT asset management services, refurbishment, and complete recycling.	Many interactions directly with the informal e-waste sector. Buy e-waste.
P4	Gauteng	Small	Create collection mechanisms with a focus on portable e-waste.	Little interaction. It has been approached by the informal e-waste sector.
P5	Gauteng	Large	E-waste collection, refurbish, recycle.	No interaction.
P6	Gauteng	Medium	Collect, recycle, and dispose.	Little interaction when informal recyclers try to sell e-waste.
P7	Gauteng	Large in solid waste Small in e-waste	Collect, dismantle, and refurbish. Sell parts or products.	Little interaction.
P8	Western Cape	Large	E-waste collection, refurbishment, recycling, and disposal.	Interact with more than 700 informal recyclers daily.
P9	Gauteng	Large, one of the largest independently owned operators and traders of recyclable material in SA.	Provides a multitude of waste management services specialising in the minimisation of waste streams and the collection of recyclable waste.	Little interaction.
P10	Gauteng	Medium	Collect, dismantle, refurbish, recycle, and dispose	No interaction.
P11	Gauteng	Medium	Collect, recycle, dispose, and training	Little interaction.
P12	Gauteng	Medium	Collect, recycle, dispose, and training	No interaction.

APPENDIX D – QUALITATIVE INTERVIEW PROTOCOL

Notes:

The following questions were used to guide the qualitative interviews. The first section is directly applicable to the formal e-waste sector while the second section relates to their perceptions and experiences of and with the informal e-waste sector. The order of the questions varied based on the answers from the participants. The interview protocol also allowed for additional follow-up questions.

Formal e-waste sector questions

1. Are there any barriers or difficulties that you face when collecting e-waste, for example, any issues or risks around collecting and working with e-waste – safety or health-related? If so, care to elaborate?
2. Are there any impacts of legislation to register and handle e-waste properly on your business (make it difficult or costly to handle e-waste)?
3. Have you interacted with informal recyclers? If yes, how often do you interact with the informal e-waste sector and what has your experience been?
4. What potential do you see in forming a partnership with the informal e-waste sector?
5. What are the barriers or potential issues of working with the informal e-waste sector?
6. What do you believe are key things to consider when working with the informal e-waste sector?
7. What advice do you have for the potential formalisation of the informal collection of e-waste (how do you think the formalisation could work)?

Based on your experiences and interactions with the informal e-waste sector, could you comment on the following based on your experiences and perceptions:

1. How do informal recyclers collect their e-waste and how much do they collect?
2. Where are the general places/people that informal recyclers collect e-waste from?
3. Who are the types of people informal recyclers sell e-waste?
4. What prices do informal recyclers get for the e-waste or metals sold? Is this enough to make a living on?
5. Do informal recyclers feel unsafe when collecting the e-waste or are there people making it difficult for informal recyclers to collect?
6. How big is their collection community?
7. Is there a significant competition between informal collectors and formal collectors?
8. What do you think can improve the work circumstances of informal recyclers?

9. Do you think informal recyclers are cautious about change?
10. Do you think informal recyclers will consider working with formal recycling companies and collecting e-waste for them if this leads to better circumstances?

APPENDIX E – INTERVIEW DATA CAPTURING AND ORGANISATION



Figure 14: Interview data capturing and organisation

APPENDIX F – INTERVIEW DATA ANALYSIS PROCESS

Themes	Challenges & Barriers for collection & recycling	Opportunities & Potential for formalisation	Key considerations to formalise and work it	Un/Willingness of companies	Lack of knowledge & awareness	Barriers & Constraints to formalise/work with it
1	Transport cost is value The cost of transport alone is detrimental. transport is in most cases more than what the material is worth. Yes, most of the client got small e-waste to dispose, it makes it difficult to collect these items. Need to determine if the e-waste is valuable enough to collect (cost-efficient). Collection cost is sometimes more than the value of the waste. Small amount of e-waste to collect due to the number of newsmen and informal collectors. Unless if the newsmen are even fully registered, informal collectors are not. Potential to use the if The main problem for us, as a company, is that this material, of which has no value, lands up at our facilities and it cost us money to dispose safely, with low operational loss (cost).	Informal e-waste sourcing Informal sector = e-waste producers We have been approached by informal collectors. They have a range of products Definitely, that is what they do currently as they do not have access to the real recyclers that is only present in the big cities Yes, it's already happening. A lot of formal recycling facilities depend on the e-waste that the informal sector brings in. The informal sector contributes a lot towards collection of e-waste. This will reduce the volume of waste that goes to landfill. Instead all that will be recycled. Potential!! It will increase the job opportunities. increase in productivity, recycling targets achieved When the productivity is high, it will bring a positive outcome and job satisfaction. Yes, because this will up the e-waste tonnage of the formal collector Manual processes If your processes are manual you are limited to process a lot of e-waste - up for if it's fill the gaps We can recycle materials up to a point. We give these materials to the informal sector for free, they dismantle further manually and sell it back to us. Different roles and responsibilities. It works quite well. Bigger and smaller companies must be managed different in formalisation process. * Smaller companies function different - can use the manual labour. If your processes are manual you are limited to process a lot of e-waste just more than 500kg/day A few years back we had about 30 people that segregated the materials but now we have technology that can strip the e-waste up to a point that is still cost-effective for us. "smaller companies are still manual" There is no reason why formalisation will provide e-waste for formal companies. Not too much incentive or authorization if they are stopped OR legislation change The private sector alone cannot change SA problem. A lot more focus on the government is needed. We know from experience that the ANC is not interested they are more about making money. I am here to employ people but need big support from bigger companies and government. Government uses recyclers to remove general waste and materials to get to e-waste. Legislation is only good on paper. Registered companies are being punished for ignoring the law while other recyclers do what they want and get away with it. Legislation for recycling and disposal only costs money one takes a lot of time. A lot of big and corporate companies only want to see your papers to use for themselves. They have used e-waste papers to collect e-waste from other companies or hire cheaper companies to do the work. How can they prove that they have the correct paperwork - who evaluates this? Corporate companies think that small companies cannot manage a big e-waste load and exploits small companies to their advantage. Corporate business should follow to regulations and the needed certifications as well. How can we do right if the government does not? What expense do we have to follow? Waste to	Identity & background considerations Yes. Should right need to informal settlement in Gt. Quite a large scale buying back from the informal sector. Try as much as we can to help small businesses in the informal settlement and provide growth or help where we can. There is a definite potential to work together and we try to do this already. The informal sector for e-waste is not as big as for SWM so it will be easier to form a relationship with them. We try and help them. We deal with the CC and speak with them. So far they are very glad and appreciative of our help so we are in a good relationship with them. Try as much as we can to help small businesses in the informal settlement and provide growth or help where we can. We really try and help them by either employing them or donate food and blankets. We try and get them into groups to get their waste into a central area and then help with transport We give sector to the informal sector. We do not have a problem with them. I do not know if still exists, but I have seen a company that is not interested in collecting their material Formal facility registration/licence Big organisations also have to realise they need to be compliant and are not able to do what they want. Cash-flow You must always have enough cash which can be challenging. Good security measures to minimize them Communication. We then have to know how to handle people and how to communicate with them. *Need to motivate them to want to formalise. Mutual beneficial. Yes, but we need to explain why formalisation will benefit them. If formally comes with a cost, they will not buy it. Need to give enough incentives to want to be apart of formalisation. Make it simple to telling them what they need to do and what you want from them. Depends on how it is packaged and conveyed. No one likes to change so they need to see the benefits it holds for them. They are not educated on high level. They will not understand all the detailed legislation. * Negotiate with them in a manner they will understand	Relationship, trust, and transparency Yes. Should right need to informal settlement in Gt. Quite a large scale buying back from the informal sector. Try as much as we can to help small businesses in the informal settlement and provide growth or help where we can. There is a definite potential to work together and we try to do this already. The informal sector for e-waste is not as big as for SWM so it will be easier to form a relationship with them. We try and help them. We deal with the CC and speak with them. So far they are very glad and appreciative of our help so we are in a good relationship with them. Try as much as we can to help small businesses in the informal settlement and provide growth or help where we can. We really try and help them by either employing them or donate food and blankets. We try and get them into groups to get their waste into a central area and then help with transport We give sector to the informal sector. We do not have a problem with them. I do not know if still exists, but I have seen a company that is not interested in collecting their material Formal facility registration/licence Big organisations also have to realise they need to be compliant and are not able to do what they want. Cash-flow You must always have enough cash which can be challenging. Good security measures to minimize them Communication. We then have to know how to handle people and how to communicate with them. *Need to motivate them to want to formalise. Mutual beneficial. Yes, but we need to explain why formalisation will benefit them. If formally comes with a cost, they will not buy it. Need to give enough incentives to want to be apart of formalisation. Make it simple to telling them what they need to do and what you want from them. Depends on how it is packaged and conveyed. No one likes to change so they need to see the benefits it holds for them. They are not educated on high level. They will not understand all the detailed legislation. * Negotiate with them in a manner they will understand	Lack of knowledge & awareness Consumer, policy maker, and company lack awareness The biggest thing about South Africa's failure is that people are not educated. They do not know the consequences of for e-waste dumping waste on the street or the road. Education can help motivate them to formalise. Constant awareness creation, especially from the government is needed. Consumers cannot understand that they have to pay for collection which creates complexity. People need to know the values - awareness and education. People tend to just want money. Need to communicate with the informal sector and consumers on the value of e-waste, the processes and what goes into it, and why you can or cannot recycle. People do not see what happens behind "the screen" Perceived value related to e-waste that it will make you rich Education is so important. Most companies and people are unsure of where to take their e-waste - where to dispose or how to recycle. A lot of valuable small businesses that do not know	Barriers & Constraints to formalise/work with it Contracting leading to complications There is a definitely negative thing about the IF sector, but we also need to look at it it always their fault?" Of course there are always risks. Generally, not the volumes that make it feasible for them. Unfortunately, they have problems with drugs and then opening up to them face brings risks with it as well. We do not know what is from a criminal of legitimate source. We have been broken into. but it is difficult because they cherry pick. They do not tend to be very honest on the materials that come in. Simply cover stage with low value products. Want to get a mix of low and high value recyclables and then refurbishable products. We only want small, personal e-waste in very good condition, and they cannot always ensure that. A lot of e-waste. Yes, items such as batteries, capacitors and screens need to be handled with care as these items need to be recycled in an environmentally friendly manner and if they are damaged when collecting this will not be possible. I need to sign a document for certificate of origin. Need to know that the device or components are not illegal - need to be able to be traced because we will take responsibility for it. Repairwork is very complicated for us. We also have different types of e-waste. The informal sector does not care about institutions or formal recycling facilities - they care about their livelihoods - how can they be incentivised. Easily go to a competitor with better prices. Formalisation is a sector that does care about formalisation". "We need to understand what they actually care about." They do not want to take responsibility of being organised. Few challenges - BEE is brilliant because empowerment is needed but putting people in a position without training or education is setting them up for failure. Help them but they have to learn as well (from the company and personal) - train them, licensing what they need to collect, how to collect, what to do, etc. There is no registered and formal training available for the informal sector to learn everything on recycling they need to know - a basic course that matrix is not needed for. Existing courses is very high-level. Need for an apprentice repair course - 3 month course. Need basic workshop training "case study where training was too intense and overwhelming" (technical / language terms) The informal sector is untrustworthy and unreliable. Yes as they search waste from peoples' wheelie bins, it is not easy for them to be trusted by the owner of the Illegal e-waste low back difficulties Informal collectors come by and sell e-waste to us, but we do not want their e-waste. The police is on our case and looks through our e-waste because the informal collectors steal electronic and electrical products. We have to identify who we should buy from. We take a photo of them and fill out documents. We have to store the e-waste for 7 days so that the police can check if anything is stolen. They are in contact with us. This implies the company can lose money if the police takes it away. Municipality equipments theft. This makes any scrap yard to be targeted by the authorities. We do not trade in metals and therefore the people dismantle the products on pavements in front of the scrap dealers to sell the copper, aluminium, etc. This leads to illegal dumping of the plastic products. Difficult to work with the informal sector. They tend to show behavioural problems. Scrap dealers. Unfortunately, not all of them buy products to sell but becomes illegal dumping and then the reason of recycling and not only money - there should not be a crisis first for people to realise how serious the situation is - then it is too late. T. Very difficult. A lot of people to deal with and need
2	Government support & legislation implementation The private sector alone cannot change SA problem. A lot more focus on the government is needed. We know from experience that the ANC is not interested they are more about making money. I am here to employ people but need big support from bigger companies and government. Government uses recyclers to remove general waste and materials to get to e-waste. Legislation is only good on paper. Registered companies are being punished for ignoring the law while other recyclers do what they want and get away with it. Legislation for recycling and disposal only costs money one takes a lot of time. Current level of operations, a lot of submissions. Not a lot of cost involved but a lot of time and effort. Only costly certifications we are busy with is ISO9001. If we required more volumes, automation, and another premises we would need a waste management licence with ISO 14001. Other ISO's will benefit us as well but it is very costly. Very costly and timely - >200m/year for compliance. Original legislation of SA is still designed for a linear economy and waste products. Makes difficult to collect e-waste under hazardous legislation - will probably take about 30 years to fully change legislation. The definition of e-waste is still wrong. NEMA - Application for license is a complete mess. Operate very slow. SOGA are day threshold. Not need a license yet. Might change soon to agree against the same. Second hand goods act. Record that they don't buy stolen goods - ID, passport, picture, serial number, contact n, address, proof of income. Gauteng department of Agriculture & rural development - to get the license is complete chaos. EPR collection and legislation details With regards to EPR it is a very good system if managed correctly, unfortunately it is not yet in SA, however if it does eventually come to SA it will put most of the informal collectors out of business EPR looks to set up a collection network but the problem is that it takes the control away of companies that are successful in what they do. It can be a good idea with a lot of thought but into it. Alternately, why change a plan if it already works without additional funding? Issues with POs and EPR. If you are not registered you cannot claim admin to claim creates a bottleneck. middlemen make money and leave producers paying or consumers with little. big miscommunication between companies, producers, and POs to how to claim and who should claim Government cannot be in charge of EPR funding - they cannot influence money specifically for e-waste funding is then open to other projects - public funding. Also, if claims are put in for a certain amount the one year, it is extremely difficult to claim the next year. The government is too easily bribed to use contractors that benefit them and not according to the	Support system and interface organisations Need a support system that can be hands-on Corporate companies cannot deal with the informal sector - they are very unregulated. We do not have the same buy-back power as big recycling companies so it will be difficult to deal with the informal sector ourselves. Need interface organisations of cooperatives to formalise the informal sector - work between the two sectors. POs are the middlemen between producers and the government. Incorporate into formal facilities through these associations - provide better training from a to z. Brings more opportunity for funding. eWASA won't know who the waste pickers are. We need the work of an academic foundation, bring these associations will. The idea may be that POs are the informal sector underground if POs are too strict. NDOs can work but it would have to be very corporate business levels of people on the board of collection agencies to oversee the money, industry, recyclers, refurbishers, academia. Triple accreditation might be needed then.	Perceived issues People only tend to see the negative of the IF sector - either they are entitled, stive, stive - things that are probably true to a degree. The things is there are people like this in the corporate world too. Then we have to realise some of them don't care - that even educated and high-income people acts like that. We cannot always blame the informal sector and the government. What are we doing to bring changes? "We are not going to fix the world by only looking at the negative" "Stop complaining and see the positive and how we can help to change the negative" How they are seen. Their work is not all waste. They need to be recognised, not seen as waste. Take away the stigma. Waste to be seen as essential. "Bring new back" "I just because the materials are called waste the people working with it is not." People really see waste different than front feeders. Some people will make a difference when they are collecting because they will say they are collecting to sell and buy things, even though they are trying to provide for their families	Perceived issues Potential but the formalisation would have to be simple. "Do as relevant the wheelie". "Do as well-engineer the solution". Must be able to include all the factors for a successful e-waste management system without making it too complex. The informal sector will just go to the next person if selling their products are to be difficult. "Have to create an enabling regulatory framework that enables both the formal sector that well established to interact and engage with the informal sector that has no knowledge about compliance, and the framework must be very flexible". The moment the framework is rigid, the first issue will throw out the framework - the informal sector will leave. We need to create opportunity for the informal sector that is very structured. Just needs to be more structured. Individual waste producers are not organised and can make it difficult to find more structure The informal sector is actually well-organised. They have a close circle by where they sort materials and divide among each other. Self-organised - informal sector is organised in their own way and we have to strive it.	Care and awareness creation. It is a lifestyle Need academia to highlight these issues. Awareness needs attention! People tend to care even less now than years back. (People and companies need to focus on the values and the reason of recycling and not only money - there should not be a crisis first for people to realise how serious the situation is - then it is too late. Not enough awareness - big events are needed.	
3	EPR collection and legislation details With regards to EPR it is a very good system if managed correctly, unfortunately it is not yet in SA, however if it does eventually come to SA it will put most of the informal collectors out of business EPR looks to set up a collection network but the problem is that it takes the control away of companies that are successful in what they do. It can be a good idea with a lot of thought but into it. Alternately, why change a plan if it already works without additional funding? Issues with POs and EPR. If you are not registered you cannot claim admin to claim creates a bottleneck. middlemen make money and leave producers paying or consumers with little. big miscommunication between companies, producers, and POs to how to claim and who should claim Government cannot be in charge of EPR funding - they cannot influence money specifically for e-waste funding is then open to other projects - public funding. Also, if claims are put in for a certain amount the one year, it is extremely difficult to claim the next year. The government is too easily bribed to use contractors that benefit them and not according to the	Training potential and facilities We look at becoming a training facility then competing with big refurbishing companies. Would be nice the interest with the informal sector and teach them how e-waste management works, the regulations behind it, various fractions, how to manage waste streams better, health hazards. Looking at training as part of growth strategy. In contact with people to form a SETA approved programme but it is a mid-long term projects. The informal sector for e-waste is not as big as for SWM so it will be easier to form a relationship with them. Try to get into the SA legally - have to be on the critical lists (list (appliance repair) - need to do very difficult courses for this. Code between themselves. Usually informal collector Necessities for acquiring EPR status We only accept if they have an ID copy of license Find a way to ensure vendor onboarding process. Audit through ID, NDA documents, POA, legally binding document that controls morals and ethical conduct. Give a lot of formal companies more peace of mind - without making them give up their sources that is legally obtained. Just to ensure materials coming in is not stolen. Being able to capture everything. It will take a few years to build a relationship and trust, but they can still undermine you. Would need some kind of contract. May not have the correct certification but they can operate at an elevated level with formal recycling facilities. Collectors with vehicles are much more accountability and traceability. To get assistance in acquiring the e-waste accreditation. Cannot overlook that - needs to be registered and licensed. Need to be documented - ensure that they have traceability. Credit to the grow is important. Want to know where stuff is coming from. If need to audit you want to be able to trace outputs. Not motivate	Incidents It is really important to first collect and then transport. Need a specific site that is certified and licensed that the informal sector can dismantle e-waste into plastic and metals there and sell that. Get more for it than transporting it. Much cheaper to transport very valuable materials (e-waste) already dismantled - less volume and weight. Transport efficiency. (Even dogfood as they use their dogs for protection from gangsters) If they can have decent facilities where they can strip their material would make their lives better and keep the environment clean as well. They also need incentives in other parts of the value chain - not just money. Difficult to say - depends on they money and incentives they get. Storage can be a good non-financial incentive. More incentives than money is to be apart of new curriculum (launch to be come a WEEE entrepreneur and be able to own their own business. Unfortunately, compliance scares them off. Need to show obeying legislation has benefits			
4	EPR collection and legislation details With regards to EPR it is a very good system if managed correctly, unfortunately it is not yet in SA, however if it does eventually come to SA it will put most of the informal collectors out of business EPR looks to set up a collection network but the problem is that it takes the control away of companies that are successful in what they do. It can be a good idea with a lot of thought but into it. Alternately, why change a plan if it already works without additional funding? Issues with POs and EPR. If you are not registered you cannot claim admin to claim creates a bottleneck. middlemen make money and leave producers paying or consumers with little. big miscommunication between companies, producers, and POs to how to claim and who should claim Government cannot be in charge of EPR funding - they cannot influence money specifically for e-waste funding is then open to other projects - public funding. Also, if claims are put in for a certain amount the one year, it is extremely difficult to claim the next year. The government is too easily bribed to use contractors that benefit them and not according to the	Incidents It is really important to first collect and then transport. Need a specific site that is certified and licensed that the informal sector can dismantle e-waste into plastic and metals there and sell that. Get more for it than transporting it. Much cheaper to transport very valuable materials (e-waste) already dismantled - less volume and weight. Transport efficiency. (Even dogfood as they use their dogs for protection from gangsters) If they can have decent facilities where they can strip their material would make their lives better and keep the environment clean as well. They also need incentives in other parts of the value chain - not just money. Difficult to say - depends on they money and incentives they get. Storage can be a good non-financial incentive. More incentives than money is to be apart of new curriculum (launch to be come a WEEE entrepreneur and be able to own their own business. Unfortunately, compliance scares them off. Need to show obeying legislation has benefits	Incidents It is really important to first collect and then transport. Need a specific site that is certified and licensed that the informal sector can dismantle e-waste into plastic and metals there and sell that. Get more for it than transporting it. Much cheaper to transport very valuable materials (e-waste) already dismantled - less volume and weight. Transport efficiency. (Even dogfood as they use their dogs for protection from gangsters) If they can have decent facilities where they can strip their material would make their lives better and keep the environment clean as well. They also need incentives in other parts of the value chain - not just money. Difficult to say - depends on they money and incentives they get. Storage can be a good non-financial incentive. More incentives than money is to be apart of new curriculum (launch to be come a WEEE entrepreneur and be able to own their own business. Unfortunately, compliance scares them off. Need to show obeying legislation has benefits	Incidents It is really important to first collect and then transport. Need a specific site that is certified and licensed that the informal sector can dismantle e-waste into plastic and metals there and sell that. Get more for it than transporting it. Much cheaper to transport very valuable materials (e-waste) already dismantled - less volume and weight. Transport efficiency. (Even dogfood as they use their dogs for protection from gangsters) If they can have decent facilities where they can strip their material would make their lives better and keep the environment clean as well. They also need incentives in other parts of the value chain - not just money. Difficult to say - depends on they money and incentives they get. Storage can be a good non-financial incentive. More incentives than money is to be apart of new curriculum (launch to be come a WEEE entrepreneur and be able to own their own business. Unfortunately, compliance scares them off. Need to show obeying legislation has benefits		

Figure 15: Interview data coding and categorisation