Spatial Planning Strategies to Improve Sustainable Household Solid Waste Collection Practices In Peri-Urban Villages Of Small Towns: A Case Study Of Thohoyandou In Thulamela Local Municipality, South Africa.

BY

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RESEARCH TITLE

SPATIAL PLANNING STRATEGIES TO IMPROVE SUSTAINABLE HOUSEHOLD SOLID WASTE COLLECTION PRACTICES IN PERI-URBAN VILLAGES OF SMALL TOWNS: A CASE STUDY OF THOHOYANDOU IN THULAMELA LOCAL MUNICIPALITY, SOUTH AFRICA.

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THIS DISSERTATION IS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE ESMURP DEGREE TO THE DEPARTMENT OF URBAN AND REGIONAL PLANNING UNDER THE FACULTY OF SCIENCE, ENGINEERING AND SCIENCE AT THE UNIVERSITY OF VENDA

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Declaration

I, MUTWANAMBA PFARISO (19003408), declare that this dissertation is my original work and has not been submitted for any degree at any other institution or university. The research does not contain another person's writings unless specifically acknowledged and referenced.

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Dedication

This work is lovingly dedicated to my parents, Nkhumbudzeni Tshisikhawe and Father Mutwanamba Leonard Nthangeni, whose unconditional love, prayers, and sacrifices have been the foundation of my strength and perseverance. Your belief in me has inspired me to dream bigger and reach higher. To my two sisters and one brother, thank you for your unwavering support and encouragement and for constantly reminding me of my purpose. Your presence in my life is a constant source of motivation. I also dedicate this work to every young woman striving to break barriers and overcome limitations. May this achievement serve as a reminder that with determination and faith, anything is possible. This journey has been challenging but deeply rewarding, and I am grateful to everyone who stood by me. Your love and support have carried me through, and I share this accomplishment with you all.

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Abstract

Globally, the generation of municipal solid waste (MSW) is rising at an alarming rate, with projections indicating an increase from 2.01 billion tonnes in 2016 to 3.40 billion tonnes by 2050. This surge, driven by urbanisation, population growth, and changing consumption patterns, presents a pressing challenge for developed and developing nations. Among the most critical components of MSW is household solid waste, which constitutes a significant share of total waste volumes and demands effective collection and management systems to safeguard public health and environmental sustainability. However, in many developing contexts, particularly in peri-urban areas, the delivery of solid waste collection services remains inconsistent, inefficient, and unsustainable. The study investigates how spatial planning principles can be leveraged to address systemic challenges in household waste collection. The research was guided by the following objectives: 1. Characterise the current household solid waste collection practices in peri-urban villages of Thohoyandou town. 2. Identify factors that impede sustainable household solid waste collection in peri-urban villages of Thohoyandou town. 3. Propose sustainable strategies for household solid waste collection practices in peri-urban villages of Thohoyandou town. A mixed-methods approach was used, combining qualitative and spatial data collection techniques. Primary data were gathered through field observations, semi-structured interviews, and household surveys, while secondary data included policy documents, spatial plans, and maps. The study applied spatial analysis tools to assess settlement patterns, road networks, and service coverage. The methodology enabled a detailed understanding of current collection practices and the spatial factors influencing their effectiveness. The findings reveal that irregular waste collection, limited municipal resources, poor road access, and scattered settlements significantly hinder sustainable household solid waste management in the study area. Moreover, the absence of spatial planning in waste management policy results in service inefficiencies and environmental risks. Therefore, the recommendations emphasise implementing local waste management policies, introducing municipal solid waste collection levies, formalising waste collectors, improving collection efficiency, promoting recycling, integrating new technologies, and adopting a data-driven approach for sustainable waste management. These strategies aim to address identified gaps in governance, infrastructure, and community engagement, enhancing overall service delivery in Muledane and Maniini. These insights have important implications for planners, policymakers, and local municipalities. Integrating spatial planning into waste management can promote service equity, environmental sustainability, and community well-being. This research contributes a practical framework for designing inclusive and sustainable household solid waste collection systems tailored to peri-urban contexts in small towns across South Africa and similar settings globally.

Keywords: *Spatial planning, Household solid waste, Peri-urban areas, Sustainable solid waste management, Service delivery*

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List of Abbreviations

CEPA	California Environmental Protection Agency
CRE	Circular Economy
DEA	Department of Environmental Affairs
EVL	Exit, voice, and loyalty
EU	European Union
GHG	Greenhouse Gases
GIS	Geographic Information System
HSW	Household Solid Waste
IDB	Inter-America Development Bank
IDP	Integrated Development Plan
IoT	Internet of Things
IWMP	Integrated Waste Management Plan
MSA	Municipal Systems Act
MSW	Municipal Solid Waste
NEMA	National Environmental Management Act
NSWS	National Waste Management Strategy
NUA	New Urban Agenda
SDF	Spatial Development Framework
SDGs	Sustainable Development Goals
SPLUMA	Spatial Planning and Land Use Management Act
SWM	Solid Waste Management
SWMS	Solid Waste Management System
UN	United Nations
UNEP	United Nations Environment Programme
USA	United States Of America

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WHO	World Health Organisation
WTP	Willingness To Pay

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Chapter One: Introduction

1.1. Introduction and background

Global municipal solid waste (MSW) generation rose from 1.3 billion tons in 2012 to 2.1 billion tons (0.74 kg/capita/day) as of 2016, which by 2050 is expected to increase by 70% to reach a total of 3.40 billion tons sssor 1.42 kg/capita/day (Abubaka, et al, 2022; Maalouf & Mavropoulos, 2022; Costas, et al , 2023; Valavanidis., 2023; Nawar, et al , 2024). The world population is expanding in line with the general trend (Prakash et al, 2023). The demand for goods is currently higher than it has ever been before (Adeleye, 2021). This has resulted in the production of more solid waste than ever before (Oluwatobi & Tien-C., et al, 2023). Africa is a rising continent with a lot of development taking place, having a youthful, robust, growing population (Zhechen et al, 2024; Sheburah Essien et al, 2024). Africa's urbanisation is projected to double in the next decade, with an equally increasing population in urban and city surroundings (Yu et al, 2021; Knoblauch et al,2024). Municipalities in South Africa are responsible for general solid waste management (SWM) in both residential areas and industrial sites (Gomez Camacho et al,2021; Kalina et al,2024). However, SWM is not implemented in all rural areas of South Africa (Golzary et al, 2024; Raphla et al, 2024), even against the background of socioeconomic improvement and increased consumption patterns in these communities (Nkululeko et al, 2023). Household solid waste (HWS) (i.e., waste generated during day-to-day household work) is one of the main components of municipal solid waste, and a large proportion of municipal waste management budgets is allocated to managing household solid waste (Tanwi et al,2024; Kibonde, 2024; Ogunwale et al, 2024). The collection sector is a geographic region where a vehicle travels to collect solid waste (Blandine & Sammy, 2022). A collection trip is the geographical region where a vehicle travels until it reaches its solid waste storage capacity (Adedara et al, 2021; Singh et al, 2024; Nawar et al, 2034). A collection trip consists of the routes between the garage, collection sector and destination (typically a transfer station or landfill) (Ferrão et al, 2024).

A collection sector is composed of one or more collection circuits or routes that can be performed during a workday (Negreiros Gomes, et al, 2024; Araiza-Aguilar, et al, 2024), the lack of practical evaluation of the solid waste collection performance is considered a gap in improving the solid waste collection system in Africa (Hoang., et al, 2024). Spatial planning is a governance practice pursuing coordinated improvement of mobility, housing, food production and other functions with a spatial impact (Wen et al, 2023; Fu et al, 2024). These institutions combine a forward-looking mindset (planning for the future, considering trends and long-term impacts) with immediate, purposeful actions to address current societal problems (Van Dijk, 2021; Xia et al, 2023). These activities are intertwined, visionary and pragmatic at the same time (Gao et al, 2024). The key

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aspects of spatial planning include land use management, environmental planning, infrastructure development, social planning, and economic development (Zheng et al, 2023; Chioatto & Sospiro, 2023). Depending on the spatial plan and area income level, collection can be done by any method: wheelbarrows, manual tricycles, motor tricycles, taxis, mini-compact trucks, and large compact or dump trucks, or long trailers (Volsuuri, 2023). While the standard collection rate should be 100%, global collection rates vary from 39% for low-income countries to 96% for high-income countries (World Bank, 2019; Adedara et al, 2023). Poor household solid waste collection practices deprive the progress towards an integrated solid waste management in households (Bošković et al, 2024). Knowledge of current practices and perception of household solid waste management is necessary for accurate decision making in the move towards a more sustainable approach (Fadhullah, 2022; Phuon et al, 2021). The South African national standards for solid waste collection acknowledge different levels of service delivery, depending on the practicality and cost-efficiency in a given geographic area (Haywood, 2021; Ayeleru et al, 2021).

Small towns are very important for current economic development (Powe et al, 2022). A classic paper by Rondinelli (1983) argued that developing towns and small cities are essential for developing hinterlands, transforming subsistence into commercial agriculture, and integrating urban and rural economies, in the context of Sub-Saharan Africa (Sabyasachi et al, 2022). It is widely believed that small towns have been playing a crucial role in rural sustainable development (Zhao et al, 2023), as they provide most public services for rural residents living in hinterland villages (Aliaskarov et al, 2023; Pratomo et al, 2022). The peri-urban is a product of the urbanisation wrought by global economic and socio-political functions, and this continuum is derived from the ongoing demographic processes and rural–urban migration (Mardiansjah, 2020; Mardiansjah et al, 2021). The term ‘peri-urban’ was used by the Organisation for Economic Co-operation and Development in 2007 to describe urban growth in Europe in the 1980s and denoted a transitional zone that is neither urban nor rural and is instead defined as a ‘grey area’ (Sahana., 2023; Lichter, et al, 2021). High population growth and increasing economic activities in peri-urban due to high birth rate, low standard of living, and increasing agricultural activities together with the lack of training in modern SWM practice have resulted in the generation of volumes of solid waste which pose public health and environmental threats (Samuel et al, 2022; Kumar, et al, 2024; Goswami, et al, 2024).

This research focuses on Spatial planning strategies to improve sustainable household solid waste collection practices in peri-urban villages of small towns: A case study of Thohoyandou in Thulamela Local Municipality, South Africa. The selected village in this study is Maniini and Muledane, both of which are experiencing rapid growth.

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1.2. Rationale of the study

Due to the increased demand for solid waste collection resulting from the increased waste volume generated by both local residents and tourists, the management of MSW collection and transportation becomes more difficult and challenging, consequently leading to a corresponding rise in collection (Narat, 2024; Rattanawai et al, 2024). With the popularity of waste classification and increasing requirements for coordinated solid waste management towards sustainability, it is essential to study how to generate efficient waste collection solutions for classified treatment towards social-economic and environmental goals (Shuhan et al, 2023; Boontaveeyuwat, 2024). Analysing urban solid waste collection rates not only implies understanding the solid waste sorting behaviour of the households, but also the behaviour of the local governments and the companies responsible for collecting waste (Ignacio et al, 2022; Niyomdecha et al, 2021). Around 28 million tons of MSW are annually generated in Egypt, with 40% in the Greater Cairo Region (GCR) (Hussieny, 2022). Although the government aims at improving the MSW service coverage and collection efficiency, formal collection service is still limited and operates with low transportation efficiency, resulting in illegal waste collection and dumping (Alsayed et al, 2023). Since the 1980s ′s, some Mexican municipalities have subcontracted HSW collection services to private companies, with an eye on increasing the efficiency of this service (Oláguez, 2024; Rueda-Avellaneda et al, 2021). However, the impact of private management on the Mexican waste sector performance has not been evaluated (Alejandro, 2021; Benitez-Bravo, 2021).

MSW management remains a significant challenge globally, particularly in peri-urban areas of developing countries where rapid urbanisation, spatial fragmentation, and limited infrastructure impede efficient service delivery. While various countries have adopted different models of collection ranging from kerb-side recycling in the USA (Ulloa-Murillo, 2022; Soni et al., 2022) to competitive service zones in Barcelona (Bel & Sebő, 2021; Arcas-Pilz et al., 2023), many still struggle with inefficiencies, poor spatial coverage, and a lack of sustainable planning frameworks.

In developing contexts such as Karbala (Razzaq et al., 2021; Kareem et al., 2022) and Egypt (Hussieny, 2022; Alsayed et al., 2023), solid waste collection is often executed through outdated systems without spatially informed routing or efficiency mechanisms. In Bolivia, for instance, open dumping remains dominant in smaller towns (Ferronato et al., 2020; Navarro et al., 2021), while selective solid waste collection initiatives are emerging but remain underexplored (Cristina et al., 2021). Similarly, in China, attempts to integrate informal collectors into formal systems highlight the complexity of governance and coordination (Liu, 2024; Zhu et al., 2021; Fangfang et al., 2021; Zhao et al., 2024). Despite growing awareness of recycling practices, most existing studies focus on solid waste volumes, recycling systems, or operational efficiency, with limited emphasis on the spatial planning dimension of solid waste collection in peri-urban settings, where informal and dispersed settlements present logistical and infrastructural challenges (Fadak & Nabaa, 2023; Narat, 2024; Rattanawai et al., 2024). Moreover, while ergonomics, socio-economic factors, and health risks of collection

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workers have been acknowledged (Essessinou & Degla, 2024; Anna, 2023), the integration of spatial strategies into solid waste collection systems remains insufficiently addressed.

Critically, few studies evaluate the role of settlement patterns, road access, land-use zoning, and spatial planning frameworks in shaping the success or failure of household waste collection systems especially in small towns of Africa (Debrah, 2021). Additionally, the perceptions, behaviours, and participation of residents, particularly in peri-urban areas, are often overlooked, despite their influence on system success (Coffin et al., 2023; Gajendra, 2024; Sondh et al., 2022). The effective management of municipal solid waste (MSW) is a critical challenge globally, particularly in rapidly urbanising regions, such as peri-urban areas, which exist at the intersection of rural and urban spaces. These areas often experience rapid population growth, informal settlement expansion, and inadequate infrastructure, leading to significant environmental and public health risks. The peri-urban villages of Maniini and Muledane in Thohoyandou, South Africa, face these challenges acutely, with irregular waste collection, poor road access, and fragmented spatial planning undermining sustainable solid waste management (SWM). This study was motivated by the need to address these pressing issues through a spatial planning perspective, which is often overlooked in existing waste management frameworks. This research topic was chosen due to the critical need for innovative and context-specific approaches to sustainable household solid waste collection in peri-urban settings. A critical gap in the literature is the limited attention given to the role of spatial planning in improving household solid waste collection in peri-urban areas. Many studies focus on technical, economic, and institutional factors but often neglect the spatial dimensions that influence waste collection efficiency, such as road network design, settlement patterns, and land-use planning. In the case of Maniini and Muledane, the lack of integrated spatial planning has resulted in fragmented waste collection practices, poor accessibility, and service inequities. This study seeks to address this gap by exploring how spatial planning strategies can be leveraged to improve waste collection systems, enhance service delivery, and promote environmental sustainability in these peri-urban contexts. The study will focus on identifying spatial planning strategies that enhance the efficiency of household solid waste collection in the peri-urban villages of Maniini and Muledane. It will explore how spatial planning can improve collection routes, optimise resource allocation, and reduce environmental impacts. By integrating spatial analysis with stakeholder feedback, the study aims to provide practical, data-driven solutions that align with local needs and broader sustainability goals.

1.3. The problem statement

Current household solid waste collection practices in the Thohoyandou peri-urban area are neither effective nor sustainable, and it is imperative to improve household solid waste collection. there is a lack of integration between spatial planning and SWM policies, resulting in fragmented and unsustainable practices. These challenges undermine the municipality's efforts to promote environmental sustainability, public health, and service equity. Household solid waste collection is a critical issue affecting different villages; therefore, it is

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essential to identify and implement spatial planning strategies that can ensure sustainable household solid waste collection practices. It is also crucial to identify and address the problem associated with household solid waste collection to ensure a sustainable environment, thereby promoting the right to a safe and healthy environment as enshrined in the Constitution of the Republic of South Africa.

1.4. Aim of the research

Aim: To bring to the fore spatial planning strategies that can enhance sustainable household solid waste collection practices in peri-urban (Maniini and Muledane) villages of small towns, using Thohoyandou in the Thulamela Local Municipality as a case study.

1.5. Objectives of the research

1. Characterise the current household solid waste collection practices in peri-urban villages of Thohoyandou town.
2. Identify factors that impede sustainable household solid waste collection in peri-urban villages of Thohoyandou town.
3. Propose sustainable strategies for household solid waste collection practices in peri-urban villages of Thohoyandou town.

1.6. Research questions

The main research questions for this study is: What spatial planning strategies can be used to improve sustainable household solid waste collection?

Research questions	Research subsidiary questions
1. What characterises the current household solid waste collection practice in peri-urban areas?	1.1. What are the sources of solid waste? 1.2. Who collects solid waste? 1.3. How is solid waste collected? 1.4. How often is solid waste collected? 1.5. What time do they collect? 1.6. What kind of solid waste is collected?
2. Which factors impede sustainable household solid waste practices in Thohoyandou peri-urban?	2.1. How is the current system? 2.2. What are the problems?
3. What sustainable strategies can be proposed to improve household solid waste collection practices in peri-urban villages of Thohoyandou town?	3.1. What is the role of the municipality? 3.2. What planning-based interventions can be proposed? 3.3. What role can local communities play? 3.4. What kind of improvement is needed? 3.5. What are sustainable collection practices? 3.6. How can planning improve collection? 3.7. What makes practices more sustainable?

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	3.8. How can communities support collection? 3.9. What tools improve waste planning? 3.10. Which policies support better collection? 3.11. How to reach underserved areas?

Table 1.1: Research questions

Source: Mutwanamba (2024)

1.7. Hypotheses

H_0 (Null Hypothesis): Spatial planning strategies have no significant effect on the sustainability of household solid waste collection practices in peri-urban villages of Thohoyandou.

H_1 (Alternative Hypothesis): Spatial planning strategies play a significant role in enhancing sustainable household solid waste collection practices in peri-urban villages of Thohoyandou.

H_2 (Competing Alternative Hypothesis): The effectiveness of household solid waste collection in peri-urban villages of Thohoyandou is primarily influenced by governance policies and financial resources rather than spatial planning strategies.

1.8. Significance of the study

The importance of the study is to provide spatial planning strategies to improve the solid waste collection in peri-urban villages (Maniini and Muledane). Human activities always generate solid waste. Proper household solid waste collection is important for the protection of safety and environmental quality. Community members will have knowledge about recycling programs and how they can generate income for themselves, and this will also stimulate local economies. The households could benefit from this study since new, improved solid waste collection spatial strategies will be offered. The Department of Environment and Planning will find strategies on how to improve solid waste collection. Once the municipality implements the strategies, there will be a change in the collection process. Sustainability and environmental care bring us face-to-face with effective solid waste management. The community will gain knowledge on recycling and reuse. Different academic scholars could also benefit, as they will learn more about how to manage solid and waste collection in rural areas.

By focusing on spatial planning strategies, this research provides a framework for integrating sustainable waste collection practices into broader land use and settlement planning. The study also seeks to contribute to academic knowledge by bridging the gap between spatial planning and environmental management, offering insights into how planning tools and approaches can support sustainable development in underserved areas.

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Practically, it is expected that the findings of the study inform local government, planners, and policymakers in designing more effective, inclusive, and sustainable household solid waste collection systems.

1.9. Scope of the study

1.9.1. Physical scope

This study is limited to Thohoyandou, located in the southern part of the Vhembe District, northwest of Malamulele along the R524 main road. Thohoyandou is surrounded by small rural townships such as Maungani, Ngovhela, Vondwe, Phiphidi, Muledane, Duthuni, Tshisahulu, Shayandima, Makwarela, and Maniini. The selected villages for the study are Maniini and Muledane, both situated outside the main town and experiencing rapid growth. These two villages are developing and growing very fast. The study focuses on areas that fall outside the core urban zones but are still influenced by urban expansion and spatial development pressures. The selected villages will represent diverse spatial characteristics and service delivery challenges to provide a comprehensive understanding of solid waste collection issues in peri-urban contexts.

1.9.2. Theoretical scope

This study is guided by three key theoretical frameworks:

- Space Production by Henry Lefebvre (1991): This theory emphasises the relationship between space, social relations, and production, highlighting how spatial structures impact and are shaped by social processes.

- Principal-Agent Framework by Jensen and Meckling (1976): This framework focuses on the relationships between stakeholders (principals) and their agents, particularly the challenges of aligning interests and reducing inefficiencies in public services.

- Exit, Voice, and Loyalty Model by Albert Hirschman (1970): This model examines how individuals or groups respond to declining service quality, either by exiting (withdrawing) or voicing (seeking improvements), providing a basis for understanding community responses to waste management challenges.

1.9.3. Conceptual scope

The study explores key concepts such as spatial planning, sustainable development, solid waste management systems, and peri-urbanisation. Spatial planning is examined as a strategic tool for organising land use, infrastructure, and service delivery to enhance environmental sustainability and quality of life. Sustainable household solid waste collection refers to practices that are environmentally sound, socially inclusive, economically viable, and supported by appropriate institutional and policy frameworks. The study also

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conceptualises peri-urban areas as transitional spaces experiencing rapid growth and developmental challenges due to their position between urban and rural settings.

1.9.4. Temporal (time) scope

This study focuses on the current state of household solid waste collection in the peri-urban villages of Thohoyandou. Reflecting on three decades of democracy in South Africa, many communities, particularly in rural and peri-urban areas, continue to face significant service delivery challenges. These include inadequate sanitation facilities and inconsistent or non-existent solid waste collection services.

It has been 10 years now since the Spatial Planning and Land Use Management Act (SPLUMA) was implemented, but there is still a gap between the towns and rural areas. Municipality is not addressing the imbalance between the rural area and its main town, for this reason, many municipalities are failing to promote the principle of spatial sustainability and spatial imbalance. At the village municipality, hardly any waste is collected, while in the main town, it is collected every day.

1.9.5. Spatial scope

The study area is in South Africa, Limpopo, Vhembe district, Thulamela Local Municipality in Thohoyandou. Thohoyandou is in the northern part of Limpopo province, within Thulamela local municipality, which shares borders with Musina Municipality in the northern direction, and Makhado, Collins Chabane local municipalities in the western direction, respectively, as well as Greater Giyani Local Municipality in the southern direction, as indicated. Maniini and Muledane are allocated outside of Thohoyandou; these two villages are becoming urban through a spatial planning transformation of the rural. A diverse area and one of the fastest-growing zones, as the population grows and new areas open up for development. Peri-urban areas are commonly populated with small landholdings used for hobby farms, community gardens, or small-scale, non-commercial agricultural enterprises.

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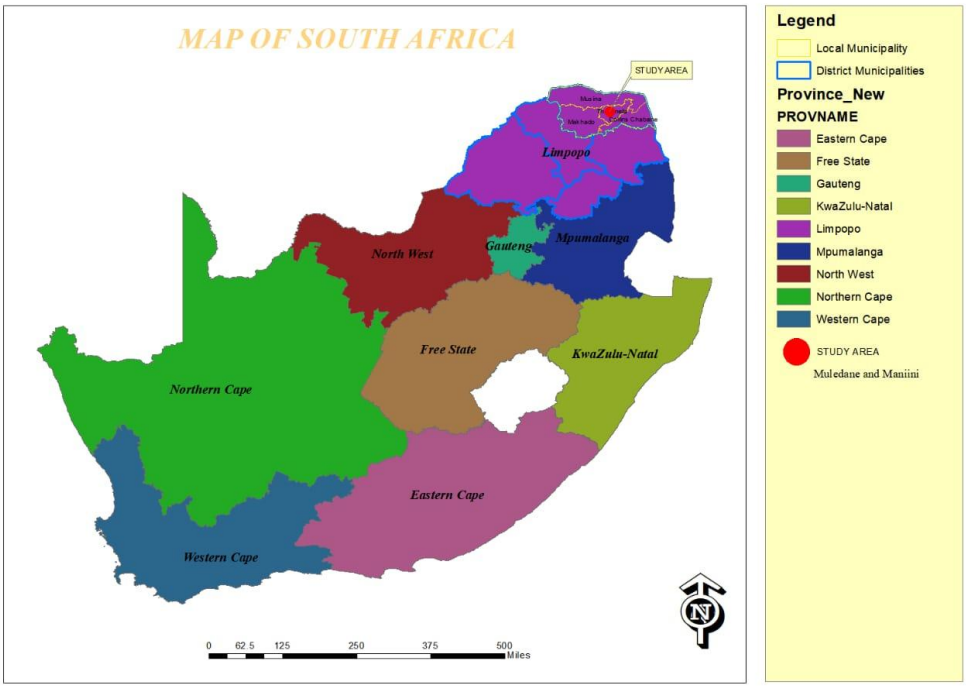

Figure 1.1: Location of the study area in the national and provincial context

Source: Mutwanamba (2024)

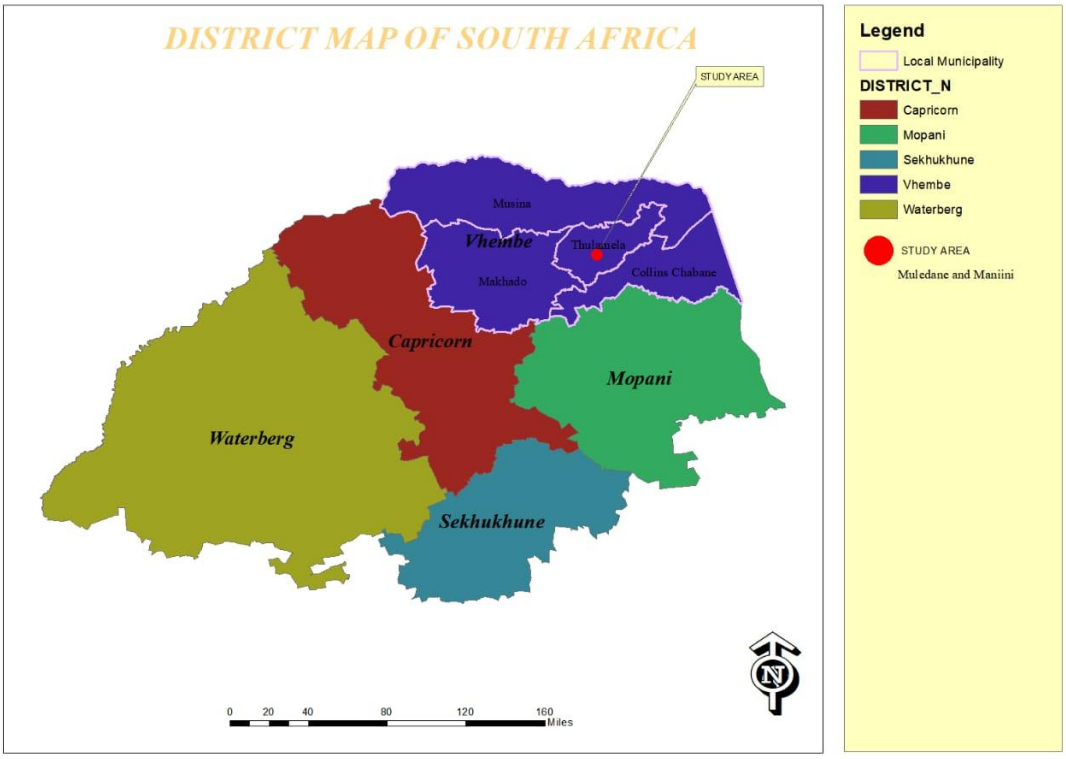

Figure 1.2: Location of the study area in the provincial and regional context

Source: Mutwanamba (2024)

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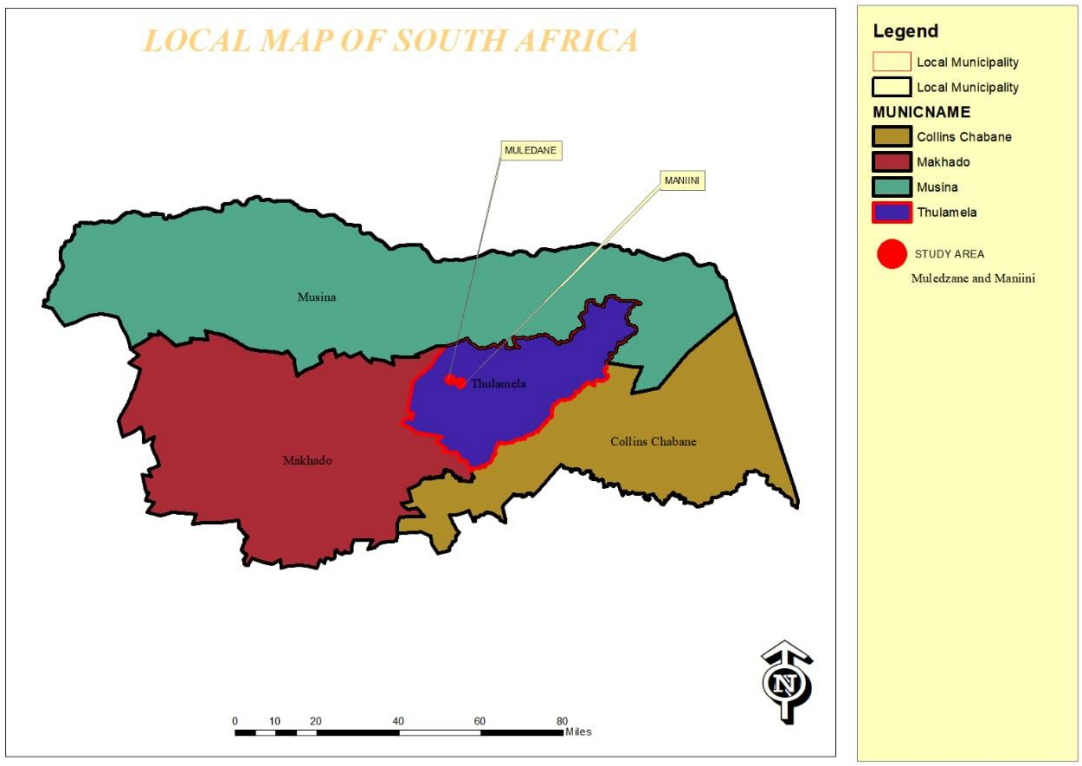

Figure 1.3: Location of the study area in the local context

Source: Mutwanamba (2024)

1.10. Definition of the key terms

A dustbin is a container specifically designed for the collection and temporary storage of waste materials. Dustbins are commonly found in homes, offices, public spaces, and various other environments where waste is generated (HumSaq, 2023).

Environmental sustainability is about acting in a way that ensures future generations have the natural resources available to live an equal, if not better, way of life as current generations (Kazmi, 2023).

Household refers to a family or group of people living together, it's a social unit under one roof. (Vocabulary.com Dictionary, 2024)

Illegal dumping is the disposal of unwanted materials in inappropriate places. Be it household rubbish, building waste or industrial debris, improper disposal has disastrous effects on the environment, economy and community (Tracey, 2022).

Peri-urban areas are neither urban nor rural in the conventional sense, and their conditions and issues are different from urban and rural areas, which mix both with complexities (Lanxin, 2023).

Recycling is the recovery and reprocessing of waste materials for use in new products. The basic phases in recycling are the collection of waste materials, their processing or manufacture into new products, and the purchase of those products, which may then themselves be recycled (Encyclopedia Britannica, 2024) .

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Rural development generally refers to enhancing people's quality of life and economic well-being in isolated and sparsely populated regions (Department of Higher Education and Training, 2024).

Small towns are defined by the United Nations as urban agglomerations with a population ranging from 20,000 to 500,000, by the United Cities and Local Governments (Agergaard, 2021).

Solid waste collection is a part of the process of solid waste management. It involves the gathering or picking up of solid wastes from various sources, such as households, commercial establishments, and industrial facilities, and hauling them to the disposal site or transfer station (Nathanson, 2024).

Solid waste generation rates estimate the amount of waste created by residences or businesses over a certain amount of time (day, year, etc.) (California Environmental Protection Agency (CEPA), 2024).

Solid waste prevention is about reducing the amount of waste generated, particularly hazardous waste, and minimising the impact of that waste on the environment. It involves consuming fewer resources and can lead to lower costs for recycling or disposing of waste (Abubakar, 2022)

Solid waste refers to the range of garbage materials arising from animal and human activities that are discarded as unwanted and useless (Agarwal, 2021).

Solid-waste management is the collection, treatment, and disposal of solid material that is discarded because it has served its purpose or is no longer useful (Athanson, 2024).

Spatial planning is a process of organising territory, land use, and managing competing interests, aiming to guide development while ensuring environmental protection and land conservation, as well as involving local communities (Nadin et al, 2021).

Waste is any material that is not needed by the owner, producer, or processor (Ogwueleka & Naveen, 2021).

Waste Minimisation refers to the use of source reduction and/or environmentally sound recycling methods prior to energy recovery, treatment, or disposal of wastes (National Waste Management Strategy (NWMS), 2020).

1.11. Chapter layout

Chapter 1

Chapter 1 introduces the study by providing background on the challenges of household solid waste collection in peri-urban villages of Thohoyandou. It outlines the research problem, highlighting the need for spatial planning strategies to improve solid waste collection. The aim and objectives were clearly stated, guiding the study's focus, including the hypothesis. Key research questions were posed to explore current practices, barriers, and possible solutions. The chapter explained the significance of the study for planners, policymakers, municipalities, and communities. It defines the physical, conceptual, spatial and temporal scope

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of the research. The structure of the entire study was outlined in the chapter layout. Overall, Chapter 1 sets the foundation for the research journey.

Chapter 2

Chapter 2 reviews existing literature on spatial planning, sustainable solid waste management, and peri-urban development. It explores theoretical frameworks and concepts that link spatial planning with service delivery and environmental sustainability. The chapter discussed different household solid waste collection models and factors affecting their effectiveness. It highlights challenges common in peri-urban areas, including infrastructure gaps and weak institutional coordination. Empirical studies from similar contexts are reviewed to identify best practices and lessons. The chapter identifies knowledge gaps in integrating spatial planning with sustainable waste collection. These gaps justify the need for this study and shape its analytical focus.

Chapter 3

Chapter 3 outlines the policy and legislative frameworks guiding spatial planning and waste management in South Africa. Key national and local policies are discussed, including the National Environmental Management: Waste Act and the SPLUMA Act. The chapter examines how these policies influence service delivery in peri-urban areas. It then provides a detailed description of the study area, Thohoyandou, in the Thulamela Local Municipality. Geographic location, demographic characteristics, land use patterns, and settlement structure are described. The chapter highlighted the physical and spatial challenges affecting waste collection in peri-urban villages. It sets the context for understanding service delivery limitations in the area. This background supports the research analysis in later chapters.

Chapter 4

Chapter 4 presented the research design and methodological approach used to achieve the study's objectives. It outlines the qualitative and quantitative methods adopted and the rationale for choosing them. The chapter described the study population, sampling methods, and selection of peri-urban villages in Thohoyandou. Data collection techniques such as interviews, questionnaires, observations, and document reviews are discussed. It explains the tools and procedures for analysing both spatial and non-spatial data. Ethical considerations, including informed consent and confidentiality, are also addressed. The chapter ensured the reliability, validity, and credibility of the research process. Overall, it provides a clear roadmap for how the study was conducted.

Chapter 5

Chapter 5 presented and analysed findings related to the first research objective, characterising current household solid waste collection practices in the peri-urban villages of Thohoyandou. The chapter described the types of waste generated and common disposal practices by households. It examined the frequency, accessibility, and reliability of municipal waste collection services. Community responses, observations, and spatial data are used to assess coverage and service patterns. The role of informal waste collectors and local

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initiatives is also discussed. Variations in solid waste practices across different villages are highlighted. The findings reveal service gaps and inconsistencies in the current system.

Chapter 6

Chapter 6 explored the factors that impede sustainable household solid waste collection in peri-urban villages of Thohoyandou. The analysis draws from community feedback, stakeholder interviews, and spatial observations. Key barriers include poor road infrastructure, limited municipal resources, and weak policy enforcement. Institutional challenges, such as a lack of coordination and insufficient budget allocation, are highlighted. Social factors are also discussed, including low public awareness and limited community participation. Spatial planning issues that contribute to inaccessibility and service inefficiencies are analysed.

Chapter 7

Chapter 7 presents strategies and planning recommendations to improve sustainable household solid waste collection in Thohoyandou's peri-urban villages. The chapter drawn on previous findings and best practices from literature and case studies. It suggests spatial planning interventions such as improved road networks, clustered settlements, and designated waste collection points. Policy integration between spatial planning and solid waste collection is emphasised. The role of community engagement, education, and informal waste collectors is explored. Planning tools like GIS (Geographical Information System) and zoning are recommended to support data-driven decisions. Practical, low-cost, and inclusive strategies are proposed for local implementation and beyond.

Chapter 8

Chapter 8 provides a comprehensive summary of the key findings from the study. It revisited each research objective, highlighting insights into current solid waste collection practices, barriers to sustainability, and potential planning strategies. Based on these findings, practical recommendations are presented for municipal planners, policymakers, and community stakeholders. These include improving infrastructure, integrating spatial planning with solid waste services, and enhancing community participation. The chapter concluded by reflecting on the study's overall contribution to knowledge and practice. The study is acknowledged, and areas for future research are suggested. The chapter reinforces the importance of planning in achieving sustainable solid waste collection in peri-urban areas. It closes with a call for integrated, inclusive, and context-responsive solutions.

1.11. Summary of chapter 1

Chapter 1 introduced the study's background, It discusses how poor solid waste collection practices threaten environmental sustainability, public health, and urban functionality. The chapter defines the problem as the lack of integration between spatial planning and solid waste management policies in Thohoyandou's peri-

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urban areas, resulting in fragmented and unsustainable waste collection practices. The study aims to identify spatial planning strategies that can address these issues. The aim and objectives clearly focus on understanding current practices, identifying barriers, and recommending sustainable collection strategies. The research questions explore who collects waste, how it is done, the challenges faced, and how planning can improve outcomes. Three hypotheses are proposed, examining the influence of spatial planning, governance, and financial resources on sustainable waste collection. The significance of the study is emphasised for communities, planners, policymakers, and scholars. It is intended to inform better waste collection strategies, enhance environmental health, and contribute to academic and practical knowledge. The scope includes the physical area (Maniini and Muledane), theoretical frameworks (Henri Lefebvre's spatial theory, Principal-Agent Theory, and Hirschman's Exit-Voice-Loyalty model), and conceptual terms related to waste management and spatial planning. The temporal scope reflects on post-apartheid developments and the lack of balanced municipal services. The chapter concludes with an outline of the structure of the remaining chapters in the dissertation.

Chapter Two: Literature Review (Concepts, Literature Review Per Objective Case Studies, And Theoretical Framework)

2.1. Introduction

Chapter two reviews the literature to understand the major concepts that underpin the research. literature or narrative review is a comprehensive review and analysis of the published literature on a specific topic or research question (Grant, 2022). This chapter provides a detailed review of literature related to spatial planning strategies for improving sustainable household solid waste collection in peri-urban villages. It begins by clarifying key concepts such as spatial planning, solid waste, and peri-urbanisation. The literature is reviewed according to the study's objectives, focusing on current planning practices, existing solid waste collection methods, and sustainable strategies. Relevant case studies are examined to draw lessons from similar contexts. The chapter also presented the theoretical framework guiding the study. This framework helps interpret the relationship between spatial planning and solid waste collection.

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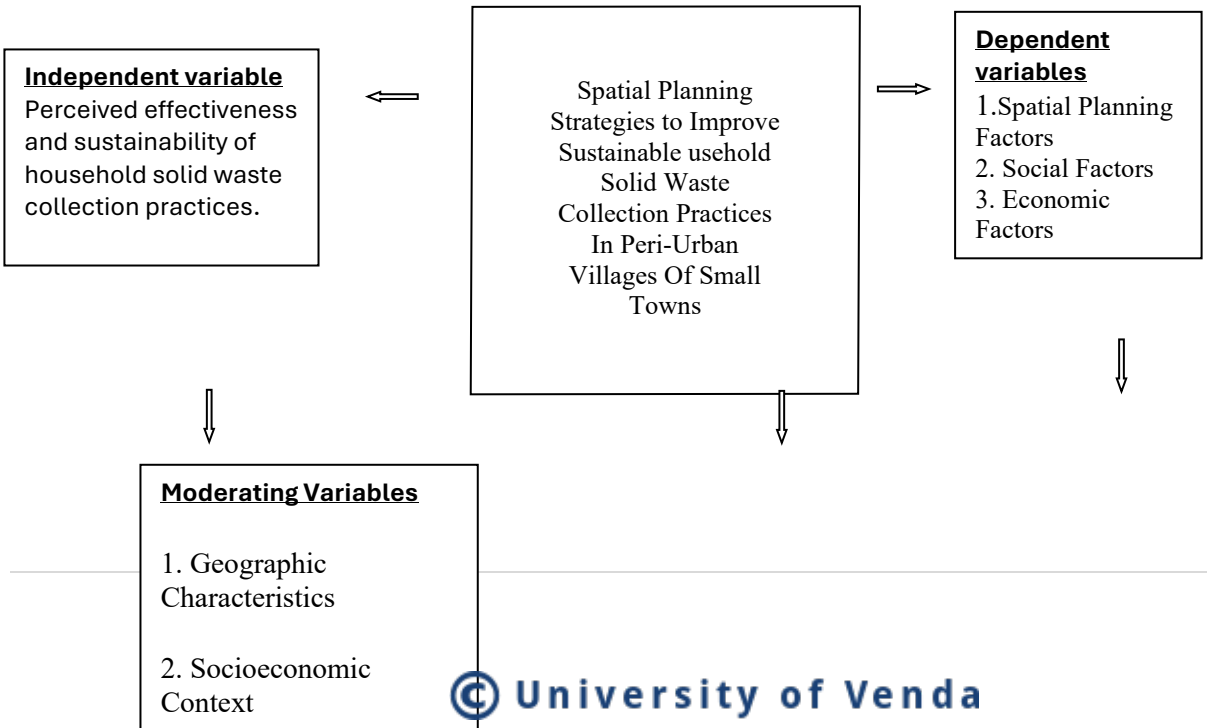
2.2. Conceptual framework

A conceptual framework illustrates the expected relationship between the variables (Titova et al, 2022). It defines the relevant objectives for the research process and maps out how they come together to draw coherent conclusions, conceptual frameworks are often represented in a visual format and illustrate cause-and-effect relationships (Swaen & George, 2024; Philip, 2023). It encompasses the thinking of the researcher regarding the title of the study to be conducted, problem or gap identified and desired to be examined or filled, posers to be raised, sufficient interactions with the literature, relevant existing theories, adoption of appropriate methodologies, data gathering, analyses, discussion of results/ interpretation, conclusions and recommendations, contributions to the existing body of knowledge and suggestions for further studies in the field (Rafiu et al, 2023; Magvira, 2022). The diagram of the conceptual model is shown below in figure 2.1.



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Mediating Variables

1.Community engagement

2. Regulatory enforcement

3. Public awareness and education

Figure 2.1: Conceptual Framework of the study

Source: Mutwanamba (2024)

2.2.1. Solid waste

Solid waste refers to any type of garbage, trash, refuse or discarded material; it can be categorised according to where the waste is generated, for example, as MSW, health care waste and e-waste (WHO, 2022). Solid waste is the unwanted or useless solid materials generated from human activities in residential, industrial or commercial areas (Varjani et al, 2022). Solid waste is a material that is discarded or disposed of, depending on where the waste is generated, it can be classified as municipal solid waste, industrial solid waste, or agricultural solid waste (Saira & Shanthakumar, 2023). Solid waste is a health hazard and causes damage to the environment due to improper handling (Singh et al, 2022). Solid waste is any substance in a solid form that is unwanted/unused and/or unvalued and is discarded or discharged (Nukusheva, 2023). Solid waste open dumping refers to the act of discharging or otherwise disposing of solid waste in an environment outside of proper pollution management functionalities (Anshika, & Pratap, 2021).



Figure 2.2: Waste generation

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(Source: World Bank, 2022)

The above figure 2.1 shows the amount of solid waste generated around the world, and most countries are generating more solid waste, but few of them are getting collected. The amount of trash created is set to rise as the world population continues to grow and, most of all, grows more affluent. Between 2016 and 2050, waste is expected to increase by as much as 70 per cent, according to the World Bank, 2022. Globally, increasing quantities and complexity of solid waste has become a menace in many market towns (Mochache, et al, 2020).

A growing population also implies that solid waste generation will also double, if not triple, from the developments and human activities associated with a growing urban populace (Shi et al, 2021). Solid Waste generation from a global level is expected to double by 2050, with cities and urban centres being the highest contributors to solid waste generation (Ogutu & Kathambi, 2022; Mzobe et al, 2024). In Africa, only 55% of the annually generated 125 million tons of MSW is collected (Yllah et al, 2023). African cities have shown a growing interest in the issues of uncollected solid waste (Faten & Lamia, 2020; Oliveira Cunha and Sorin, 2024). In 2024, Africa will also be expected to improve its solid waste management, this will involve putting in place more concrete solutions for the collection, sorting and recycling of this waste, which could reach 244 million tonnes per year by 2025 if current trends continue (Nkweauseh., et al, 2023), In 2016 alone, the continent generated 174 million tonnes of solid waste, according to UN-Habitat (Inès, 2024)

Urbanisation and community agglomeration in urban areas are increasing the complexity of solid waste (Nani, 2024). As a result of increasing population, the quantity of solid waste is continuing to grow (Hasyim, 2023). Inadequate solid waste management can lead to environmental contamination and health risks (Frazer-Williams & Sankoh, 2024). Several contaminants can cause danger to human health that are contained in solid waste or generated from solid waste burning and dumping (Valerie et al, 2022). MSW is made up of various wastes generated by households and institutions such as schools, hospitals, slaughterhouses, and public restrooms (He et al, 2023). MSW is not well managed in developing countries due to the alarmingly increasing solid waste production, which is more than the capacity of the cities and municipalities (Li & Chen, 2023). It was reported that waste collection rates are often lower than 70% in low-income countries, and more than 50% of the collected waste is often disposed of through uncontrolled land filling (Fikadu SD, et al, 2022).

Solid waste characterisation is a critical component in the pursuit of sustainable waste management (Osman et al., 2023). It provides the necessary understanding of solid waste composition, which aids in strategising appropriate solid waste handling and treatment systems (Yu et al,2023). It also plays a vital role in shaping policies, guiding infrastructure development, and optimising solid waste management systems to effectively address the challenges posed by solid waste (Tarigan et al, 2023). Solid waste management has to consider the composition or characteristics of waste (Ferraro et al, 2023). It is urgent to calculate the amount and

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composition of all faculty's solid waste generation (Soni et al, 2023). Solid waste characterisation must provide complex fractions of the solid waste generation rate or the number of materials before any treatment (Zekkos et al, 2024). Information of the composition and volume of waste is an essential part of selecting the most appropriate system for sustainable waste management (Simangunsong., 2021).

2.2.2. Household solid waste

HSW (i.e., solid waste generated during day-to-day household work) is one of the main components of municipal solid waste, and a large proportion of municipal waste management budgets is allocated to managing household solid waste (Tanwi et al, 2024). HSW is one of the primary sources of MSW, comprising food wastes, paper, plastic, rags, metal and glass from residential areas (Fadhullah et al, 2022). Household solid waste is the residue generated daily by people as a result of consuming goods and services (Ouhsine et al, 2020; Dzawanda et al, 2022). The research considered the definition of household solid waste by Tanwi et al, (2024) because solid waste from households is one of the major contributors to municipal waste, and with the increase in urbanisation, municipal solid waste is forming the bulk part of solid waste. Households are the primary source of MSW, and most of the solid waste collected is from households.

HSW is rapidly increasing due to accelerated population growth and urbanisation (Haywood, 2021). Most of the solid waste is not separated by households because of a lack of awareness and, in some cases, negligence (Shiferaw et al, 2023). Furthermore, HSW is highly heterogeneous and is widely dependent on the socioeconomic status of the households (Noufal M, 2020). South Africa is facing a huge challenge regarding waste management, the disposal of household waste is a major challenge in solid waste management (Shonisani & Ntsieni, 2021). Households in developing countries are the primary waste generators (Ghosh, 2022). Household solid waste poses various threats to public health and negatively impacts flora, fauna, and the environment, especially when it is not properly collected and disposed (Tursunov et al, 2024). In addition, household solid waste releases toxic chemicals into the atmosphere and soil whenever it is decomposed or burned (Barinova et al., 2020).

2.2.3. Sustainable solid waste management

SWM is a cross-cutting issue that can be directly or indirectly linked to the 17 UN SDGs because it is an essential utility service (Fadugba et al, 2022). The three dimensions (or pillars) of sustainability are the environment, the economy, and society (Oluwatuyi et al, 2020). Sustainable solid waste management is a multifaceted issue with political, socioeconomic, institutional, and environmental components (Fadugba et al, 2022). The management of MSW has always represented an important challenge of our society, and it is a constantly evolving issue characterised by variable temporal and spatial specificities (Arabiat et al, 2023; Viljoen et al, 2021). The United Nations'2030 target continues to prioritise environmental sustainability (Adeleye., et al, 2022), As a result, various levels of government in South Africa have implemented various

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efficient solid waste collection strategies, but there have been reported inefficiency of these program(s) in many parts of the nation (Del Carmen et al, 2023).

Local authorities and municipalities mainly develop collecting and sorting strategies (Fiorillo & Merkaj, 2024). Different residential units may have different collection & sorting mechanisms (Tan et al, 2024). Collection and sorting systems are essential and important parts of SWM practices (Xiaoning et al, 2023). A well-established solid waste collection system increases the performance of the sorting facility, which achieves a convenient solid waste stream for recycling activities, a solid waste flow in high amounts, and low contamination (Selin et al, 2021; Marutlulle, 2021). Solid Waste collection is an important part of the solid waste management system (SWMS), transportation costs and carbon emissions can be greatly reduced by proper vehicle routing (Linard et al, 2023; Omotayo, 2024). The traditional approach to solid waste Collection (Scheduled collection and curbside collection) is time-consuming, inefficient, unreliable, and lacks real-time assessment (Radhika & Sandip, 2024; Mashiane & Odeku, 2024).

Management of solid waste generated from households has become an emerging challenge in developing countries like Pakistan (Khan et al, 2022). It is mainly due to the lack of explicit environmental standards for institutional waste management (Namoun, 2022). Currently, in Pakistan, the overall quantity and diversity of solid waste in educational institutes are rapidly increasing with the increase in the number of students and staff (Jamshaid,2021). The process of SWM comprises multiple sequential activities, including waste disposal in the containers by the citizens, waste collection by the truck fleet, and finally, waste transportation to the designated waste landfills or recycling centres (Teshome, 2021). The existing government structure in South Africa is struggling to provide solid waste services to the growing number of urban and rural residents and does not have the capacity to diversify solid waste management practices and move towards a circular economy in waste (Okafor et al, 2022). The inability to provide solid waste services to the majority all residents and its non-compliance with SWM regulations indicate the weak government structure (Abdallah et al. 2020). This demands for the exploration of each actor and their engagement in solid waste management, for which the concept of solid waste governance is taken as an entry point (Nikita S,2022). More importantly, many problems in the cities and towns of the global South are attested to be often associated with a weak or inadequate municipal solid waste management system underpinning severe direct and indirect environmental and public health issues at every stage of waste collection, handling, treatment, and disposal (Abubakar, et al, 2022). In other words, inadequate and weak municipal solid waste management is attested to result in indiscriminate dumping of waste on the streets, open spaces, and water bodies (Derdera et al., 2023). Artificial intelligence is a rapidly advancing technology that is gaining popularity in various industries, particularly waste management (Fang et al, 2023). The incorporation of artificial intelligence and robotics in the design and operation of solid waste treatment plants can revolutionise how solid waste is managed (Yigitcanlar & Cugurullo 2020), leading to increased operational efficiency and more sustainable waste management practices (Goutam et al, 2021).

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2.2.4. Small rural towns

South Africa is a country with many small towns, each rich in heritage and culture and with their own unique spatial character (Seboko et al., 2024). Unfortunately, most small towns are in distress (Coroș et al., 2024). The focus of investment to bring about spatial transformation has typically been in either cities or villages, i.e. urban or rural (Alam et al, 2023). However, Arndt, Davies and Thurlow (2018) suggest that a 3rd way to make the small towns grow would be to invest in secondary cities and small towns (Semilet, 2023). Small towns are embedded in the cultural landscape and sit at the intersection of rapid urbanisation and industrial agricultural practice two of the most significant features of the Anthropocene (Patrick, 2023). In the countryside, recent private economic investments and new opportunities attracting population and settlement have contributed to the emergence and growth of smaller towns in rural areas (Rasca et al, 2024).

Emergent towns foster expectations of access to better urban living for migrants, who anticipate the transformation of new settlement areas with infrastructure and services being introduced over time; migrants tend to invest more in their permanence there (Cristina, 2022). Rural areas provide unique amenities for recreational purposes which are highly appreciated by urban inhabitants, this generates an important but often hidden relationship between the urban and the rural (Cozzi and Prete, 2022). The transformation of rural places is characterised by structural changes, which involve changes in economic activities, usually from agricultural to non-agricultural (Hu et al, 2024). The changes take place in space resulting in the transformation of spaces by effecting changes to the socioeconomic and biophysical characteristics of spaces (Matai et al; 2022). Small town development plays a crucial role in urban-rural systems, especially in developing countries (Zhang et al; 2022). Small towns have limited financial and human resources for the application of innovative digital technologies in management activities and are forced to independently solve many issues related to the life of the city, primarily for the development of the accumulated human potential (Yakshimbetova et al, 2022). The lesson learnt from this concept is that small towns in South Africa, though rich in culture and strategically positioned between urban and rural spaces, are often overlooked in development planning and investment. They are rapidly growing due to migration and economic shifts, creating demand for improved infrastructure and services. However, these towns face resource limitations, making sustainable development and spatial planning challenging. Despite this, they play a crucial role in connecting rural and urban systems and hold potential for transformation

2.2.5. Peri-urban

The peri-urban area is a dynamic area and continues to develop in various aspects along with the development of the city and the surrounding area, so that it can shift its rural appearance towards urban areas (Janviter et al, 2022). In the rapidly growing world, where farming land is shrinking due to horizontal urban expansion and development-induced projects, agricultural productivity should grow by 70% to meet food needs (Solomon et al, 2021). Nowadays, the huge production of MSW is one of the most strongly felt environmental issues, consequently the European Union (EU) delivers laws and regulations for better waste management,

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identifying the essential requirements for waste disposal operations and the characteristics that make waste hazardous to human health and the environment (Mancino et al, 2022). Rapid expansion in population, urbanisation and economic growth has resulted in a change in lifestyle and living standards with a consequent increase in thousands of metric tonnes of MSW per year (Goswami et al, 2024). Peri-urban areas suggest that local bodies require increased administrative abilities to deal with the complex problems of managing waste associated with the increasing urbanisation (Kandpal, and Saizen, 2022More broadly, peri-urban landscapes globally, and especially in Europe, are experiencing similar political, social and environmental drivers of land-use change in their peripheries (Shaw et al., 2020; Haldar et al, 2024), resulting in the loss of natural capital (Matthew, 2024This fact suggests that previously rural populations moving to urban communities must develop new associations, institutions and relationships based on a new set of collective challenges (Abanyie et al., 2021). Peri-urban areas have enormous potential to play a positive role in enhancing urban sustainability at the global level (Chettry et al, 2023; Boukari et al, 2023), the process of urbanisation will continue to grow exponentially in the coming decades (Spencer, 2022).

The expansion of roads and the advent of new economic opportunities promote unplanned growth in areas surrounding metropolitan centres, which increases the complexity (Haldar et al, 2023). Urban expansion beyond the city's administrative boundaries has mostly altered villages (Douini et al, 2024). These peri-urban villages are experiencing unforeseen changes in demographic, economic, land-use, and environmental characteristics (Vashishtha et al, 2024). The concept of peri-urbanisation is grabbing the attention of urban planners and policymakers globally (Ankit& Aparajita, 2023). The peri-urban zone is defined by a transition zone between agricultural and urban land use, as well as urban characteristics in rural land, and unplanned growth in the surrounding regions of urban body, which is aided by road expansion and the development of new economic opportunities (Haldar, et al, 2023).

The lesson learnt from this concept is that peri-urban areas are rapidly evolving and complex spaces, shaped by unplanned urban expansion, demographic shifts, and changing land-use patterns. These zones face mounting pressure on infrastructure and services, particularly waste management, due to increased population, economic activity, and lifestyle changes. As rural areas take on urban characteristics, local governments require enhanced planning and administrative capacities to manage these transitions effectively. This highlights the critical need for integrated spatial planning strategies tailored to the unique challenges of peri-urban environments.

2.2.6. Solid waste collection

Solid waste collection is the process of gathering and transporting waste materials that are discarded by households, businesses, and industries (Radwan et al, 2021). Solid waste collection is the gathering or picking up of solid wastes from the various sources but also hauling of these wastes to the disposal site or transfer station and unloading there (Gallardo, 2021). Solid waste collection is a service that requires citizen cooperation in the provision and use of proper containers in order to keep the community clean and essentially

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free of rats, flies, and other vermin (Nursetyowati et al, 2024). Solid waste collection is the service provided by local governments or private contractors that involves the regular pickup and transportation of waste from residential, commercial, and sometimes industrial sources to designated facilities for treatment, recycling, or disposal (Oluwaseun and Olayemi, 2023).

Solid Waste collection is a critical step in managing waste, yet rates vary largely by income levels, with upper-middle- and high-income countries providing nearly universal waste collection (World Bank, 2020). Low-income countries collect about 48 percent of waste in cities, but this proportion drops drastically to 26 percent outside of urban areas. Across regions, Sub-Saharan Africa collects about 44 percent of waste while Europe and Central Asia and North America collect at least 90 percent of waste (World Bank, 2020). This is also supported by the figure below

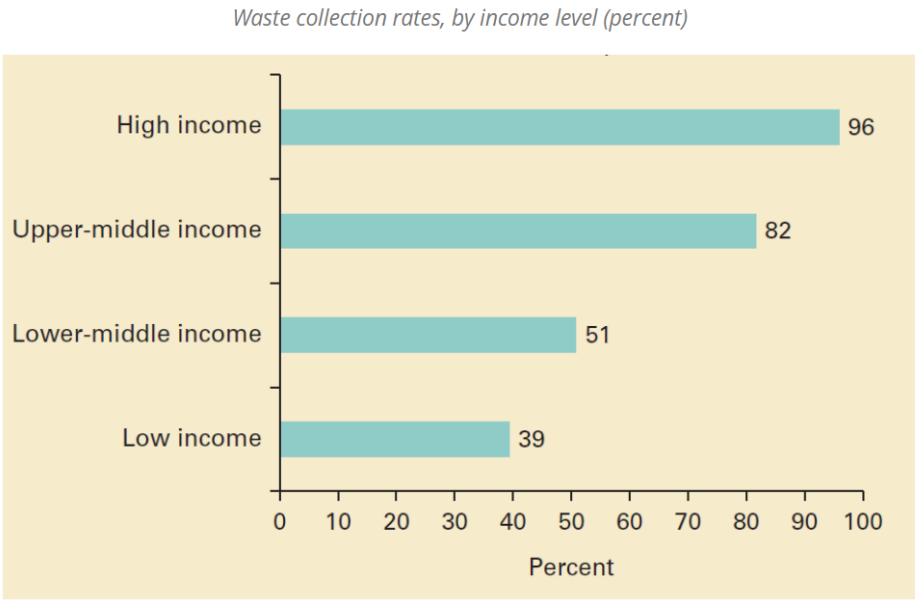

Figure 2.3: Waste collection by income

Source: World Bank, 2020

There exist three major phases of solid waste collection in Africa: the informal phase, primary and secondary phase (Seyedsahand, 2023; Tembo et al, 2024). The informal and primary phases are basically the ones from household to community collection points (Murugesan, 2020; Madonsela et al, 2024). The formal institutions, such as urban councils and private operators, are the ones in charge of the secondary phase (Hannan, 2020; Apio et al,2024). Solid wastes are usually transported from community transfer points to landfills or final disposal sites (Golzary et al,2024). Private operators have also been utilised in solid waste collection, they collect solid waste directly from households by a door-to-door approach (Zamathula, 2024).

Financial inclusion increases the likelihood of households opting for the collection method of solid waste disposal relative to burning, public dumping and indiscriminate disposal of solid waste (Mbwilo & Mahenge, 2022). Financial inclusion enables households to opt for a healthy solid waste disposal method (collection

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method), hence, in policymakers' attempts to improve solid waste disposal, paying attention to financial inclusion can be a very useful strategy (Immurana et al, 2022). While separating waste is easier to achieve at residences, collecting waste in separate components from residences may be more difficult than from workplaces (Apaydin, Ömer et al, 2023). Therefore, different methods of solid waste separation can be used in residences and workplaces (Apaydin, Ömer et al, 2023). Low-density solid waste in the composition leads to a relative increase in waste volume, affecting the capacity and operational efficiencies (Rogerson et al,2024). The solid waste production will reach up to 2.2 billion tons by 2025 (Tian et al, 2022). In such circumstances, countries across the globe have been following measures to reduce waste by adopting green/circular practices, which are focused on closing the loop of the supply chain (Tanveer, 2023). In simple words, it is the move towards circular economy (CRE) from the linear method of production, which creates more waste (Zhang et al, 2022). Solid waste generation is an important issue in solid waste collection, solid waste generation is defined as "the amount of waste that one person throws out during a certain period in terms of weight or volume (Al-Taai & Suaad, 2022). However, it turns out that the solid waste problem is a problem that needs special handling (Li et al, 2024). This condition is because waste is related to all human, animal, plant, and biological activities, the more volume of waste increases, the more diverse the composition (Aziz et al 2024). The Ministry of Environment and Forestry in South Africa stated that the national waste generation amount is 175,000 tonnes per day, or the equivalent of 64 million tons per year if using the assumption that 0.7 kg of waste is generated per day per person (Aziz et al, 2024).

The key lesson learnt is that solid waste collection is a complex, resource-dependent, and context-specific process that requires coordinated efforts between municipalities and households. While it is a fundamental municipal service, its effectiveness varies globally based on income levels, infrastructure, and financial inclusion. In low-income and peri-urban areas, limited resources, rapid population growth, and poor planning exacerbate SWM challenges. Effective collection practices go beyond infrastructure and legislation they require public participation, financial support, environmental education, technical skills, and a shift towards circular economy models.

2.2.7. Spatial planning

Spatial planning is a systematic approach to allocating and harmonising land uses to avoid environmental problems and promote coordinated development rooted in theories of rationality and communicative planning. Spatial planning balances social, economic, and ecological interests through vertical and horizontal policy integration focused on shaping spatial outcomes for rural and urban transformation (Matai & Chirisa, 2022). The process of spatial planning, even if it is about the smallest spatial unit, encompasses an entire range of steps and participants (Yang et al, 2024). A harsh representation of the planning process divides it into plan-making and plan implementation phases, which overlap at some points (Nikolić et al, 2021). Spatial planning plays a crucial role in shaping the future of urban development and land administration (Vujić et al, 2024). While land registration information is necessary for spatial planning processes, it is also probable that changes

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in land registration data occur in line with spatial plan decisions (Okan et al, 2024). The solid waste management of residents' area - an integral organisational and technological spatial-oriented system, a component of the functional and planning structure of the city (Liudmyla & Oleksii, 2024). The town-planning organisation of solid waste management is aimed at improving the ecological condition and improving the comfort and quality of life of the inhabitants (Liudmyla & Oleksii; 2024). one of the major difficulties for small town is connecting the SWM system with the municipal waste collection service because of the highly congested spatial arrangements and lack of accessibility (Nilufar et al; 2022). The issue of spatial inequality in the distribution of solid waste management infrastructure in Ghana is not new,various studies have highlighted spatial inequality, and often the cause is pinned on SWM costs (Volsuuri et al, 2022). For instance, analyses from the study show that the door-to-door waste collection in low-income and peri-urban communities was less economical (high operational cost) due to limited access routes to residents (Volsuuri et al, 2023). The development of any country relies on several factors, including a growing population, a robust economy marked by high-rise buildings, improved living standards, and heightened consumption levels (Vujić & Gašparović, 2024). However, these positive developments also lead to a significant increase in solid waste generation, necessitating advanced techniques and technologies for effective management (Borase et al, 2024).

The lesson learnt is that spatial planning is a fundamental tool for organising land use, infrastructure, and services in a way that supports sustainable development, especially in complex and rapidly growing areas like peri-urban villages. In the context of SWM, spatial planning enables the integration of waste collection systems into the broader urban fabric, improving accessibility, efficiency, and environmental health. These challenges emphasise the need for context-sensitive spatial planning strategies that consider the unique geographic, economic, and social conditions of peri-urban areas. Effective spatial planning can bridge the gap between residents and municipal services, making sustainable solid waste collection more achievable.

2.2.9. Factors that hinder the proper household solid waste collection

Some solid wastes, such as discarded plastic containers of pesticides are hazardous, they are generated from diverse sources and discarded in waste bins or at dumpsites (Bui et al, 2022). Their chemical composition necessitated special handling procedures and disposal methods to safeguard the environment and human health (Faber & Prelogović, 2023). The lack of infrastructure to manage such wastes in developing countries makes it a huge challenge and threat to public health (Kwakye et al, 2024). Where such infrastructures are available, the identified existing or potential impacts of deploying facilities for waste management are of concern (Folarin, 2022). Increases in populations and urbanisation have made it a challenge not only to handle large quantities of waste generated but to dispose of them safely (Ravichandran et al, 2021). Financial limitations often affect the capacity of local governments or private firms to provide effective waste collection services (Voukkali et al, 2024). Insufficient funding can result in fewer trucks, personnel, or collection points, especially in peri-urban or rural areas (Sajid et al, 2022). A study from 2021 highlights the financial challenges

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faced by municipal authorities in addressing waste management issues effectively (Akinmoladun et al., 2022). More factors are presented in the table 2.1 below.

Factors that hinder the proper household solid waste collection	Reference
Lack of Time and Convenience	Strydom,.2018
Insufficient Space	Mngomezulu, et al., 2024
Lack of Knowledge and Awareness	Hosseini et al., 2022
Inconvenient or Inadequate Facilities	Ebrahimi et al., 2021, Kubanza, N. S. (2024)
Financial Constraints	Silamlak., et al, 2021
Lack of Community Participation	Fadhullah, 2022
Negative Perceptions and Attitudes	Hosseini et al., 2022, Lozano, 2022
Cultural and Behavioural Factors	Chultz et al., 2020
Inconsistent Collection Schedules	Said et al., 2021
Inadequate Policy and Governance	Abubakar et al, 2022

Table 2.1: Factors that hinder the proper household solid waste collection

Source: Mutwanamba (2024)

The lesson learned is that household solid waste collection faces a wide range of interrelated challenges, especially in developing and peri-urban areas. These include infrastructural deficits, financial limitations, inadequate policy frameworks, and weak community participation. Additionally, factors such as lack of awareness, cultural attitudes, space constraints, and inconsistent collection schedules further hinder effective service delivery.

2.3. Literature review per objective

2.3.1. Characterise the current household solid collection practices in peri-urban.

Solid Waste Collection is a part of waste management that includes the systematic collection of discarded materials, including recyclables, compostables, and non-recyclables. This process is integral to minimising environmental impact, controlling pollution, and supporting sustainable waste management practices (Wan et al, 2022). Solid Waste Collection is a process aimed at not only removing waste from collection points but also facilitating the segregation of recyclables and compostables from general waste, thereby supporting waste reduction, resource recovery, and environmental conservation (Zhou et al, 2022). Previous research on collection efficiency focused on evaluating the MSW collection service performed by private companies and local governments (Salazar-Adams, 2021). Research reveals that private waste collection companies may outperform the government's efficiency, however, in terms of eco-efficiency in MSW collection service (Romano et al.,2020). Effective solid waste collection practices are not all about legislative solutions, but a combination of the environmental, social, technical, technically skilled human resources, financial and

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technological resources, resource recycling, environmental pollution awareness programs and public participation (Duran & Mert, 2024). As a result of insufficient resources, MSW in Africa remains a challenge, and it is often not yet given the highest priority (Noah et al, 2020). Due to the increasing volume of solid waste and the increasingly complex administration of its collection and disposal, solid waste management is quickly becoming a demanding issue for municipalities all over the world (Doussoulin & Cristian, 2022). Benchmarking the effectiveness of municipal solid waste management is critical for assessing municipalities' resource management performance and developing public policies for improvement (Doussoulin & Cristian, 2022).

To support the objective, the researcher will look at the case study from Nairobi, Kenya, by Karanja et al. (2021), which highlights similar challenges, where only 45% of peri-urban households had access to regular waste collection, and most residents disposed of waste in open spaces or drains. Similarly, in Accra, Ghana, a study by Amoah et al. (2020) found that peri-urban communities relied heavily on informal collectors due to gaps in municipal service delivery. The study found that in Uganda, Mbale's peri-urban villages, despite municipal responsibility, solid waste collection was erratic (Nabukeera & Muwanguzi, 2023). Community members depended heavily on informal waste collectors due to limited waste bins and collection frequency (ibid). Spatial constraints and lack of land-use integration further limited the effectiveness of the collection system (Nabukeera & Muwanguzi, 2023).

2.3.2. Identify factors that impede sustainable household solid waste collection in peri-urban areas.

In Lusaka, Zambia, a case study by Chileshe and Moonga (2020) found that despite community willingness to pay for waste collection, limited road access, inconsistent schedules, and lack of enforcement mechanisms undermined effective waste management. Similarly, a study in Ibadan, Nigeria (Adedibu & Okekunle, 2019) linked poor service delivery in peri-urban zones to fragmented planning and a lack of inter-agency coordination. In Kampala, Uganda, peri-urban solid waste collection efforts were impeded by irregular settlement growth, narrow roads, and insufficient enforcement of urban development plans (Isunju et al., 2020). The study showed that even when communities were willing to pay, poor infrastructure made service delivery unfeasible (Isunju et al, 2020). Institutional coordination failures between departments worsened collection inefficiencies (Isunju et al, 2020). A recent study in Kenya, Thika, found that financial constraints, inadequate legal enforcement, and a negative public attitude towards formal waste systems reduced sustainability in peri-urban waste services (Mutheu & Wambua, 2024). Lack of space for community bins and poor road conditions led to widespread illegal dumping and burning (Mutheu & Wambua, 2024). Vietnam, Ho Chi Minh City despite being a major city, peri-urban areas experienced logistical and spatial barriers to regular collection (Le & Duong, 2020). Land-use conflicts, poor accessibility, and low public willingness to separate waste contributed to unsustainable practices (Le & Duong, 2020). In Kenya, Nairobi's outer zones, corruption in waste management contracting, irregular collection schedules, and insufficient waste education hindered progress. The city's growth outpaced the infrastructure investment needed for coverage (Ndung'u &

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Kinuthia, 2023). Malawi, Lilongwe have a lack of waste legislation enforcement, low municipal revenue, and negative public attitudes towards paying for waste collection services were found to be primary barriers in newly developing peri-urban areas (Chimbwete & Mbewe, 2022).

2.3.3. Propose sustainable strategies for household solid waste collection practices in peri-urban areas.

Case Study of Rwanda, Kigali integrated GIS-based waste route planning with community waste banks in peri-urban districts (Tuyisenge et al., 2022). The model improved service efficiency, encouraged household segregation, and enabled municipal monitoring through mobile apps. The study recommends digital spatial systems for sustainable urban-rural waste transition zones (Tuyisenge et al., 2022). Case Study of Mzuzu, Malawi, researchers examined how cooperative models with spatially designated waste drop-off points enhanced sustainability in peri-urban zones (Kawonga & Kambewa, 2023). Community education and locally trained waste handlers played a role in improving the adoption of better waste practices (Kawonga & Kambewa, 2023). Pune, India, used a decentralised model using ward-level waste management hubs and household segregation initiatives, which led to improved collection efficiency (Bhat & Deshpande, 2021). The city promoted a zero-waste policy supported by community-based organisations and mobile tracking apps (Bhat & Deshpande, 2021). Belo Horizonte, Brazil, integrated waste management included cooperatives of waste pickers, strategically planned collection points, and digital route optimization (Dias et al., 2023). The model reduced waste in open areas and increased recycling rates in poorer zones (Dias et al., 2023). Tanzania, Dodoma local authorities partnered with youth groups in peri-urban communities to carry out door-to-door collection (Mchome & Komba, 2022). Using motorbikes for hard-to-access areas and community sensitisation campaigns made this approach effective and replicable (Mchome & Komba, 2022).

2.4. Case studies

2.4.1. Developed countries

2.4.1.1. Case study of the city of Bragança, Portugal, solving a Capacitated Waste Collection Problem using an Open-source Tool (Filipe A, 2022)

increasing complexity in municipal solid waste streams worldwide is pressing SWMS, which need solutions to manage the waste properly (Filipe A, 2022). Waste collection and transport is the first task, traditionally carried out by countries/municipalities responsible for waste management (Filipe A, 2022). In this approach, drivers are responsible for decision-making regarding collection routes, leading to inefficient resource expenses (Filipe A, 2022). In this sense, strategies to optimise waste collection routes are receiving increasing interest from authorities, companies and the scientific community (Silva et al, 2022).

Different studies were conducted in the city of Bragança. Workers in this strand usually focus on waste collection route optimisation in big cities, but small towns could also benefit from technological development to improve their SWMS (Silva et al, 2022). Waste collection is related to combinatorial optimisation that can

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be modelled as the capacitated vehicle routing problem (Perebynos et al, 2023). Advances in the industry combined with population growth in cities are increasing the complexity of MSW streams worldwide (Biswas et al, 2023). Due to the increased complexity of waste management, management costs are becoming a public concern. Investments in this sector are often left aside in low and middle-income countries, which can lead to environmental and health problems of inappropriate MSWM (Biswas et al, 2023).

2.4.1.2. Case study in Minamata City, Kumamoto Prefecture, Japan: Optimizing the number and location of household waste collection sites by multi-maximal covering location model.

Convenience has consistently been perceived as one of the crucial determinants of household recycling behaviour in source separation systems studied over the last several decades (Zhuo & Yan, 2022). Although residents' accessibility to collection sites significantly affects household recycling behaviour, allocating the collection sites for household waste is complex for policymakers (Zhuo & Yan, 2022). It requires balancing between residents' needs and the limited budgetary and human resources of local government and consideration of waste management policies (Zhuo & Yan, 2022).

The multi-maximal covering location model (MMCLM) to solve the waste collection site allocation problem based on residents' satisfaction while considering the capacity of municipal services (Zhuo & Yan, 2022; Government of Japan, 2024). In the study, MMCLM was applied in Minamata City, Kumamoto Prefecture, Japan, a city with more than 25 years of successful experience in implementing household recycling. Six scenarios were developed to allocate recyclable waste collection sites (Mekonnen & Tokai, 2020). A similar study was done with 10 new sites in Minamata City, where there was a more than 5% improvement in average access distance to drop off waste for all households (Ghosh et al, 2020). 30 new sites could effectively reduce the average access distance by 72.4% for 324 households who currently have to walk more than 10 minutes, and 8.0% of the average access distance for all residents (Ghosh et al, 2020).

2.4.2. Developing countries

2.4.2.1. Case study of Malaysian Cities: A Review of Future Household Waste Management for Sustainable Environment in Malaysian Cities.

In recent years, Malaysia has faced environmental challenges caused by MSW, especially household solid waste. Among all the household waste, plastic and paper are the most unmanaged waste that cause environmental issues (Cheng et al, 2022). The management of solid waste is the most significant task faced by the authorities in developing nations' small and major cities, and the municipal waste management budget has increased due to the increasing generation of such solid waste (Cheng et al, 2022). Household waste, which is the 'garbage' or 'trash' generated by the domestic, contributes to part of the MSW (Cheng, K.M., et al, 2022). Similar studies were also done by Ebekozien et al (2022). According to an estimate, Malaysia would generate more than 25,000 tons of household waste per day as urbanisation and the population increase rapidly. The increasing amount of unmanaged household solid waste that consists of kitchen, organics, and inorganic

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components that emit greenhouse gases (GHGs) have led to a climate crisis such as an amplification of extreme weather and is directly linked to severe flood, e.g., Zhengzhou's flood that causes damage to 9000 homes or equivalent to the loss of 2 billion USD ((Ebekozien, et al, 2022).

Several recycling associations in Malaysia have carried out their practices for better waste sustainability and management to curb the increasing amount of household solid waste (Mohd Mohadis & Shompa, 2024). However, the effectiveness is still vague in achieving smart and effective household solid waste management (Mohd Mohadis & Shompa, 2024). Malaysia faced the challenge mainly due to inadequate waste infrastructure development and relying heavily on solid waste to be disposed of in sanitary landfills (Moh & Manaf, 2020). Additionally, the awareness of protecting the environment and recycling rate among Malaysian citizens is still considered low. Therefore, Malaysia is yet to hit the targets of diverting 40% of the waste from landfills and increasing recycling rates to 22% (Iacovidou & Kok, 2020). By contrast, industrialised nations create a substantial volume of plastic and paper garbage, contributing to the higher heating value of MSW due to its lower moisture content and carbon content (Nanda & Berruti, 2021).

Lastly, although technology has simplified the process of waste management in different areas such as Internet of things (IoT), waste-to-energy technologies as strategies to reduce waste from sending to landfill, businesses also play their role in utilizing the technology and sustainable strategies to reduce cost and environmental pollution (Okedu, et al, 2022; Ali & Talmizi, 2024). Good governance can control the citizens' actions to a certain degree. However, education is important as an awareness of the consequences of improper waste management and the social factors are the anchor point to realise the sustainable cities initiatives that many countries have targeted (Okedu et al, 2022).

2.4.2.2. Case study of Bolivia: Assessment of municipal solid waste collection in Bolivia

In Bolivia, the SWM system focuses primarily on the collection and transportation to final disposal sites. In Bolivian small cities, open dumping is the only option, while in megacities sanitary landfills and selective collection pilot actions start to be implemented (Fernando et al., 2020). In the national regulations, it is indicated that the municipalities should prioritise prevention to reduce waste generation and environmentally safe final disposal (Ferronato et al., 2020; Ferronato et al., 2019). However, waste collection and appropriate final disposal are still challenging for towns and small cities, also regarding other waste fractions, such as healthcare waste (Ferronato et al., 2020). A similar study was done on Bolivian policymakers and engineers who require support for evaluating possible management improvements, reducing costs, and quantifying environmental impacts (Lozano Lazo et al, 2023). The use of GIS is a methodology that has proven to be relevant for planning and improving MSW collection routes in developing countries (Ferronato et al., 2019; Medrano-Flores, 2023). The study was carried out in 2017 in the Municipality of Viacha, a developing city in the Bolivian Andean plateau, where waste open dumping is the common practice (Villca Mamani, 2023).

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The study was conducted in four steps: fieldwork, GIS analysis, LCA and economic assessment, and the final comparison of scenarios. The hypothesis behind this work is that field research combined with GIS and LCA can indicate solutions for the improvement of solid waste collection that will lead to both a reduction in environmental impacts and the financial expenses (Ferronato et al, 2021; Gamarra & Roncoli, 2023).

The collection system is applied in three different methods. The first method is called “fixed or corner stop”. It is the most economical method, and the one mostly applied in Viacha (Ferronato et al, 2021). It consists of collecting MSW at street corners, where a bell is played at the arrival of the vehicle, and the users go to deliver their waste. The operation must be repeated as many times as necessary until all users are served. The second method is the “door to door” collection (Ferronato et al, 2021; COOPI-Cooperazione Internazionale, 2022). The users deliver the waste in front of the door of the house or business (in small bags), and the trucks collect the waste. This method is implemented only in a few parts of the city. The last one is the “kerbside method” (Ferronato et al, 2021). The users leave the waste into containers or bins, which will be collected by the operators of the collection vehicle (semi-mechanised type) (Ferronato et al, 2021; Inter-American Development Bank (IDB), 2012). Increasing the coverage of public fee collection is challenging. However, local administrations can start from an appropriate management and improvement in the system, asking for national support for financing new collection trucks and public awareness campaigns, at the same time, policymakers need support for evaluating the best options (Ferronato et al, 2021; Gonzales, & Herrera, 2022).

2.4.3. Africa case studies

2.4.3.1. Northern Africa case studies

2.4.3.1.1. Case study of Morocco: household solid waste, Khouribga city: Solid Waste Management Challenges and Solutions

In Morocco, like in many developing countries, the management of solid waste, especially household solid waste, is a major concern (Salama & Chennaoui, 2024). It is estimated that each person generates an average of 0.67 kilograms of urban waste per day, while in rural areas, this figure is 0.3 kilograms per day. The collection of urban solid waste is regular and almost daily, reaching approximately 5.5 million metric tons per year (Salama & Chennaoui, 2024). The management of household waste is a major concern for all urban communities (Salama & Chennaoui, 2024). In this context, efforts are being made to optimize and improve the collection of household solid waste in the urban municipality of Khouribga (Salama & Chennaoui ,2024; Mountassir, M., et al, 2023).

The study has revealed the existence of technical and social constraints that hinder the smooth operation of the current solid waste collection in this city. Therefore, the mobilization of the municipality, service providers, and the population is necessary to overcome these challenges (Salama and Chennaoui ,2024; Chirmata, 2021). A similar study was conducted in Morocco, where Morocco is facing a continuous increase

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in the volume of waste generated, which can be explained not only by steady population growth but also by the evolution of production and consumption patterns, as well as improvements in the standard of living. (Dahchour., and Hajjaji, 2020).

2.4.3.1.2. Case study of Ngor Municipality (Dakar, Senegal): Household Solid Waste, a Challenge of Urban Sanitation: Case of Ngor Municipality (Dakar, Senegal)

The study aims to understand factors that are causing the malfunction of the garbage collection system in the municipality of Ngor. Ngor village (traditional village) is characterised by compact dwellings, originally the districts of Grand Ngor, Petit Ngor, Ndiogorann and Ndaré (Ndiaye et al, 2021). In the Senegalese capital, Dakar, the variation in household waste production reduces it to 244 kg/inhabitant/year. Waste production is estimated at 10918 kg per day (Ndiaye et al, 2021; Woodside Energy, 2024). Surveys conducted in the Commune show that waste production varies from one concession to another (Ndiaye et al, 2021). Thus, determining the amount of waste was not easy, as households also use several types of waste bins for home storage (Ndiaye et al, 2021).

A similar study was done where the organisation of waste collection has experienced many dysfunctions in Senegal in general and in the commune of Ngor in particular, with institutional change, waste management is experiencing instability by key actors. Indeed, garbage collection is mandatory and is governed by the environmental code, which includes the collection, transport, storage, recycling, and disposal of waste, as well as the monitoring of disposal sites (Le Monde, 2024). Waste collection is carried out by the city of Dakar, which hires concessionaires to collect (World Bank, 2020; Hutson, 2021). The rapid and uncontrolled traditional urbanisation linked to a high population growth creates an organisational failure in the collection, as some parts of the Commune are inaccessible areas (World Bank, 2020). Spatial occupation is characterised by spontaneous habitat with areas where the roads are narrow, unpaved, sandy, in other words, impractical for the dump trucks used by the collection, this is evidence of access to the collection service being very unequal in neighbourhoods (Trinomics, 2020). A similar study was done whereby the household abandons waste in nature that can be very harmful to their environment and their health, thus, not all waste products are collected every day and end up in sometimes-permanent wild dumps (Mberu et al, 2022).

Various laws and regulations have been adopted by Senegal for the management of solid waste: the law on the code of hygiene, the law on the environment code, the law on the code of local authorities and the decree regulating the collection garbage (Bigon, 2024). The setting up of these is not accompanied by any measure of effective implementation; they had no effect not only because of their overhaul in relation to the needs, technical, technological, environmental and economic constraints, but also because of the lack of complementarity between them. However, it is necessary to emphasise their ignorance of the populations (Seiyefa et al, 2024).

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2.4.3.2. Eastern Africa case studies

2.4.3.2.1. Case study of Kisumu City, Kenya: Existing household solid waste source separation practices and their contribution towards sustainable solid waste management: The case of Kisumu City, Kenya.

An effective measure to improve waste management levels and convert household solid waste into useful materials is to conduct source separation instead of just burning or burying it (Chen, 2017; Onyango et al, 2024). The study sought to examine the existing household solid waste separation practices and their contribution towards sustainable solid waste management in Kisumu City of Kenya. Source separation and recycling are important elements in SWM as both offer sustainable and effective solutions to mounting waste (Nadia et al., 2018; Dianati et al, 2021). The main body of source separation is the community resident (Zhang & Wen, 2014). Rahman et al. (2017) and Otundo Richard, M. (2024) agreed that waste separation at source was very important in the 3r initiative. Separating waste at the source directly supports material recovery by producing a more homogenous and high-value stream, which is easier to recover (Onyango et al, 2024). Approximately 70% of respondents reported making attempts to sensitise their household members on the importance of the separation of household solid wastes. This finding suggests that some residents are taking the initiative and actively promoting waste separation practices within their households (Onyango et al, 2024). Household solid waste source separation practices on sustainable solid waste management in Kisumu City, Kenya. The Majority of respondents believed that household waste separation was possible, and around 62% reported practising waste separation (Ishuga et al, 2024). Food wastes, recyclables, and plastics were the most commonly separated waste types, while hazardous waste and metals were less frequently separated, barriers to waste separation included inadequate waste storage containers, time consumption, inconvenience, and perceived unpleasantness (Kathambi et al, 2024). However, respondents recognised the hygiene benefits and importance of waste separation (Ogutu et al, 2021). A significant proportion of respondents also reported making efforts to sensitise their household members on waste separation (Ogutu et al, 2021).

2.4.3.2.2. Case study of Mukono Municipality, Uganda: Household's willingness to pay for improved solid waste collection services in Mukono Municipality, Uganda

Waste management still remains a big challenge in most urban cities in Uganda. The study sought to investigate the household's willingness to pay (WTP) for improved solid waste collection services in Mukono municipality in Uganda (Namukuve, 2021). To estimate the mean WTP and to find out the factors that influence the amount that households are willing to pay for improved solid waste collection services in Mukono municipality (Namukuve, 2021). A total of 400 households in nine (9) wards were systematically selected with a random start from two (2) divisions in Mukono Municipality (Namukuve, 2021). A probit regression model was used to establish the factors influencing households' willingness to pay for improved

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solid waste collection services (Namukuve, 2021). Households' mean willingness to pay per month was estimated through the double-bounded contingent valuation method, while the interval estimation method was used to determine the factors affecting the amount that households are willing to pay per month for solid waste collection service (Namukuve, 2021; Alalipour & Namutebi, 2024). Results showed that the most common waste management practice used by households was burning (44.5%) (Namukuve, 2021). A similar study was done: were households willing to pay for the improvement in solid waste collection services. This portrays hope for the successful implementation of the program, especially if it is well planned (Muheirwe et al, 2023). The probit model results revealed that income, gender, whether a household is satisfied with the current solid waste collection services, and those already paying for solid waste collection services significantly affect the willingness to pay for improved solid waste collection services (Muheirwe et al, 2023; Kizza-Nkambwe, 2023).

The study, therefore, recommended that sensitisation of the people in Mukono municipality on the value of proper solid waste management should be conducted. Secondly, a vibrant solid waste collection system should be established in the municipality lest the quality of the health of the environment and human population will be compromised (Muheirwe et al, 2023). Lastly, the estimated mean willingness to pay value should be the amount that policy makers should ask households to pay per month, if solid waste is to be collected on a door-to-door basis (Muheirwe et al, 2023).

2.4.3.3. Southern Africa case studies

2.4.3.3.1. Case study of plastic waste recycling and its implications for sustainable development in Mbare, Harare, Zimbabwe

Recycling of plastic waste gives a general overview of the main environmental issues related to plastic disposal (Chipfunde, 2023). It gives a rundown of the amounts and sorts of plastics in the waste stream and furthermore the primary impacts of recycling on the plastic material itself, the environment and also the national economy(Chipfunde, 2023; Kwenda et al, 2021). The two main types of recycling are mechanical and chemical recycling. The research also compares the methods of recycling which are already in use and selecting the best in a bid to save the environment from pollution (Chipfunde, 2023).

The study also sought to discover the challenges and benefits associated with plastic waste recycling (Chipfunde, 2023). From the main findings, there is a lot of plastic waste in Mbare (Harare) because of the shortage of bins and an ineffective waste collection system (Chipfunde, 2023). A similar study was done in Harare, where the plastic waste collection system should be complemented by the Harare city council, which should register waste collectors and recyclers for incentives by signing an agreement contract with them (Chireshe et al, 2023). Mbare has become the most ideal urban area to develop a waste collection centre as plastic waste has become a major problem (Chileshe et al, 2023).

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2.4.3.3.2. Case study in Maseru City, Lesotho: Municipal solid-waste collection and disposal management using geospatial techniques in Maseru City, Lesotho

The use of geospatial techniques plays a crucial role in solid waste management (Makhosi, 2021). Collection and transportation of solid waste must be done in an efficient manner to avoid negative environmental impacts (Mokopanela, 2024). At the time of study, there are no collection and routing system in Maseru City, leading to haphazard collection and disposal of MSW (Makhosi, 2021). GIS and Remote sensing techniques were used to carry out suitability and network analysis, and location of MSW collection points. The study found out that the dump site (Ts'osane) was used by MCC and was not suitably located, hence more suitable alternative dump sites have been proposed (Makhosi, 2021). However, Ts'osane dump site was adopted in the analysis as it is the one used by MCC at the time of study (Makhosi, 2021).

In this regard, 334 collection points have been determined based on population and generated solid waste per Constituency and were randomly located in the study area (Makhosi, 2021). However, due to the policy that within 25m from the road no development could take place, only collection points which fell v within 25m from the road were selected and used in the routing analysis (Makhosi, 2021). One truck was used in the analysis, although more trucks could be used as it was at the time of study (Motaung, et al, 2024). For future research, there is a need to research on policy so that criteria for locating solid waste disposal and location of collection points is explicitly specified in the law to be able to conduct scientific analyses (George, 2024).

2.4.3.4. Western Africa case studies

2.4.3.4.1. Case study of Nikki (Benin), Design of a Municipal Solid Waste Collection System in Situations with a Lack of Resources

Waste collection is one of the most important public services in a town (Esther, 2021). However, waste collection has not been effectively implemented in some places due to the lack of economic and management resources (Esther, 2021). The waste is placed in inappropriate sites with the consequent risks of pollution and unhealthy conditions for the inhabitants, therefore, establishing a municipal solid waste collection plan can be complicated (Esther, 2021).

In Nikki, the municipal solid waste collection system was adapted to this type of situation, where not much money can be invested and where data are limited (Sanya, 2024). In these cases, municipalities need to use their existing resources effectively (Koudenoukpo et al, 2023). The first step was to gather information about the type and amount of waste generated and the characteristics of the town (Esther, 2021). The second step was to propose the location of the bins and, finally, the waste collection routes. With all this data, the technical and human resources were set (Esther, 2021). The methodology used was validated in a real case, the town of Nikki (Benin) in Africa (Esther, 2021). The collection of three waste fractions was designed with the actual resources of the city in order to offer a realistic implementation. Similar situations can be found around the

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world, and this case study can be used as an example to improve the waste management practices in some places with low resources (Esther, 2021).

2.4.3.4.2. Case study of Niamey, Niger: Overview of Attitudes and the Household Solid Waste Management System in Niamey, Niger: Opportunities and Impacts

Management of household solid waste is insufficient (Moussa et al, 2023). It was found that 12% of households only subscribe to private pre-collection operators, 38% contract their waste to informal structures, and 50% evacuate their waste themselves (Moussa et al, 2023). Sorting or any other separate waste treatment is not applied, and landfills do not conform to norms of sustainable management (Moussa et al, 2023). The main consequence is the proliferation of anarchic deposits of solid household waste, however, 95% of households surveyed are aware that household solid waste can have impacts on health and the environment (Moussa et al, 2023). It was also found that solid waste collection and pre-collection activities are significant sources of revenue but need to be structured (Moussa et al, 2023). The results also show that the attitude of households towards waste management varies according to the status of the habitat (Moussa et al, 2023).

Thus, two types of pre-collection have been observed in the pre-collection stage (Moussa et al., 2023). The first type is a voluntary collection, residents carry their waste using half-bins, aluminium or plastic buckets, wheelbarrows, or other containers to a container or collection area just a short distance from their homes, usually less than 250 m (Moussa et al, 2023). The second type is the door-to-door collection, which is handled by the informal sector. In this type of organised pre-collection, micro-enterprises, associations, or neighbourhood committees are used to collect waste using a simple transport system such as rickshaws, animal-drawn carts, or human-drawn carts (Moussa et al, 2023).

The collection of waste is similar to that of grouping containers containing waste and transferring their contents into the collection bins installed by the City Council (Hama et al, 2024). This grouped waste is transported to landfills, which are also used as disposal sites (Ndam et al, 2023). The latter is only unused spaces or former quarries that have become large, untreated ravines (Ndam et al, 2023). These dumps are located all around the city and constitute a real threat to the environment and the local inhabitants (Moussa et al, 2023). Indeed, it was found that households accumulate and abandon garbage in the streets, on vacant lots, and in public places such as neighbourhood markets and open gutters.

A similar study was done in Niamey: the solid household waste collection system in the Niamey Municipal District is poorly managed and is characterised by the absence of a rigorous control framework (Djibo and Zakari, 2021). Indeed, not all the management stages are appropriate and remain risk factors for public health through the degradation of the quality of the living environment of the population and the environment (Djibo and Zakari, 2021). The lack of technical and financial means does not allow the municipal sanitation service to operate correctly in this management. Also, the low income of the population, associated with the people's negligence, constitutes an obstacle to the good practice of this waste management (Zongo and Sory, 2024).

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This leads to the multiplication of uncontrolled dumps on the roads, in the gutters, and in the undeveloped peripheral neighbourhoods, but also to the emergence of uncontrolled landfills, sources of various health and environmental risks (Wannous et al, 2024).

2.4.4. South Africa case studies

2.4.4.1. Case study of Soweto, South Africa

The illegal dumping of waste is one of the major causes of land degradation, which presents a problem for the global environment for both the developed and developing world (Sibongiseni, 2020). The illegal dumping of both building rubble and domestic waste results in groundwater pollution, air pollution and the contribution to the greenhouse gas budget (Sibongiseni, 2020). Illegal dumps cost the local municipalities a lot of money for the clean-up and removal of the illegally dumped waste (Sibongiseni, 2020). Therefore, there is a need for mapping and monitoring illegal dumps (Sibongiseni, 2020). Mapping and monitoring illegal dumps will enhance the prevention of the problem and develop technologies to aid the efficiency of service delivery. The traditional methods of detecting and mapping illegal dumps are usually expensive and require a lot of human resources (Makgato, 2024).

A case study report aimed at developing a remote-sensing-based approach to detect and map illegal dumping in Soweto (Omotayo, 2024). The results demonstrated the ability of WorldView-4 imagery and object-based image classification techniques to detect, map, and differentiate between building rubble and domestic waste (Nengovhela, 2023). Machine learning algorithms produced an overall accuracy of 93.98% for Random Forest and 94.91% for Support Vector Machine. Additionally, factors such as population density, household size, level of education, and household income were associated with the spatial distribution of these dumps (Stokes and Lawhon, 2024).

2.4.4.2. Case study in Stellenbosch Local Municipality: South Africa Waste characterisation in Stellenbosch Local Municipality, South Africa

HSW produced in the study area is collected by refuse compactor vehicles. The vehicles are operated by a driver and five crew members (Nell, 2022). Houses in all formal areas are required to place their 240-litre municipal-issued wheelie bins on the pavement outside their homes on refuse collection days (Nell, 2022). HSW is collected once a week, from Monday to Friday, housing complexes may also request refuse collection three times a week (Mondays, Wednesdays and Fridays), which is offered by the municipality at an increased tariff (Nell, 2022). A separation at source initiative, which is implemented in specific areas within the municipal area, enables residents to place recyclable waste in clear bags next to their wheelie bins on collection days (Nell, 2022). A different vehicle collects and transports recyclables to a small materials recovery facility located adjacent to the landfill site, where the recyclables are sorted manually before being baled and transported to recyclers (Jefthas, 2023).

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HSW is collected from informal areas by removing 6 to 3 skips up to five times a week, the municipality prefers the use of skips in these areas because access to homes is often hindered by low-hanging electrical cabling and a lack of formal roads (Heckrath,2018; Kadhila et al , 2023). Consequently, the locations of skips are usually determined by the ease with which refuse removal vehicles are able to reach them and not necessarily by other equally significant factors such as the distances between the skips and residents (Hendricks., 2018 ; Nell.,2022). Few published HSW characterisation studies are conducted at sub municipal level the composition of HSW as well as the socio-economic factors that influence HSW composition are reported here for 10 suburbs in the Stellenbosch Municipality (Nambahu, 2023). Organic waste made the greatest contribution to the waste stream by mass (35%), although its contribution by volume was proportionally lower (Nambahu, 2023). The chief contributor to the waste stream by volume was plastics (47%), followed by paper and cardboard (26%). The mean waste generation rate (0.68 kg/capita/day) in these Stellenbosch suburbs was found to be slightly higher than the average rate reported in similar studies worldwide (Nell, 2022). During the study it was found that household size and income can be used as explanatory variables for waste generation and composition for the 10 suburbs characterised (Nambahu, 2023). Plastic packaging, paper and cardboard, and glass waste fractions were the most affected by household income (Nell, 2022).

The case studies reviewed reveal several critical lessons applicable to improving household solid waste collection in peri-urban areas. Across diverse contexts, effective waste management systems were found to rely on the integration of spatial planning principles with operational solid waste collection practices. Key strategies include enhancing community participation, adopting technology-based solutions such as GIS for route optimisation, and ensuring alignment with relevant policy and legislative frameworks to promote sustainability. Furthermore, successful models emphasised the need for adequate infrastructure, clear institutional roles, and sustainable financing mechanisms. These lessons are directly relevant to the current study, as they offer practical, adaptable approaches that can inform the development of context-specific strategies for the rapidly growing villages of Maniini and Muledane. By aligning these insights with local spatial characteristics and governance structures, the study seeks to propose solutions that enhance service efficiency, promote environmental sustainability, and foster long-term community engagement.

2.5. Theoretical framework

2.5.1. Space production by Henry Lefebre, triad (1991)

The spatial Triad is a model created by Henri Lefebvre, this model provides a framework to recognize the three elements of producing space (Fuchs, 2021). These three elements of the Spatial Triad are 'representation of space', 'representational space' and 'spatial practices' (Goonewardena et al., 2008). The formation of space occurs through these three elements of the model. Representation of space the element 'representation of space' is origionally called 'espace concu'(McCann, 1999). This form of social space is most dominant in the

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production of space and is central to the production of abstract space, since it is a conceived space rather than lived. Representational space is the element 'representational space', which is originally called 'espace vecu'(McCann, 1999). In this element, the symbolic value is given to a place by its inhabitants, which corresponds to the term lived space. Shortly, the place gets meaning (McCann, 1999). Spatial practices the element 'spatial practices' is origionally called 'espace percu' and refers to daily life (McCann, 1999). Everyday routines and experiences form their own social space. This corresponds to the concept perceived space (McCann, 1999).

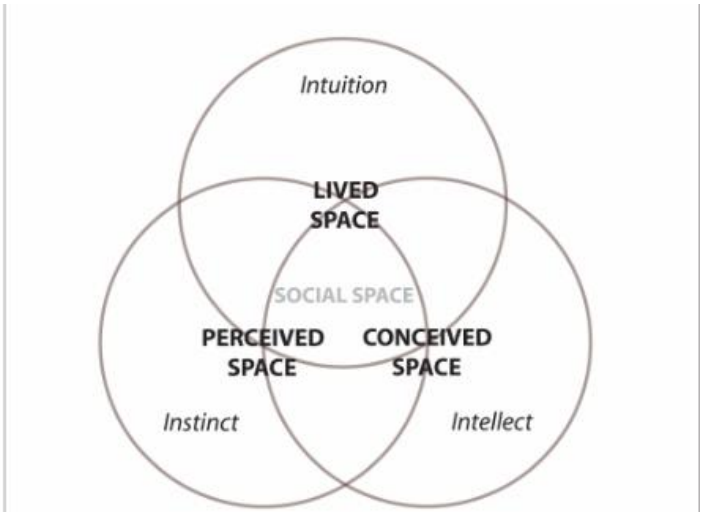

Figure 2.4: Henri Lefebvre's triad of space production.

Source: Wiedmann, & Salama, (2012).

Firstly, he defined ‘conceived space’ as the space conceptualized by scientists, also known as ‘representations of space’ (Soja, 1989). These representations are abstract as they are rooted in the principles, beliefs and visions held by practitioners, decision-makers and others who are in a position to impose their personal notion of ‘order’ on the concrete world and so create a practical impact on space within social and political practice (Lefebvre, 1991,). Conceived space is thus based on knowledge and science in combination with ideology (Lefebvre, 1991). Lefebvre defined ‘perceived space’ as the space of ‘spatial practice’. He defined it as the space where movement and interaction take place, where networks develop and materialize . Thus, it includes both daily routines on an individual level and networks as the result of collective movements (Stanek, 2011). He maintains that the specific spatial practice of a society can only be evaluated empirically by analysing and studying the structure of its networks (Lefebvre, 1991).

Lefebvre’s theory of the production of space has undergone a remarkable renaissance during recent years (Shields, 2005). Although Lefebvre’s texts on Marxism, on everyday life, and on the city were widely read at the time, his reflections on space aroused little interest (Buser, 2012). The problem of space did not yet figure on the theoretical agenda (Buser, 2012). But today, Lefebvre’s book The Production of Space is routinely quoted (Schwarze, 2023). The “spatial turn” has taken hold of the social sciences and questions of space are

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accorded a great deal of attention, extending beyond geography (Schwarze, 2023). In essence, this is linked with the combined processes of urbanisation and globalisation, at all scales new geographies have developed (Kipfer, 2022). These new space-time configurations determining our world call for new concepts of space corresponding to contemporary social conditions (Kipfer, 2022).

Lefebvre's The Production of Space to examine strategies of metropolitan regionalism in the Capital District, New York (United States) (Schmid, 2022). Interpreting the city-region as a social product reflecting the co-constitutive relationship of conceived, perceived and lived space spatial elements, the argues are that the silences of lived space within metropolitan regionalism are indicative of a post-political condition where hegemonic vision, discourse and ideology deny a robust urban democracy (Schmid, 2022). It is this ability to engage with the dynamism of social change and the relationships between spaces which makes Lefebvre's spatial theory immensely valuable for the study of emerging and shifting structures of governance (Shields, 2013). Lefebvre and lynch look at different sides of the same issue, Lefebvre exam-ines how space is produced, by space, he means settlement space: town and city, neighbourhood and region (Shields, 2013). Space, as a universal phenomenon, is both rural and urban, though the book focuses on the latter. It is nevertheless given particular (non-universal) form in a specific settlement by a local culture (Shields, 2013). By production, he means the sum of human endeavours whose accumulated history has resulted in a settled place. It is not a process that can be codified in a how-to guide for real estate developers, nor in the development of regula-tions by government planners (Neuman,1992).

The concept of social space is still a key concept for those professions in the social sciences, urban planning and architecture today (Makinde and Amao, 2024). Even though the term challenges any single definition, social space can largely be assumed as the notion that urban space is not just an inert outline in which social life just takes place (Makinde and Amao, 2024). Lefebvre argued that the spaces in which individuals school, work, and live are socially produced in everyday natural life (O'Brien, 2023). He recommended a socio-cultural-oriented method of evaluating urban space to deliver an answer to the oppressive consumer urban planning practices of the government (Yuncu et al, 2022). The spatial exclusion and segregation that seemed to be deteriorating in cities owing to the extensive construction of the enormous, publicly and privately funded housing developments on the fringes of urban spaces could only be resolved with the advent and development of a new social, cultural and economic oriented method and approaches to space in the urban planning, and social sciences (Haffner, 2009)

This theory is related to the study because the space where people live needs a municipality or local government to provide service delivery, which includes solid waste collection. For a community to be liveable, it needs a lot of services. The department of spatial planning and environment is responsible for managing household waste collection. Population increases, rapid urbanisation, booming economy, and the rise in the

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standard of living in developing countries have greatly accelerated the rate, amount and quality of the municipal solid waste generation. Household solid wastes are usually generated from variable sources where different human activities are encountered. In addition, most countries worldwide are facing a serious challenge in managing domestic food waste. The improper bin collection practices, collection, transfer and or transport systems have great effect on the characteristics of the solid wastes. Space-enabling co-production in solid waste management, many municipalities face challenges due to growing waste generation and limited collection capacity, especially in rural areas. It positioned this notion on the development of institutions for the expression of the ideal and model of discussion at liberty from domination, with equivalent power to affect decisions and judgments given to all affected. There is a need and desire for provisions for the addition of public involvement into planning processes and building. People and community participation has played a distinct and important role in the development and discourse of spatial planning. Municipal planners have reacted to these systems of grassroots involvement with a series of consultation and participatory mechanisms. Planning legislation should comprise provisions for community participation in planning resolutions. Nevertheless, the range and level of participating mechanisms in the present Town Planning Act were generally viewed as inadequate. For these explanations, public and community participation remains at the vanguard of planning concepts, predominantly in studies based on collaborative planning. Therefore, there is a need for appropriate forms and public and community participation in design and planning processes, to address and resolve some limitations and shortcomings in public participation in planning models, by way of bringing spatial conflicts and skirmishes up-front, to the establishment of the planning scheme. This is attained by concentrating the participation and involvement of concerned and interested parties at the stages and phases of planning scheme amendment and development. With the significant and pivotal role of planning schemes in the evaluation of development, this offers a significant opportunity for the criticism of the local and state's core and central planning instruments.

Lefebvre's triad provides a useful framework for analysing the gap between spatial planning and sustainable solid waste collection. Space practices it includes how the communities, municipal service and solid waste collectors interact with the spatial environment in terms of solid waste collection. This includes the movement of solid waste collection trucks in peri-urban and rural areas. The accessibility of solid waste collection in communities, this includes the availability of illegal dumping. This more like how people a treating their spaces. Representation of space in terms of municipal spatial policies for solid waste management. How the residential layout is designed and affecting the solid waste collection system. The resident's behaviour and perception towards the issue of solid waste collection. The role of local knowledge is very important on shaping the sustainable solid waste collection. The sustainable solid waste collection depends on integrating spatial planning with the behaviour of communities towards solid waste collection and the residents experience. This is also summarized by the diagram below to get the clear understanding about the Lefebvre theory and solid waste collection.

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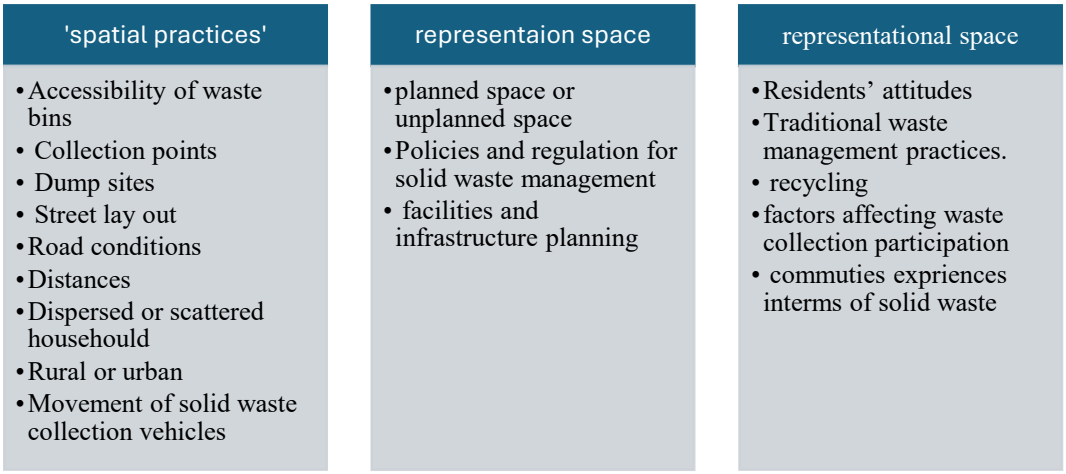

Figure 2.5: The relationship between Lefebre's triad and solid waste collection.

Source: Researcher (2024)

2.5.2. Theoretical principal-agent framework, Jensen and Menckling (1976)

Principal-agent theory has found extensive development and use in the field of scientific research methodology, for example, in accounting, marketing, economics, political science or organisational behaviour (Eisenhardt, 1989). The model of local decision-making is based on the hypothesis of "constrained" monopoly power on the part of local governments (Bravo et al, 2004). It adds to the contribution of the principal-agent theory by assuming that monopolistic behaviour is constrained by voters' efforts to monitor the outcomes of policies and that local governments' policies affect local property values (Bravo et al., 2004). An empirical test of the model for the Portuguese local authorities indicates that the hypothesis of "monitoring" may be accepted and that of capitalisation can only be accepted in relation to local public services not to local taxes on property (Musawir, 2024). The principal-agent theory of organisations ("agency theory" from here on) encapsulates the idea that public sector performance can be improved if incentive-based contracts between different actors are implemented (Ivanov et al, 2024. Principals will be more likely to achieve their desired outcomes, while agents will have clarity around work programs and goals (Mahzoon et al, 2024). Agency theory has had considerable influence on the theory and practice of public administration and policy since its emergence in the 1970s (Gauld, 2018).

The analysis of principal-agent relationships have been extended to analyse several areas of the political market, leading the political economist to study the instruments available to the principals to control their agents, such as: Developing democratic decision-making processes that increase political participation and competition (Guruganesh, et al , 2020). Increasing voters' control over political outcomes and creating schemes- which may include regulations and the institutional organization - that facilitate monitoring of the results from public policies (Bergman, and Lane, 1990), As to, given the existence of several tiers of government and sometimes of complex institutional settings (such as, the Congress or parliament committees,

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bureaus and interests groups) which affect political decisions, there is not a simple and single agent-principal relationship (Gailmard, 2014). The institutional approach has been applied to analyse the American political system. This method focuses on examining formal structures, processes, and institutions to understand how they shape political outcomes; Einswer and Meir (1990) stressed the importance of the rules and the particular organisation and activities of committees for political outcomes and more recently, Poole (1996) uses a similar approach to study the legislative system, analysing the role of legislators as both agents of their constituents and ideologues, while Kroszner (1998) analyses the relationship between the organization of Congress and interest-group competition. local public economy view, assuming that the incentives for voters to control local politicians depend upon several factors, but mainly on voters.

Principal-agent framework is a rapidly developing approach to the analysis of contractual relationships within the private sector (Sappington, 2023). The argue is that it should be a promising approach to the analysis of public policy commitments as well (Sappington, 2023). As a matter of fact, it allows the statement of a number of basic public policy problems in terms of an integrated framework (Bergman, and Lane, 1990). The making and implementation of public policy involve fundamental contractual problems referred to as asymmetric information, moral hazard, bounded rationality and adverse selection (Bergman, and Lane, 1990).

The accountability and oversight relationship between the elected public representatives and the bureaucracy is often explained through the principal-agent relationship (Gailmard, 2010). The principal-agent theory is widely regarded as the foremost theoretical framework for explaining the accountability and oversight studies, particularly in public administration (Schillemans & Busuioc, 2014). In South Africa's municipal legislative context, the political leadership, meaning, the mayors and councillors, have an obligation to ensure that officials comply with the law and applicable internal controls(Department of Environmental Affair(DEA) , 2018). It is critical that compliance or the ability to curb non-compliance is dependent on how the municipal council, as the principal, exercise its oversight obligations, roles and responsibilities to focus and rein in non-compliant and deviant municipal officials (Khaile et al, 2021). Procedurally, the executive mayor and the executive committee are expected to exercise "political leadership by proposing policies, guiding the development of budgets These pressures exacerbate challenges faced by municipalities including lack of financial resources, operational challenges, enforcement of legislation, and poor planning and management (Bernhold, and Wiesweg, 2021). As a result, a lot of municipalities are currently struggling to provide basic waste management services (De Sousa, 2023). In 2018, about 12.2 million households received refuse removal in South Africa while 323 478 households did not receive solid waste collection (Stats SA, 2018). and performance targets and oversee their implementation by monitoring the performance of municipal officials" (RSA, 2011: 74). The total domestic waste generated by households in South Africa is estimated at 12.7 million tonnes per annum, and approximately 3.67 million tonnes of this waste are not collected and treated through formal waste collection systems, resulting in large amounts being dumped

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illegally (Rodseth et al., 2020). Equally, non-executive councillors have the responsibility to exercise oversight on the executive mayor, the executive committee and municipal officials (Khaile, et al ; 2021).

This theory suggests that the problems such as non-compliance occur as a result of municipal officials transgressing and behaving in an unethical manner, while underplaying the role of the municipal councils as principals in the problem of non-compliance with municipal financial legislation. In this regard, this article aimed to highlight the inadequacy of this explanation in the non-compliance problem afflicting municipalities in South Africa (Khaile, et al ; 2021). DEA (2012) also found that the policy and regulation environment does not always actively encourage or enforce the waste hierarchy, due to this challenge, there is a missed opportunity of generating an estimated R10 billion per annum from recycling. Therefore, the availability of those waste by-laws and legislation become less useful (DEA, 2012). Lack of enforcement of by-laws leads to a number of waste management challenges such as illegal dumping and illegal waste management activities including recycling and processing of waste in unsustainable and often harmful ways negatively impacting on human health and the environment (Miller, 2005).

This theory is linked to the study because in order to have effective waste collection or waste management there is a need to follow different framework and policies. South Africa has different policy that address the issue of solid waste collection. Poor management of available fleet for waste collection is the main cause of problems. Waste collection trucks that are not well serviced leads to regular breakdowns. Common reasons raised for not doing regular maintenance service on tucks is the lack of spare capacity, old age of the vehicle fleets, and the cost associated with servicing of old vehicles. Hydraulic system failures of these trucks is one of the problems identified in many municipalities. Most of the municipalities in South Africa do not have source separation programs. In some municipalities source separation programmes are run by private operators through provision of separate containers for source separation of recyclables and drop-off points. The amount charged per customer for waste services is not enough to carry out sustainable services. On top of this problem, there are some customers who default on payments and this makes matters worse. The province has waste by-laws but the challenge is the implementation of the by-laws. Having good by-laws on the books only and not effective on the ground is not so helpful in the waste management service. The changes and amendments in the legislation becomes a challenges to the municipality which is still trying to keep up with the older versions of the legislations.

There is a significant shortage of human, technical, equipment and financial resources and that makes it difficult to deliver a good waste service. The Integrated Waste Management Plan (IWMP) is not implemented because of lack of budget to carry out all the activities planned. The infrastructure is aging and there is no maintenance plan in place. This poses a challenge in the near future once that infrastructure cannot function anymore. There is a notable lack of waste collection, capturing and reporting to Waste Information System (reliable data, access to information, identify priority waste streams requiring

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government intervention). This hamper proper and informed planning, management and leaves the managers with a reactive management approach as opposed to proactive one.

Since this theory examines the relationship between the principal and the agent , Most of the time conflicts happens. The principal is the municipal and the agent is the household this includes people who are hired by municipal to collect solid waste. The municipality delegates the solid waste collection task to the solid waste collectors. Challenges come when agents do not comply with municipal collection policies, due to a lack of knowledge. Spatial planning is important since it will help in improving solid waste collection effectiveness by ensuring better coordination of infrastructure and facilities. Municipality rely on household to dispose their solid waste properly at designated points. There are key challenges of solid waste explained by principal agent theory, which include budget constrain, skipping collection in a remote areas and not complying with the municipal policies.

2.5.3. Exit, Voice, and Loyalty (1970) , Albert Hirschman

Although writing nearly forty years ago, Albert Hirschman's famous exit, voice, and loyalty (EVL) model raises a salient contemporary concern that expanding choice may reduce voice because having more exit options reduces the incentive to complain (Hirschman, 1970).In this model, users exit instead of voicing concerns to providers in ways that could improve performance (Hirschman, 1970). Hirschman also includes loyalty into his model, which is attachment to the current provider and moderates the tendency to exit (Dowding and John 2012). In his use of loyalty and account of dissatisfaction, Hirschman is surprisingly up to date, as his approach is consistent with contemporary perspectives in public administration that recognise rational economic-actor models of exit in markets do not match the evidence on how users actually respond to service decline (Jilke, Van Ryzin, and Van de Walle 2016).

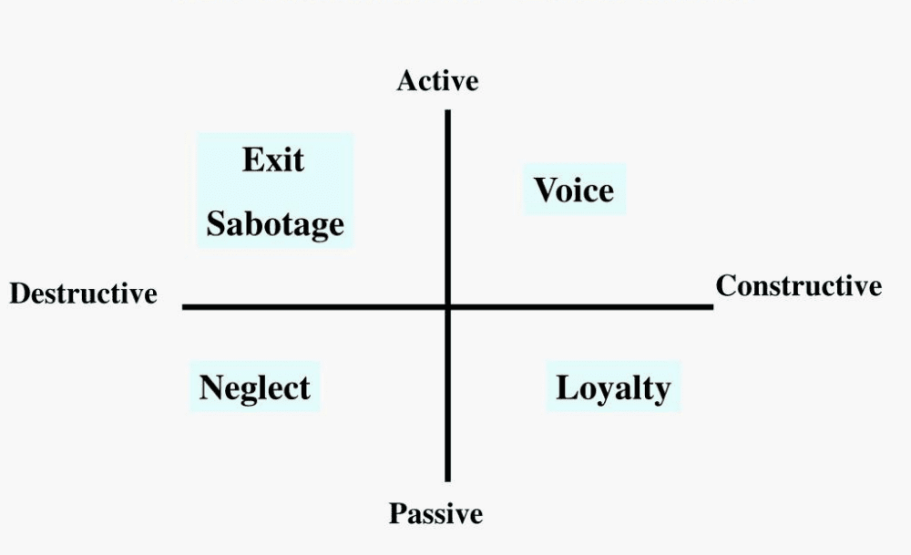

Figure 2.6: Exit, voice, and loyalty (EVL) model.

Source: Rusbult et al ., 1982

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Decline in service quality leading to dissatisfaction of users is a common problem that providers of public services face (Schoppa, 2023). Hirschman was interested in theorizing how users react to service quality decline and what choices they were likely to make, in particular when they respond with voice, consisting of individual and collective user complaints about their situations to service providers, which has been a major topic of interest in public management ((Schoppa, 2023). Even though Hirschman's idea has been heavily cited in the literature in public policy and public management, there have been relatively few applications to the study of public services and very little experimental evidence (John, 2017).

Exit and voice themselves represent a union between economic and political action. Exit is associated with Adam Smith's invisible hand, in which buyers and sellers are free to move silently through the market, constantly forming and destroying relationships, voice, on the other hand, is by nature political and at times confrontational (Hoffmann, and Elizabeth.,2006).

While both exit and voice can be used to measure an organisation's decline, voice is more informative in that it also provides reasons for the decline (Dowding et al., 2000). Exit alone only provides a warning sign of decline (Dowding et al., 2000). Exit and voice also interact in unique and sometimes unexpected ways; by providing more significant opportunities for feedback and criticism, exit can be reduced (James & John, 2021); conversely, stifling dissent leads to increased pressure for members of the organisation to use the only other means available to express discontent, departure (Brubaker, 2023). The general principle, therefore, is that the greater the availability of exit, the less likely voice will be used (Dowding, Keith,2015). However, the interplay of loyalty can affect the cost-benefit analysis of whether to use exit or voice (Dowding, Keith,2015). Where the organisation is loyal (as evidenced by intense patriotism politically or brand loyalty for consumers), exit may be reduced, especially where options to exit are not so appealing (small job market, political or financial hurdles to emigration or moving) (Charreire-Petit, and Surply, 2020). Loyal members become especially devoted to the organisation's success when their voices are heard and when they can reform it (Hult & Morgeson, 2020).

By understanding the relationship between exit and voice, and the interplay that loyalty has with these choices, organizations can craft the means to better address their members' concerns and issues, and thereby effect improvement (Saunders, 2020). Failure to understand these competing pressures can lead to organisational decline and possible failure (Peeters et al, 2020). Unlike forms of exit, gaming does not seek to establish or turn to an alternative service provision; rather, gaming entails informal and subversive mechanisms to access an existing public service (Choi and Chung, 2020). Gaming follows citizens' actual experience with, or expectation of, public service delivery as unlikely to achieve a satisfying outcome if they play ‘by the book’(Gunnarsdóttir, 2020). Moreover, gaming strategies encompass a category of behaviours that ranges from direct, straightforward rule-breaking, such as offering bribes (Farrell, 2021).

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While some municipalities grow, others decline, when municipalities are in disastrous conflicts or degrade service quality, residents may move away, speeding up a cycle of decline (Hoffmann, 2022). Drawing on Albert Hirschman's Exit, Voice, and Loyalty (EVL), Recent EVL studies for local governance have examined whether citizens, in general, are more likely to exit or voice complaints as a consequence of dissatisfaction with municipal goods and services (Burgess, 2022). Few studies, however, have tested EVL under specific circumstances of municipal decline (Hirschman, 2020). The central government sets the national criteria of fiscal soundness, and further mandates the local governments which fall short of the criteria to design and implement a fiscal reform plan under the supervision of a central agency (Shinohara, 2016).

The theory will be useful to the study because when people are not satisfied with the municipality's service, they take matters into their own hands and seek a solution. When people are not satisfied with the service delivery, they voice out their needs through service delivery protests. These service delivery protests are typically triggered by the failure of municipalities to provide communities with basic quality services such as electricity, water, tarred roads, sanitation and waste removal. In general, corruption, financial mismanagement, and unproductive operations are among the challenges that contribute to municipalities' ineffective service delivery. Local municipalities must enhance and promote community participation. Community members ought to be involved in all planning and decision-making processes within the municipality. This will contribute positively to effective service delivery. Community members must be allowed to participate freely in all municipal systems and be encouraged to pay for services.

Essential services are not available to the poor and the indigent in Municipality because of a lack of funding and inadequate infrastructure. Even with municipal democratic mechanisms like the ward committee system, insufficient community consultation only serves to exacerbate problems with service delivery. Consequently, it has been suggested that poor lines of communication between the municipality's internal and external stakeholders contribute to public unrest there. The provision of services is central to the role of local government because it has the potential to address the triple difficulties of poverty, unemployment, and inequality in underprivileged neighbourhoods. This is supported by diagram which shows the flow of relationships between Exit, Voice, and Loyalty

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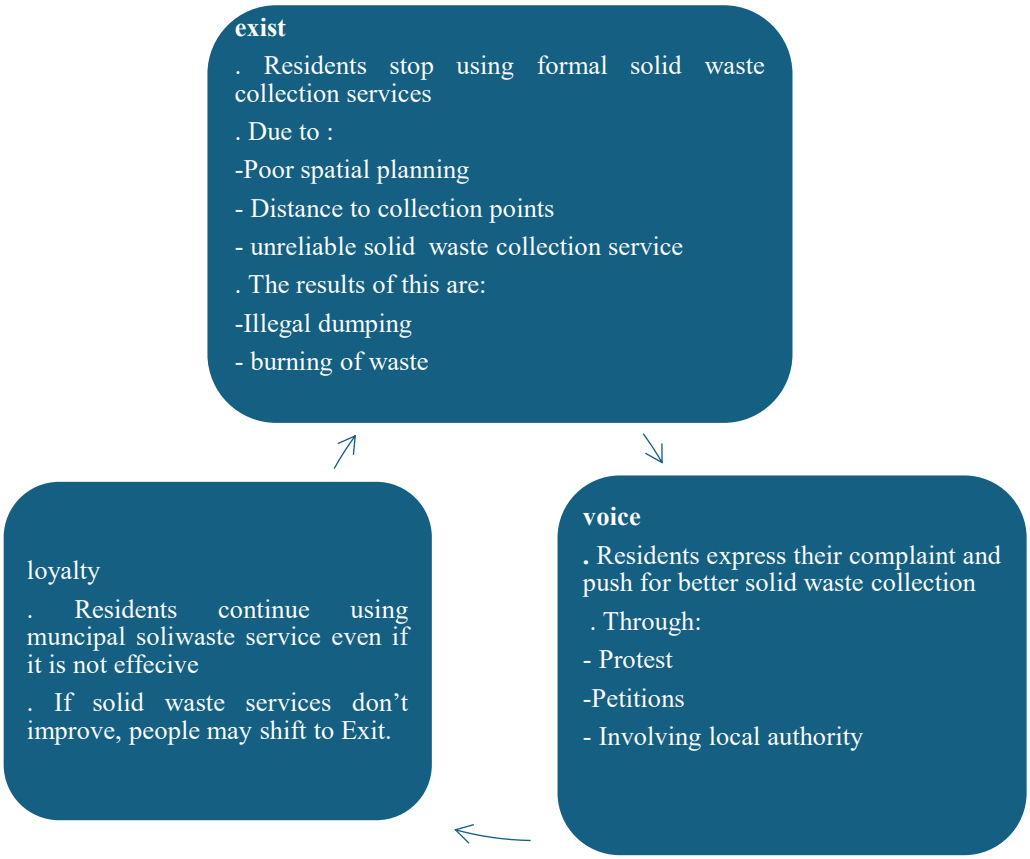

Figure 2.7: The relationship between and Exit, Voice, and Loyalty

Source: Researcher (2024)

2.7. Debate about the literature above

The discourse on sustainable household solid waste collection in peri-urban settlements presents a complex interplay between spatial planning, socio-economic dynamics, governance structures, and technological interventions. Scholars diverge significantly in their assessments of what drives or hinders effective waste collection in such settings.

One central area of contention lies in the role of spatial planning in enabling or constraining sustainable waste management. On one side, spatial planning is seen as a transformative tool to integrate waste collection into broader urban systems, addressing spatial inequalities and improving service delivery in informal and low-income settlements (Liudmyla & Oleksii, 2024; Vujić & Gašparović, 2024). However, others argue that in many developing countries, spatial planning remains largely abstract and top-down, disconnected from the lived realities of peri-urban dwellers (Volsuuri et al., 2022). The implementation gap often leaves waste collection systems underdeveloped or unworkable due to poor road infrastructure, inaccessible housing layouts, and inadequate spatial data. Another layer of debate surrounds the governance and institutional approach. Scholars like Abdallah et al. (2020) and Okafor et al. (2022) contend that weak municipal institutions and fragmented mandates result in poor coordination, inefficiency, and unsustainability of waste

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collection services. However, counter perspectives emphasise the potential of community-based models and informal actors to fill the void left by public service failures, especially in peri-urban Africa (Mutheu & Wambua, 2024; Nabukeera & Muwanguzi, 2023). Yet this too is contested, as reliance on informal systems can perpetuate inequality, lack accountability, and hinder data collection necessary for planning.

There is also no consensus on the role of technology and innovation. Some scholars highlight the promise of GIS, digital route optimization, and artificial intelligence in enhancing waste management efficiency (Tuyisenge et al., 2022; Fang B et al., 2023). These innovations are shown to be effective in cities like Kigali and Bragança. However, critics caution that such solutions often fail to consider local capacity, affordability, and the socio-political realities of peri-urban areas, where basic services are still lacking (Yakshimbetova et al., 2022; Ferronato et al., 2020). The digital divide could further marginalize the most vulnerable communities if not addressed within an inclusive planning framework. Furthermore, there is ongoing debate regarding the agency of households in sustainable waste practices. While some studies emphasize behavioural factors such as awareness, willingness to pay, and sorting practices (Namukuve, 2021; Ishuga et al., 2024), others argue that focusing too heavily on household behavior without addressing systemic issues like infrastructure, governance, and financing can be misleading and ineffective (Isunju et al., 2020; Chileshe & Moonga, 2020). This raises the question: should the emphasis be on citizen responsibility or systemic reform?

Lastly, divergent views exist on the applicability of Western models of solid waste management in developing contexts. Case studies from Japan and Portugal demonstrate high levels of optimization and community compliance, but their direct application in places like Thohoyandou's peri-urban villages may not be feasible due to contextual differences in governance, finance, and socio-spatial characteristics (Zhuo & Yan, 2022; Filipe A, 2022). Hence, the debate continues on the need for context-specific models that merge global best practices with local realities. In summary, the literature presents a rich but conflicting set of arguments regarding sustainable household solid waste collection. This study positions itself within this debate, seeking to reconcile these tensions through spatially grounded strategies that reflect the lived experiences, governance limitations, and planning gaps in the peri-urban areas. The literature presents an unresolved but enriching debate on how to achieve sustainable household solid waste collection in peri-urban areas. The disagreement lies not in the importance of the issue but in the means to address it.

2.6. Summary of the chapter

Chapter 2 provides a detailed literature review that underpins the study on spatial planning strategies for sustainable household solid waste collection in peri-urban villages. It begins by defining key concepts such as solid waste, household solid waste, sustainable solid waste management, small towns, peri-urban areas, solid waste collection, and spatial planning. These concepts are crucial in understanding the challenges and

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opportunities for waste management in rapidly urbanizing and resource-limited contexts. The chapter emphasizes that household solid waste is a major component of municipal solid waste, driven by urban growth and lifestyle changes, and that its management is hindered by poor infrastructure, limited community awareness, inadequate funding, and weak policy enforcement. The literature is also reviewed in line with the study's objectives. For the first objective, current waste collection practices in peri-urban areas are assessed, revealing gaps in municipal service delivery and reliance on informal systems, as evidenced in case studies from countries like Kenya, Ghana, and Uganda. The second objective identifies barriers to sustainable waste collection, such as poor road access, lack of public engagement, and institutional fragmentation. The third objective presents successful strategies drawn from global case studies, including GIS-based route planning, decentralized waste systems, and public-private partnerships. Finally, the chapter introduce three theoretical frameworks: Henri Lefebvre's Spatial Triad, which explores the relationship between space, practices, and perception in planning, Exit, Voice, and Loyalty, and the principal-Agent Theory, which addresses governance and accountability in service delivery. Together, these theories provide a lens through which spatial planning and solid waste collection can be integrated for sustainable outcomes.

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Chapter Three: Detailed Description Of The Study Area, Legislation And Policy Framework)

3.1. introduction

This chapter describes the study area and reviews the legislation and policy frameworks guiding solid waste collection. Solid waste collection is a complex process influenced by various spatial, environmental, social, and institutional factors. For it to be effectively implemented, various legislative instruments and policy directives must be considered and adhered to. The detailed description of the study area offers important background information on the spatial planning context, land use and settlement structure, and the area's physical, geographical, demographic, and socio-economic characteristics. This context is essential in helping the researcher understand the specific challenges and opportunities associated with sustainable household solid waste collection in peri-urban villages. The legislative and policy framework section highlighted the institutional structures, legal mandates, and regulatory instruments influencing solid waste collection practice.

3.2. Detailed description of the study area

3.2.1. Overview of Thohoyandou, Maniini, Muledane and Thulamela Local Municipality

Thohoyandou is a rural town in Thulamela Local Municipality in the Vhembe district of Limpopo province, South Africa. It is in the north of Limpopo province, surrounded by many peri-urban villages and rural areas. It supplies services to the surrounding villages in Thulamela Local Municipality. Historically, Thohoyandou town was the capital of the Venda people before the democratic transition in South Africa in 1994. After the apartheid, the town experienced rapid urban growth, transitioning from semi-rural into a dynamic peri-urban centre with increased infrastructure, urban growth, extreme structure decay, and population pressure. Small towns and villages are key elements of rural revitalisation, the future development of villages should consider both the impacts of small towns and the endogenous growth of villages. In the past, land use changes were observed in the peri-urban villages of Thohoyandou town. The land value is increasing, and development is happening at a fast rate, which also increases the population.

The selected villages are Maniini and Muledane, they are located near Thohoyandou. The distance from Maniini to Thohoyandou is 5,8 km, and from Thohoyandou to Muledane is 6.7 km. Over the years, these two areas have changed spatially, these peri-urban areas are transitional places between urban and rural that are important from spatial, economic, social and even political aspects. Figure 3.1. shows the boundary of the study area Maniini, which is adjacent to the Thohoyandou area, so much development is happening there. Figure 3.3. shows the boundary area of Muledane.

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Figure 3.1: Boundary area of Maniini

Source: Mutwanamba (2024)

The map uses orange to differentiate the Maniini boundary from the surrounding areas. The area is peri-urban in the Maniini blocks K, M, and some of block L. It has a rural area, Tshikovha, under traditional leadership. It has a dense residential pattern. Maniini has many landmarks, including different schools, churches, soccer fields and commercial sites. To the east of Maniini is Thohoyandou block M and some extensions of Thohoyandou. In the east, there is Tshilungoma village. The west direction has a residential area that includes more developed parts of Thohoyandou. In the south, green space and water bodies are available.

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Figure 3.2: Boundary area of Muledane

Source: Mutwanamba (2024)

Muledane is one of the selected villages in the study; it is the peri-urban area of the Thohoyandou area and has a highly dense residential layout. The area has both formal and informal housing, with more urban developments being expanded. In the north is Thohoyandou Block J and another urbanised area of Thohoyandou. It connects Thohoyandou N in the west with transport network links and commercial developments. In the east and south, residential areas and agricultural activities are expanding. The diverse housing structures affect the solid waste collection and transportation. Growing urbanisation in the area will lead to a lack of solid waste collection services.

3.2.2. Spatial Planning Context

Spatial planning consists of national, provincial and local policies that guide the surrounding environment, but it is not easy to implement the policies due to rapid urbanisation. Thulamela Local Municipality SDF plays an important role in shaping the area, it promotes urban growth, service delivery and environmental protection. Maniini and Muledane are characterised by fragmented development and a lack of spatial integration. Land use conflicts are a serious problem in Thulamela Local Municipality because residents do not follow planning policies.

Kevin Lynch, in his seminal book The Image of the City (1960), identified five key elements that contribute to the mental image people have of a city. These elements include Paths, Edges, Districts, Nodes and Landmarks (Lynch, 1960). These elements are shown in Figures 3.3 and 3.4. The solid waste collection service depends on the designed routes network and accessibility of the routes. In Maniini and Muledane, some roads are poorly planned, and some are narrow, which hinders the trucks from passing to collect waste.

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Nodes such as collection points and recycling centres are key for solid waste collection. Landmarks are used for public awareness campaigns such as recycling. Kevin Lynch's elements are important in the integration of solid waste collection and spatial planning. It helps to understand how people navigate urban spaces, which is essential for planning efficient and sustainable solid waste collection.

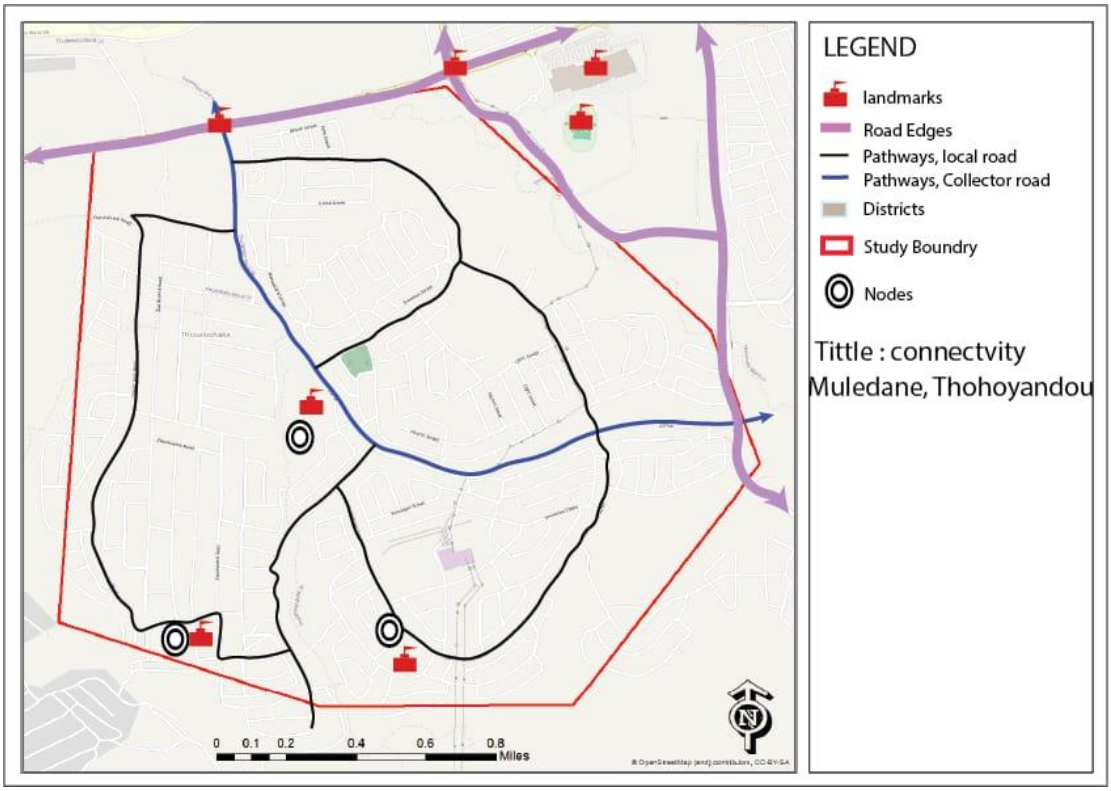

Figure 3.3: Connectivity map of Muledane area

Source: Mutwanamba (2024)

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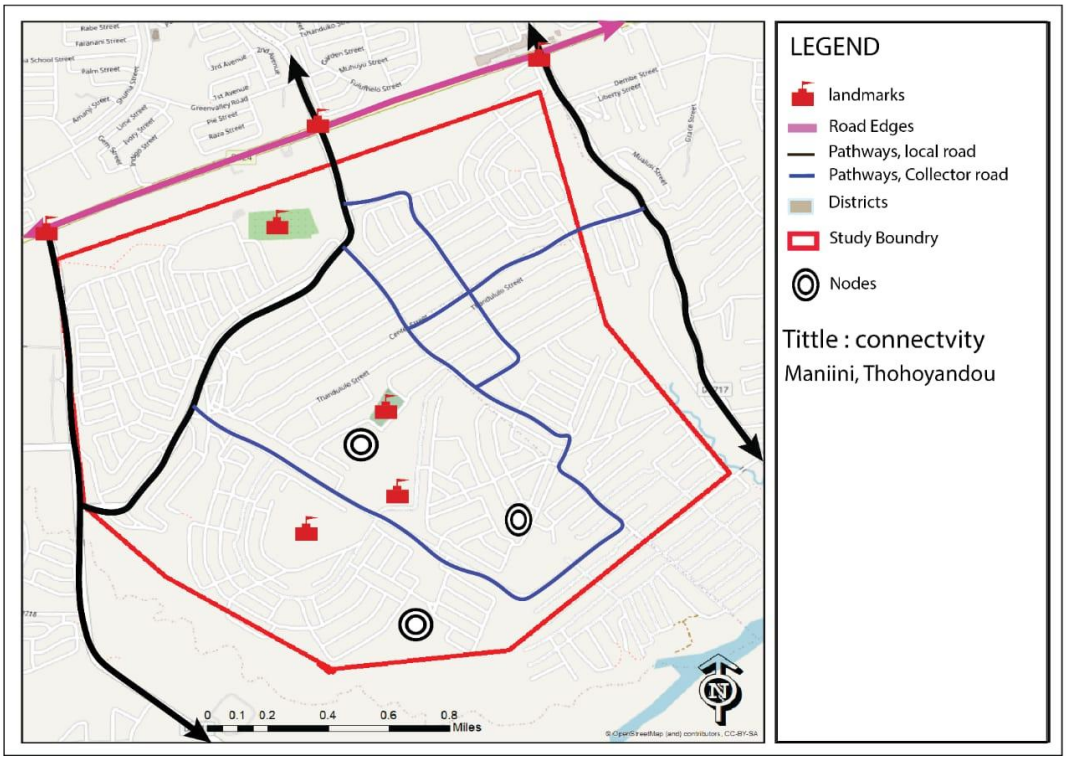

Figure 3.4: Connectivity map of Maniini area

Source: Mutwanamba (2024)

3.2.3. Physical and Environmental Features

Thohoyandou Town and its peri-urban villages are characterised by a subtropical climate, with long, warm summers and mild winters. The region receives approximately annual rainfall, mainly during summer. The area's topography consists of gently undulating hills with a mix of fertile soils suitable for agriculture. The main river in the region is the Luvuvhu River, which supplies small rivers. Maniini is located near the Nandoni dam, which has perennial and non-perennial rivers. This plays a critical role in water supply and ecological sustainability. Rapid urbanisation has strained natural resources, raising worries about pollution and land degradation.

3.2.4. Socio-Economic and Livelihood Aspects

Thohoyandou town has experienced rapid population growth, with its peri-urban villages experiencing rapid expansion. The Town is populated due to rural-urban migration, and it is the main town in Most of the villages around Venda and Malamulele. When the population increases, solid waste generation also increases. The households in the surrounding villages are characterised by extreme poverty, and few people are rich. The town is characterised by informal trading and markets, which shows a lack of formal jobs. Most people stay in peri areas to access the town since the rent in the CBD is expensive.

Small-scale farming, retail, informal trade, and public sector jobs are the main drivers of the local economy. The University of Venda, Local government, and the travel and tourism industry offer important job opportunities. High unemployment rates and wealth disparity remain significant issues, especially in peri-

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urban areas. Numerous households depend on unofficial economic pursuits such as garbage collecting, subsistence gardening, and street sales. Many communities lack access to adequate trash disposal facilities, and poverty impacts household waste management practices.

3.2.5. Land Use and Settlement Structure

Thohoyandou Town has a mixed land-use pattern with commercial, residential, educational, and administrative zones. The town CBD is densely developed, with shopping malls, government offices, and educational institutions. Peri-urban areas are expanding rapidly, often without formal planning, leading to sprawling informal settlements with limited infrastructure. Housing types range from formal brick structures to informal dwellings, creating disparities in access to solid waste collection.

3.2.6. Solid Waste Management Context

Thulamela Local Municipality faces solid waste management challenges, particularly in peri-urban villages where solid waste collection services are inconsistent and lacking. Households generate a mix of organic, recyclable, and non-recyclable waste, but limited recycling infrastructure and awareness contribute to improper disposal methods such as open dumping and burning. The Thulamela Local Municipality is responsible for waste collection, but service delivery is often hindered by infrastructure constraints, financial limitations, and informal settlements that are difficult to access. Informal waste pickers play a role in recycling plastics, paper, and metals, but their work is largely unregulated and underappreciated.

3.2.7. Governance, Policies, and Institutional Framework

Thulamela Local Municipality has solid waste management by-laws, but enforcement remains weak due to resource constraints and public non-compliance. National policies, such as the National Environmental Management: Waste Act (2008) and the IWMP, guide local waste management strategies, but implementation gaps persist. There are also community-based solid waste management initiatives, including school recycling programs and awareness campaigns, but they require more excellent municipal support and funding.

3.3. Legislation and policy framework

3.3.1. Sustainable Development Goals (SDGs)

SDGs refer to a set of goals that provide a path towards building a future that is socially, economically, and environmentally sustainable (Nishitani et al., 2025). These goals are widely acknowledged as a global framework by which stakeholders align themselves to drive a sustainable future for people and the planet (Quaye et al, 2024). The SDGs address both means, as these changes will bring about measurable changes in human well-being, national economic development, and a better environment on Earth (Shabani et al, 2023). They also support a peaceful environment of peace and safety, conditions for inclusion and participation with the rule of law (Elsheekh et al, 2021). SDG goal number 11 is the proportion of municipal solid waste collected and managed in controlled facilities out of total municipal solid waste generated by cities (Caglar et al, 2023). By 2030, cities' adverse per capita environmental impact will be reduced by paying special attention to air quality and municipal and other waste management (Kopecká et al, 2023). The indicator measures the progress

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of the performance of a city's MSW management (UN, 2022). It aims to determine the proportion of municipal solid waste regularly collected and treated in a city (UN, 2022).

Rapid growth and urbanisation processes in developing countries over the past decades have negatively affected cities, such as high rates of poverty and unemployment; problems related to providing infrastructure and social services, in addition to environmental problems and depletion of local resources; and other adverse economic, social, and environmental impacts be annexed on cities (Blevins et al, 2023). Therefore, the need to achieve the SDGs appeared in all countries (Elsheekh et al, 2021). Conversely to that, the SDGs accelerated research in the field of municipal solid waste management, also, they encouraged the transition of innovations focusing on sustainable and circular methods in the sector (Ye et al, 2023). The importance of proper waste management is visible, especially in low-income countries, because these tend to grapple with the lack of effective solid waste management, which inevitably causes diverse negative impacts (Castellani et al, 2022). The following SDGs guided the study:

1. Goal 11 aims to "make cities and human settlements inclusive, safe, resilient and sustainable."

2. SDG 3: Good Health and Well-being

3. SDG 12: Responsible Consumption and Production

4. SDG 13: Climate Action

5. SDG 17: Partnerships for the Goals

The SDGs were chosen because they provide a global framework for sustainability, directly supporting this study's goal to enhance solid waste collection in a sustainable manner.

3.3.2. Basel Convention (1989)

The Basel Convention, established in 1989, is a global treaty designed to protect human health and the environment from the adverse effects of hazardous waste, including certain types of household waste (Danton et al., 2024). Recognising the challenges of managing household waste, which can contain hazardous components, the Convention has implemented several initiatives to promote environmentally sound management (Danton et al, 2024). The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes and other wastes requiring special consideration (Matemilola, 2023). Its scope of application covers a wide range of wastes defined as "hazardous wastes" based on their origin and/or composition and their characteristics, as well as four types of wastes defined as "other wastes" - household waste, incinerator ash, particular plastic wastes and certain electronic and electrical wastes (Korcheva, 2023).

According to (Puckett, 2024), the provisions of the Convention centre around the following principal aims:

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- The reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal.
- The restriction of transboundary movements of hazardous wastes except where it is perceived to be by the principles of environmentally sound management.
- A regulatory system applies to cases where transboundary movements are permissible.

The Basel Convention has developed technical guidelines to assist countries in managing household waste in an environmentally sound manner (Danton et al, 2024). These guidelines provide comprehensive strategies for waste characterisation, data collection, separation at source, recycling, energy recovery, and final disposal. They emphasise the importance of handling hazardous substances within household waste and offer best practices tailored to various socio-economic contexts (UNEP, 2005). This legislation is important to the study because the study focuses on improving household solid waste collection in peri-urban villages. The Basel Convention promotes principles such as safe handling, treatment, and disposal of waste critical components in improving solid waste collection systems and reducing environmental and health risks.

3.3.3. The New Urban Agenda (NUA) (2016)

Commit to urban planning processes incorporating integrated water resources planning and management, considering urban-rural linkages at the local and territorial scales, and ensuring the participation of multiple sectors, stakeholders, and communities (Caprotti et al, 2017). It promotes environmentally solid waste management, reaffirming waste reduction, reuse and recycling, setting zero-landfill targets, and converting to energy only the waste that cannot be recycled (Satterthwaite, 2016).

It supports universal access to sustainable waste management systems based on the principle of decentralisation in decisions on alternatives to unregulated waste disposal (Caprotti et al, 2017). The promotion of extended producer responsibility schemes, including waste generators and producers in financing urban waste management systems, reducing the hazards of waste streams, and increasing recycling rates through better product design (Conference on Housing and Sustainable Urban Development (Habitat III)., 2016). The legislation is important to the study because the study investigates spatial planning strategies to improve household solid waste collection. The NUA emphasises the importance of spatial integration, urban-rural linkages, and participatory planning, which are critical for enhancing service delivery in Maniini and Muledane.

3.3.4. Spatial Planning and Land Use Management Act 16 of 2013 (SPLUMA)

SPLUMA is a national law that was passed by Parliament in 2013, SPLUMA sets the principle that all land development applications must be submitted to the municipality as the authority of first instance without actually prescribing in detail how spatial planning and land use management issues are to be dealt with within municipal areas (Rural development & land reform, 2013). SPLUMA seeks to promote consistency and uniformity in procedures and decision-making for all land development within its authority (Nel, 2016)

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There are 5 Development principles contained in Section 5 of the Act have been identified to guide and inform planning decisions. These are the principles of:

- Spatial Justice
- Spatial Sustainability
- Spatial Efficiency
- Spatial Resilience
- Good Administration

The concepts of "spatial justice", "spatial sustainability", and "spatial resilience" are related to social justice, sustainability and resilience but are deeply rooted within spatiality. The concepts are not defined in-depth in the Act, and limited academic scrutiny has been given thus far. This leaves vast scope for interpreting these principles on both conceptual and contextual levels (Barclay et al, 2016). Many people in South Africa continue to live and work in places defined and influenced by past spatial planning and land use laws and practices, which were based on racial inequality, segregation, and unsustainable settlement patterns (Nel, 2016). SPLUMA is a national framework act that requires provincial legislation to enable municipalities to enact spatial planning and land use management by-laws. The municipal SPLUMA by-laws prescribe how land use applications and appeals are dealt with (Nel, 2016).

The legislation is important to the study because the study focuses on spatial planning strategies to improve household solid waste collection. SPLUMA provides the legislative foundation for spatial planning at the municipal level, ensuring that waste collection services are integrated into land use plans and settlement designs. The principle of spatial justice is particularly relevant, as it promotes equitable access to services, including waste collection, for marginalised and underserved areas such as peri-urban villages. This supports the fair distribution of infrastructure and prevents illegal dumping due to a lack of services. Spatial sustainability and efficiency are crucial for ensuring that solid waste collection points, roads, and disposal facilities are strategically located to minimise environmental impact and optimise service delivery routes. Spatial resilience ensures that waste management systems can adapt to rapid urban growth, informal settlement expansion, and climate-related risks, all of which are challenges faced by Thulamela Local Municipality. Through good administration, SPLUMA ensures that policies, procedures, and land use decisions are transparent and participatory, aligning with the need for community involvement and accountability in waste collection services.

3.3.5. The Constitution of the Republic of South Africa (1996).

South Africa's 1996 Constitution outlined the creation of three levels of government: municipal, provincial, and national (Klug, 2010). These spheres are separate, reliant on one another, and connected (De Vos & Freedman, 2014). To enable efficient service delivery, the three sectors must exercise their authority and perform their duties to effectively coordinate their operating strategies (De Vos & Freedman, 2014). In order to ensure that the rights to the environment as outlined in the constitution are honoured, federal, provincial,

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and municipal governments are required to take legal, practical, and other reasonable measures (Murray & Klug, 2004). Waste management practices can cause environmental pollution and adversely affect human health. The South African Constitution promotes environmental rights and improves the environmental governance framework (Bilchitz, 2007). The Constitution establishes the right to an environment safe for human health and welfare. Establishes the legal obligation to safeguard the environment by promoting conservation (Liebenberg, 2010) and striking a balance between the rights to meaningful economic and social progress and the right to environmental protection. Environmental responsibilities are distributed across numerous government organisations and industries (Dixon & Roux, 2013).

Furthermore, the Constitution emphasises the need to protect the environment for the benefit of present and upcoming generations with appropriate legislative and other actions (Currie & De Waal, 2013.). Hence, it is within the municipalities' provision that IWMPs must work to uphold all residents' rights within the municipal boundaries by this clause, as well as promote and increase environmental protection from any degradation as guaranteed by the South African Constitution (Pieterse, 2014).

The legislation is important because it establishes the legal obligation for Thulamela local Municipality to manage solid waste in a way that protects public health and the environment. Supports the decentralisation of waste management to local authorities, aligning with the focus of this study on peri-urban household waste collection. Reinforces the principle of environmental rights, which justifies efforts to improve solid waste services in underserved communities. Promotes intergovernmental collaboration to ensure consistent, coordinated, and efficient waste management strategies. Maniini and Muledane fall into a grey area between urban development and rural governance, this constitutional responsibility is crucial. These areas frequently suffer from service delivery backlogs due to rapid urbanisation, informal housing, and weak planning coordination. The constitutional directive compels Thulamela Local Municipality to ensure that all communities receive equitable solid waste management services regardless of location or income level. The Constitution also promotes cooperative governance, requiring all government spheres to coordinate service delivery efforts. This is important for integrated waste management, which often depends on collaboration between environmental departments, planning units, and community stakeholders.

3.3.6. The Waste Act (Act No. 59 of 2008)

The Waste Act discusses explicitly the regulation of waste management activities and the management of the waste sector (Ncube, 2024). The Act is based on how the three government spheres (national, provisional and local) are given their respective legislative and executive duties under the Constitution (Ncube, 2024). In terms of environmental protection and pollution control, the Constitution gives both the national and provincial governments concurrent legislative authority (section 146 of the Constitution) and the local government's cleaning and refuse collection, refuse dumps and solid waste disposal are solely under the purview of the province legislature (Zhakata & Gundani, 2023). When national uniformity is necessary to resolve a problem

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successfully, the Constitution permits national legislation to establish national norms and standards about specific issues (DFFE, 2024).

IWMPs must be developed per Chapter 3, Section 11 of the Waste Act. The IWMPs should establish mechanisms for collaborative governance to address issues like solid waste planning, the appointment of solid waste management officials, and performance reporting (Muswema et al, 2012). In addition, as the constitution requires, national and provincial government agencies must support municipalities in carrying out their responsibilities (Muswema et al, 2012).

The legislation is important to the study because the research focuses on solid waste collection in peri-urban communities where service delivery is often inconsistent. The Waste Act holds local municipalities accountable for providing waste collection services to all households, including those in informal or rapidly urbanising settlements. The study promotes sustainable practices in household solid waste collection. The Waste Act's emphasis on reduction, reuse, and recycling provides a legislative foundation for implementing environmentally responsible strategies in Maniini and Muledane.

3.3.7. National Domestic Waste Collection Standard (2011)

National Domestic Waste Collection Standard addresses the collection of waste and includes requirements for separating waste at source, measures to promote recycling, and prescriptions for collection frequency. Regarding discretionary national norms and standards, the priority is to develop technical standards for waste management activities that do not require a licence (DEA, 2012). These standards will promote re-use, recycling and recovery of waste. Standards will also be developed for soil quality and remediation of contaminated land (Mkhize, 2017). These standards were finalised in 2012.

Other discretionary norms and standards have been identified and developed using the following criteria (Nhamo, 2014):

- Contribution to achieving the waste management hierarchy, focusing on waste reuse, recycling and recovery.
- Extent of the environmental impact.
- Impact on availability of landfill space.
- Relationship to other priority sectors (such as waste-to-energy and its contribution to the climate change mitigation strategy).
- Existence of established, proactive industries that adhere to additional operating standards.
- Existence of standard operating procedures, which may be converted into standards for particular sectors or companies with multiple sites.
- Elements of the waste transportation sector that have not been adequately regulated.

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The legislation is important because the study examines solid waste collection in peri-urban areas, where services are often irregular or absent. The Standard sets clear expectations for equitable waste collection, ensuring that all households, including those in Maniini and Muledane, receive regular and reliable services. In many peri-urban areas, poor road infrastructure limits access for solid waste collection vehicles. The Standard encourages municipalities to devise context-sensitive solutions, such as using smaller vehicles or establishing communal collection points, aligning with the spatial planning considerations. It includes provisions for public education and participation, encouraging communities to take ownership of local waste issues that are key to implementing sustainable solutions in areas experiencing rapid urbanisation and limited municipal reach. The Standard enhances performance measurement and reporting mechanisms for municipalities.

3.3.8. The National Environmental Management Act, 107 of 1998 (NEMA).

The National Environmental Management Act, No. 108 of 1998, governs environmental management in South Africa, a framework law that all state agencies follow. According to Section 28 of the NEMA Act (Kidd, 2011; Ashukem, 2024):

"*Any person who causes has caused or is likely to cause serious pollution or degradation of the environment must take reasonable steps to prevent such pollution or degradation from occurring, continuing or recurs, or to the extent that such environmental harm is permitted by law or cannot be reasonably avoided or stopped, to reduce and remedy such environmental pollution or degradation*".

Some of the guiding ideas from NEMA have been adopted into South Africa's environmental law. A life cycle approach to solid waste management, producer responsibility, precautionary principles, and polluters pay in principle are some of these guiding ideas (Hall, 2022). In addition, the law imposes a duty of care on anybody who significantly damages the environment, requiring them to take action to stop the damage if there is no other reasonable way to avoid it (DALRRD, 2023)

The law's Chapter 5 of the Law also addresses how to encourage proper environmental management to guarantee integrated environmental management of operations and, in addition, how to start integrated solid waste management by providing mechanisms for cooperation and coordination (Nel & Du Plessis, 2001). Environmental impact assessment techniques and procedures are closely integrated with licensing laws for solid waste management activities, NEMA modifications, and regulations that have established a precise regulatory framework (Feris, 2010.).

Thus, NEMA justifies environmental rights in the course structure and provides a foundation for collaborative governance. It also enables decision-making regarding the environment and environmental issues in an integrated manner within the context of environmental management (Kotzé, 2007).

The legislation is important because the study promotes sustainable solid waste collection in peri-urban areas. NEMA supports this through its duty of care provision, which legally obligates municipalities and

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stakeholders to prevent pollution and manage waste responsibly. NEMA aligns with the research's focus on spatial planning strategies, as it advocates for integrated approaches to development that balance social, economic, and environmental priorities that are key when setting up waste collection infrastructure in expanding peri-urban areas. Where new solid waste infrastructure or collection points are proposed, EIA procedures required under NEMA help ensure that the environmental impacts are minimised and adequately managed. NEMA emphasises cooperative governance, aligning with the study's advocacy for collaboration between municipal departments, traditional authorities, and community-based organisations to improve waste management in peri-urban settings.

3.3.9. National Waste Management Strategy (NWMS) 2020

The NWMS provides government policy and strategic interventions for the waste sector and is aligned and responsive to the SDGs of Agenda 2030 adopted by all United Nations (UN) member States. It is also aligned and responsive to South Africa's National Development Plan (NDP): Vision 2030, our country's specific response to and integration of the SDGs into our overall socio-economic development plans (Nhamo, 2024).

In line with the outcome-based planning approach of government, the strategy is premised on three (3) pillars which will see a future South Africa with zero waste in landfills, cleaner communities, well-managed and financially stable waste services, and a culture of zero tolerance of pollution, litter and illegal dumping (Grewan, & Trois, 2023). The government's priorities will be achieved through three (3) supporting pillars: Waste Minimisation, Effective and Sustainable Waste Services, Compliance, Enforcement and Awareness. The outcomes, strategic pillars, interventions, and actions collectively consolidate and build on the eight (8) overarching goals of the 2011 strategy (Nyika et al., 2020).

The success of the NWMS 2020 depends on the extent to which it finds a foothold in local and provincial government and the private sector, however the government and businesses alone cannot solve our waste problems. Increasing recycling rates to promote the circular economy depends on changing consumer behaviour, such as separating waste at source, which all South Africans should practice (Moyo, 2024). The revised NWMS seeks to build on existing initiatives in schools and draw on community-based organisations and NGOs to help clean up our communities and reduce our economy's carbon footprint by correctly disposing and recycling waste (Grewan & Trois, 2023).

The legislation is important because the study focuses on improving household solid waste collection in peri-urban villages. The NWMS 2020's emphasis on waste minimisation and resource recovery provides a policy framework that supports the development of sustainable collection strategies tailored to these communities. By advocating for integrated waste management planning, the NWMS 2020 complements spatial planning strategies to optimise waste collection routes, siting waste facilities, and overall urban development in peri-urban settings.

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3.3.10. The Municipal Systems Act (Act No 32 of 2000)

According to Section 25 of the Municipality System Act (MSA), every council of the municipality must approve an integrated development plan (IDP) for the municipality within a specified time from the start of their elected term (Malan, 2020). Regarding solid waste management practices, the act states that sectoral environmental plans, such as IWMPs for waste management, are expected to be included in the IDP, and municipalities must make sure that appropriate resources are allocated in their IDPs in order to meet the goals outlined in each plan (Malokane,& Muyengwa, 2021).

According to Thulamela Local Municipality IPD 2023/2024- 2025/26, "Various key service delivery improvements achieved during the financial year under review confirmed the appropriateness of strategic direction embarked upon at the beginning of the term of office of the current leadership. We want our towns and villages to be very clean. As we improve waste management, we procured 20 skip bins, strategically distributed within the municipal area".

The legislation is important because the Act provides a comprehensive framework for municipalities to deliver services, including waste management, ensuring that such services are equitable, accessible, and sustainable. This aligns with the study's focus on improving household solid waste collection in peri-urban villages. The Act requires municipalities to adopt Integrated Development Plans (IDPs) that coordinate and align resources and efforts across various sectors. Incorporating waste management into these plans ensures a holistic approach to spatial planning and service delivery, directly supporting the study's objectives.

3.3.11. Spatial Development Frameworks (SDF)

SDF is a document that holds the spatial status quo of areas within a specific municipality jurisdiction and is guided by development informants to establish spatial implications (Mashiri M. et al., 2017). In the context of solid waste management, SDF provides guidelines for the municipality to prepare an Integrated Development Plan that incorporates objectives set out to ensure strategic assessment of the environmental impact and specify land uses in a particular area (City of Johannesburg, 2024). In addition, IDP development proposals must avoid the loss of biodiversity and ecosystem disturbance from solid waste management practices. Furthermore, degradation and pollution of the environment must be avoided and minimised (Midvaal Local Municipality, 2023).

The legislation is important because SDFs provide a structured approach to integrating various municipal functions, including waste management. Municipalities can ensure that waste management infrastructure and services are effectively aligned with current and future land uses by embedding waste collection strategies within the spatial planning framework. Through the spatial analysis inherent in SDFs, municipalities can design and implement waste collection routes that are efficient and cost-effective. This optimisation reduces operational costs and enhances service delivery, particularly in complex peri-urban environments.

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3.3.12. Municipality by-laws

Municipal By-laws' principal goal is to ensure that solid waste is minimised, recycled, reduced, reused, recovered, and entirely disposed of in an environmentally responsible manner, promote sustainable development and environmental fairness by implementing reasonable and practical solid waste management policies under the municipal jurisdiction, control the gathering, moving, storing, throwing away, treating, and recycling of waste under the control of the municipal council (Steytler & De Visser, 2020). The By-law also ensures effective solid waste management practices in residential, commercial and industrial areas, enforces appropriate sanctions for illegal dumping and other offences and forbids their occurrence (eThekwini Municipality, 2022).

The municipality shall provide a service for removing and disposing of domestic refuse subject to such conditions as it may determine. Every occupier of a property shall use the service for the removal and disposal of domestic refuse provided by the municipality concerning all domestic refuse emanating from such property (Thulamela Local Municipality by law, 2024). No person other than the municipality or a person authorised thereto by the municipality shall remove domestic refuse from any property and dispose of it. The municipality may require every occupier of a property to provide on such property a container with a capacity of not less than 85 litres, constructed of a material approved by the municipality and with a close-fitting lid and two handles for the accumulation of domestic refuse (Thulamela Local Municipality by law, 2024).

The legislation is important to the study because the Waste Management By-Law provides a structured approach for managing waste collection, transportation, and disposal in Thulamela. It outlines the municipality's and residents' responsibilities, ensuring that waste management processes are legally organised. The by-law stipulates that residents must store waste in approved receptacles and place it in designated collection areas. This ensures that waste is contained correctly, reducing environmental hazards and promoting public health. Incorporating the provisions of the Thulamela Municipality's Waste Management By-Law into the study offers a localised perspective on regulatory measures that influence waste collection strategies. Understanding these by-laws is crucial for developing effective, compliant, and community-focused waste management solutions in peri-urban villages within the municipality.

3.3.13. White paper on Environmental Management

Waste hierarchy is established within South Africa's environmental policy via the White Paper on Environmental Management. The first stage of solid waste management is waste prevention, which South African policy encourages (Kotzé & Paterson, 2009). A systematic and hierarchical technique to help with integrated waste management, it is characterised as the trash hierarchy created in South Africa (. It also talks about avoiding solid waste, recovering waste, reducing waste, reusing waste, safely treating garbage, and eventually disposing of waste as a last option (DEA, 2010).

Set targets to minimise waste generation and pollution at source and promote a hierarchy of waste management practices, namely reducing waste at source, reuse, recycling and safe disposal as a last resort (Strydom &

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King, 2009). To regulate and monitor waste production, enforce waste control measures, and coordinate the administration of integrated pollution control and waste management through a single government department (Du Plessis, 2015).

The legislation is important to the study because the White Paper advocates for environmentally sustainable development, which includes effective waste management practices. This aligns with the study's focus on improving household solid waste collection in peri-urban villages, ensuring that waste disposal methods do not harm the environment. The policy highlights the importance of public participation in environmental governance. Engaging local communities in the design and implementation of waste management systems can enhance their effectiveness and sustainability, a key consideration for the study. Incorporating the principles outlined in the White Paper into the study provides a policy framework that ensures waste management strategies contribute to sustainable development goals and environmental protection in peri-urban communities.

3.4. Summary of the chapter

This chapter provided a detailed overview of the study area. It examined the legislative and policy frameworks relevant to sustainable household solid waste collection in peri-urban villages of Thohoyandou within Thulamela Local Municipality. The geographical, physical, socio-economic, and spatial characteristics of the selected villages Maniini and Muledane were discussed to contextualise waste collection challenges in areas experiencing rapid urbanisation, informal settlement growth, and infrastructure limitations. The chapter further explored the spatial planning context, emphasising the role of the Thulamela Spatial Development Framework (SDF) and the significance of Kevin Lynch’s urban design principles in enhancing accessibility and service efficiency. The physical and environmental features and socio-economic dynamics, such as poverty, unemployment, and informal economies, were key factors influencing solid waste generation and management practices.

A comprehensive review of relevant legislation and policy instruments was presented, including the SDGs, the Basel Convention, The New Urban Agenda, SPLUMA, the Constitution, the Waste Act, NEMA, and the National Waste Management Strategy (2020), among others. These frameworks collectively provide the regulatory basis for implementing integrated, equitable, and sustainable waste management systems. Particular attention was given to how each law or policy promotes environmental protection, community involvement, service delivery equity, and spatial justice. In conclusion, the chapter established the institutional and spatial foundation upon which effective solid waste collection strategies can be developed.

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Chapter Four: Research Methodology

4.1. Introduction

This chapter outlines the research methodology adopted to investigate sustainable household solid waste collection in the peri-urban villages of Maniini and Muledane. Guided by a pragmatist philosophy, the study applied a case study design and a mixed-methods approach, combining qualitative and quantitative techniques. Data were collected through questionnaires, semi-structured interviews, field observations, mapping, and photography to understand solid waste collection practices comprehensively. The study targeted households and municipal officials, and the sample was calculated. Sampling methods included purposive, convenience, and stratified random sampling to ensure a representative and context-specific sample. Both primary and secondary data sources were used to strengthen the reliability of the findings. Qualitative data were analysed thematically, while SPSS was used for quantitative analysis. Ethical considerations such as informed consent, anonymity, and voluntary participation were strictly observed.

4.2. Research philosophy (pragmatism)

A research philosophy is a set of fundamental beliefs that guide the design and execution of a research study, and different research philosophies offer different ways of understanding scientific research (Tamminen & Poucher, 2020). However, determining one's philosophical position requires understanding the distinctions between various stances, alongside reflective awareness of the inherent assumptions researchers hold regarding knowledge acquisition and testing (Creswell & Plano, 2011; Martin et al., 2022). Pragmatism is premised on the idea that research can steer clear of metaphysical debates about the nature of truth and reality and focus instead on 'practical understandings' of concrete, real-world issues (Kelly & Cordeiro, 2020). The term paradigm discusses a community of specialists' shared generalisations, beliefs, and values regarding the nature of reality and knowledge. (Creswell & Clark, 2011; Lincoln, 1990; Patton, 2002; Rossman & Rallis, 2003; Kaushik & Walsh, 2019.).

The pragmatist philosophy guided the investigation of sustainable household solid waste collection in peri-urban villages. Pragmatism emphasises practical solutions to real-world problems, aligning with the research objective of improving solid waste collection through spatial planning. The philosophy allowed for using mixed methods, combining qualitative and quantitative approaches to gather comprehensive data. Qualitative tools such as interviews and observations captured lived experiences and community perspectives. Quantitative methods like questionnaires and statistical analysis measured solid waste collection frequency. This flexible approach ensured that both technical and social aspects of solid waste collection were addressed. Pragmatism also supported stakeholder engagement, encouraging collaboration between households and municipal officials. The research was thus grounded in real-life contexts and focused on actionable outcomes. Overall, pragmatism enabled a practical, inclusive, and solution-oriented study.

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4.3. Research design

The research design refers to the overall strategy that you choose to integrate the different components of the study coherently and logically, thereby ensuring you will effectively address the research problem; it constitutes the blueprint for the collection, measurement, and analysis of data (Thakhur, 2021). A case study research design usually involves qualitative methods, but quantitative methods are sometimes also used. Case studies are suitable for describing, comparing, evaluating and understanding different aspects of a research problem (McCombes, 2023). Case Studies are a qualitative design in which the researcher explores in depth a program, event, activity, process, or one or more individuals (Priya, 2021). The case(s) are bound by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period (Priya, 2021).

The study used a case study research design to explore sustainable solid waste collection in the peri-urban villages of Maniini and Muledane. This design allowed for an in-depth examination of spatial planning issues within a real-world setting. It was suitable for capturing the complex environmental, social, and governance dynamics affecting solid waste collection. Focusing on two villages enabled the researcher to compare local conditions and environmental structures. Data collection methods such as interviews, questionnaires, and observations were used to gather diverse perspectives. The design supported triangulation, ensuring the validity and depth of findings. It allowed the researcher to study household behaviour, municipal involvement, and spatial factors in detail. The design helped generate tailored, actionable strategies by focusing on a specific context.

4.4. Research Approach

There are different ways to examine and explain a study and its findings, such as using numbers as a measure, a descriptive style, or a mixture of both; there are two research approaches: quantitative and qualitative (Taherdoost, 2022). Combining these basic approaches leads to a mixed-methods research approach, commonly used by researchers in various research studies (Taherdoost, 2022). This study used a mixed-methods approach, combining qualitative and quantitative methods. The qualitative approach involved interviews, field observations, and mapping to explore community experiences and identify challenges in waste collection. The quantitative approach used structured questionnaires to gather measurable waste generation and data on collection patterns. SPSS was used for statistical analysis to identify trends and relationships. This integration allowed for a more holistic understanding of the problem. The mixed-methods approach ensured data triangulation, enhancing the validity and depth of the findings. It aligned with the study's pragmatic philosophy and supported practical strategy development. Overall, it enabled the researcher to address both social and technical aspects of solid waste collection.

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4.5. Population description

The group of people or entities the study focuses on is called the 'population of interest'; this includes individuals, pairs, groups, organisations, or other similar entities (Hossan et al., 2023). The study's findings can be applied to or used for this group, which is the leading group the research is about (Hossan et al., 2023).

Unit of description	Population in figures	Number of Household
Thohoyandou Town	69 453	17 345
Maniini village	13 644	3804
Muledane villages	13 772	3441
Municipal officials	4	-

Table 4.1: shows population description

Source: SA Statistics 2011

Figure 4.1 shows the population description of the number of people and households in Maniini and Muledane. Maniini village is divided into four sections: Maniini K, Maniini L, Maniini M and Maniini Tshikovha. Maniini K, L, and M follow under municipality leadership, and Maniini Tshikovha follow under traditional leadership. The household of Maniini M (1206), Maniini K (1428), Maniini L (621) and Maniini Tshikovha (549). Muledane, like many areas in South Africa, falls under both traditional leadership and municipal governance. The research has used the households to find out the sample size.

4.6. Sample size determination

Sample size determination is the essential step of research methodology; it is choosing the number of observers or replicates to include in a statistical sample (Simarjeet, 2021). Sample size calculation is an important early step in any research to attain sufficient statistical precision and better utilise available resources. If the sample used is too small, the study will not provide reliable answers to study questions (Garg et al., 2024). Furthermore, a sample more significant than the required size may put more individuals at risk in specific interventions; it is, therefore, crucial for researchers to determine the required sample size before conducting research studies to ensure that they have enough sample size to draw meaningful conclusions without wasting available resources (Jihad, 2023).

Various online calculators are available to determine the Raosoft sample size calculator (Raosoft, 2010). Raosoft offers a specific tool for calculating sample size, the Raosoft Sample Size Calculator. This tool helps researchers and organisations determine the appropriate sample size needed for surveys or studies to ensure that results are statistically valid and representative of the population (Alqahtani et al, 2022). If known, input the estimated proportion or use the default value (usually 50% for maximum variability) (Memon et al., 2020). This sample size was calculated using Rao software, the sample size calculator. It was determined based on several households of 7242 [Muledane (3441) and Maniini. (3804).], and the sample size for this study is 261.

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According to the alternative of Raosoft ware, the recommended confidence level is 90 % when the sample size is more than 261, with a margin of 5.45% error.

4.7. Sampling techniques

When the entire population cannot participate in a study or the members of the target population cannot all be identified, sampling is employed to gather data presumed to be representative of that target population (Stratton SJ, 2021). Sampling techniques are categorised into probability or non-probability methods. Probability sampling methods incorporate random selection, which ensures that each case in the population has an equal likelihood of being selected (Berndt, 2020). This study employed both non probability (Purposive sampling and Convenience sampling) and probability sampling techniques (Stratified random sampling) to ensure a comprehensive and inclusive representation of participants relevant to the research on spatial planning strategies to improve sustainable household solid waste collection practices in peri-urban villages of Thohoyandou, within Thulamela Local Municipality. Sampling allowed the researcher to select a subset of individuals from the population-representative enough to generalise the findings.

4.7.1. Purposive sampling technique

Purposive sampling refers to a group of non-probability sampling techniques in which units are selected because they need characteristics in your sample (Makwana et al., 2023). In other words, units are selected "on purpose" in purposive sampling. This sampling method relies on the researcher's judgment when identifying and selecting the individuals, cases, or events that can provide the best information to achieve the study's objectives (Nikolopoulou, 2023). The researcher selects only those subjects that satisfy the objectives of the study based on the researcher's conviction (Wang, 2024). It is a sampling technique where the researcher relies on their discretion to choose participants from the study population. Thus, the sampling process depends on the researcher's judgment and knowledge of the context (Campbell., 2020).

Purposive sampling is a non-probability technique where participants are intentionally selected based on their relevance to the research topic. This study used it to choose municipal officials, and community members with direct knowledge of household solid waste practices. The villages of Maniini and Muledane were also purposively selected due to their rapid growth and proximity to Thohoyandou. This approach ensured that the data collected was rich, relevant, and context-specific. It aligned with the study's pragmatic philosophy, emphasising practical solutions to real-world problems. By targeting informed individuals, the study gained more profound insights into local solid waste collection challenges. Purposive sampling also improved the efficiency of data collection by focusing on key informants. Overall, it played a crucial role in enhancing the quality and focus of the research findings.

4.7.2. Convenience sampling technique

Convenience sampling is a non-probability sampling method where units are selected for inclusion because they are the easiest for the researcher to access. This can be due to geographical proximity, availability at a given time, or willingness to participate in the research (Khan, 2020). Convenience sampling means that the

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researchers utilise a readily available sample and have access to it, which can apply to almost any research (Jawad et al., 2022). However, the term is exclusively employed if the availability of participants was the researchers' mere concern in choosing a sample and when they could not select from various populations and research sites (Mittal et al., 2024).

This study was used to assess key informants from the Thulamela Local Municipality involved in solid waste management. These included officials from the departments of Spatial Planning and Environmental Management. The first official referred the researcher to another relevant expert, enabling a snowball approach to reach additional stakeholders. It allowed the researcher to collect valuable data from informed and accessible participants.

4.7.3. Stratified random sampling technique

Stratified random sampling is a method of selecting a sample in which researchers first divide a population into smaller subgroups, or strata, based on shared characteristics of the members and then randomly select among each stratum to form the final sample (Julia Simkus, 2023). Stratified sampling is the technique of probability sampling in which the characteristics of a precise variable are interpreted in the universe relative to this variable; for example, if we considered a sample of 100 people in a universe of 500 people based on sex variable, and the population consist of 200 females and 300 males, there should be 60 males and 40 females (Iliyasu, and Etikan., 2021). This study stratified households based on their geographic location (Maniini and Muledane) and income levels (low, middle, and high). This technique ensured that the sample represented different socio-economic and governance groups well. The method helped capture diverse household experiences in solid waste generation and collection. By reducing sampling bias, it enhanced the reliability of quantitative findings. It also supported the study's goal of understanding spatial and social variations in solid waste collection. Overall, stratified sampling contributed to a more accurate and balanced dataset. The researcher also selected every fifth household based on a walking route.

4.8. The study sample

A study sample refers to a subset of individuals or units selected from a larger population to conduct research (Khan, 2024). Researchers use samples to collect data and make inferences about the entire population without studying every member (Taherdoost, 2020). Besisahar, Nepal (Amogne & Yalew, 2024): This study involved 230 households, focusing on waste generation characteristics and management practices. The researchers divided households into economic categories (low, middle, and high income), allowing for targeted analysis across different income levels. The sample size was significant enough to provide statistically meaningful insights across these categories.

Oshogbo, Nigeria (Amos et al., 2024): Researchers initially distributed 220 questionnaires to households to understand the challenges and prospects in municipal solid waste management. Although only 88 were returned, the intended sample demonstrates that a figure around 220 is a solid benchmark for this type of study. The challenges faced (low return rate) also highlight the importance of setting a slightly higher initial

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sample size to accommodate non-response. Bengaluru, India (Goswami et al., 2024): In this study, 300 households were selected using random sampling, including urban, peri-urban, and rural zones. The sample size allowed the researchers to analyse differences in waste management practices across geographic contexts. The data collection was thorough, involving door-to-door surveys, and the sample size ensured that the findings could be generalised to a larger population.

The above case studies are examples to support the use of a sample size of 261 households in the current study. They illustrate that such a size is well within the accepted range of comparable studies and sufficient for generating reliable, valid, and generalisable findings in household solid waste management research. Furthermore, the diversity of geographic locations (South Asia and Sub-Saharan Africa) and study designs in these examples adds credibility to the sample size, reinforcing its applicability to the Muledane and Maniini villages in the Thulamela Local Municipality study area.

Sampled element	Frequency
Municipal officials	4
Households	261

Table 4.2: Sample size
Source: Mutwanamba (2024)

As shown in Table 4.2, 261 households were selected through a combination of stratified random sampling, purposive sampling, and convenience sampling techniques to ensure representation across different income levels, governance structures, and geographical locations. Four municipal officials were selected purposively for their roles in spatial planning and environmental management within Thulamela Local Municipality. 2 villages, Maniini and Muledane, were chosen based on their rapid urbanisation, mixed leadership systems, and relevance to the study objectives.

4.9. Data collection

One of the main stages in a research study is data collection, which enables the researcher to find answers to research questions (Babbie, 2020). Data collection is collecting data to gain insights regarding the research topic; there are different types of data and data collection methods accordingly (Taherdoost, 2021). Data collection is an important research stage; it helps understand and improve household solid waste collection systems. In order to provide a greater understanding of household solid waste, data collection aims to reveal patterns and insights. Data collection is the foundation for informed decision making, operational efficiency, environmental impact and data analysis pertinent to household solid waste collection. This study's data collection method includes primary and secondary data; data collection methods are discussed in detail below.

4.9.1. Primary data collection methods

Primary data is unpublished material obtained directly from a source and has not been altered by anyone; in other words, researchers employ various techniques to obtain and compile primary data for a specific objective

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(Silverman, 2020). As a result, primary data have higher validity, trustworthiness, objectivity, and authenticity (Rakhimova, 2023). Primary data was collected through questionnaires, semi-structured interviews, mapping, photography and field observations. This data helped in understanding the effectiveness of the current solid waste collection practices and identifying areas that need improvement. Before collecting data, the objective were clearly understood.

4.9.1.1. Observation

observation permits researchers to observe circumstances mentioned in interviews and situations informants may be reluctant to divulge; this method allows them to gain new insights and awareness of any descriptions their informants may have provided during an interview (Morgan., 2022).

Observation is a key qualitative data collection method that involves systematically watching and recording behaviours, events, or conditions in their natural setting. This study used direct observation to gain first-hand insights into household solid waste collection practices in Maniini and Muledane villages. This method allowed the researcher to observe the physical environment, such as the presence and condition of solid waste bins, solid waste accumulation points, illegal dumping sites, and the types of solid waste commonly generated. It also provided an opportunity to assess how frequently solid waste is collected and whether the infrastructure in place supports sustainable waste practices. A structured observation checklist was used to record observations consistently. The researcher did not intervene in any activities but observed and documented what was happening naturally within the community. This approach helped uncover practical issues that may not have been fully revealed through interviews or questionnaires, such as informal waste disposal behaviours or using designated collection points.

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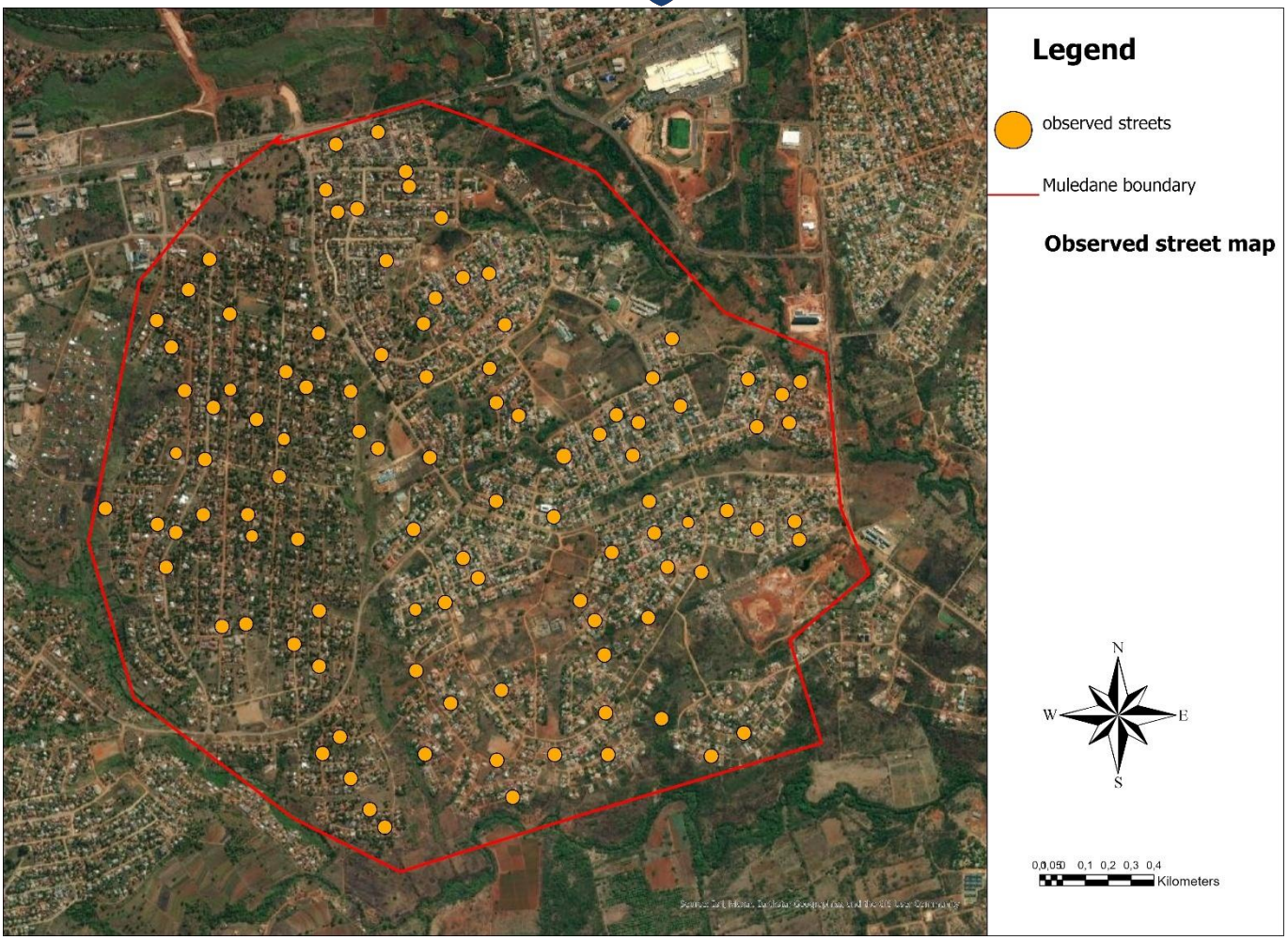

Figure 4.1: Observed street in Maniini

Source: Mutwanamba (2025)

The observed street map of Muledane, as illustrated in figure 4.1.above, provides a spatial overview of the areas where street-level observations were conducted to assess household solid waste collection practices. The map shows a comprehensive distribution of observation points, represented by yellow dots, spread across the village and enclosed within the red demarcated boundary of Muledane.

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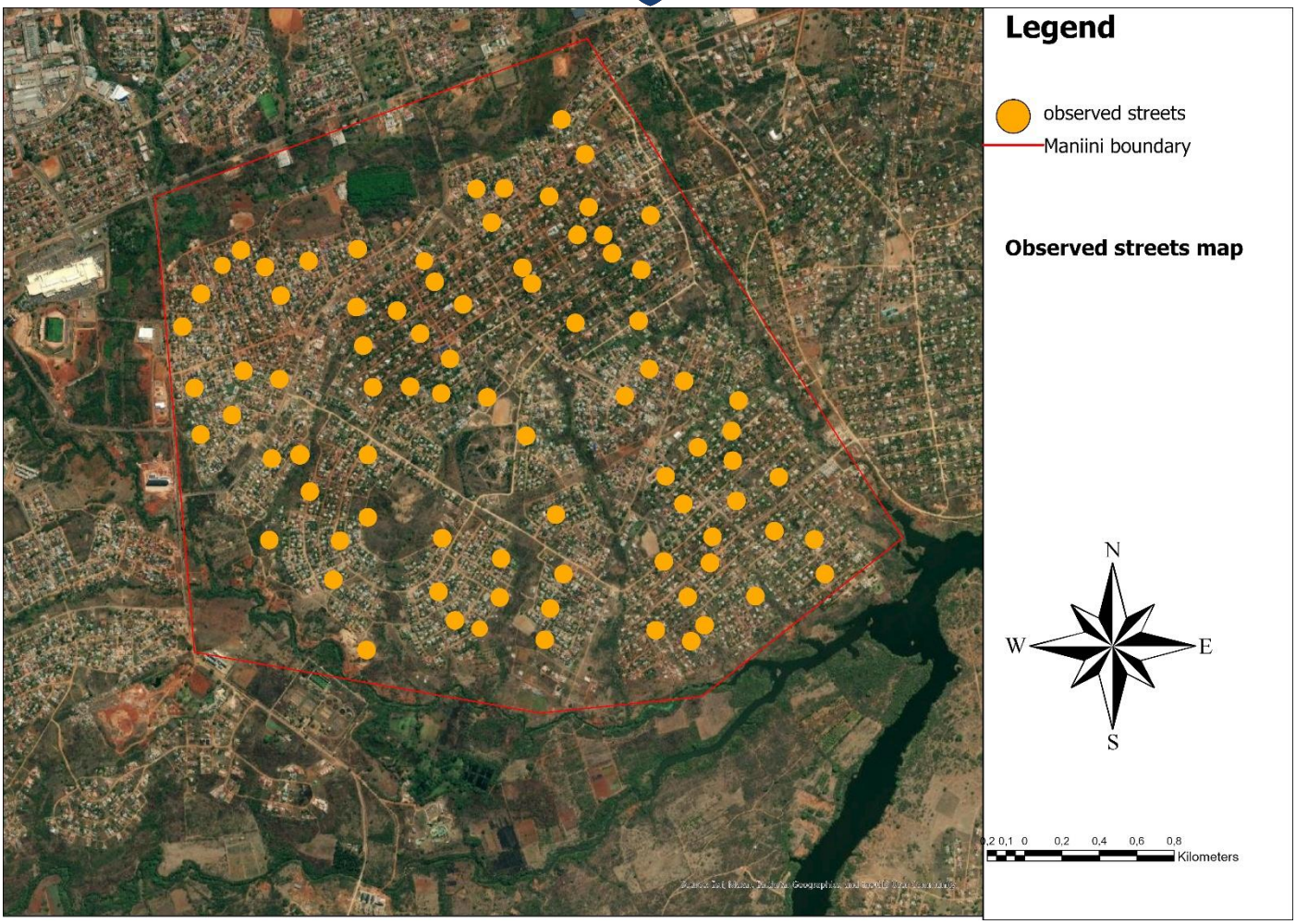

Figure 4.2: Observed street in Muledane

Source: Mutwanamba (2025)

Figure 4.2 shows the observed street map of Maniini, depicted above, which provides a detailed spatial layout of the area under investigation for solid waste collection practices. The red boundary line outlines the perimeter of Maniini, while the orange dots represent the streets that were observed during data collection. These observed points are well distributed throughout the village, indicating a widespread spatial coverage across the settlement.

4.9.1.2. Questionnaires

A questionnaire is an important instrument in a research study to help the researcher collect relevant data regarding the research topic, it is significant to ensure that the design of the questionnaire is arranged to minimise errors (Kumar, 2019). As the heart of the survey, a questionnaire is based on questions to gather data from respondents (Jain, 2021). Questions are the translated form of what researchers need for their study, which is addressed using the respondents' answers (Taherdoost, 2022).

Questionnaires are a widely used data collection tool to gather structured information from many respondents. This study administered questionnaires to 261 households in Maniini and Muledane villages to collect quantitative data on household solid waste collection. The questionnaire included a combination of closed-

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ended and open-ended questions aimed at capturing data on waste generation frequency, types of waste, storage methods, disposal practices, and the level of satisfaction with municipal waste services.

Description	Locality	Sample	Number of questionnaires administered	Number of questionnaires returned
Household	Maniini and Muledane	261	261	238

Table 4.3: Questionnaire distribution

Source: Mutwanamba (2025)

Table 4.3 above presents the distribution of questionnaires administered across the two study sites, Maniini and Muledane. A total sample size of 261 households was targeted for the survey. Out of these, a total of 238 questionnaires were successfully administered. The slight discrepancy between the targeted sample and the number of completed questionnaires is attributed to instances of incomplete participation by some respondents. Questionnaires allowed for efficient data collection across a large sample and provided measurable variables that could be analysed statistically using SPSS. Respondents completed the questionnaires in person and online, depending on their accessibility and preference. The anonymity of the questionnaire responses encouraged participants to answer honestly and share their experiences and opinions. The questions aligned with the study's objectives and were pre-tested before full deployment to ensure clarity and relevance. The data obtained from the questionnaires formed the basis for identifying patterns, challenges, and potential strategies for improving household solid waste collection in peri-urban settings.

4.9.1.3. Semi- structure interviews

In an interview, the researcher asks the questions directly. An interview may be face-to-face, via phone or online with or without videos (Silverman, 2020). When initiating new research projects, interviews have been recommended as one of the suitable data collection tools in the literature (Jain., 2021).

Semi-structured interviews were conducted with municipal officials, these interviews aimed to gain an in-depth understanding of the challenges, roles, and perceptions surrounding household solid waste collection. The researcher used an interview guide to ensure consistency across interviews while allowing room to probe deeper into specific responses. Interviews were conducted face-to-face, and with participants' consent, conversations were audio-recorded to capture detailed responses. This method allowed participants to freely express their experiences, opinions, and suggestions, offering valuable insight into solid waste collection's practical and policy-level aspects in peri-urban areas.

4.9.1.4. Mapping

Mapping has evolved from a cartographic tool into a critical research method that enables the spatial representation of real-world phenomena. In recent years, it has become central to environmental, urban, and social research, where spatial understanding is vital for planning and decision-making. In particular, GIS (Geographic Information Systems) and remote sensing technologies have enabled researchers to collect,

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visualise, and analyse geospatial data more efficiently and accurately (Galatro & Dawe, 2024; Al-Worafi, 2023).

Mapping is a spatial data collection method used to identify and analyse the geographical distribution of phenomena. This study employed mapping to locate solid waste generation points, dumping sites, collection routes, and waste bin locations within Maniini and Muledane villages. This method was crucial for understanding the spatial patterns of waste disposal and identifying areas with poor service coverage or frequent illegal dumping. The researcher used digital tools such as GPS, ArcGIS pro, and Google Earth pro to collect and visualise geographic data. Coordinates were recorded for each observed location during field visits, including hotspots of waste accumulation and infrastructure locations like bins and transfer points. These data were then used to create thematic maps highlighting areas of concern, inefficiencies in collection routes, and opportunities for improved spatial planning. Mapping supported the visual representation of waste-related issues and assisted in proposing more efficient and sustainable household solid waste collection strategies. It provided a spatial dimension to the study, aligning with the research's focus on spatial planning and its role in waste management.

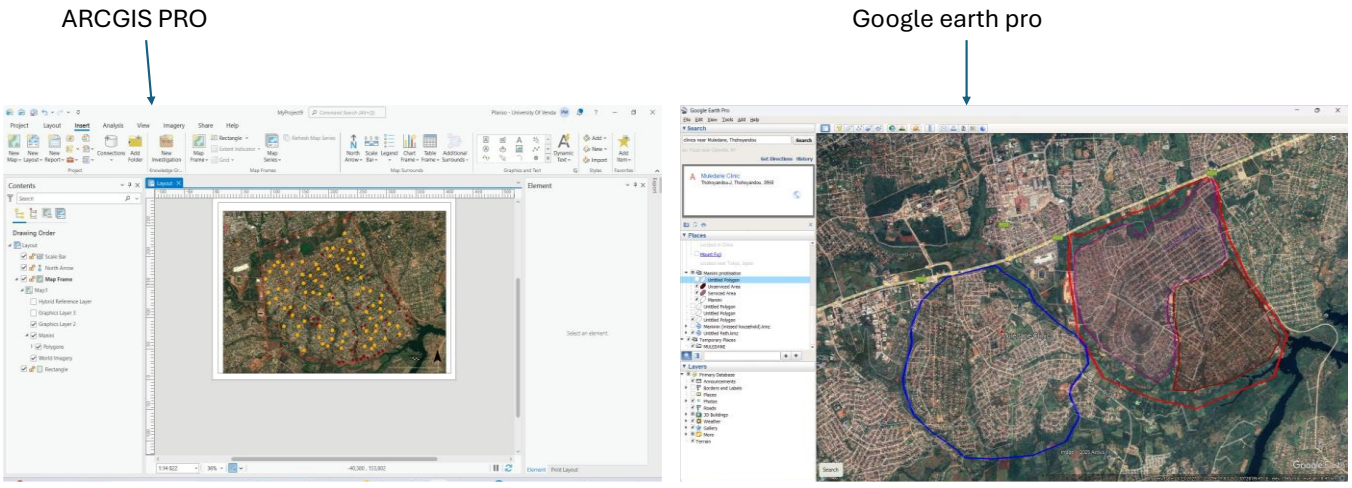

Figure 4.4: Mapping

Source: Mutwanamba (2025)

Figure 4.4: Mapping above visually demonstrates the mapping process and digital tools used during the spatial data collection phase of the study. Providing evidence of the software applications ArcGIS Pro and Google Earth Pro used to map the two study areas, Maniini and Muledane. By including figure 4.4. the researcher

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effectively supports the explanation that GIS-based mapping was integral to identifying gaps in service delivery and informing spatial planning strategies for improved household solid waste management.

4.9.1.5. Photography

Using pictures in social research requires a theory of how pictures get used by both picture makers and viewers (Paiva V. et al., 2022). In order to use photographs either as data or as data generators, we need to have some notion of how viewers treat and understand photographic images, whether those viewers are informants or researchers (Alves., et al., 2021). Photography was used to document the physical state of household solid waste collection practices in Maniini and Muledane. Images of solid waste bins, collection points, illegal dumping sites, collection vehicles, and areas where waste accumulation was evident were taken. These photographs were evidence of existing infrastructure and operational challenges, such as overfilled bins, lack of proper storage, and irregular solid waste collection. Photos were taken using a high-resolution camera (iPhone 11 Pro Max) to ensure clarity and detail. The researcher ensured ethical compliance by seeking permission before taking photos, especially in private or sensitive areas. Photography complemented other data collection methods, such as observation and mapping, by providing a visual record that supported the research's narrative and analytical aspects. The collected images were used to strengthen findings, aid in spatial analysis, and create awareness materials and presentations. Overall, photography added depth to the study by visually illustrating the issues and conditions that households and local authorities face in managing solid waste.

4.9.2. Secondary data collection

Secondary data sources include previously published books, magazines, journals, unpublished autobiographies, biographies, etc. (Paiva V. et al., 2022). Thus, data collection is mandatory to accomplish the research process, and therefore, it is the fundamental tool of research (Mazhar., 2021). Therefore, secondary data for this study were collected through reliable and adequate sources. These include 35 relevant books, journals and official documents from the government (e.g. NDP 2030, The Constitution, Waste Act, etc.) and Thulamela Local Municipality (e.g. IDP). Start by defining the research question and identifying the specific information you need. This will help the researcher identify the type of secondary data needed and where to find it.

Government publications, which include data on solid waste generation and collection. National, regional and local government reports on solid waste collection management practices and statistics can provide more insights into solid waste collection patterns. Academic journals and articles can offer detailed analyses and findings from previous studies on solid waste collection. Online databases that aggregate data from various sources can be used. For example, the Science Direct database offers access to studies that use socio-economic data to analyse solid waste collection systems. International organisations, for example, the United Nations (UN), The World Bank, the United Nations Environment Programme (UNEP), the International Solid Waste

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Association (ISWA), the International Telecommunication Union (ITU) and The Basel Convention Regional Centre for Asia and the Pacific (BCRC China).

These documents provided important contextual information on waste generation trends, current policies, service delivery frameworks, and demographic profiles of the study area. Academic literature from platforms like ScienceDirect, Springer, and Google Scholar was also reviewed to understand waste management practices in similar settings and to support the study's theoretical foundation. Secondary data supported the identification of gaps in policy implementation, best practices, and challenges in solid waste collection at both national and local levels. This method enhanced the depth and credibility of the research by allowing for triangulation, comparison, and validation of findings across multiple data sources. It also contributed to formulating informed recommendations for improving household solid waste collection through spatial planning.

4.10. Data analysis

Data analysis is collecting, modelling, and analysing data using various statistical and logical methods and techniques (Galatro & Dawe, 2024). Data analysis is the researcher's means of converting the information collected into defensible actionable sets of conclusions and reports (Al-Worafi, 2023)0. Once the data has been collected, appropriate data analysis methods have to be chosen; the choice of the method depends on the type of data collected. Some data analysis methods require certain specific types of data (Kumar, 2024). Data analysis can forecast the amount of solid waste generated in different areas; this will help plan and allocate resources more efficiently. Data was analysed using qualitative and quantitative data analysis methods to attain the objectives highlighted in Chapter 1, section 1.5.

4.10.1. Qualitative data analysis

Qualitative data analysis examines, interprets, and organises non-numerical data such as interview transcripts, observation notes, photographs, and documents to identify patterns, themes, meanings, and insights (Kiger & Varpio, 2020). It is commonly used in social sciences and applied research to understand human experiences, behaviours, and social contexts (Braun & Clarke, 2022).

Qualitative data analysis involves examining non-numerical information such as interview transcripts, observations, and field notes to identify patterns, themes, and insights. This study collected qualitative data through semi-structured interviews, field observations, and photographic documentation in the villages of Maniini and Muledane. These data were analysed using the thematic analysis method, which allowed the researcher to explore recurring themes and underlying meanings related to household solid waste collection practices. The thematic analysis involved coding responses, grouping similar ideas, and identifying overarching themes that emerged from participants' narratives. This approach was used to interpret responses about challenges in waste collection, community engagement, institutional roles, infrastructure conditions, and attitudes toward waste disposal. The analysis was guided by conceptual frameworks such as Lefebvre's

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theory of spatial production and Hirschman's Exit, Voice, and Loyalty model, which provided a deeper understanding of how social, spatial, and governance factors influence waste management behaviour in peri-urban areas. Through this method, the study uncovered critical issues such as inconsistent collection services, lack of designated waste storage points, and limited coordination between municipal authorities and traditional leaders. These themes were presented through narrative descriptions and linked to the broader objectives of the research. Qualitative analysis thus provided rich, context-specific insights that complemented the quantitative findings and contributed to a holistic understanding of sustainable solid waste collection strategies. The data was also analysed using STEEP analysis, STEEP analysis is a framework for assessing how Social, Technological, Economic, Environmental, and Political external factors.

4.10.2. Quantitative data analysis

Quantitative data analysis examines numerical data to identify patterns, relationships, and trends (Ali, 2021). It involves using statistical techniques to analyse data collected through tools like surveys, structured questionnaires, or experiments . This type of analysis allows researchers to test hypotheses, make predictions, and generalise findings from a sample to a larger population (Menon & Mittal, 2020). Common methods include descriptive statistics (e.g. mean, standard deviation, frequency) and inferential statistics such as regression analysis, correlation, and ANOVA. Quantitative analysis is valued for its objectivity, reproducibility, and ability to draw statistically valid conclusions (Creswell & Creswell, 2018).

Quantitative data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 26, which allowed for examining numeric data gathered through household questionnaires. The analysis involved descriptive and inferential statistics to identify trends, relationships, and patterns in household solid waste collection practices. Descriptive statistics such as frequencies, percentages, means, and standard deviations were used to summarise household characteristics, waste generation volumes, collection frequency, and satisfaction levels with municipal services. These statistics provided an overview of the general waste management situation in Maniini and Muledane. In addition to descriptive analysis, regression analysis was performed to examine the relationship between key variables such as household income, education level, distance to collection points, and waste collection frequency. This inferential method helped determine whether socio-economic and spatial factors significantly influence waste collection efficiency and service accessibility. By using multiple linear regression, the study was able to predict how certain independent variable impacted dependent variables like waste collection satisfaction or waste generation levels. The combination of these quantitative methods enhanced the rigour of the analysis and supported evidence-based recommendations for improving spatial planning strategies in waste management. The results were visualised through tables, charts, and graphs to make interpretation easier and more impactful.

4.11. Research ethics

This research considered all ethical issues relating to norms and standards when conducting human research as per guidelines from the University of Venda policy on research ethics, which states that "all research should

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be conducted in committed to the principles of excellence and quality, integrity, accountability, transparency, community engagement and Ubuntu diversity and social responsibility" (Research Ethics Committees, 2019). Research involving human beings as participants is important for advancing knowledge in the sphere of human welfare; University research has made a substantial contribution to the welfare of society (Policy on Research Ethics).

The project was registered with the University of Venda, as the study involved human involvement. Participants were requested prior consent to participate in interviews, questionnaires, photography, and recording interviews. In addition, they were informed that involvement in the study is voluntary and that they can withdraw from participating at any time if they do not wish to proceed. All the information from the participants was be treated with confidentiality and anonymity and used for research purposes only.

4.12. Reliability and credibility of the research

Ensuring the reliability and credibility of research findings is essential to uphold the quality and trustworthiness of the study. In this research, multiple strategies were employed to ensure that the data collection process and the interpretation of results were dependable and valid. Reliability refers to the consistency and stability of the research instruments and procedures. To achieve this, the study used a pre-tested questionnaire to check for clarity, relevance, and consistency of responses. The same structured tools and procedures were applied across all participants, reducing the possibility of bias or variation due to measurement errors. Data were also cross-checked for completeness and accuracy before being entered into SPSS for analysis. Credibility, on the other hand, relates to the truthfulness and authenticity of the findings. The study used data triangulation to enhance credibility, combining questionnaires, interviews, observations, mapping, and photography. This allowed the researcher to validate responses by comparing multiple sources of data. Engaging key informants such as municipal officials further strengthened the credibility of qualitative data, ensuring that the perspectives collected were grounded in real experiences.

Additionally, ethical research practices such as informed consent, confidentiality, and voluntary participation helped build trust with participants, encouraging honest and open responses. Field observations and photographic evidence also added to the authenticity of the findings by visually documenting real-world waste management practices. Together, these efforts ensured that the study's findings on household solid waste collection practices in Maniini and Muledane are both reliable and credible, providing a strong foundation for evidence-based spatial planning recommendations.

4.13. Research limitation

While this study was carefully designed to investigate spatial planning strategies for improving sustainable household solid waste collection in Maniini and Muledane villages, certain limitations were encountered during the research process. participant responsiveness, while efforts were made to reach the full sample of

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261 households, not all respondents completed the questionnaire thoroughly, which may have affected the consistency of some data. Language and literacy barriers also posed challenges, especially among older and less-educated participants, requiring the use of interpreters in some cases. One significant challenge was the practical difficulty of working in peri-urban settings, where infrastructure is often limited and communities are dispersed. This made it time-consuming and, at times, logistically difficult to reach all selected households, particularly in areas with poor road access. access to respondents was occasionally constrained, particularly among municipal officials whose schedules were demanding. This limited the number of in-depth interviews that could be conducted. Travelling to conduct interview it becomes a problem because the limited budget ,the university do not provide us with the research fund.

4.14. Methodological summary

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Research objectives	Data collection tools		Sampling methods	Data analysis and interpretation tools	Variables
	Primary data	Secondary data			
(1) Characterise the current collection practice in Muledane and Maniini villages.	Semi-structured interviews, questionnaires, mapping, and photograph	Journal publications, Articles, newspapers	Purposive, stratified random, and convenience	Descriptive statistics, thematic analysis, regression, mapping	Solid Waste types, frequency of collection, storage methods
(2) Identify factors that impede sustainable solid waste practices in Muledane and Maniini villages.	Semi-structured interviews, questionnaires, mapping, and photographs	Journal publications, Articles, newspapers	Purposive, stratified random, and convenience	Descriptive statistics, thematic analysis, regression, mapping	Income level, distance to collection points, and infrastructure quality
(3) Propose sustainable strategies for household solid waste collection practices in peri-urban villages of Thohoyandou town.	Semi-structured interviews, questionnaires, mapping, and photographs	Books Journals Articles	Purposive, convenience	Descriptive statistics, thematic analysis, regression, mapping	Stakeholder roles, spatial layout, and infrastructure availability

Figure 4.3: Methodological summary

Source: Mutwanamba (2025)

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4.15. Chapter Summary

This chapter presented the research methodology employed to investigate sustainable household solid waste collection in the peri-urban villages of Maniini and Muledane. Grounded in pragmatist philosophy, the study adopted a case study design and mixed-methods approach, integrating qualitative and quantitative techniques. The target population included households and municipal officials, and a sample size of 261 households was determined using the Raosoft calculator, ensuring statistical reliability. Sampling techniques included purposive, convenience, and stratified random sampling to ensure diverse representation. Data collection methods comprised questionnaires, semi-structured interviews, field observations, mapping, and photography, with primary and secondary data sources used to enhance reliability. Qualitative data were analysed thematically, while SPSS facilitated quantitative data analysis through descriptive and inferential statistics. The chapter also addressed ethical considerations, ensuring informed consent, confidentiality, and voluntary participation. Reliability and credibility were maintained through data triangulation and standardised instruments. While the methodology was robust, limitations such as participant non-responsiveness, literacy barriers, and logistical challenges in peri-urban areas were acknowledged. Overall, the methodology was carefully crafted to align with the study's objectives, offering a strong foundation for evidence-based recommendations in subsequent chapters.

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Chapter 5: Characterising The Current Household Solid Waste Collection Practices In Peri-Urban Villages Of Thohoyandou Town

5.1. Introduction

This chapter presented and analysed the data collected for this research, with a primary focus on answering research objective 1: Characterising the current household solid waste collection practices in peri-urban villages of Thohoyandou town. The analysis employed quantitative and qualitative methods to examine the dataset's various trends, relationships, and potential causal factors. The study selected Maniini and Muledane as case study villages, where data were collected using structured questionnaires from 261 sampled households, with 238 responses successfully returned. The quantitative data were analysed using descriptive statistics (mean and standard deviation) and regression analysis, while the qualitative data were examined through thematic analysis. By employing a pragmatic approach, this research ensured that objective statistical insights and contextual human experiences were considered in developing effective spatial planning strategies to enhance sustainable solid waste collection. The findings of this analysis have provided a clear understanding of existing household solid waste collection practices, stakeholder involvement, and the efficiency of current methods.

5.2. Demographic Overview of Respondents

Different villages surround Thohoyandou town; the chosen ones for this research are Maniiini and Muledane. Qualitative data were collected from these two villages using a questionnaire. The researchers looked at demographics, including gender distribution, age group, level of education, occupational status, household income levels, place of residence, and household size, to find the relationship with the current household solid waste collection practices. The demographic overview laid the foundation for understanding how household characteristics influence solid waste collection practices in Mannini and Muledane. By analysing gender, age, education, occupational status, income levels, and household size, the research has identified key points for enhancing service delivery and ensuring equitable access to solid waste collection resources.

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5.2.1 Gender Distribution

The respondents were asked to indicate their gender to know how males and females behave towards the solid waste collection. The gender of respondents is examined how individuals of different genders respond to issues related to the collection of solid waste in households. Aimed at understanding how gender influences different aspects of solid waste collection. The gender breakdown of the respondents who participated in the study is shown in Figure 5.1 below.

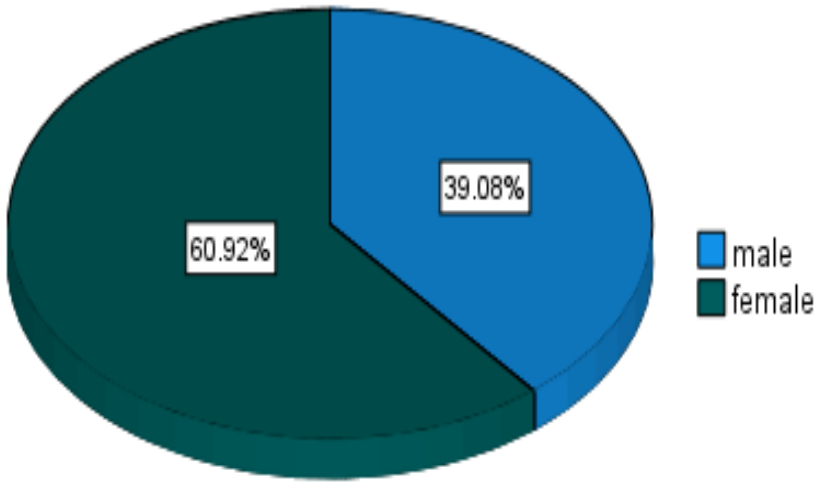

Figure .5.1: Gender Distribution

Source: field data (2025)

The analysis of gender distribution among survey respondents revealed a significant gender balance of the 238 respondents, 93 (39.08%) were male, while 145 (60.92%) were female. This indicated that female participants comprised most of the survey sample, aligning with broader demographic patterns in the Thulamela Municipality. The findings gain further relevance when triangulated with the IDP data for 2021–2022. According to the IDP, the municipality comprises 64,593 male-headed households and 65,728 female-headed households, totalling 130,321. This near-equal distribution of male- and female-headed households underscores the importance of ensuring gender representation in regional studies. Furthermore, the population description highlights the number of people and households in Maniini and Muledane, two key areas within the study. Maniini village is home to 13,644 individuals and 3,804 households, while Muledane has 13,772 individuals and 3,441 households. The detailed breakdown of

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Maniini into its subsections—Maniini K (1,428 households), Maniini M (1,206 households), Maniini L (621 households), and Maniini Tshikovha (549 households), further illustrates the complexity of the area's governance, divided between municipal leadership and traditional authority. These percentages and distributions provide crucial insights into the gender dynamics and household compositions, forming a robust foundation for the study's analysis of household solid waste collection practices.

In addition to the analysis from regression analysis, although gender differences were explored about solid waste collection practices, regression analysis revealed that gender does not have a statistically significant impact on how effective or sustainable households perceive the current collection services to be ($p = 0.635$). This means that both male and female respondents reported similar levels of satisfaction or dissatisfaction, regardless of differences in roles or responsibilities in household waste management. This finding suggests that gender-based interventions may not be necessary for improving overall perceptions of waste collection effectiveness. Instead, broader system-level improvements, such as consistent service delivery and infrastructure upgrades, are likely to benefit all households, irrespective of gender.

In this study, male and female differences exist in terms of access to and satisfaction with solid waste collection services. Most women face more challenges (for example, physical accessibility and time limitations due to domestic duties) compared to men in accessing services. Maniini and Muledane are located in rural areas where poverty is high, and women in households with low economic resources face more time constraints because of additional domestic duties. This could affect their ability to participate in utilising solid waste collection services effectively.

5.2.2 Age Group

Figure 5.2 below provides the age group of the respondents, the age distribution of respondents highlighted a balanced representation across different age groups, with notable insights drawn from the percentages. The 46-55 age group forms the largest segment, accounting for 28.99% of the sample, followed by the 26-35 age group at 20.17% and the 36-45 age group at 19.75%. The youth demographic, represented by the 18-25 age group, makes up 14.71% of the total respondents, while those aged 56 and above constitute 16.39%. These figures revealed a diverse range of perspectives,

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with a significant proportion of the survey capturing input from middle-aged respondents, particularly those between the ages of 46-55.

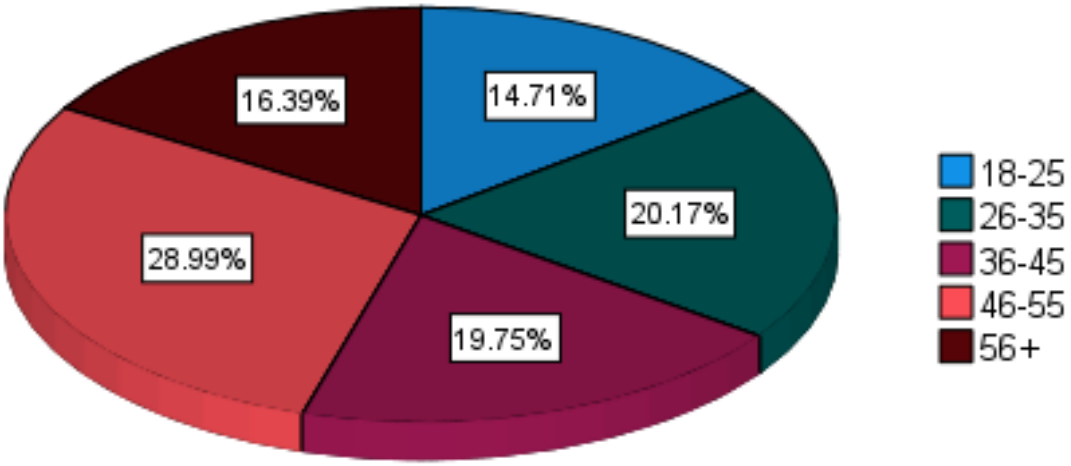

Figure .5.2.: Age Respondents

Source: field data (2025)

Additionally, the relatively high representation of the 26-35 and 36-45 age groups ensures that the working-age population, often considered a critical segment for decision-making and planning, is adequately included. The youth (18-25) and senior respondents (56+) also contributed meaningfully, albeit in slightly more petite proportions, ensuring that voices from younger and older cohorts are incorporated. When triangulated with the IDP for the Thulamela region (2021-22), this distribution showed some alignment, particularly in reflecting the prominence of younger age groups, such as the 18-25 and 26-35 cohorts, which are highlighted in the broader population structure. Furthermore, the regression analysis showed that age had a weak but statistically significant influence on how households perceive the effectiveness of solid waste collection services ($p = 0.550$). Specifically, older respondents tended to rate the collection services slightly more favourably than younger age groups. This may be due to different levels of expectations or varying degrees of tolerance toward service delays and inefficiencies.

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Different age groups contributed differently to the generation of solid waste. Younger and older age populations engage differently in solid waste segregation, sustainable disposal and recycling. The age group can impact the planning of solid waste collection routes and facilities. A solid waste collection system must be planned well to accommodate different age groups. Young people respond very well to digital platforms, such as WhatsApp, where people remind each other about pickup times and days, and reward apps for recycling. Middle-aged people are key influencers in the community.

5.2.3. level of Education

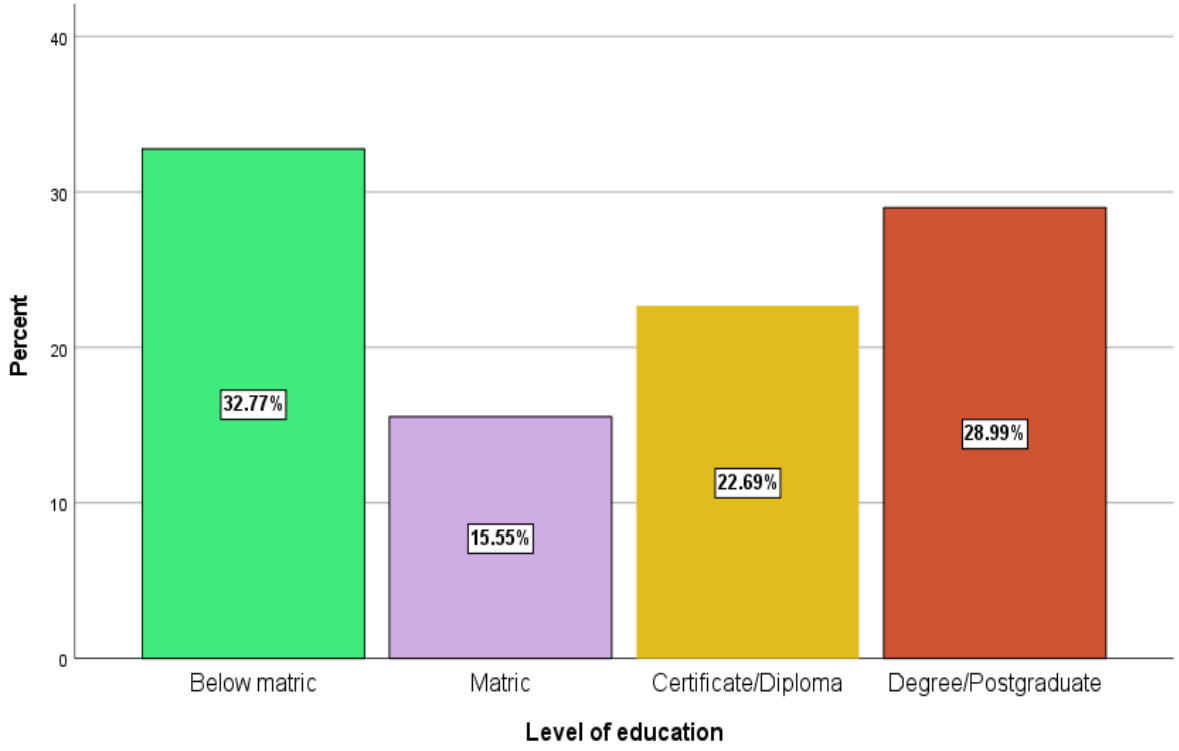

Figure .5.3: Educational Attainment

Source: field data (2025)

Figure .5.3 above analysed the level of education among respondents, revealing a diverse distribution of educational attainment, providing valuable insights into the area's demographic profile. A significant proportion, 32.77%, of respondents reported having an education level below matric, highlighted a substantial segment of the population with limited formal education. This is followed by 15.55% of respondents who have completed matric, reflecting a smaller but notable group that has attained the basic level of secondary education. Interestingly, a considerable portion of the

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population, 22.69%, holds a certificate or diploma qualification, suggesting that a significant number of individuals have pursued post-secondary but non-degree qualifications, equipping them with technical or vocational skills. Notably, 28.99% of respondents reported having a degree or postgraduate qualification, indicating a relatively high tertiary education level among a substantial population segment. The cumulative percentages further underscore the educational progression within the community, with nearly half of the respondents (48.3%) having achieved at least a matric level and a notable 71.0% having attained qualifications beyond matric.

The regression results showed that education level has a weak and statistically borderline effect on perceived solid waste collection effectiveness. Although the p-value (0.082) is above the standard threshold of 0.05, it is relatively close, indicating that educational attainment may be a marginal influencer in shaping perceptions of waste collection performance. The positive B coefficient (0.123) indicated that respondents with higher educational levels tend to rate solid waste collection services as more effective. However, the relationship is not strong enough to be statistically significant and should be interpreted with caution.

This slight positive trend may reflect heightened awareness among more educated individuals, who are likely to understand the importance of structured waste management systems, environmental protection, and civic accountability. On the other hand, it's also possible that highly educated respondents may have higher expectations, making them more critical of inadequacies in solid waste services, which would counteract the positive effect.

This distribution underscored a balanced mix of educational attainment levels, with a commendable proportion of respondents pursuing higher education, reflecting potential human capital that could contribute positively to the area's development. However, a significant percentage of individuals below the matric level highlighted the need for targeted educational interventions to bridge the gap and enhance overall community development. The education level impacts participation, awareness and compliance regarding sustainable solid waste collection practices. Different education levels influence how people handle solid waste, including the willingness to adopt sustainable practices. Highly educated communities are more likely to adopt advanced solid waste

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segregation, and they generate less solid waste. The low-education community needs visual guidance and community engagement programs for proper solid waste collection.

5.2.4 Occupational Status

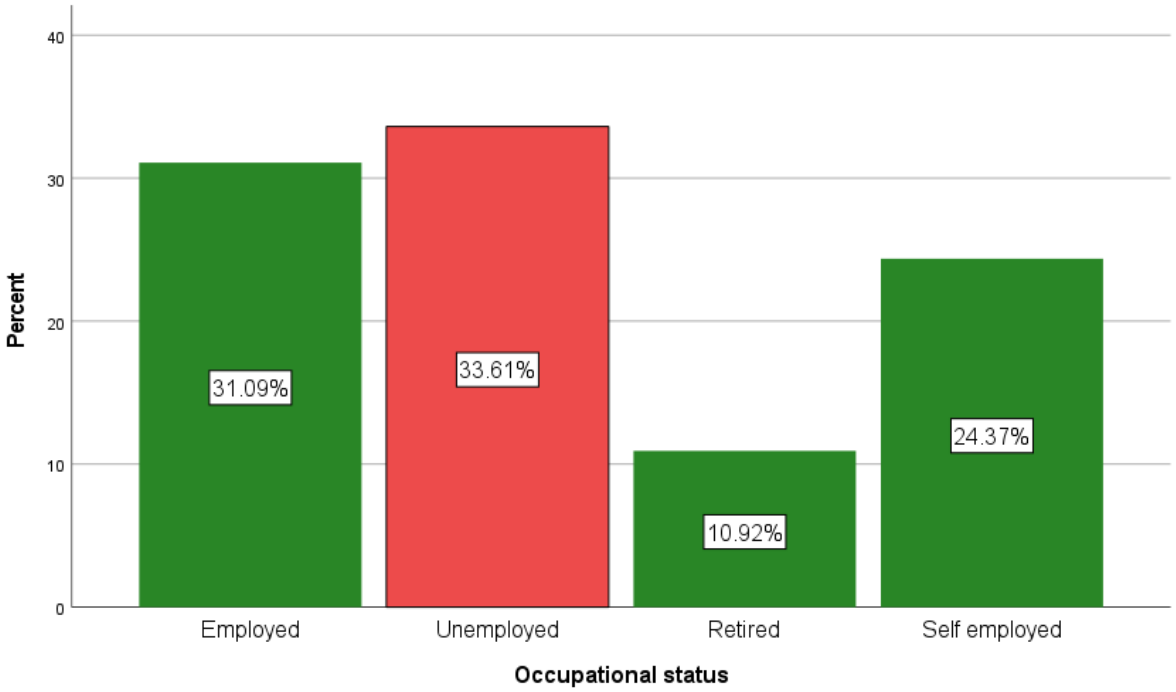

Figure .5.4: Occupational Status

Source: field data (2025)

Figure 5.4 above shows the distribution of the respondents' occupational status. The data revealed that among the surveyed respondents, 33.61% are unemployed, making this the largest occupational category. This high unemployment rate aligns with challenges identified in similar studies, such as Viljoen et al. (2021), which highlighted that unemployment often exacerbates issues related to household waste management in rural and remote areas due to limited financial resources and reliance on public or communal waste collection systems. Meanwhile, 31.09% of respondents are employed, indicating that approximately one-third of the population contributes economically, which could influence their capacity to afford private solid waste collection services or engage in sustainable waste management practices. Additionally, 24.37% of

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respondents are self-employed, suggesting a degree of entrepreneurial activity. Self-employed individuals may experience specific challenges, such as managing waste from small businesses, which is often not covered by municipal waste collection.

Occupational status was included in the regression analysis to determine whether a respondent's employment status influences their perception of how effective and sustainable solid waste collection services are in the study areas. The results clearly showed that occupational status does not significantly influence perceptions of solid waste collection effectiveness in Muledane and Maniini. The very high p-value of 0.934 and the near-zero standardised beta (–0.005) indicate that whether a respondent is employed, unemployed, self-employed, or retired has no predictive value in this model. This suggests that perceptions of waste collection services are not shaped by one's economic activity, but are more likely influenced by systemic or environmental factors, such as collection frequency, reliability, and availability of infrastructure.

The retired category accounts for 10.92% of respondents, highlighted a smaller, yet significant, proportion of the population who may rely on fixed incomes and thus have limited means to invest in solid waste collection solutions. These percentages underscored the socioeconomic dynamics influencing waste management behaviours and highlight the need for tailored interventions. As Viljoen et al. (2021) emphasise, understanding the occupational distribution in a community is critical for developing effective waste management policies, especially in resource-constrained settings where unemployment and low-income levels create barriers to sustainable practices.

Occupational status affects solid waste generation disposal habits and engagement with solid waste collection services. Town and regional planners can use the data to optimise solid waste collection schedules, infrastructure development, and community programs for sustainable household solid waste collection. Employed people generate less household waste due to eating out. Occupational status affects how and where solid waste is generated and how people engage with solid waste collection services. A spatially inclusive solid waste collection strategy should tailor collection infrastructure, frequency, and awareness programs to match community needs.

5.2.5 Household Income Levels

Figure 5.5 below shows the income level, the study data shows that income levels in the surveyed population are distributed across five categories, with the most significant

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proportion of respondents, 39.08%, earning R5100 and above. This is followed by 21.85% of respondents who earn between R3600 and R5000. These two higher-income brackets account for over 60% of the population, indicating that a significant portion of the surveyed households fall within the middle-to-upper-income categories. On the other hand, 17.23% of respondents earn between R600 and R1500, while 11.34% earn between R1600 and R3500. The lowest income group, earning R0 to R500, comprises 10.5% of the total population.

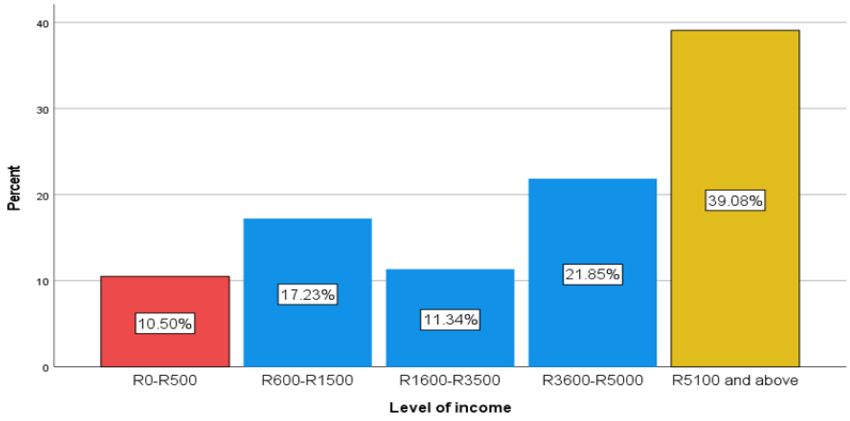

Figure .5.5: Household Income Levels

Source: field data (2025)

Regression analysis showed that household income levels did not significantly influence perceptions of the effectiveness or sustainability of solid waste collection services in the study area ($p = 0.712$). This suggests that both low- and high-income households expressed similar levels of satisfaction or dissatisfaction with the solid waste collection system in Muledane and Maniini. Even though higher-income households might be expected to demand more reliable services, or have the means to secure private alternatives, this did not translate into statistically different satisfaction levels.

When comparing these findings to Ramukhwatho, du Plessis, and Oelofse's (2016) study on household food wastage in Tshwane, it is evident that income levels significantly influence household behaviours, particularly in solid waste generation. The Tshwane study highlighted that higher-income households are more likely to generate larger quantities of food waste, often due to their ability to afford more food, which increases the likelihood of wastage. Similarly, the World Bank (n.d.). Data reinforces the correlation between income levels and global waste generation trends,

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showing that households in higher-income brackets consume more and subsequently generate more waste, including solid and food waste. Applying these insights to the current data, it is plausible to infer that households in the R5100 and above income bracket are more likely to contribute significantly to waste production in the surveyed area. Conversely, the lower-income groups (R0 to R500 and R600 to R1500) will likely exhibit more conservative consumption and solid waste practices due to financial constraints. This triangulation underscores the importance of income-specific solid waste collection strategies, particularly for the higher-income brackets most likely to contribute to solid waste accumulation.

Low-income residents need a solid waste collection that is accessible and free to avoid problems like illegal dumping, as referenced in Maniini Tshikovha. The place is a low-income residential area, it is on the outskirts of the Maniini area. The residents do not receive solid waste collection, resulting in burning waste and illegal dumping along the river and wetlands. The same situation is happening in Muledane block Vhatukani. Middle-income requires structured, solid waste segregation and collection schedules. High-income areas require specialised recycling, composting, and electronic solid waste collection services. It is evident from the data that household income affects solid waste generation, disposal and engagement in sustainable solid waste collection. Spatial planning strategies should ensure equitable access to solid waste collection services regardless of income level while encouraging sustainable practices across all income groups.

5.2.6. Place of residence

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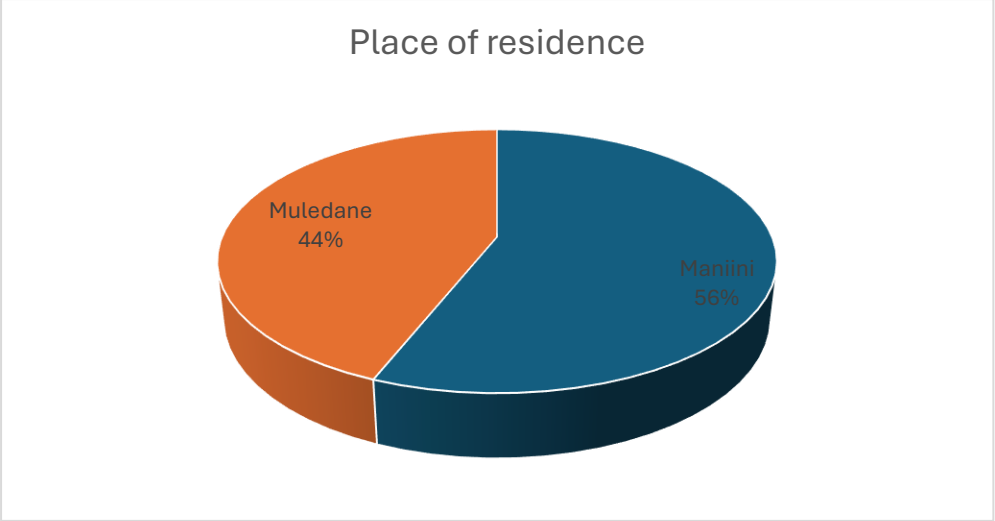

Figure 5.6: Place of residence

Source: field data (2025)

Figure 5.6 shows the pie chart showing the residents' distribution between the two areas. Muledane represented 44% of the residents, and Maniini comprises a slightly more significant portion with 56% of the population. According to the study, this distribution highlighted the relative populations of these two areas, which are growing rapidly. The research context of Muledane and Maniini, which are peri-urban areas undergoing spatial transformation, is crucial, as it influences solid waste collection practices and the challenges faced by the local municipality in managing solid waste.

The regression analysis assessed whether the place of residence, whether respondents lived in Muledane or Maniini, significantly influenced their perception of the effectiveness and sustainability of household solid waste collection services. The findings revealed that place of residence had an unstandardised coefficient (B) of –0.328, a standardised beta of –0.143, and a p-value of 0.189, which is above the 0.05 threshold for statistical significance. This suggests that although there is a slight tendency for respondents from one area to report lower satisfaction levels, this difference is not statistically meaningful. The confidence interval [–0.818, 0.162] and the t-value of –1.318 further confirm the lack of a strong relationship. These results indicate that spatial location alone does not significantly predict how respondents perceive waste collection effectiveness.

The uneven distribution of residents between these two areas can impact how solid waste collection strategies are applied, with a higher population in Maniini likely

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putting more pressure on waste collection systems. This demographic distribution is essential in developing practical and sustainable waste collection strategies for these areas.

5.2.7. Household Size

The survey data, as illustrated in Figure 5.6, indicates that household sizes in the studied area vary significantly. The survey data revealed that household sizes in the studied area vary significantly, with the majority comprising five members, accounting for 62.03% of the total respondents. This indicates that medium-sized households are predominant in the community. Households with four members represent 11.39%, while smaller households with two and three members account for 1.27% and 4.22%, respectively. Larger households comprising six members comprised 8.44%, and households with seven members contributed 4.22%. Additionally, eight-member households account for 8.02%, while those with nine members constitute only 0.42%. The cumulative percentage analysis highlights that 78.9% of households have up to five members, while households with more than five members gradually taper off, reaching a cumulative total of 100% at nine members.

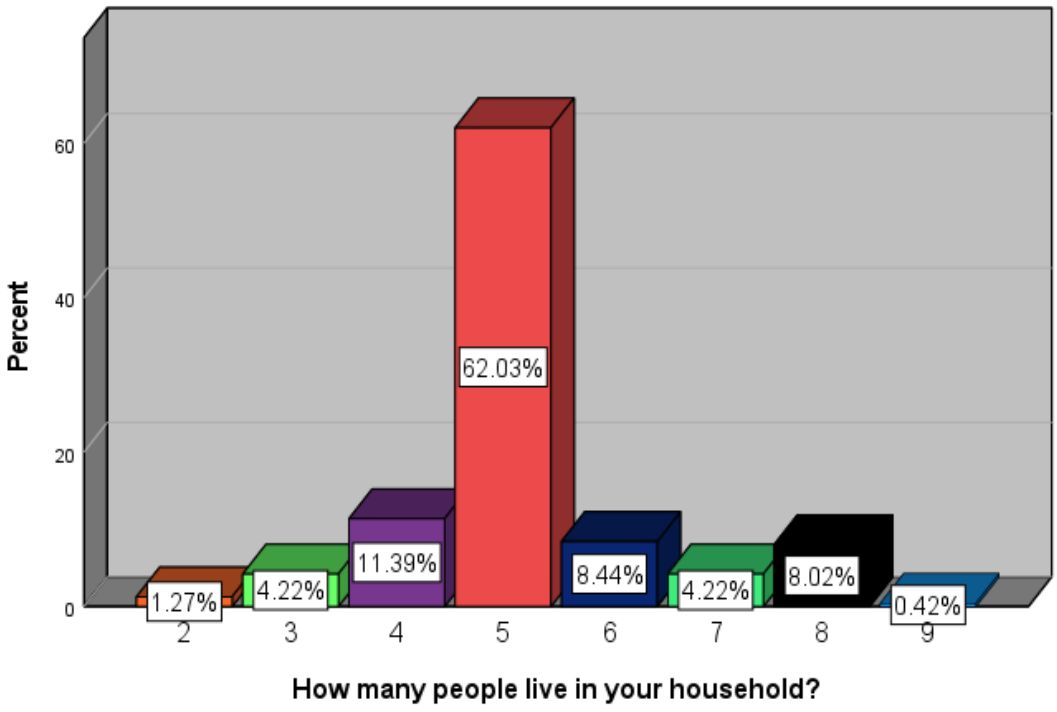

Figure 5.7: Household size

Source: field data (2025)

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The regression analysis explored whether the number of individuals residing in a household significantly influenced the perception of the effectiveness and sustainability of current household solid waste collection practices in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was 0.035, with a standard error of 0.062, and a standardised beta coefficient (Beta) of 0.036. This revealed a very weak positive relationship, suggesting that as household size slightly increases, there is a marginal rise in the perception of effective and sustainable solid waste collection. However, this relationship is statistically insignificant, as the p-value is 0.578, which is substantially greater than the conventional threshold of 0.05. The t-value was 0.557, further indicating that the effect of household size on waste collection perceptions is weak and unreliable. The 95% confidence interval for B, ranging from –0.088 to 0.157, includes zero and is relatively wide, which also implies a lack of precision in the estimate and confirms the insignificance of household size as a predictor.

This finding suggests that the challenges of solid waste collection in peri-urban areas of Muledane and Maniini are not driven by household size, but are instead reflective of broader service delivery issues such as insufficient infrastructure, irregular collection schedules, and spatial planning gaps. Thus, interventions aimed at improving waste management should focus more on operational efficiency and accessibility, rather than tailoring service models based solely on household composition.

Similar trends were observed, when triangulated with the findings of the Journal of the Geographical Association of Tanzania (2024), which analysed household solid waste generation patterns in Morogoro Municipality, where medium-sized households were common contributors to solid waste. Furthermore, Nyampundu et al. (2020) observed in Dodoma City that larger households contribute proportionally higher amounts of waste, particularly in market areas, emphasising the influence of household size on waste management strategies. The current study's emphasis on household size distribution highlighted the need for tailored waste management approaches that consider the predominance of medium-sized households while addressing the needs of larger households, which may place additional pressure on waste collection systems.

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5.3. Subsections for Section B: Characterising the Current Household Solid Waste Collection Practices in Muledane and Maniini

5.3.1. Parties for Household Solid Waste Collection

The analysis of household solid waste collection responsibility in Muledane and Manini revealed notable trends in the frequency distribution. Most respondents (67.65%) identified the municipality as the primary entity responsible for household solid waste collection, indicating a significant reliance on local government structures for waste management services. However, 9.24% of respondents reported that households are responsible for waste collection, reflecting a notable population segment that may lack access to municipal services or prefer alternative collection methods. Additionally, 23.11% of respondents indicated that solid waste collection does not apply to their households. This could be attributed to insufficient service coverage, uncollected waste, and self-managed waste disposal methods. Figure 5.8 below shows different organisations that provide household solid waste collection. The statistic shows that there is a high reliance on municipal services. However, it also shows a gap in solid waste collection provision, especially in peri-urban households.

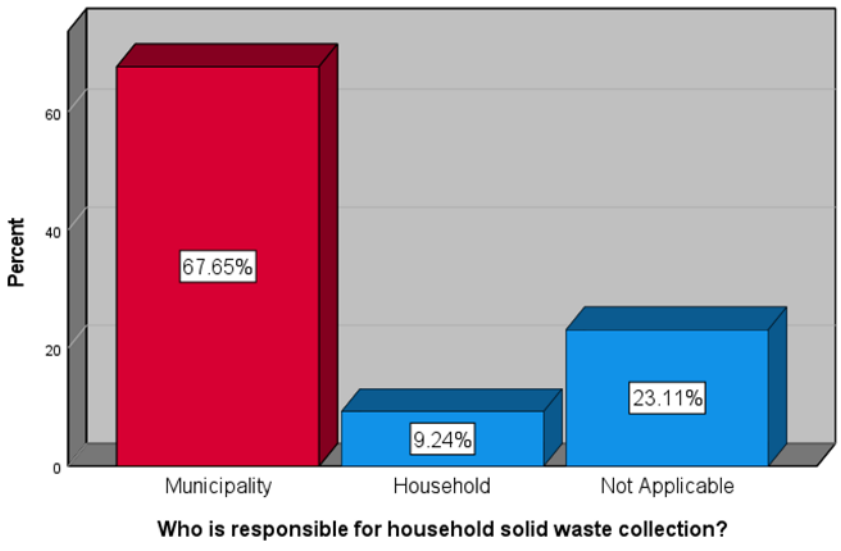

Figure .5.8: Parties for Household Solid Waste Collection

Source: field data (2025)

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When respondents said it is not applicable, it applies to them because, in some areas, they do not receive municipal collection services. After all, they do not pay for municipal services. From a semi-structured interview, the Department of the Environment at the Thulamela Local Municipality confirmed that some areas do not receive solid waste collection because the municipal collection program has not been extended to all the regions due to a lack of resources.

The regression analysis examined whether the party responsible for household solid waste collection influenced respondents' perceptions of the effectiveness and sustainability of waste collection services in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was 0.148, indicating a small positive relationship between the responsible party and perceptions of effectiveness. This means that when responsibility is clearly assigned (e.g., to the municipality, private companies, or community groups), there is a slightly better perception of how effective and sustainable the collection services are. However, this relationship was not statistically significant, as the p-value was 0.272, which is higher than the 0.05 benchmark. This means that the effect is not strong enough to be considered meaningful or reliable in this study.

The standardised beta coefficient (Beta) was 0.162, suggesting a moderate standardised influence, but again, it is not statistically significant. The t-value of 1.101 supports this, showing that the result is weak. The 95% confidence interval for B ranged from –0.117 to 0.412, which includes zero, further confirming that the predictor is not statistically reliable. The correlations were low: the zero-order correlation was –0.033, the partial correlation was 0.077, and the partial correlation was 0.066, all indicating a weak relationship between the party responsible and the dependent variable.

These findings align with observations in similar studies, such as Viljoen et al. (2021), which highlighted challenges in rural waste management, including limited municipal service coverage and relying on households to manage their waste in remote areas like the Hantam Municipality. Furthermore, the National Domestic Waste Collection Standard (2011) under South Africa's Waste Act mandates municipalities to provide adequate waste collection services, yet the observed 23.11% reporting "Not Applicable" underscores gaps in adherence to these standards, highlighting persistent challenges and inequitable service delivery and access. These variations emphasise the

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critical need for targeted interventions to bridge service delivery gaps, improve municipal capacity, and ensure that waste collection services reach all households effectively, especially in underserved areas.

According to Thulamela Local Municipality officials, the number of households receiving refuse removal services at least once a week is 120,068, and households using their refuse dump amount to 40,660. Households with no rubbish disposal services total 96,234."this statement supports the findings above. The data aligns with NEMWA, which mandates municipalities ensure effective, sustainable solid waste collection. Regardless, there is a presence of households that are not served. Spatial planning gaps are contributing to unequal collection services in peri-urban. Thulamela Local Municipality's integrated waste management plans must be re-evaluated to ensure inclusivity.



Picture 5.1: Municipal solid waste collection

Source: field data (2025)

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The researcher also observed the collection done by the municipality in many parts of these two villages, the process that the workers used. The municipal solid waste collection is shown in picture 5.1. Workers are actively engaged in collecting and loading solid waste onto a municipal garbage truck. The workers manually pick up waste from the roadside and dump it into the truck. Black plastic bags and a trash bin are visible, indicating a mixed method of waste collection.

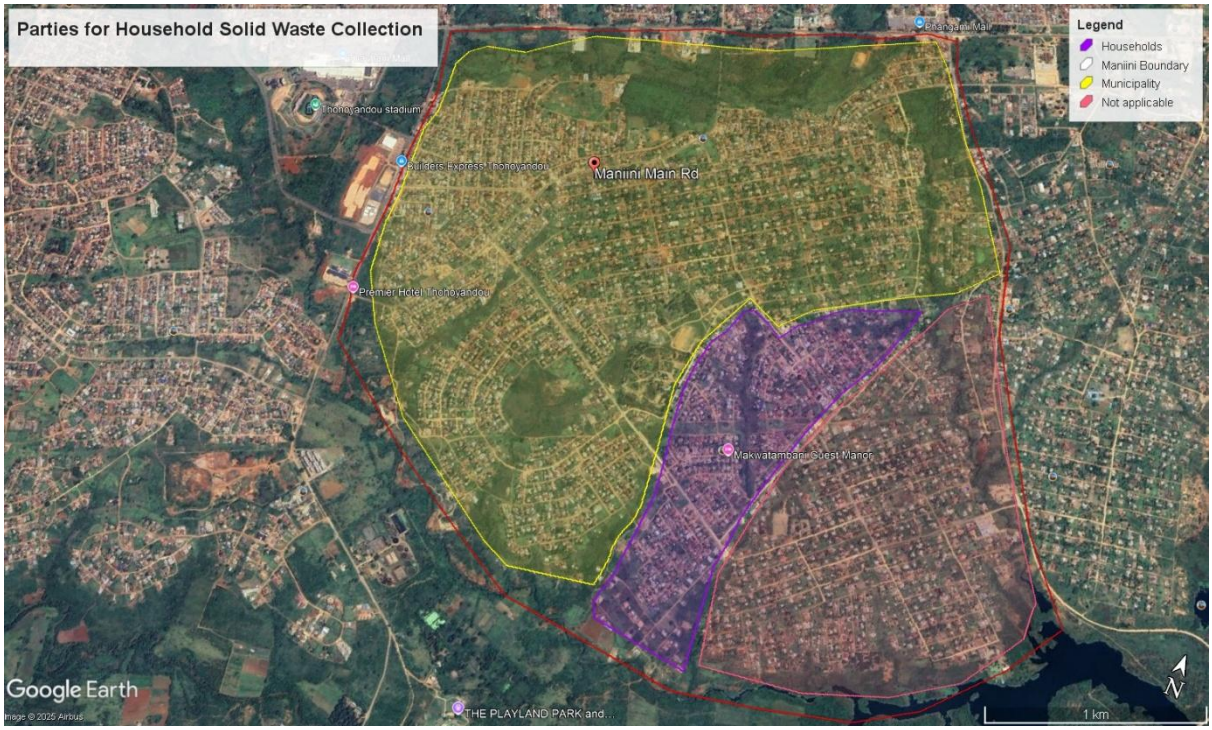

Figure 5.9: Spatial Distribution of Solid Waste Collection Responsibility in Maniini Village

Source: Mutwanamba (2025)

Figure 5.9 shows the map spatial distribution and delineation of responsibilities for household solid waste collection services in Maniini village, one of the two peri-urban case study areas in Thohoyandou, Thulamela Local Municipality. From the map most of the collection is done by the municipality.

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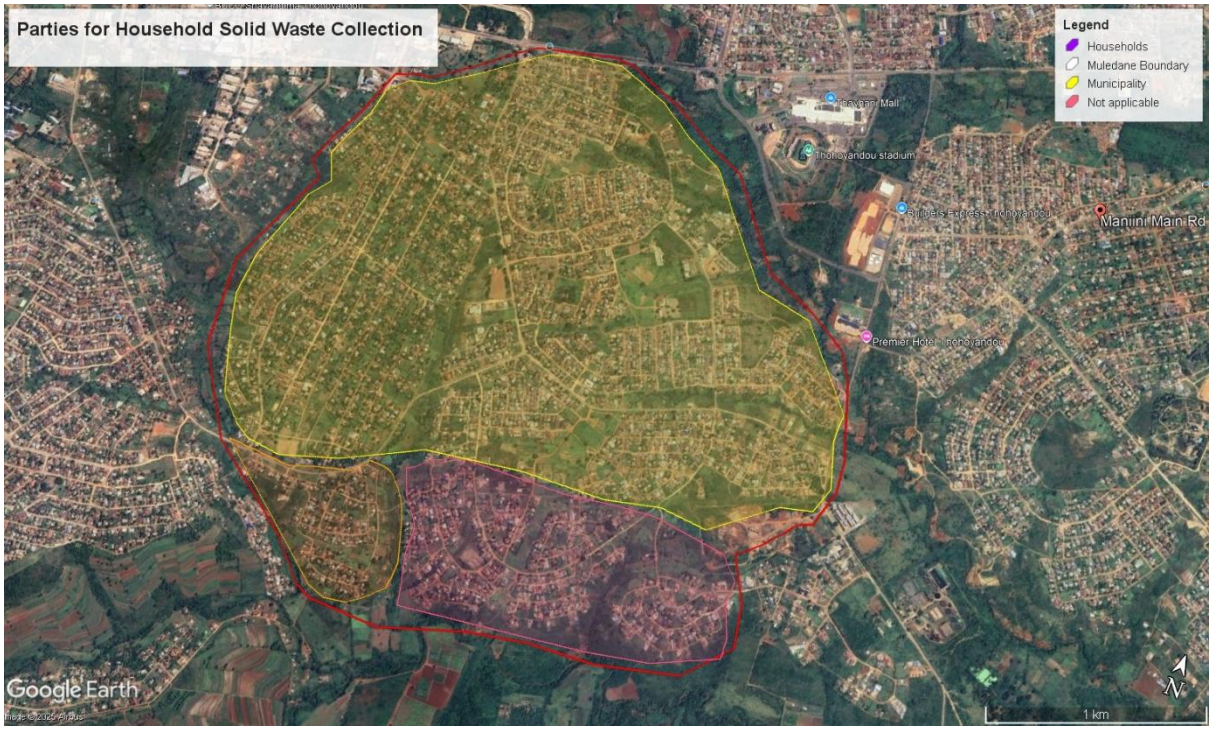

Figure 5.10: Spatial Distribution of Solid Waste Collection Responsibility in Muledane Village

Source: Mutwanamba (2025)

Figure 5.10 shows a map that illustrates the spatial layout of Muledane village in Thohoyandou, as it relates to household solid waste collection responsibilities. It identifies and categorises the parties responsible for solid waste collection.

5.3. 2. Methods of Solid Waste Collection

The data on methods of solid waste collection highlighted significant variations in the frequency of use for different collection methods within the study area, as shown in Table 4.2. Wheelbarrows are utilised with varying frequency, as evidenced by 48.3% of respondents indicating they "never" use them. In comparison, 21.4% reported using them "always," resulting in a mean value of 2.47 and a standard deviation of 1.655. This suggests that while wheelbarrows are moderately utilised in some cases, their use is inconsistent across households. Similarly, manual tricycles appear to have limited use, with 45.8% of respondents indicating "never" and only 1.3% reporting "always," giving a mean of 1.83 and a lower standard deviation of 0.996, which implies a general agreement among respondents about their infrequent use. Motor tricycles exhibit even

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less usage, with a dominant 73.9% reporting "never" and a mean of 1.47 alongside a standard deviation of 0.884, reinforcing the perception that this method is rarely employed.

Criteria	Never	Rarely	Sometimes	Often	Always	mean	Std. Deviation
Wheelbarrows	48.3%	10.9%	8.0%	11.3%	21.4%	2.47	1.655
Manual tricycles	45.8%	37.4%	5.9%	9.7%	1.3%	1.83	0.996
Motor tricycles	73.9%	9.2%	12.6%	3.8%	0.4%	1.47	0.884
Taxis	40.8%	36.6%	10.5%	10.5%	1.7%	1.96	1.043
Mini-compact trucks	43.3%	22.7%	7.6%	19.3%	7.1%	2.24	1.369
Large compact or dump trucks to long trailers	24.8%	5.0%	3.4%	31.9%	34.9%	3.47	1.595

Table 5.1: Methods of solid waste collection

Source: field data (2025)

Taxis, on the other hand, show slightly broader use, with 40.8% reporting "never" and 10.5% indicating both "sometimes" and "often," leading to a mean of 1.96 and a standard deviation of 1.043. This reflects some diversity in their usage, albeit with a tilt toward infrequency. Mini-compact trucks also have a mixed usage pattern, with 43.3% reporting "never" and 19.3% reporting "often." The mean for this category stands at 2.24, with a standard deviation of 1.369, reflecting moderate variability. In contrast, large compact or dump trucks and long trailers show a more pronounced and consistent usage pattern, with 24.8% reporting "never" and the highest percentage, 34.9%, indicating "always." This method yields a mean of 3.47 and a relatively high standard deviation of 1.595, reflecting its prominent and consistent role in solid waste collection in the area.

The regression analysis assessed whether the methods used for household solid waste collection significantly influenced respondents' perceptions of the effectiveness and sustainability of these services in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.139, indicating a weak negative relationship between the method of waste collection and the perceived effectiveness of the waste management system. This suggests that when less formal or manual methods such as wheelbarrows and tricycles are used, there is a slight decline in residents' confidence in the sustainability and efficiency of the waste collection system. The standardised beta

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coefficient was –0.164, further confirming the weak inverse relationship. However, this relationship was not statistically significant, as evidenced by a p-value of 0.231, which is far above the commonly accepted significance threshold of 0.05. The t-value of –1.201 supports this lack of statistical significance, implying that the method of waste collection does not have a meaningful or consistent impact on how residents view the waste management system. Additionally, the 95% confidence interval for the B coefficient ranged from –0.367 to 0.089, which includes zero and reflects the unreliability of the effect.

Motor tricycles had the lowest percentage of respondents reporting never using them. This shows a lack of infrastructure and accessibility for such vehicles. Manual tricycles have a high usage level, showing that many households rely on non-motorised transport for waste transportation. This is because of the affordability and lack of road networks. The highest dependency on large trucks shows that large-scale municipal solid waste collection systems dominate and cover a large area. Roads and pathways should be designed to accommodate motorised solid waste collection vehicles particularly motor tricycles, which navigate narrow spaces better than large trucks. Households using wheelbarrows and manual tricycles benefit from designated drop-off points closer to residential areas.

When triangulated with findings from Ahmed's (2018) discussion on solid and hazardous waste management, these variations align with the observation that infrastructure availability, economic factors, and operational preferences heavily influence solid waste collection methods. The predominance of large compact trucks in the "always" category suggests that they are likely the primary method of formal municipal waste collection, as highlighted in the literature. Furthermore, similar situations were observed in Accra and Nairobi, Studies in Accra (Amoah et al., 2020) and Nairobi (Karanja et al., 2021) similarly report high dependence on informal waste collectors in peri-urban zones. The same trend is evident in Thohoyandou peri urban, where some households self-manage their waste or rely on wheelbarrows and manual tricycles due to the lack of municipal infrastructure, especially in low-income zones of Maniini Tshikovha and Muledane Block Vhatukani

Linking to the principal-agent theory, the reliance on manual and informal solid waste collection (wheelbarrows, manual tricycles) shows municipal waste authorities' failure

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in service provision (principal). Table 5.3 shows Henri Lefebvre's triad of space production.

Henri Lefebvre's triad of space production	Description
Conceived space	The IWMP exist but is not fully implemented in small towns.
Perceived space	The low use of motorised transport shows a lack of well-planned waste collection routes and infrastructure in peri-urban areas.
Lived space	Residents improvise solid waste collection using wheelbarrows and tricycles, revealing a mismatch between formal policies and on-the-ground realities.

Table 5.2: Henri Lefebvre's triad of space production

Source: Mutwanamba (2025)

Looking at the SPLUMA principle, spatial justice emphasises equal access to services. However, the data showed that peri-urban areas have inadequate access to collection services, reflecting spatial inequalities. The principle of spatial efficiency promotes efficient land use and infrastructure planning. The low use of motorised transport in solid waste collection shows inefficiencies in road networks and spatial planning.

Depending on the spatial plan and area income level, collection can be done by any method: wheelbarrows, manual tricycles, motor tricycles, taxis, mini-compact trucks, and large compact or dump trucks to long trailers (Volsuuri, 2023). The statement by Volsuuri (2023) aligns with the data presented in Table 5.1, which illustrates the frequency of different household solid waste collection methods. The choice of collection method depends on spatial planning and area income levels, as suggested by the variation in the use of different transport types. The findings from Table 5.1 confirm that waste collection methods vary depending on spatial planning and income levels. Low-income peri-urban areas may rely on wheelbarrows and tricycles due to affordability, while higher-income regions or those with better infrastructure benefit from mini-compact trucks and large dump trucks. This supports Volsuuri's (2023) claim that waste collection methods are context-dependent and influenced by settlement patterns and available resources.

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5.3.3. Frequency of Waste Collection

Figure 5.11. The data below shows the frequency of household solid waste collection in the study, revealing a clear trend in how often waste is collected in the area. The most significant proportion, 62.18%, of respondents reported that their household solid waste is collected once a week. This indicates that weekly waste collection is the predominant practice in the area, reflecting a regular service functioning for most households. On the other hand, a substantial 32.35% of respondents indicated that their household waste is not collected at all. Figure 5.8 highlighted a significant gap in solid waste collection coverage, with nearly one-third of the households in the study area experiencing a lack of regular waste collection services. Only a tiny minority, 5.46%, reported that their household waste is collected twice weekly, suggesting that more frequent collections are not widely implemented.

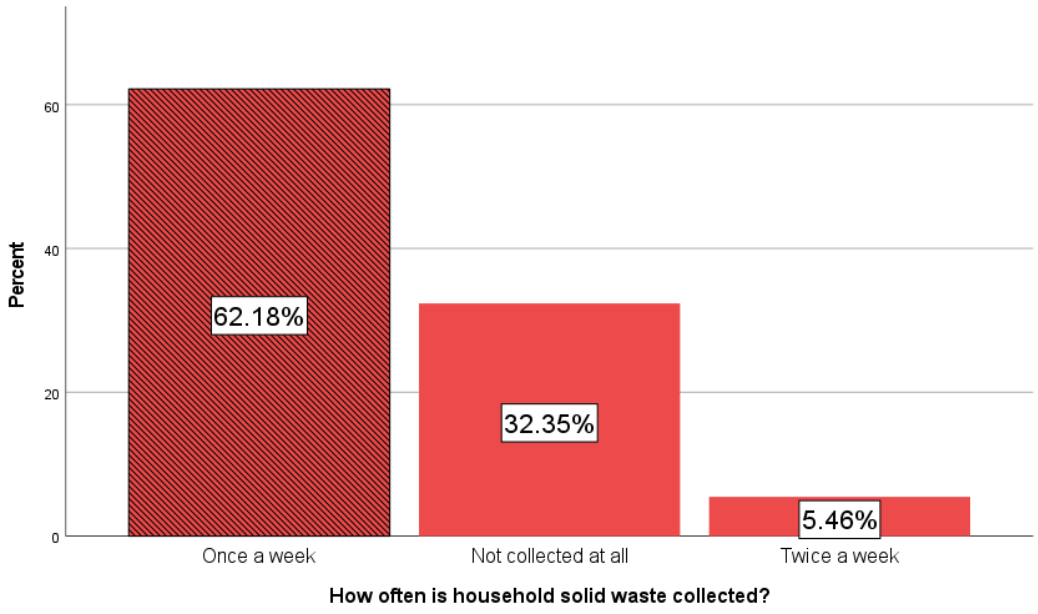

Figure .5.11: How often household solid waste collected

Source: field data (2025)

In terms of the cumulative percentages, including both those receiving weekly collection services and those with no collection at all raises the figure to 94.5%, signifying that most respondents fall into these two categories. This concentration of responses on just a few options suggests a polarised waste collection system in which the majority either have weekly collections or none, with only a tiny portion receiving

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more frequent services. Households receiving solid waste collection once per week show that most residents have access to formal collection services. However, this is insufficient for many households, resulting in illegal dumping and burning of waste. The 32.35% is alarming as it shows that nearly one-third of peri-urban residents lack access to municipal solid waste collection; the gap indicates that the municipality is biased towards well-developed areas. Weekly collection schedules show that most households have overflowing solid waste, introducing drop-off points allows easier access for unserviced residents. The Thulamela Local municipality officials also said that they are aware that they do collection once per week in most villages, which they admit is not enough. Thulamela, as the local municipality, is facing many challenges regarding solid waste collection.

The regression analysis investigated whether the frequency with which household solid waste is collected influences respondents' perceptions of the effectiveness and sustainability of the waste management system in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was 0.131, and the standardised beta coefficient was 0.122, indicating a weak positive relationship. This implies that as the frequency of waste collection increases, there is a slight improvement in how residents perceive the effectiveness and sustainability of the service. Despite this positive direction, the relationship was not statistically significant, as the p-value was 0.216, which is above the 0.05 threshold. The t-value of 1.240 further supports the insignificance of the variable, meaning the frequency of collection does not have a reliable or meaningful impact on perception levels. The 95% confidence interval for B ranged from –0.077 to 0.339, and since this range includes zero, it reinforces the finding that the variable is not a statistically valid predictor.

A similar situation was observed in "Case Study of Malaysian Cities, (Cheng, K.M et al., 2022). (Ebekozien et al., 2022)" Household solid waste is increasing, putting pressure on the environment (pollution). The peri-urban population has grown rapidly, and households generate more solid waste. This puts municipality resources under pressure, municipalities face the challenge of managing the waste of the increasing population, 32.35% prove that the municipalities are failing to manage solid waste in peri-urban areas due to the growing population.

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When compared with the National Domestic Waste Collection Standards, as outlined in the *National Environmental Management: Waste Act, 2008*, it is evident that the standards emphasise consistent and reliable waste collection schedules, emphasising reducing irregularities in collection frequency. The fact that such a significant portion of respondents in this study indicated that waste collection is either irregular or non-existent points to a discrepancy between the standards set by the National Waste Act and the reality faced by many households in the study area. The data presents a concern about the adequacy and sustainability of waste management services, particularly for the 32.35% of households that report no waste collection, a figure that starkly contrasts with the Act's emphasis on regular collection.

Furthermore, in reference to 2.4.3.4.1. Case study of Nikki (Benin), Design of a Municipal Solid Waste Collection System in Situations with a Lack of Resources. The data from the survey similarly resemble the situation in Benin. Limited financial and logistical constraints constrained solid waste management. 32.35% of households do not receive waste collection at all, forcing them to resort to illegal dumping and burning waste, which is similarly happening in Nikki. Nikki's lesson is that limited solid waste collection was a significant problem for peri-urban and informal settlements, requiring innovative and low-cost collection; from the data, households that receive collection twice a week indicate that solid waste collection services are not equitable.

5.3. 4. Provision of Solid Waste Bags

In analysing the data provided regarding the responsibility for providing solid waste bags, a clear trend emerges regarding who is responsible for this task, as shown in Figure 5:13 below a substantial portion of respondents, 52.1%, indicated that the municipality is responsible for providing solid waste bags. This is the most significant percentage and signifies that the Municipality plays a key role in ensuring the provision of waste bags for households. A smaller group, 23.11%, believed that the responsibility lies with individual households, suggesting that a significant proportion of the population manages waste collection resources themselves.

The remaining 24.79% of respondents indicated that the provision of solid waste bags is not applicable in their context, which could reflect either the lack of a solid waste bag provision system in their area or the use of alternative waste management methods.

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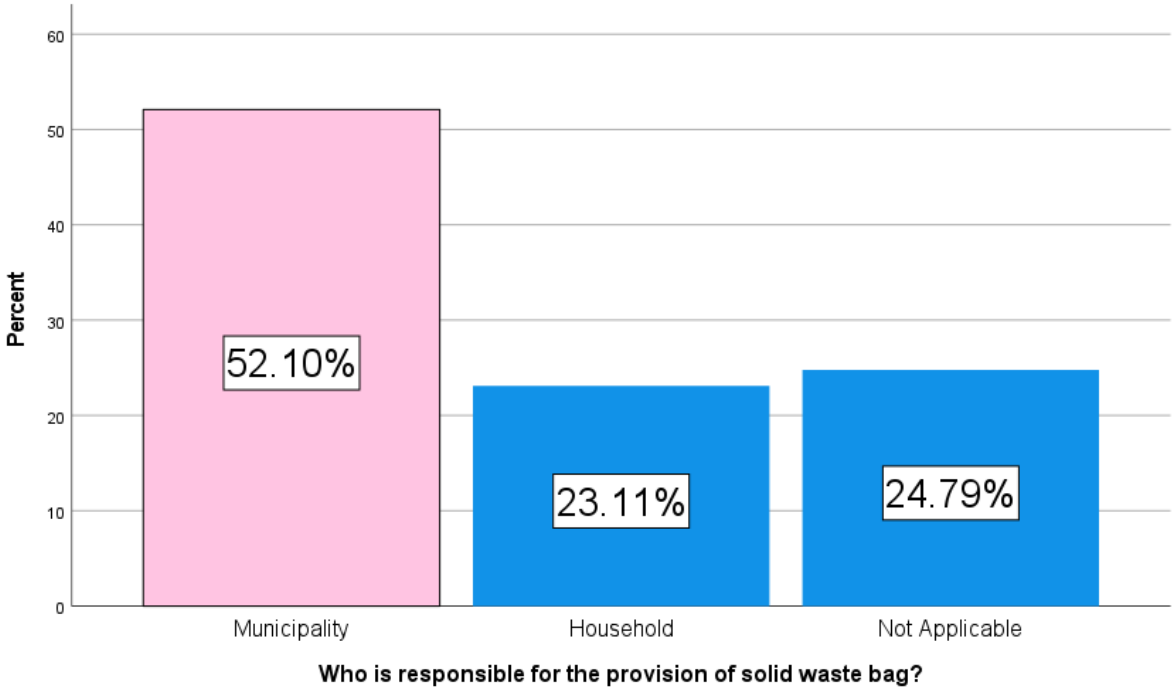

Figure.5.13: The responsibility for the provision of a solid waste bag

Source: field data (2025)

The regression analysis explored whether the entity responsible for providing solid waste bags influenced respondents' perceptions of the effectiveness and sustainability of household waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.236, indicating a negative relationship between this variable and the perception of waste collection effectiveness. This suggests that when there is ambiguity or dissatisfaction regarding who provides solid waste bags whether it be the municipality, households themselves, or another party residents are more likely to perceive the waste collection service as less effective or sustainable.

The standardised beta coefficient was –0.256, which denotes a moderate inverse effect, though still statistically not significant. The p-value was 0.098, slightly above the standard threshold of 0.05, meaning the relationship does not meet the criteria for statistical significance but is relatively close to being marginally significant. The t-value was –1.665, which indicates a moderate but statistically inconclusive effect. The 95% confidence interval for B ranged from –0.516 to 0.044, and because this interval includes zero, the result is not statistically reliable.

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When triangulated with this, the data illustrated the diverse approaches to solid waste management practices, where the municipality is seen as the primary actor in waste provision, but a significant portion of the population either believes they are responsible or faces a situation where waste bag provision does not apply. Municipality authorities providing solid waste bags is evidence that it is responsible for public service for solid waste management. Households' responsibility indicates a household awareness of self-provision where municipal service is lacking. It is not applicable to areas where households do not receive solid waste collection services at all, which means that households are responsible for their solid waste. However, a gap between solid waste collection services still needs immediate attention. From the semi-structured interview conducted at Thulamela Municipality, the officials indicated that it is not their duty to provide solid waste bags to households, it is just a favour to support the household with prioritising the solid waste collection system. The Municipality volunteers to give households solid waste bags, but not all households get them.

SPLUMA advocates for coordinating spatial planning, focusing more on the principle of spatial justice, which is linked to 24.79% of respondents still excluded from collection services. This shows spatial inequalities in service provision. NWMS 2020 emphasises access to solid waste collection services and producer responsibilities households responsible for their solid waste bags must implement this strategy. SDFs and municipality by-laws need to include solid waste collection in their policies. Not applicable shows areas where local service must focus when planning strategically.

Linking to the principal-agent theory, municipalities must act to benefit the communities regarding collection service. The household responsible for their solid waste bins, which are not applicable, shows the municipality's failure, this means that the municipality is not meeting public expectations.

5.3.5. Modes of Waste Collection

The data on household solid waste collection methods in the area revealed interesting insights when looking at the percentage distribution shown in Figure 5.14 below. The most common method for collecting household waste is curbside collection, with 55.88% of respondents indicating this as the primary method. This is followed by the "House to house" method, which accounts for 27.73% of the responses. While still

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significant, block collection is utilised by 15.13% of the respondents, reflecting a lower prevalence than the other methods. Delegated service, which might indicate more individualised or private handling of waste, was the least utilised option, with only 1.26% of respondents indicating it as their method of waste collection. These percentages suggest that curbside collection is the dominant waste collection system in the area. In contrast, though presented, other methods like house-to-house and block collection represent smaller portions of the total responses.

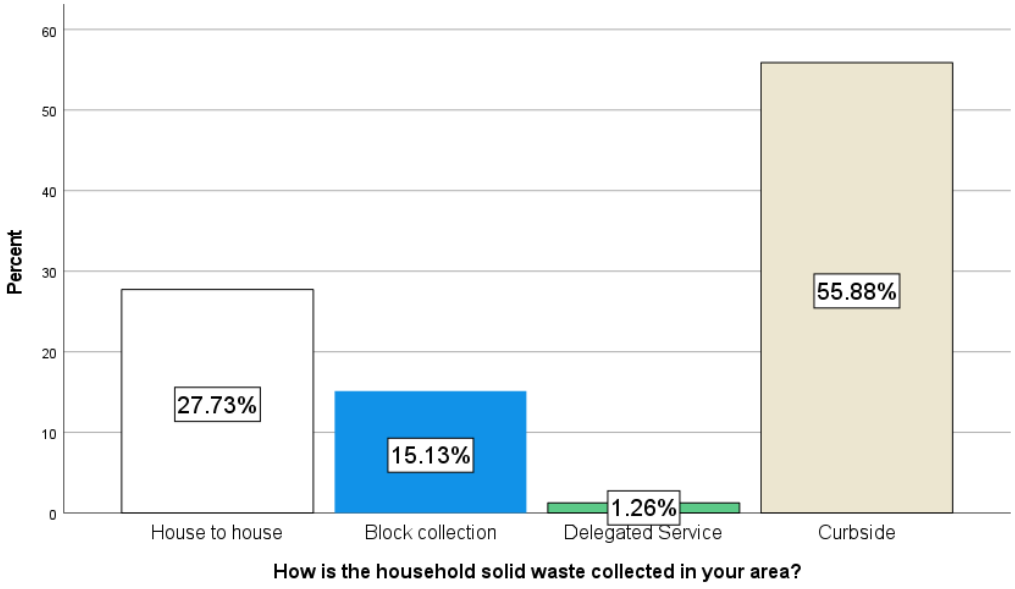

Figure 5.14: How solid waste is collected in the area

Source: field data (2025)

These figures offer an overview of the primary methods employed for household waste collection, highlighting curbside collection as the most widely adopted method, with a substantial gap between it and other alternatives. High dependency on curbside collection indicates a formal municipal solid waste collection service. This method aligns with national waste management standards but poses risks like littering due to pick-up delays and animal scattering waste. This shows the municipality provides formal solid waste collection infrastructure in some peri-urban areas. Households who receive house-to-house collections are in well-developed areas with sophisticated infrastructure. This method reduces littering, improves efficiency, and needs more resources from the municipality. Households that have municipality collection fees

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receive such kind of service. This method is for those who stay in urban areas or high residential zones. Delegated service percentage shows that a few areas depend on another collection service. This shows municipal inefficiency. Linking the data from the interview guide, which was conducted at Thulamela Local Municipality, the officials said, "Because these two villages are our peri-urban, which is growing fast, the municipality needs to prioritise house-to-house collection because it is accessible by every household. Only a few parts of those villages do not receive collection at all because the areas are inaccessible. Still, they try all means to block collections, and most households are too lazy to bring their waste to the collection points". The researcher also observed that these areas do not have well-designated collection points, and the collection points there on infrastructure are just open spaces with nothing and no sign to show that these are collection points.

The regression analysis evaluated whether the mode of household waste collection referring to the specific way in which waste is physically collected (e.g., from curbsides, central points, door-to-door, etc.) significantly affects how residents perceive the effectiveness and sustainability of household waste collection services in the peri-urban villages of Thohoyandou. The unstandardised coefficient (B) was –0.139, which indicates a negative relationship. This means that certain modes of waste collection, particularly those that may be inconvenient, inconsistent, or poorly structured, are associated with reduced satisfaction and lower perceptions of service effectiveness. In simple terms, the more disorganised or distant the waste collection method is, the less effective and sustainable it is perceived to be by the community.

The standardised beta coefficient was 0.164, showing that this negative relationship persists even after adjusting for other variables in the model. However, this relationship is not statistically significant, as the p-value is 0.231, which is well above the 0.05 significance threshold. The t-value of -1.201 also reflects that this predictor does not have a strong or reliable effect on perceptions of waste collection effectiveness. The 95% confidence interval for B ranges from –0.367 to 0.089, and since it includes zero, it further confirms the lack of statistical significance. This means we cannot confidently say that the mode of collection has a true effect, positive or negative, on how residents evaluate waste services.

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The Waste Act (2008) and the National Domestic Waste Collection Standard 2011 vary in their collection methods, indicating levels of compliance with solid waste collection standards. Spatial planning should integrate solid waste collection infrastructure to expand equitable service provision. Areas that rely on block collections and delegated service lack municipal planning and implementation. SDG 11 promotes inclusive, safe, resilient and sustainable urban development. Local government must provide adequate solid waste collection in urban and peri-urban areas. Linking exists, voice and loyalty exist, delegated service and block collection resort to illegal dumping because municipal service is adequate. Voice, curbside collection, household advocacy, so that the collection service changes door to door. Loyalty: households using block collection demonstrate resilience despite collection service gaps.

The data aligns with a statement by Radhika and Sandip (2024). The traditional approach of Collection (Scheduled Collection, Curbside collection) to the solid waste collection is time-consuming, inefficient, unreliable, and lacks real-time assessment (Radhika & Sandip, 2024). The statement by Radhika and Sandip (2024) critiques traditional waste collection methods, such as scheduled and curbside collection, for being time-consuming, inefficient, unreliable, and lacking real-time assessment. As seen in the chart, the high reliance on curbside and scheduled collection methods supports the argument that traditional waste collection remains inefficient and unreliable. These methods lack real-time assessment tools such as GPS tracking, smart bins, or automated scheduling, which could enhance efficiency. Furthermore, a similar situation was observed in Uganda; the case study of Uganda (Nabukeera & Muwanguzi, 2023) shows how spatial constraints and weak integration of land-use plans hinder service delivery. This is mirrored in Maniini and Muledane, where poor road infrastructure and uneven spatial planning make accessing all areas difficult for motorised collection (e.g., large trucks), forcing reliance on curbside and block collection methods. Only 5.46% of respondents benefit from waste collection more than once per week, reinforcing the issue of infrequency in waste removal services.

5.3. 6. Effectiveness and Accessibility of Collection Points

Table 5.4 below shows the analysis of the effectiveness and accessibility of solid waste collection points, revealing a varied perspective among respondents, as reflected by the percentage distribution and corresponding mean and standard deviation values.

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Regarding the sufficiency of designated solid waste collection points, the majority of respondents, 48.3%, strongly disagreed, while only 3.4% agreed, and 40.3% strongly agreed. The mean value of 2.81 indicated a neutral to-disagree stance, with a high standard deviation of 1.904, suggesting significant variation in opinion about the adequacy of waste collection points. This shows that while some respondents agreed, a large portion disagreed or were neutral, indicating an inconsistency in the availability of collection points. On the location of solid waste collection points, 44.1% disagreed with the statement that they were at a reasonable distance, and only 36.1% agreed. The mean value of 2.80, coupled with a lower standard deviation of 1.098, suggests a stronger tendency towards disagreement than the first criterion but with a relatively more consistent opinion among respondents. This indicates that many respondents feel the distance to collection points is not ideal.

Criteria	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	mean	Std. Deviation
There are sufficient designated solid waste collection points	48.3%	6.7%	1.3%	3.4%	40.3%	2.81	1.904
Solid waste collection points located at a reasonable distance	8.4%	44.1%	8.8%	36.1%	2.5%	2.80	1.098
Household Waste is collected timeously	17.2%	24.4%	37.4%	17.2%	3.8%	2.66	1.070
The current household solid waste collection practices are practical and sustainable	17.2%	41.6%	13.0%	24.8%	3.4%	2.55	1.138
Health problems due to household solid waste	16.4%	20.6%	8.8%	37.0%	17.2%	3.18	1.377

Table 5.3: effectiveness and accessibility of collection points

Source: field data (2025)

Regarding the timeliness of household waste collection, 24.4% disagreed, and 17.2% strongly disagreed. Meanwhile, 17.2% agreed, and 3.8% strongly agreed. The mean value of 2.66 shows a tendency towards disagreement with the timeliness of waste collection, and the standard deviation of 1.070 indicates moderate variability in responses, reflecting differing experiences with collection schedules.

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The statement on the effectiveness and sustainability of current solid waste collection practices also shows a notable divide in opinion, with 41.6% disagreeing, 24.8% agreeing, and 17.2% strongly disagreeing. The mean value of 2.55, combined with a standard deviation of 1.138, indicates a general dissatisfaction with the effectiveness of waste collection. However, there is some variation in how respondents perceive the sustainability of the practices. Finally, regarding the health problems caused by household solid waste, the responses were more evenly distributed, with 37.0% agreeing and 17.2% strongly agreeing. The mean value of 3.18 indicated a slightly optimistic view towards the presence of health issues linked to waste, and the standard deviation of 1.377 suggests a higher degree of variability in responses. This could imply that while a substantial portion of respondents acknowledged health risks, a diverse range of perceptions about their severity exists.

48.3% strongly disagreed that there are sufficient collection points, while 44.1% disagreed. This shows that many households feel there is a lack of proper solid waste collection infrastructure, which shows a massive gap in spatial planning in peri-urban villages. 44.1% of respondents disagreed that collection points are not a reasonable distance, and 36.1% agreed. This indicates that the spatial distribution of collection points is poorly planned, with many households finding them inconveniently located. Many households travel long distances to get to the collection points. Collection points need to be strategically placed to minimise travel distance. 37,4% of the respondents are neutral on whether solid waste is collected in a timely manner, and 17.2% strongly disagree. It indicated a lack of reliability in solid waste collection services. While other areas are experiencing delays in the collection of solid waste. 37% agreed that sold waste leads to health. Furthermore, this shows poor solid waste collection in Thulamela Local Municipality. Lack of collection points increases the risk of illegal dumping, environmental pollution, and health hazards. Poor accessibility discourages proper solid waste disposal and increases the chances of uncollected solid waste pill up in the environment. Long distances to collection points affect older people, disabled, and children, making proper disposal difficult. Inconsistent solid waste collection leads to solid waste overflow, attracting flies and odour and contributing to unhygienic living conditions. Delays in solid waste collection lead to household dissatisfaction and loss of trust in the municipal service. Regarding the effectiveness and accessibility of solid waste collection, the Thulamela municipality said that they do not see anything wrong

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with the solid waste collection system; if households perceive that the system is not working, it is their fault since they do not follow solid waste regulations.

This regression analysis focused on whether the perceived adequacy and accessibility of designated solid waste collection points influence respondents' views on the effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was 0.070, and the standardised beta coefficient (Beta) was 0.117, indicating a weak positive relationship. This suggests that when respondents believe that there are sufficient and accessible collection points, their perception of the waste collection system tends to improve slightly. However, the relationship was not statistically significant, as the p-value was 0.260, which is above the 0.05 threshold. The t-value was 1.129, which also reflects a low level of statistical confidence in the predictive power of this variable. The 95% confidence interval for B ranged from –0.052 to 0.192, and since this range includes zero, it confirms that the relationship is not reliably different from no effect at all.

In reference to SDG, particularly goals 11 and 12, the lack of sufficient solid waste collections and efficient collection in Maniini and Muledane contradicts SDF targets of ensuring access to sustainable and resilient urban services. Basel Convention 1989 focuses on the international solid waste movement; its principle highlights the need for local governments to implement waste minimisation. The high percentage of dissatisfaction in the study shows that municipality need to improve solid waste collection to comply with global waste standards. In the constitution of South 1996, section 24 highlighted the right to a safe and healthy environment, and section 152 gives municipalities responsibility for solid waste management. The current situation in Maniini and Muledane shows that the municipality is failing in service delivery, which violates constitutional rights to a clean environment. Strengthening solid waste collection policies and infrastructure investments is essential for aligning with constitutional mandates. Overall, the data indicates that while some respondents perceive a lack of collection points, poor accessibility, and ineffective waste management practices, others acknowledge some level of health risk from improper waste handling. The variability in responses, as highlighted by the standard deviations, suggests that the experiences of waste collection differ significantly within the study areas.

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Picture 5.2: Solid waste mismanagement

Source: Field data (2025)

Picture 5.2 shows signs of solid waste mismanagement, including illegal dumping, mixed waste, and overflowing waste collection points. When cross-referencing these observations with the survey data in Table 5.2, several critical insights emerge regarding the effectiveness and accessibility of waste collection points in the study areas. Solid Waste is placed along a paved walkway and illegally dumped in open space, supporting the claim that waste collection points are inadequate. The mixture of organic and non-organic waste shows a lack of waste segregation. Solid waste disposal appears unregulated.

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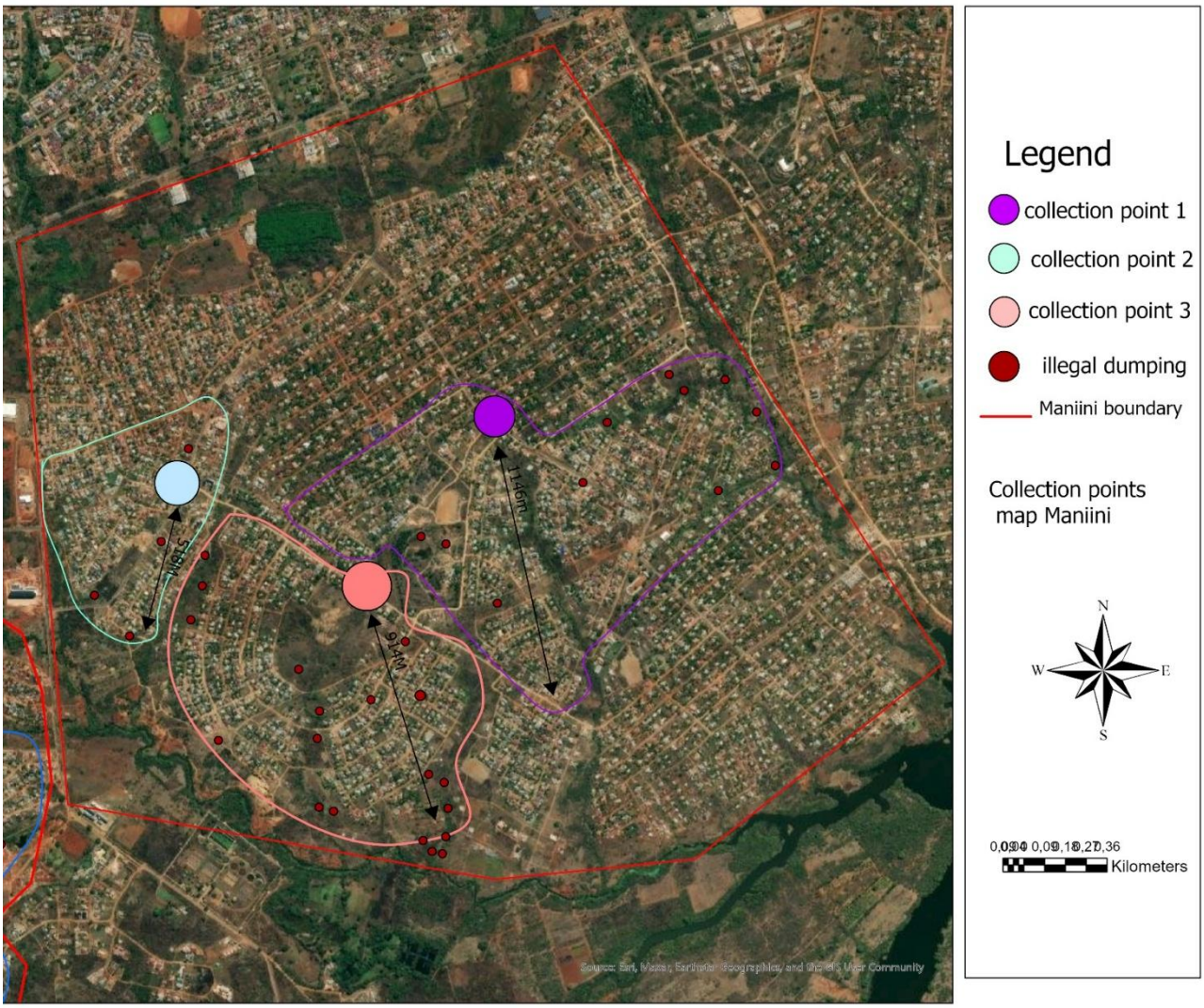

Figure 5.15: Collection points map maniini

Source: Mutwanamba (2025)

Figure 5.15 provides a detailed spatial representation of the three main households' solid waste collection points and their respective service coverage zones, as well as the distribution of illegal dumping sites within the village. The distance is clearly shown in

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the map from one collection point to the last household, this indicates that there is no effectiveness and accessibility of waste collection infrastructure in peri-urban settings.

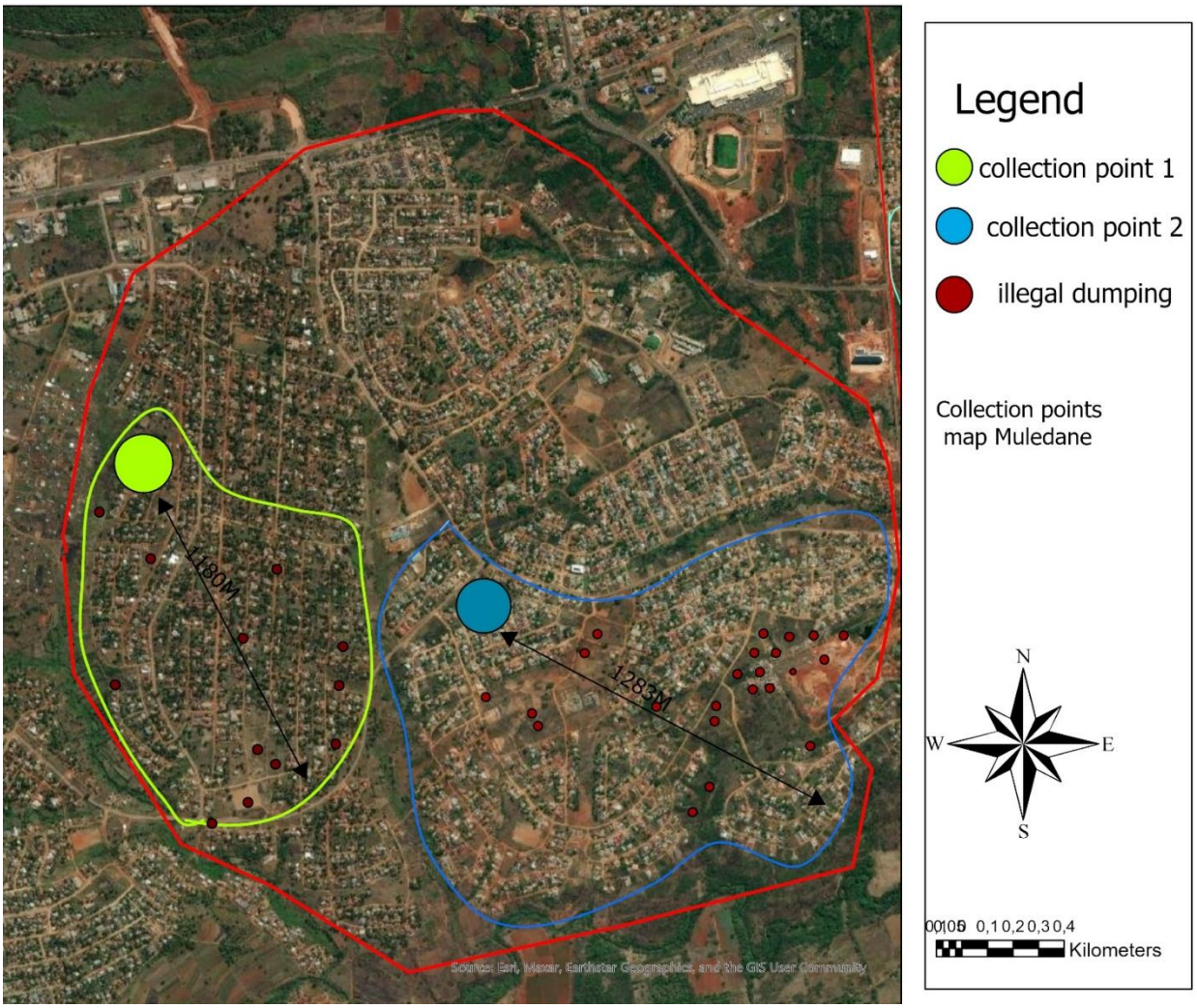

Figure 5.16: Collection points in Muledane

Source: Mutwanamba (2025)

Figure 5.16 shows the map, which displays the spatial distribution of two main household solid waste collection points in Muledane village, along with their respective coverage zones and illegal dumping sites. Collection Point 1 (green) covers the western side of the village, while Collection Point 2 (blue) serves the eastern zone. Despite these collection facilities, there is a high concentration of illegal dumping, especially within

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the service areas, indicating poor accessibility, inadequate infrastructure, or infrequent collection. Distances from some households to the nearest point exceed 1,200 meters, suggesting that many residents face challenges reaching collection points.

5.3.7. Composition of Household Solid Waste

The data presented in Table 5.3 outlines the responses related to the types of waste that constitute the bulk of household solid waste in Muledani and Manini. Starting with plastic and rubber, the overwhelming majority (70.6%) of respondents strongly agreed that this waste type forms a significant portion of household waste. This is supported by the mean of 4.14, indicating strong agreement. However, there is a notable variation with a standard deviation of 1.532, reflecting some degree of disagreement among a small portion of respondents (17.6% strongly disagreed and 1.3% disagreed). For glass and metals, the distribution is more varied, with 66.4% of respondents agreeing that these materials contribute significantly to household waste. However, 16.8% disagreed, and 5.0% strongly disagreed, indicating a mixed perception. The mean of 3.54 reflects moderate agreement, and the standard deviation of 1.017 shows less variability compared to plastic and rubber, suggesting that respondents generally agreed, but there is still a noticeable difference in individual responses.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std. Deviation
Plastic and rubber	17.6%	1.3%	1.3%	9.2%	70.6%	4.14	1.532
Glass and metals	5.0%	16.8%	4.6%	66.4%	7.1%	3.54	1.017
Paper and cardboard	2.1%	8.0%	43.3%	30.7%	16.0%	3.50	0.927
Yard trimmings	6.7%	25.6%	10.5%	40.8%	16.4%	3.34	1.215
Food leftovers	7.1%	2.9%	3.8%	34.0%	52.1%	4.21	1.132

Table 5.4: Composition of household solid waste

Source: field data (2025)

Paper and cardboard waste also received mixed responses, with 43.3% of respondents remaining neutral and only 16.0% strongly agreeing that these materials form the bulk of their household waste. The mean of 3.50 is fairly close to neutral, showing only slight agreement, and the standard deviation of 0.927 suggests that opinions were more consistent among the respondents compared to plastic and rubber or glass and metals. Yard trimmings presented a more divided response, with 25.6% disagreeing and 6.7%

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strongly disagreeing that these materials are a significant portion of their waste. The mean of 3.34 suggests slight agreement, while the standard deviation of 1.215 reveals significant variation in responses, particularly from those who disagreed. Only 16.4% strongly agreed that yard trimmings were a dominant waste type, indicating lower importance than other materials. Lastly, food leftovers show a clear consensus, with 52.1% of the respondents strongly agreeing that they form a substantial portion of household waste. The mean of 4.21 is the highest across all categories, indicating strong agreement. The standard deviation of 1.132 also reflects relatively consistent responses, with just 7.1% strongly disagreeing and 2.9% disagreeing, further emphasising the importance of food waste in the area.

Regression analysis examined whether the types of waste materials generated at the household level, such as plastics, glass, paper, yard waste, and food leftovers, influence perceptions of the effectiveness and sustainability of waste collection services in the peri-urban villages of Thohoyandou. Plastics and Rubber had the unstandardised coefficient (B) was 0.026, with a p-value of 0.670 and a beta of 0.035, suggesting a very weak and statistically insignificant positive relationship. This means the presence of plastics and rubber in household waste does not significantly affect how people perceive the efficiency of collection services. Glass and Metals had a coefficient (B) of 0.141, with a p-value of 0.125 and a beta of 0.126. This shows a slightly stronger but still statistically insignificant positive relationship. Although glass and metals may be harder to collect and dispose of, their presence does not significantly alter perceptions of waste service effectiveness.

Yard waste had a B value of –0.054, a p-value of 0.418, and a beta of –0.057. This suggests a small and statistically insignificant negative relationship, implying that garden or yard waste also has minimal impact on residents' satisfaction with collection practices. Food waste had a B value of 0.090, with a p-value of 0.213 and a beta of 0.090. Again, this reflects a weak and statistically insignificant positive effect, indicating that even though food waste is common and potentially problematic, it does not significantly shape public perceptions of waste collection effectiveness.

Overall, the regression results show that none of the common household waste types (plastics, glass, paper, yard trimmings, or food waste) have a statistically significant impact on how residents perceive the effectiveness and sustainability of waste

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collection services. Although some waste types (like glass and food waste) show slightly stronger positive relationships, the p-values are all above 0.05, and the beta values are low, meaning the influence is weak and unreliable. These findings imply that residents' satisfaction with waste services is not primarily shaped by the type of waste they produce, but more likely by service-related factors such as frequency, accessibility, and infrastructure.

The above findings significantly affect sustainable solid waste collection in Maniini and Muledane. The high mean value of plastic/rubber and food leftovers revealed that these two aspects are considered the most significant contributors to household solid waste. Moderate levels of agreement on glass/metals, paper, cardboard and yard trimmings indicated that these solid wastes are recognised as important. They are produced in smaller quantities and managed to some extent through reuse and recycling. The standard deviation and mean, especially for plastic and rubber, show the variability in how different households generate solid waste.

Furthermore, the National Domestic Waste Collection Standards 2011 guide the municipality to provide equitable solid waste collection services. The presence of diverse solid waste types in the data indicates that municipalities need to enforce solid waste separation and ensure regular collection in peri-urban areas. MSA (Act mo.32 of 2000) and municipal laws, these legal frameworks empower municipalities to regulate solid waste collection. Given the high food and plastic waste levels observed, municipal authorities must improve service delivery. At the same time, the principal-agent theory examines the relationship between policy markers (principal), waste management providers and households (agent). The varying levels of solid waste generation in the data show challenges in policy implementation where households do not comply with solid waste segregation policies due to lack of enforcement. To improve compliance, municipalities should adopt mechanisms such as incentives for recycling, penalties for illegal dumping and enhanced collection efficiency.

Hence, plastic rubber and food leftovers were overwhelmingly considered the dominant waste types, with high percentages of strong agreement and higher means, indicating the strongest consensus. Meanwhile, glass and metals, paper and cardboard, and yard trimmings displayed more variability, with moderate means and more significant

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standard deviations, showing that while these types of waste are acknowledged, they are not perceived as universally significant across the respondents.

Looking at the case study in 2.4.2.2. Case Study of Malaysian Cities: A Review of Future Household Waste Management for Sustainable Environment in Malaysian Cities. The case study highlights the challenges of household solid waste management in Malaysian cities, particularly plastic and paper waste, which are significant environmental concerns; the data from Table 5.3 supports this. Malaysia's Case Study shows that plastic waste is one of Malaysia's most problematic household wastes. Its poor management leads to severe environmental issues. Reflecting on Table 5.3. 70.6% of respondents strongly agree that plastic and rubber are part of household solid waste, with a high mean score of 4.14. This confirms that plastic is a dominant solid waste type, aligning with the Malaysian case study's concern about its environmental impact. Case Study of Malaysia gives insight into the fact that paper waste is another major contributor to unmanaged municipal solid waste (MSW). Authorities struggle to manage it effectively, increasing waste management costs. Reflecting on Table 5.3, 43.3% of respondents were neutral, and 30.7% agreed that paper and cardboard are a significant part of household waste. The mean score of 3.50 suggests it is a notable but less dominant waste type compared to plastic and food leftovers. This supports the case study's point that paper waste requires better management strategies.

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Picture 5.3: Different solid waste composition

Source: field data (2025)

The picture 5.3 and the table indicate a high prevalence of plastic and rubber waste (70.6% strongly agreed), followed by food leftovers (52.1% strongly agreed) and glass/metal waste (66.4% agreed). The data indicate a significant challenge in waste management, particularly in peri-urban villages like Thohoyandou, where waste composition is diverse and dominated by non-biodegradable materials.

5.3.8. Timing of Waste Collection

As shown in Figure 5.17, the data reveal the distribution of household solid waste collection times in the specified area, highlighting variations in collection schedules. Most respondents (42.02%) indicated that waste collection typically occurs after 18:30, making this the most prevalent response and reflecting a significant preference for late collection times. In comparison, 21.01% of the respondents mentioned that waste is collected in the morning, between 08:00 and 11:30. A slightly smaller portion, 20.59%, reported that waste collection takes place in the evening, between 14:30 and 18:30. Finally, 16.39% of the respondents noted that waste collection occurs during the mid-day period, from 12:00 to 14:30.

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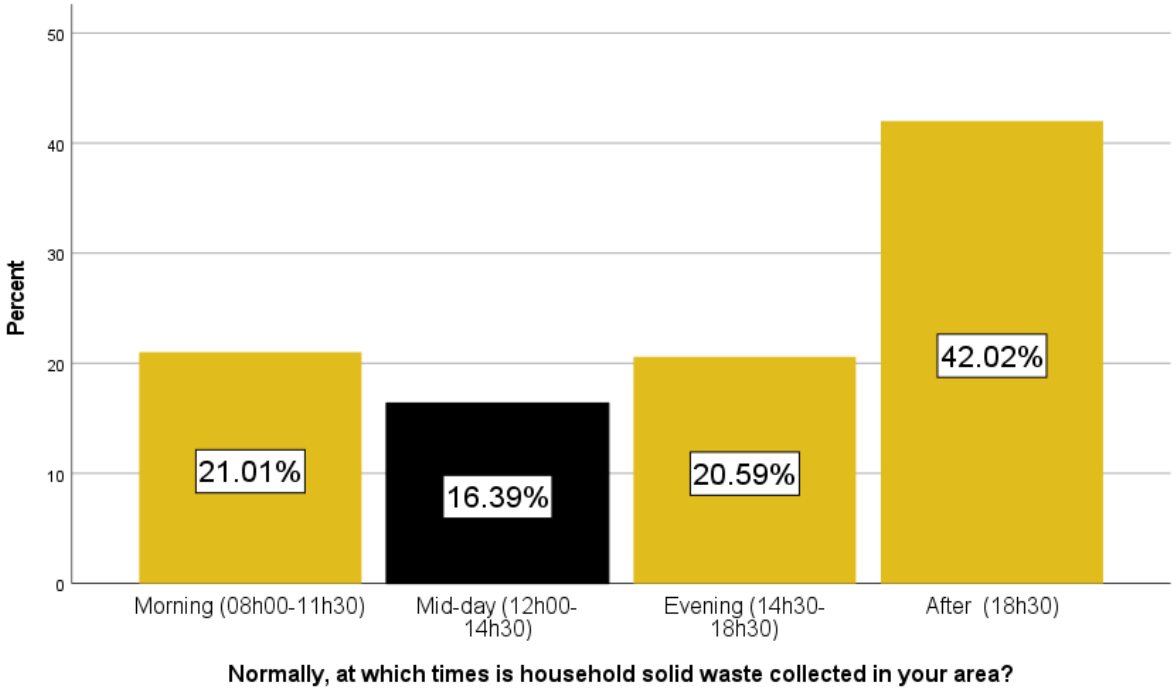

Figure .5.17: Times at which household solid waste is collected

Source: field data (2025)

Analysing these percentages, the researcher concluded that the times when waste collection occurs are spread relatively evenly across different time slots, though the late evening time is the most common. With 42.02% of respondents experiencing collection after 18:30, followed by morning (21.01%), evening (20.59%), and midday (16.39%), we can infer that a significant portion of households deal with evening and late-evening waste collection schedules. This indicates potential challenges such as reduced municipal resources during earlier hours or increased demand for waste management services later in the day. Considering the mean and standard deviation, although specific values are not provided in this response, based on the frequencies, we would anticipate that the evening and late-evening collection times (after 18:30) would likely push the mean closer toward the later periods, with higher variance due to the spread across all time slots. This variation can be associated with differences in waste management practices or logistical challenges in ensuring timely collection throughout the day.

More households reported late collection after 18h30. This indicates that night solid waste collection is a common practice in these two areas. This is due to several reasons, such as the municipality's inconsistent schedule and the fact that they do not arrive at

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the promised time. According to Thulamela, the local municipality does not have enough trucks and collects waste very late in some areas. Night collection challenges workers' safety, noise, and inconvenience for households that need to store waste overnight. A low midday collection rate between 12h00 and 14h30 indicates that Thulamela Local Municipality has few workers, according to Thulamela officials. Households experience difficulties in coordinating waste disposal with collection, this finding suggests that the Thulamela solid waste management system does not prioritise midday collection. The relatively even distribution of collection time across the morning, midday and evening periods indicates that collection schedules are not uniform across the two villages. Moreover, while waste collection time in the area is generally spread across different periods, the peak collection times after 18:30 suggest that evening hours may be the most feasible or practised option for the current waste management system.

This regression analysis assessed whether the timing of household solid waste collection that is, when during the day or week the waste is collected affects how residents perceive the effectiveness and sustainability of the collection services in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.066, indicating a weak negative relationship. This suggests that poor or inconvenient timing (e.g., irregular schedules or collection at unsuitable hours) is slightly associated with lower satisfaction with waste collection services. However, this relationship is not statistically significant, as shown by a p-value of 0.554, which is well above the 0.05 threshold. The t-value was –0.593, further indicating that the effect of collection timing is weak and unreliable in the model. The standardised beta coefficient (Beta) was –0.069, again confirming the presence of a very minor negative trend that is not meaningful in statistical terms.

The 95% confidence interval for B ranged from –0.287 to 0.154, which includes zero, confirming that this variable does not have a reliable impact. In terms of correlation, the zero-order correlation was –0.125, the partial correlation was –0.041, and the part correlation was –0.036, all reflecting a minimal and statistically unimportant association between timing and perception of waste service quality. Although inconvenient or inconsistent timing for waste collection may lead to slight dissatisfaction, the regression results show that this factor does not significantly

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influence residents' perceptions of whether household solid waste collection is effective or sustainable. Therefore, while timing may contribute to operational challenges, it cannot be considered a reliable predictor of community satisfaction on its own.

5.3.9. Waste Storage Practices

The data presented in Table 5.4 outlines the responses regarding waste storage practices, particularly focusing on three methods: plastic bags, plastic containers, and metallic containers. The respondents were asked to indicate their level of agreement with each method, providing insights into how households manage and store their solid waste. For plastic bags, the most significant response came from 65.5% of respondents, who strongly agreed with their usage, indicating that plastic bags are the predominant choice for waste storage in the area. This is further supported by a mean of 3.83, which is the highest of the three methods. However, the relatively high standard deviation of 1.745 suggests considerable variation in the responses, indicating that while plastic bags are widely used, some households may still prefer alternative methods. A small percentage, 25.2%, strongly disagreed with using plastic bags, which could point to concerns about environmental impact or alternative practices that may not be captured in this data.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std. Deviation
Plastic bags	25.2%	3.4%	0.0%	5.9%	65.5%	3.83	1.745
Plastic container	6.3%	18.1%	5.0%	63.9%	6.7%	3.47	1.062
Metallic container	10.5%	10.5%	23.1%	18.5%	37.4%	3.62	1.354

Table 5.5: Household solid waste storage

Source: field data (2025)

For plastic containers, the distribution of responses showed a more balanced range of opinions. Approximately ,63.9% of respondents agreed that plastic containers are used for waste storage, but only 6.7% strongly agreed. This is reflected in a lower mean of 3.47, signifying that while plastic containers are commonly used, they are not as universally preferred as plastic bags. The standard deviation of 1.062 indicates less variability in the responses compared to plastic bags, suggesting that those who use plastic containers are more consistent in their preference for this method. The use of

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metallic containers presented a different trend. A significant portion of respondents (37.4%) agreed with using metallic containers, and 23.1% were neutral, but only 18.5% strongly agreed. The mean of 3.62 indicates a moderate level of agreement, while the standard deviation of 1.354 suggests some level of variability in the responses. This data shows that while metallic containers are used, they are not as common or preferred as plastic bags. However, they still serve as a viable alternative for a considerable number of households. Plastic bags have emerged as the most widely used waste storage method, followed by plastic containers and metallic containers. The higher mean for plastic bags reflects their dominance in waste storage practices, though there is variability in the responses, particularly concerning environmental concerns. The distribution of responses for plastic containers and metallic containers highlights a more moderate usage pattern, with less agreement on their widespread use compared to plastic.

The regression analysis for solid waste storage practices evaluated whether the way households stored their waste prior to collection influenced their perceptions of the effectiveness and sustainability of household solid waste collection services in the peri-urban villages of Thohoyandou. The results showed an unstandardised coefficient (B) of 0.224 and a standardised beta coefficient of 0.170, indicating a moderate positive relationship. This implied that respondents who used appropriate and secure storage methods, such as sealed bins or designated containers, were more likely to view the waste collection system positively. This section of the regression analysis examined whether waste storage practices, specifically the use of different storage containers such as plastic bags, plastic containers, or metallic bins, had a significant influence on residents' perceptions of the effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou.

Plastic Bags had the unstandardised coefficient (B) for the use of plastic bags was –0.039, with a p-value of 0.446 and a beta of –0.059. This indicates a very weak and statistically insignificant negative relationship. It suggests that the use of plastic bags for storing waste may be slightly associated with lower satisfaction, possibly due to leakage, tearing, or environmental concerns, but this association is not statistically reliable. Plastic containers showed an unstandardised coefficient (B) of 0.047, with a p-value of 0.554 and a beta of 0.044. This represents a very weak and statistically

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insignificant positive relationship, meaning the use of plastic containers may slightly improve satisfaction with waste collection, but the effect is minimal and not significant. The coefficient (B) for metallic containers was –0.022, with a p-value of 0.691 and a beta of –0.026, showing a very weak and statistically insignificant negative relationship. This implies that using metallic bins does not significantly influence how residents perceive the effectiveness of collection services. Across all three storage types, the p-values are well above 0.05, and the beta values are near zero, indicating no strong or significant effect. Correlation values and collinearity statistics for each variable also suggest minimal influence and no multicollinearity issues.

The regression findings indicate that the choice of waste storage method whether plastic bags, plastic containers, or metallic bins does not significantly affect residents' perceptions of the sustainability or efficiency of household solid waste collection services. Although some storage methods may be slightly more favourable (such as plastic containers), their impact is too weak to be considered statistically meaningful. This suggests that factors like collection schedules, routes, or infrastructure may have a stronger influence on public satisfaction than the type of container used at the household level.

This finding suggests that residents do not associate service quality with how they store their waste, but rather with whether the waste is eventually collected reliably. While proper storage is important for hygiene and ease of collection, it does not in itself influence public perceptions of municipal performance. Households using basic or informal storage (e.g., plastic bags) may still rate services positively, as long as the collection is consistent and timely.

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Picture 5.4: household solid waste storage

Source: field data (2025)

Picture 5.4. illustrated the diversity of storage methods used in peri-urban Thohoyandou, highlighting a mix of both durable receptacles (metal or plastic bins) and disposable plastic bags. This correlation between observed practices and survey data underlines the importance of tailored waste management strategies that account for the containers used at the household level. The images confirm the findings in Table 5.5: households in peri-urban Thohoyandou predominantly use plastic containers and bags to store their waste, with metallic drums playing a secondary role.

5.4. Summary Of the Research Findings

The findings presented in Chapter 5 revealed significant insights into the current household solid waste collection practices in the peri-urban villages of Muledane and Maniini, located in Thohoyandou. A total of 261 questionnaires were distributed, and 238 were valid for analysis. Demographically, the majority of respondents were female (61%), highlighting the dominant role women play in household-level waste management. Most participants fell within the 46–55-year age bracket, and a substantial number possessed post-matric educational qualifications, indicating a relatively educated sample. In terms of occupational status, a notable proportion of respondents

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were unemployed (33.6%), followed by those employed (31.1%) and self-employed individuals (24.4%). Household sizes were predominantly medium (averaging five members), which influenced the volume of solid waste generated per household. Income levels varied, with lower-income areas such as Maniini Tshikovha demonstrating more severe service delivery challenges due to insufficient or absent municipal support. Slightly more participants resided in Maniini (56%) compared to Muledane (44%).

The analysis of solid waste collection practices showed that while 67.65% of households relied on municipal waste collection services, the remaining 32.35% did not have access to formal services and resorted to self-disposal or illegal dumping. Weekly waste collection was the most reported frequency; however, many respondents viewed it as inadequate given the waste volumes generated. Storage methods commonly included plastic bags and containers, yet regression analysis indicated that storage choices had no significant influence on perceptions of the effectiveness of waste collection services. The methods of waste collection varied across households depending on local infrastructure and accessibility, with the use of wheelbarrows, tricycles, and trucks being common.

Regression analysis of socio-demographic factors such as gender, age, education level, employment status, household income, household size, and place of residence revealed generally weak or statistically insignificant relationships with perceptions of the sustainability and effectiveness of household solid waste collection. This suggested that infrastructural conditions and municipal capacity, particularly road accessibility, the availability of waste collection points, and sufficient equipment, played a more substantial role in shaping collection outcomes. Additionally, qualitative responses emphasised dissatisfaction among community members, citing irregular collection schedules, poor route planning, inadequate municipal resources, and a lack of public education and awareness as key issues. These findings highlighted stark spatial inequalities between the villages, with significant disparities in service frequency, accessibility, and planning. Overall, the chapter underscored the need for integrated spatial planning interventions to address these systemic inefficiencies and promote more sustainable household solid waste collection in peri-urban settings.

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Chapter 6: Factors That Impede Sustainable Household Solid Waste Collection In Peri-Urban Villages Of Thohoyandou Town.

6.1. Introduction

Household solid waste collection remains a challenge in peri-urban villages of small towns. This chapter presented and interpreted in detail the analysis of data related to objective two: Identify factors that impede sustainable household solid waste practices in Thohoyandou peri-urban. The findings highlighted key barriers affecting solid waste collection, providing insights into challenges faced by households and municipality in managing solid waste sustainably. This chapter adopted the STEEP framework, an analytical model that categorised factors into Social, Technological, Economic, Environmental, and Political dimensions.

The study combined qualitative and quantitative techniques, including interviews, observations, and mapping. Statistical and thematic analyses were used to interpret the data, comparing respondent perceptions with existing literature on solid waste collection. Chapter 5 then characterised the current waste collection practices in the two villages. Expanding on this, the section explored how spatial factors such as settlement patterns, infrastructure, accessibility, and land use affect waste collection effectiveness. These insights helped reveal service delivery gaps and set the groundwork for proposing spatially responsive solutions in Chapter 7.

6.2. Factors negatively affect household waste collection in Muledane and Maniini

Various factors influence the delivery and effectiveness of household solid waste collection in peri-urban areas. These factors include Budget constrain, limited Human resources, shortage of waste collection vehicles, lack of equipment, poor response to waste minimisation, poor planning, poor allocation of municipal resources Poor service delivery, etc. Each of these factor plays a critical role in shaping how waste is managed within a given space. Table 6.1 presents responses to various factors contributing to unsustainable solid waste collection practices, as assessed by the respondents. The Likert scale used allows for an analysis of the degree to which each factor is perceived as affecting waste collection practices, with means and standard deviations providing an overall view of respondent perceptions.

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Factor	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Dev.
Budget constraints	7.6%	1.3%	2.5%	2.9%	85.7%	4.58	1.133
Limited human resources	23.9%	25.6%	15.5%	32.4%	2.5%	2.64	1.231
Shortage of waste collection vehicles	11.3%	24.4%	21.0%	33.2%	10.1%	3.06	1.198
Lack of equipment	3.4%	59.7%	11.8%	23.9%	1.3%	2.60	0.930
Poor response to waste minimisation	10.1%	19.3%	17.6%	31.1%	21.8%	3.35	1.290
Poor planning	31.1%	25.2%	9.7%	26.5%	7.6%	2.54	1.364
Poor allocation of municipal resources	8.8%	26.1%	20.6%	28.6%	16.0%	3.17	1.231
Poor service delivery	13.0%	24.4%	20.2%	28.6%	13.9%	3.06	1.268
Poor prioritisation of the solid waste collection service	6.3%	15.5%	13.4%	38.7%	26.1%	3.63	1.204
Poor payment of property levies	7.6%	9.2%	5.9%	42.0%	35.3%	3.88	1.206
Topography	5.9%	21.0%	18.5%	31.5%	23.1%	3.45	1.220
Climate	10.1%	27.3%	15.5%	32.8%	14.3%	3.14	1.250
Poor route planning	12.6%	28.6%	16.0%	29.0%	13.9%	3.03	1.281
Narrow road networks	15.1%	23.9%	12.6%	35.7%	12.6%	3.07	1.307
High transportation costs	14.3%	24.8%	16.4%	29.0%	15.5%	3.07	1.317
Lack of awareness	11.8%	26.9%	13.9%	35.3%	12.2%	3.09	1.256
Lack of infrastructure	7.1%	21.8%	19.3%	33.2%	18.5%	3.34	1.211
Population growth	6.3%	20.2%	14.3%	37.4%	21.8%	3.48	1.214
Irregular scheduling	6.3%	11.8%	5.9%	37.0%	39.1%	3.91	1.219
Non-compliance with environmental legislation	8.4%	27.3%	18.1%	34.5%	11.8%	3.14	1.188
Poor urban management and planning	9.2%	16.0%	13.0%	47.5%	14.3%	3.42	1.187
Household attitudes	6.7%	18.9%	12.2%	37.4%	24.8%	3.55	1.238

Table 6.1: Factors negatively affecting household waste collection in Muledane and Maniini

Source: field data (2025)

6.2.1. Social Factors

Social factors significantly impact household waste collection practices in peri-urban areas. These include population growth, household attitudes, and poor prioritisation of waste management. Understanding community perspectives and promoting solid waste consciousness are essential for sustainable solid waste practices.

6.2.1.1. Population growth

The mean score of 3.48 indicated that respondents generally lean towards agreeing that population growth affects waste collection. The standard deviation of 1.214 reflects moderate variation in responses, suggesting that while many recognise population

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growth as an issue, its impact may differ across different areas. Approximately 37.4% of the respondents agree that population growth is affecting solid waste collection, and 21.8% strongly agree, which makes 59.2% of the respondents believe that increasing population is a major factor contributing to unsustainable waste collection. This indicates that the growing number of households and waste generation is straining existing solid waste collection systems. A small number, 6.3% of respondents, strongly disagree that population growth negatively impacted solid waste collection, and 20.2% of the respondents disagree, which makes a total of 26.5% believe that population growth is not a major issue. Nearly 14.3% of the respondents remain neutral, indicating that they may not have experienced direct impacts of population growth on solid waste collection or are uncertain about its role.

The regression analysis tested whether population growth significantly influenced perceptions of effective and sustainable solid waste collection. The unstandardised coefficient (B) was 0.054, and the standardised beta coefficient was 0.062, indicating a weak positive relationship. This suggests that as the perception of population growth as a challenge increased, so too did concern about the ineffectiveness and unsustainability of waste collection. Statistically, however, the relationship was not significant, with a p-value of 0.476, above the 0.05 threshold. The 95% confidence interval ranged from -0.097 to 0.205, including zero, which confirms its insignificance. The partial correlation was 0.045, and the semi-partial correlation was 0.040, both indicating low predictive power. Although not statistically significant, the practical implications of population growth are critical. Municipalities often fail to scale up waste services at the same pace as urban expansion, resulting in overwhelmed collection systems.

When more people move to these peri-urban areas to settle, the population increases and the volume of household solid waste increases. The existing solid waste collection service struggles to handle such a growing population. Improper disposal is rising due to a lack of collection in all areas. According to Thulamela Local Municipality officials, vehicles and workers are lacking in expanding the service to other areas around Maniini and Muledane. The increase in population demands a high financial budget, and the municipality is struggling with solid waste collection due to the low budget.

The statement "Household solid waste is rapidly increasing due to accelerated population growth and urbanisation (Haywood, 2021)" is directly related to the findings

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on Population Growth in the table. 6.1. Haywood (2021) points out that rapid population growth and urbanisation lead to increased household waste generation, which strains existing waste collection systems. In Muledane and Maniini, population expansion overwhelms the municipality's capacity to manage waste efficiently, leading to irregular collection, illegal dumping, and environmental pollution. Despite the respondents' mixed views, the link between population growth and waste generation is well-documented.

From the case study in 2.4.3.1.1. Case study of Morrocco: household solid waste Khouribga city (Salama, Chennaoui,2024). The case study of Morocco mentions that the country faces a rising volume of waste due to population growth and economic changes, similar to the data from the study reflecting concerns about population growth as a contributing factor to poor solid waste collection. As more people move into urban areas, the total amount of solid waste generated increases. Morocco's population is steadily increasing, with many rural residents migrating to cities such as Khouribinga in search of better jobs. The case study reveals that each urban resident generates approximately 0.6kg of waste daily, a significant amount that must be collected and managed efficiently.

6. 3.1.4. Poor prioritisation of solid waste collection service

From the table above, the factor of poor prioritisation had a mean score of 3.63, suggesting that respondents generally view poor prioritisation as an important issue affecting solid waste collection. A moderate standard deviation (1.204) suggests that while most respondents agree, opinions vary depending on location and experience. Approximately 26.1 % of the respondents strongly agreed that poor prioritisation affects solid waste collection, and 38.7% of the respondents agreed, which makes up a total of 65,4% of households affected by poor prioritisation. This indicates that most respondents believed that municipal authorities do not prioritise solid waste collection services. A small number of 13.4% of the respondents said they are not sure that poor prioritisation affects solid waste collection. About 15.5% of respondents disagreed that poor prioritisation does not affect solid waste collection, and 8,0% strongly agreed, this makes a total of 23,8%. Indicating that some respondents believe that solid waste collection is given adequate attention. This variation indicated that prioritisation may

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differ across different areas, with some communities receiving better services than others.

The regression analysis explored whether poor prioritisation significantly influenced perceptions of the effectiveness and sustainability of household solid waste collection. The unstandardised coefficient (B) was -0.067, and the standardised beta coefficient was -0.061, showing a weak negative relationship. This suggests that as perceptions of poor prioritisation increased, perceptions of effective waste collection decreased slightly. However, the relationship was not statistically significant, with a p-value of 0.393, which exceeds the 0.05 threshold. The 95% confidence interval ranged from -0.222 to 0.088, which includes zero, confirming that this variable did not significantly predict household perceptions in the model. Partial and semi-partial correlations were -0.061 and -0.055, indicating minimal contribution to the model's explanatory power.

In addition, although poor prioritisation did not achieve statistical significance in this study, it demonstrated a notable positive trend in influencing perceptions of waste collection. In peri-urban areas such as Maniini and Muledane, where solid waste services often compete with other infrastructure needs, deprioritising solid waste management in budgeting and planning leads to systemic inefficiencies and community dissatisfaction.

6. 2.1. 2. Household attitudes

A Small number of respondents (6.7%) strongly disagreed that household attitudes contributed to solid waste collection inefficiencies. Nearly one-fifth (18.9%) of respondents disagreed that household attitudes negatively impact waste collection. 12.2% of respondents remained neutral, meaning they are uncertain about the impact of household attitudes on waste collection. More than a third (37.4%) of respondents believed that household attitudes contributed to solid waste collection inefficiencies. Nearly a quarter (24.8%) of respondents strongly agreed, meaning they view household attitudes as a major issue in waste management. Moderately high standard deviation indicates variation in how respondents perceive household behaviour as contributing to the challenge. Household attitudes mean value of 3.55 and standard deviation of 1.238, indicating that households' behaviours play an important role in the solid waste collection process. Households do not want to segregate the solid waste to make it easier

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for the waste pickers. Resistance to solid waste sorting, reluctance to participate in recycling programs and improper solid waste disposal contribute to the inefficiency of the collection system.

The regression analysis assessed whether household attitudes significantly influenced perceptions of solid waste collection effectiveness and sustainability. The unstandardised coefficient (B) was 0.044, and the standardised beta coefficient was 0.048, indicating a very weak positive relationship. This suggests that as negative household attitudes increased, so too did the perception that waste collection was ineffective, but the influence was minimal. The relationship was statistically not significant, with a p-value of 0.499, exceeding the 0.05 significance threshold. The 95% confidence interval for B ranged from -0.084 to 0.171, which includes zero and confirms the lack of statistical significance. The partial and semi-partial correlations were 0.047 and 0.043, respectively, supporting this conclusion.

Looking at the concept of household solid waste, most solid waste is not separated by households because of a lack of awareness and in some cases negligence (Shiferaw A et al, 2023). The above statement aligns with household attitude, with Shiferaw et al. (2023), who state that a lack of awareness and negligence are major reasons households do not separate their waste. Without proper knowledge or incentives, many residents fail to sort recyclables, organic waste, and non-recyclables, leading to increased waste accumulation and inefficiencies in collection services.

Waste Act (2008) Section 72 States that municipalities must promote waste minimisation and raise household awareness. Requires education and communication strategies as part of Integrated Waste Management Plans. In Muledane and Maniini, this responsibility has not been sufficiently fulfilled. Sustainable Development Goal 12 (Responsible Consumption and Production) targets waste reduction at the source and improved awareness of sustainable lifestyles. Focuses on changing public behaviours through education, awareness, and engagement. Weak public response to waste minimisation in the study area reflects a failure to localise SDG 12 targets in rural and peri-urban contexts.

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6.3.1.1. Lack of awareness

A mean score of 3.02 suggests that respondents see a lack of awareness as a moderate concern in waste collection. A moderate standard deviation (1.250) indicates that opinions on this issue vary widely, likely due to differences in educational campaigns, community engagement, and individual knowledge of waste management practices. About 43.9% of the respondents agreed that lack of awareness is affecting solid waste collection, and 13.9% strongly agreed; this makes a total of 57.7% of the respondents believe that a lack of awareness contributes to unsustainable waste collection. About 7.1% of respondents strongly disagreed that lack of awareness contributes to unsustainable solid waste collection, and 21.8% disagreed, which makes a total of 28.9% of respondents believed that lack of awareness is not a major problem. This means that a considerable portion of the household either already understands waste management practices or believes that other factors (such as infrastructure or budgeting) play a more significant role. Approximately 13.3% of the respondents remain neutral, indicating uncertainty or lack of knowledge regarding the role of awareness in solid waste collection.

Statistically, the relationship was not significant, with a p-value of 0.743, well above the 0.05 threshold. The 95% confidence interval ranged from -0.183 to 0.134, including zero, which confirms the variable's insignificance. The partial correlation was -0.023, and the semi-partial correlation was -0.021, both near zero, indicating negligible influence within the model. Although not statistically significant, the practical implications of lack of awareness are critical. Without adequate knowledge and environmental education, households are less likely to comply with proper waste disposal guidelines or participate in recycling initiatives.

Low public awareness contributes to behaviour such as improper solid waste segregation, illegal dumping and limited participation in solid waste collection. Most households do not fully understand separating which solid waste is recyclable and which is not. Without regular education campaigns, households often burn solid waste and dump it in open spaces. Such behaviour compromises health and the environment. A lack of information about the broader consequences of poor solid waste management sometimes causes a Negative household attitude. When households are unaware of how uncollected waste can lead to environmental and water contamination, they may not see

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waste management as a priority. The lack of knowledge leads to unintentional non-compliance; people may fail to pay waste collection fees, ignore waste separation guidelines and dump solid waste in unauthorised areas simply because they are unaware of the rules. Households are unaware of local drop-off centres, buyback programs (for recycling), and composting projects.

6.2. 1.3. Poor payment of property levies

Poor payment of property levies had the highest mean. A mean of 3.88 is the highest among the challenges analysed, suggesting that poor payment of property levies is one of the most critical issues affecting waste collection. A moderate standard deviation (1.206) means that while most people agree, there is some variation in responses. This suggests that while levy payment issues significantly affect waste collection, some communities may experience fewer problems due to alternative funding sources or effective municipal planning. (42.0% Agreed + 35.3% Strongly Agreed) = 77.3% of respondents believed that poor payment of property levies negatively affects waste collection; this indicated that a strong majority of residents recognise a direct link between non-payment of property levies and inefficiencies in waste collection**.** Neutral response (5.9%) indicated that very few respondents were uncertain about this issue**.** This indicates that most people have a clear opinion on whether poor levy payment affects waste collection. (7.6% Strongly Disagreed + 9.2% Disagreed) = 16.8% of respondents believed that poor payment of property levies is not a major issue; this indicates that some areas may still receive adequate waste collection services despite levy non-payment.

The regression analysis examined whether poor payment of property levies significantly influenced perceptions of waste collection effectiveness and sustainability. The unstandardised coefficient (B) was -0.151, and the standardised beta coefficient was -0.160, indicating a weak negative relationship. This means that higher levels of perceived non-payment were associated with more negative evaluations of waste collection services. Importantly, this relationship was statistically significant, with a p-value of 0.025, which is below the 0.05 threshold. The 95% confidence interval ranged from -0.282 to -0.019, which does not include zero, confirming that this variable has a meaningful impact on the regression model. The partial correlation was -0.156, and the semi-partial correlation was -0.143, both indicating moderate effect sizes. The

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multicollinearity diagnostics were within safe ranges, with a tolerance of 0.797 and a Variance Inflation Factor (VIF) of 1.255, suggesting that this variable did not distort the regression model.

This statistically significant result confirms that poor payment of property levies is a key determinant of waste collection inefficiency. In many small towns, including those in Thulamela Local Municipality, property levies are the primary source of revenue for local services. Without consistent payment, the municipality struggles to sustain operations, invest in infrastructure, or respond to growing waste management demands.

Financial inclusion enables households to opt for a healthy solid waste disposal method (collection method); hence, in policymakers' attempts to improve solid waste disposal, paying attention to financial inclusion can be a beneficial strategy (Immurana et al., 2022). Regarding findings from Immurana et al. (2022) which emphasise that financial inclusion plays a crucial role in ensuring households can afford proper waste collection services. In areas where residents lack access to financial services, they are less likely to pay for waste collection, leading to irregular or non-existent collection services. In Muledane and Maniini, financial constraints make it difficult for municipalities to expand waste collection services, maintain infrastructure, and invest in better disposal methods.

SPLUMA 2013 gives a mandate to the municipality to incorporate waste management strategies and plans on their development framework. Still, there is weak enforcement and poor coordination, which results in efficient service delivery. Additional lack of zoning and land use planning cause the collection challenges. For example, Maniini Tshikovha is inaccessible to waste collection vehicles due to narrow roads and unplanned housing developments. In addition , NWMS 2020 also emphasises integrated planning to ensure solid waste is accessible by all households, yet the municipality fails to implement it due to the different challenges mentioned above. New Urban Agenda advocates for inclusive and sustainable urban planning. ensuring that solid waste infrastructure keeps up with the pace of population growth. Waste Act 2008 gives the responsibility to local municipalities to develop waste management strategies and plans that accommodate population growth.

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The theory of principal-agent explains the relationship between a principal (task delegated) and an agent (who performs the task on behalf of the principal); problems start when the agent (municipal) does not want to agent in the best interest the of the principal (households) this due to inefficiency, corruption and resource constraints. The households lose trust in the municipality, leading to non-compliance with solid waste management regulations. The agent has more information regarding solid waste collection services, which makes monitoring difficult. Households expect timely and efficient solid waste collection service, but often experience service delivery. Agent problems arise when a municipality lacks accountability and resources.

6.2.2. Technological Factors

Technological challenges, such as outdated equipment, poor route planning, and limited access to modern waste management tools, hinder efficient waste collection. Investing in technology can improve collection frequency, reduce operational costs, and enhance overall waste management efficiency.

6.2.2.1. Lack of equipment

In terms of lack of equipment, a mean of 3.35 suggests that respondents lean toward agreeing that lack of equipment is a problem. A moderate standard deviation (1.099) means that responses are somewhat varied but not extreme. This indicated that while many agree, there are still some divided opinions, possibly due to differences in service quality across different locations. (41.6% Agreed + 12.6% Strongly Agreed) = 54.2% of respondents believe that a lack of equipment is a major challenge in waste collection; this indicates that most residents experience inefficiencies due to inadequate tools, machinery, or facilities. Neutral Response (18.1%) indicated that these respondents were uncertain whether a lack of equipment affected waste collection because some areas may have adequate equipment while others do not. (4.2% Strongly Disagreed + 23.5% Disagreed) = 27.7% of respondents believed that lack of equipment is not a significant problem, which indicates that some areas are well-equipped and do not face waste collection challenges.

The regression analysis for lack of equipment examined whether the absence of tools and protective gear significantly influenced perceptions of the effectiveness and

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sustainability of solid waste collection. The unstandardised coefficient (B) was 0.127, and the standardised beta coefficient was 0.123, showing a weak positive relationship. This means that the more respondents perceived a lack of equipment, the more they associated it with ineffective waste collection practices. However, the relationship was not statistically significant. The p-value was 0.096, which is slightly above the 0.05 threshold, indicating that while the relationship has potential practical value, it is not supported statistically. The 95% confidence interval for B ranged from -0.023 to 0.277, and since it includes zero, it further confirms the insignificance in the statistical model.

In Thulamela, the local municipality's unsustainable solid waste collection is rising due to limited funding, poor infrastructure investment, and weak policy implementation. Solid waste collection becomes slow and ineffective without proper tools such as solid waste bins, trucks and sorting facilities. Workers manually handle the solid waste without gloves, increasing physical strain and health risks. While picking up solid waste, workers lack sanitisers and handwashing facilities, which increases the risk of diseases.



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Picture 6.1: Lack of equipment

Source: field data (2025)

The truck is visibly full, as presented in Picture 6.1, and the solid waste is piled high, which indicates that the vehicle is being overused to accommodate more waste than it should be handling. This can lead to inefficiencies in solid waste collection, as the truck may need to make multiple trips or be emptied frequently, affecting collection schedules.

6.2.2.2. Poor route planning

Poor route planning is identified as a significant factor contributing to unsustainable waste collection, with a mean of 3.03 and a standard deviation of 1.281. This indicates that many respondents perceive inefficient route planning as a barrier to effective waste collection in peri-urban villages. Small number of 13.9% of respondents strongly agreed that poor route planning impacts solid waste collection, and 29,4% agreed, which makes up a total of 43.3% of respondents. About 10.9% of respondents were uncertain about the impact because of their areas receive regular collection. Approximately 31.1% of respondents disagreed, and 17,1% strongly disagreed, making up 48.2% of respondents. This indicates that some areas have better waste collection planning than others. Ineffective route planning can result in missed households, fuel inefficiencies, and longer service cycles. This is especially prevalent in peri-urban areas with narrow streets or informal housing where trucks are unable to manoeuvre efficiently. The lack of GIS-informed scheduling and data-driven route optimisation hinders equitable and cost-effective service provision.

The regression analysis investigated whether poor route planning significantly influenced perceptions of sustainable and effective household waste collection. The unstandardised coefficient (B) was 0.132, and the standardised beta coefficient was 0.084, indicating a weak positive relationship. This suggests that increased perception of poor route planning was associated with slightly stronger concern about ineffective and unsustainable waste collection. The relationship was not statistically significant, as reflected in a p-value of 0.239, which is above the 0.05 threshold. The 95% confidence interval for B ranged from -0.089 to 0.353, which includes zero, confirming that the result is statistically inconclusive. Partial and semi-partial correlations were 0.073 and 0.065, indicating a modest effect in practical terms, even if not statistically verified.

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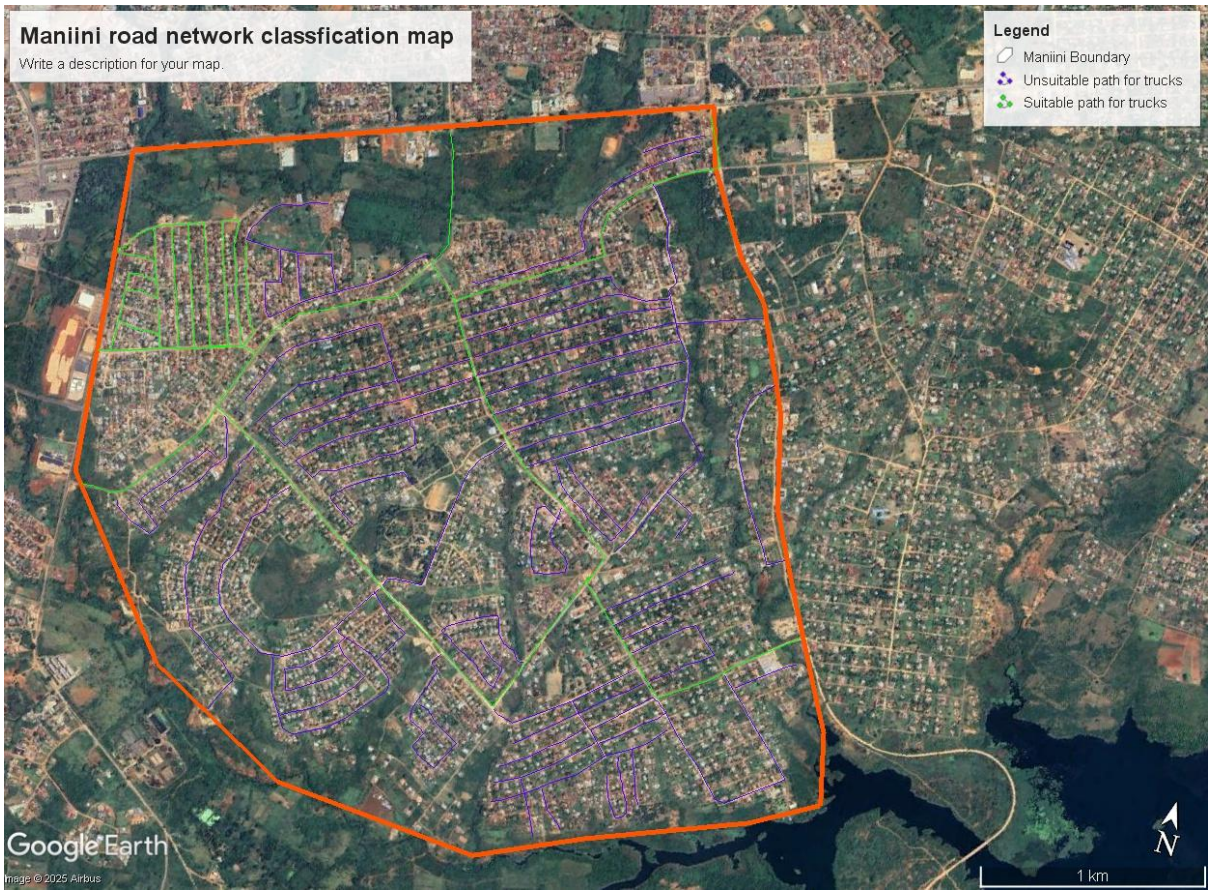

Figure 6.3: Maniini road network classification map

Source: Mutwanamba (2025)

Figure 6.3 shows that the Maniini road network classification Map further supports this finding by visually demonstrating the distribution of suitable (green) and unsuitable (purple) paths for waste collection trucks. The majority of internal roads, particularly those in denser residential zones, are marked as unsuitable for trucks, due to their narrow width, poor surface conditions, or lack of formal planning. These unsuitable paths complicate municipal truck access, resulting in missed collection points and the need for residents to transport manual waste to the nearest accessible roads.

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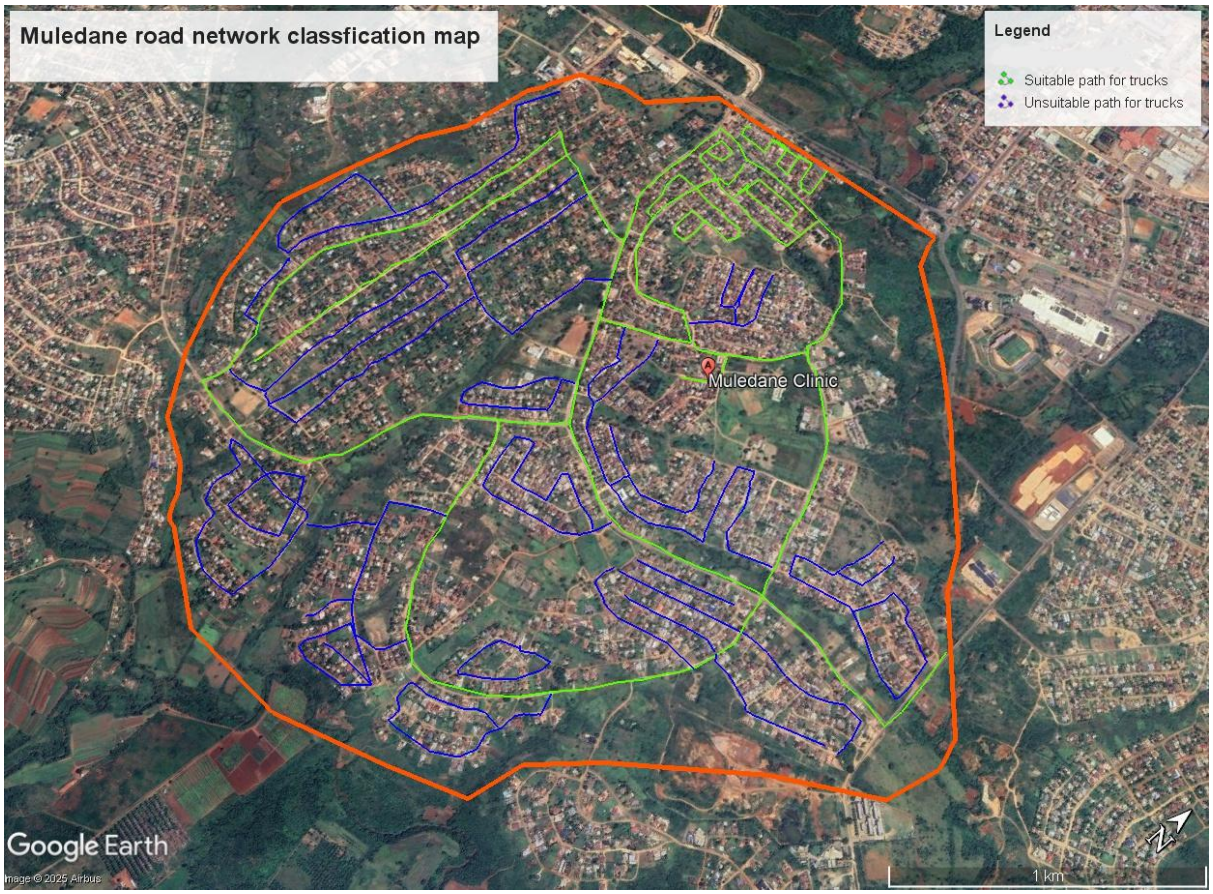

Figure 6.4: Muledane road network classification map

Source: Mutwanamba (2024)

Figure 6.4 shows the Muledane road network classification map, which categorises the road infrastructure into suitable paths for waste collection trucks (green) and unsuitable paths (blue). The map shows that a substantial portion of Muledane's internal roads are unsuitable for truck access, especially in the southern and western parts of the village.

6.2.2.3. Irregular scheduling

Irregular scheduling had a mean of 3.91, the highest among the factors in the table, with 39.1% strongly agreeing and 37.0% agreeing. This reflects a strong consensus that irregular scheduling is a critical issue for waste collection practices. The standard deviation of 1.219 indicates moderate variability, but the overall high mean indicates

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that this is one of the most commonly agreed-upon factors. Approximately 37.0% of the respondents agree that irregular schedules contribute to poor solid waste collection, and 39.1% strongly agree, which makes a total of 76.1% of respondents consider irregular scheduling a major issue affecting waste collection. This indicated that inconsistent waste collection leads to inefficiencies, waste accumulation, and potential environmental hazards. A small number of 6.3% of the respondents strongly disagree that irregular scheduling is contributing to poor solid waste collection. This indicates that while some areas might experience regular waste collection, the majority face scheduling inconsistencies. A small number of 5.9% of the respondents are neutral, showing that most individuals have a clear opinion on how scheduling affects waste collection. Households that expect regular collection cannot plan waste disposal, leading to more solid waste being dumped in open space. Inconsistent solid waste collection leads to higher costs because the municipality must deploy emergency cleanups when solid waste builds up beyond capacity.

The regression analysis tested whether irregular scheduling significantly influenced perceptions of the effectiveness and sustainability of household solid waste collection. The unstandardised coefficient (B) was -0.022, and the standardised beta coefficient was -0.028, indicating a very weak negative relationship. This implies that as perceptions of irregular scheduling increased, perceptions of collection effectiveness slightly declined, but the effect was negligible. The relationship was not statistically significant, with a p-value of 0.718, well above the 0.05 threshold. The 95% confidence interval ranged from -0.142 to 0.098, which includes zero, confirming that irregular scheduling does not statistically explain variation in perceived waste collection outcomes. The partial correlation was -0.025, and the semi-partial correlation was -0.023, reflecting very limited influence in the model. No multicollinearity issues were detected, tolerance was 0.658, and the Variance Inflation Factor (VIF) was 1.519, indicating acceptable levels of independence among variables.

To achieve sustainability, waste management policies must integrate spatial planning (SPLUMA, 2013), environmental regulations (NEMA, 1998), and local government systems (Municipal Systems Act, 2000) while fostering public-private partnerships and community engagement. Addressing these challenges effectively will ensure a cleaner, healthier environment and promote economic opportunities in the waste sector.

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6.2.2.4. Lack of equipment

The lack of equipment received a mean of 2.60, indicating that this factor is less significant in respondents' views. This means that respondents generally did not view this as a significant problem. The standard deviation of 0.930 shows a relatively moderate spread, pointing to some variation in how respondents perceive the lack of equipment. Only 25.2% of respondents (23.9% agreed + 1.3% strongly agreed) believed that lack of equipment negatively affects waste collection. Most respondents (63.1% strongly disagreed + disagreed) believed that lack of equipment is not a major issue. 11.8% of respondents are neutral, indicating uncertainty or mixed experiences.

The regression analysis assessed whether lack of equipment significantly influenced perceptions of the effectiveness and sustainability of household solid waste collection. The unstandardised coefficient (B) was 0.004, and the standardised beta coefficient was 0.003, indicating an extremely weak positive relationship almost negligible. This suggests that increases in concern over equipment shortages barely affected perceptions of poor service. This relationship was not statistically significant, with a p-value of 0.966, well above the 0.05 threshold. The 95% confidence interval ranged from -0.181 to 0.189, which includes zero, further affirming the insignificance of the variable. Both partial and semi-partial correlations were 0.003, confirming its very limited influence within the regression model.

Without proper equipment and solid waste collection workers, they fail to perform their daily duties effectively, leading to inefficient service. Equipment such as waste bins, waste bags and compactors are necessary for efficient collection, sorting and transportation of solid waste. The majority of workers in Thulamela Local Municipality lack personal protective equipment such as gloves, musk and uniforms, which exposes workers to hazardous waste, infections and injuries. When workers lack equipment, they tend to avoid a specific type of waste to protect themselves; this leads to uncollected waste and public health risks. Solid waste department confirmed that Sometimes they are unable to attend to reported cases on time because they do not have enough equipment to carry out the work.

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6. 3.2.5. Shortage of waste collection vehicles

In contrast, the factor of shortage of waste collection vehicles received a mean of 2.99, indicating a more neutral stance indicates that respondents are split on whether this is a critical issue. The standard deviation of 0.703 is relatively low, signalling consistent responses, but also highlights that this issue may not be seen as a primary concern compared to others. Only 16.4% (13.9% agreed + 2.5% strongly agreed) believed that a shortage of waste collection vehicles negatively affects waste collection. About 17.6% (15.1% disagreed + 2.5% strongly disagreed) believed that a shortage of vehicles is not a major issue. A high neutral response (68.0%) indicated that most respondents are unsure or indifferent about whether a shortage of waste collection vehicles is a significant challenge.

The regression analysis examined whether the shortage of waste collection vehicles significantly influenced perceptions of solid waste collection effectiveness and sustainability. The unstandardised coefficient (B) was -0.020, and the standardised beta coefficient was -0.013, indicating an extremely weak negative relationship. This means that as the perception of vehicle shortages increased, there was a negligible decline in the perceived effectiveness of collection services. Statistically, this relationship was not significant, with a p-value of 0.855, far above the 0.05 threshold. The 95% confidence interval ranged from -0.240 to 0.199, confirming the lack of significance as the range includes zero. The partial correlation was -0.013, and the semi-partial correlation was -0.012, indicating minimal influence within the overall regression model.

Having a few solid waste collection trucks means that solid waste is not collected frequently, leading to waste accumulation, pollution, and health risks. Municipality spends most of their time on fuel and maintenance, as few trucks are available over long distances. The villages have poor roads and networks that large trucks cannot access. When solid waste is not collected in a timely manner due to a lack of vehicles, households dump solid waste in rivers and along roads. Poor infrastructure makes it difficult for a large truck to operate effectively.

6.3.3.6. Lack of infrastructure

The mean score of 3.34 suggests that respondents see a lack of infrastructure as a moderate-to-high concern in waste collection. A moderate standard deviation (1.211)

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suggests differing opinions, likely influenced by differences in waste management infrastructure across different locations. About 33.3% of the respondents agreed that poor infrastructure impacts solid waste collection, and 18.5% strongly agreed; this makes a total of 51.7% that poor infrastructure negatively impacts waste collection. This indicated that more than half of the household acknowledges the importance of well-developed infrastructure in ensuring efficient waste solid waste collection. A small number of 7.1% of respondents strongly disagreed that infrastructure negatively impacts solid waste collection, and 21.8% of respondents disagreed, which makes a total of 28.9% of respondents who did not see infrastructure as a major issue. This means that some areas within the municipality have relatively better infrastructure, or other factors (such as financial constraints) are considered more critical. Approximately 13.3% of the respondents remained neutral, indicating uncertainty or a lack of direct impact on their waste collection experience.

These two areas have inadequate solid waste storage facilities, households lack access to proper waste bins and designated collection points. Without segregated bins for recyclables and organic waste ends up mixing, making it difficult to recycle. Thulamela Local municipalitiy officials confirmed that they have a shortage of waste collection vehicles, which delays waste collection, causing solid waste to pile up. The road's poor condition makes it difficult for trucks to access some areas. The peri-urban villages lack local recycling within their community. In reference to areas such as Maniini Tshikovha and Muledane Vhatukani, the settlements are growing without proper planning, making it challenging to place waste collection points.

Sustainable Development Goal (SDG) 11 Sustainable Cities and Communities "By 2030, reduce the adverse environmental impact of cities by improving municipal and other waste management." Emphasises the need for infrastructure expansion in line with urban and population growth. Thulamela Municipality has not kept pace with SDG 11 benchmarks in terms of waste infrastructure and urban servicing. Spatial Planning and Land Use Management Act (SPLUMA, 2013), calls for spatial integration and the equitable provision of infrastructure and services across all communities, including peri-urban areas. Peri-urban growth in these villages has occurred without structured land use planning, leading to informal expansion that lacks access to services.

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By applying the three dimensions of space to this factor, Lefebvre's Spatial Triad. Conceived Space (Representations of Space), municipal plans often fail to integrate demographic trends into infrastructure design. Spatial planning doesn't fully anticipate settlement expansion or account for unregulated urban sprawl in peri-urban zones. Top-down strategies don't translate well into the realities on the ground. Perceived Space (Spatial Practices), The lived experience of navigating unpaved roads, lack of waste bins, and informal neighbourhoods. Solid waste trucks cannot access newly formed or densely packed settlements, and workers struggle to service every household due to terrain and layout. Households create informal dump sites or burn waste as a result. In Lived Space (Representational Space), residents may feel neglected or excluded from municipal planning processes. This perception leads to disengagement, illegal dumping, and a growing environmental health crisis. The disconnect between what is planned and what is lived leads to environmental degradation and mistrust in governance.

6.3.2.7. Narrow road networks

Narrow road networks are identified as a factor contributing to unsustainable waste collection, with a mean score of 3.07, which suggests that respondents generally see narrow road networks as a moderate concern in waste collection. A moderate-to-high standard deviation (1.307) suggests that opinions on this issue vary widely, likely due to differences in local road conditions. About 12.6% of the respondents strongly agreed that narrow road networks affect the effectiveness of solid waste collection, and 35.7% of respondents agreed, which makes up 48.3%, nearly half of the respondents confirm that narrow roads negatively impact waste collection. Nearly 12.8% of respondents were uncertain about its impact because their areas had wider roads that allow truck access. Approximately 23.9% of respondents disagreed that narrow road networks affect solid waste collection, and 15.1% strongly disagreed; this makes a total of 39.8% of respondents who were unaffected. This indicates that some areas may have better-planned road networks.

The regression analysis assessed whether narrow road networks significantly influenced perceptions of sustainable and effective waste collection. The unstandardised coefficient (B) was 0.083, and the standardised beta coefficient was 0.070, indicating a weak positive relationship. This means that as concerns about

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narrow road access increased, perceptions of poor service delivery also rose, but the relationship was relatively mild. Statistically, this result was not significant, with a p-value of 0.337, which exceeds the 0.05 threshold. The 95% confidence interval ranged from -0.087 to 0.253, including zero and thus confirming the insignificance of this variable in the regression model. The partial correlation was 0.060, and the semi-partial correlation was 0.054, reflecting a limited impact on the overall model. Even though the regression results did not reach statistical significance, the practical impact of narrow road networks remains notable. Service access challenges are well documented in low-income and informal settlements where urban infrastructure has not kept pace with population growth.

During the observation, the researcher observed that roads are not built to accommodate large solid waste trucks. Trucks are struggling to access certain areas, leading to missed pickups. When vehicles force their way into tight lanes, there is a high chance of accidents. Collection workers have to walk with bins to the accessible road. This adds time and complexity to the process and increases operational costs. The municipality cannot use smaller vehicles because it increases the trips needed. The municipality may have to invest in more expensive roads when roads are very narrow.

One of the major difficulties for small towns is connecting the SWM system with the municipal waste collection service because of the highly congested spatial arrangements and lack of accessibility (Nilufar et al, 2022). Nilufar et al. (2022) highlight that small towns struggle to integrate municipal waste collection services due to spatial congestion and poor accessibility. In Muledane and Maniini, narrow and unpaved roads prevent large waste collection trucks from reaching certain households, forcing residents to dispose of waste in illegal dumpsites or open spaces. Highly congested settlements and informal housing structures exacerbate the issue by limiting designated waste collection points and proper disposal sites.

In addition, SPLUMA promotes equitable spatial planning that is efficient, sustainable, and accessible. One of SPLUMA's five development principles is spatial justice, meaning infrastructure and services (like waste collection) should reach all communities, including those in disadvantaged peri-urban areas. When municipal planning fails to consider waste truck access (e.g., not zoning space for waste routes or

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missing infrastructure upgrades in informal settlements), it directly contradicts SPLUMA's goals.

6.2.3. Economic Factors

Economic constraints such as budget limitations, high transportation costs, and insufficient financial support pose significant barriers to effective waste collection. Addressing these economic challenges is critical to improving service reliability and coverage.

6.2.3.1. Limited human resources

Limited human resources were also identified as a significant problem, as reflected in a mean of 2.64. Around 25.6% disagreed, 15.5% remained neutral, and 32.4% agreed. With a standard deviation of 1.231, there is a moderate level of variation in responses, showing that human resources are seen as a challenge by a substantial proportion of respondents. The mean indicated that a shortage of solid waste collection workers results in missed and delayed pickups, accumulating solid waste in households and streets. Municipality struggles to meet collection schedules due to rapid population growth in peri-urban areas. Small workers are forced to cover a large area, which leads to lower productivity. A lack of skilled workers means that collection trucks and bins are not properly managed.

The regression analysis further examined whether the shortage of human resources significantly influenced perceptions of effective and sustainable household solid waste collection. The unstandardised coefficient (B) was 0.052, and the standardised beta coefficient was 0.056, indicating a weak positive relationship. This suggests that as perceptions of limited human resources increased, so did concerns regarding ineffective and unsustainable waste collection, although the effect was minor. However, the p-value associated with this relationship was 0.448, well above the 0.05 threshold, indicating that the variable was not statistically significant. The 95% confidence interval for B ranged from -0.083 to 0.187, which includes zero, affirming the insignificance of the relationship. From a multicollinearity standpoint, there were no concerns. The tolerance value stood at 0.727, and the Variance Inflation Factor (VIF)

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was 1.376, both well within acceptable thresholds. This confirms that the variable did not interfere with the stability or reliability of the regression model.

Although the statistical analysis did not find limited human resources to be a significant predictor in the model, the practical implications remain vital. In peri-urban contexts like Maniini and Muledane, a lack of staff leads to reduced coverage, delays, and mounting waste, exacerbating health and environmental risks. These challenges support calls for enhanced municipal investment in personnel recruitment and training as part of a broader institutional capacity-building strategy, as recommended by the National Waste Management Strategy (NWMS, 2020).

NWMS 2020 calls for institutional capacity building (training, hiring skilled personnel). Procurement and maintenance of waste infrastructure, including trucks and equipment. Support for municipalities to implement Integrated Waste Management Plans (IWMPs). In Thulamela Local Municipality, the IWMPs are often not implemented due to lack of budget and human capacity. Fleet maintenance is poor, and some trucks are beyond their usable life. Skilled waste engineers, town planners, and GIS professionals are often absent or under-resourced in peri-urban settings.

Principal-Agent Theory (Jensen & Meckling, 1976), this theory explores the relationship between a principal (the one who delegates tasks) and an agent (the one who performs the tasks). The principal is the community/households, expect solid waste to be collected efficiently. The agent is the municipality, tasked with delivering the service. Problems that arise when Information Asymmetry Municipal officials (agents) know more about internal constraints (e.g., lack of vehicles) than the households (principals), which makes it difficult for residents to assess performance accurately.

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Picture 6.2: Limited human resources

Source: field date (2025)

From the observation, picture 6.2 shows workers loading waste onto a truck, the setting in a peri-urban area with a dirt road. The scene reflects the typical setting where limited human resources hinder efficient waste collection because the image shows the issue of a shortage of solid waste collection workers. The workers in the image are working manually, which could contribute to delays in pickups and missed collection schedules, especially in areas with rapid population growth. Three workers cannot cover the whole Maniini, it becomes difficult for them, which results in incompetence.

6. 2.3.2. Shortage of waste collection vehicles

Respondents indicated that the shortage of waste collection vehicles is a noticeable impediment, with a mean of 3.06 suggesting that respondents were slightly more likely to agree that vehicle shortages are a problem, but it is not a severe issue. A moderate standard deviation (1.198) means that responses were somewhat varied, indicating different experiences across different areas. Some neighbourhoods may suffer from vehicle shortages, while others may have enough collection trucks. (33.2% Agreed + 10.1% Strongly Agreed) = 43.3% of respondents believed a shortage of waste collection vehicles is a problem, which indicates that a significant portion of the population experiences delays or inefficiencies due to a lack of waste collection trucks. This could lead to longer waiting times for waste pickup. Neutral Response (21.0%) indicated that these respondents are unsure whether a shortage of waste collection vehicles affects waste collection. (11.3% Strongly Disagreed + 24.4% Disagreed) = 35.7% of

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respondents believed there is no significant shortage of waste collection vehicles, which indicates that some areas have enough waste collection trucks and do not experience delays.

The regression analysis for the shortage of waste collection vehicles explored whether this variable significantly influenced perceptions of solid waste collection effectiveness and sustainability. The unstandardised coefficient (B) was 0.123, and the standardised beta coefficient was 0.130, indicating a weak positive relationship. This suggests that as the perception of vehicle shortages increased, so did concerns about poor waste service delivery. Although the direction of the relationship implies that inadequate fleet availability may contribute to system inefficiency, the relationship was not statistically significant, with a p-value of 0.085. This p-value is slightly above the conventional 0.05 threshold but relatively close, suggesting the relationship might still be practically relevant even if not confirmed by statistical inference. The 95% confidence interval ranged from -0.017 to 0.264, which includes zero and confirms the absence of statistical significance. Collinearity diagnostics revealed no cause for concern. The tolerance value was 0.709, and the Variance Inflation Factor (VIF) was 1.410, both well within acceptable limits, indicating that this variable did not distort the regression model. Even though the statistical evidence did not show significance, the practical implications are undeniable. Limited access to collection vehicles leads to missed pickups and delays that frustrate residents and foster illegal dumping.

Thulamela Local Municipality has confirmed that it has a few trucks which are meant to cover the entire area under the municipality. Few trucks mean that collection schedules are inconsistent, and some regions of Maniini and Muledane are completely neglected for days and weeks. The available trucks are overused, leading to frequent breakdowns and higher maintenance costs. Old and malfunctioning vehicles contribute to inefficiencies in solid waste collection services. Few vehicles mean high fuel consumption per trip, increasing operational costs for the municipality.

From the case study in 2.2.3.1.1. Case study of Morrocco: household solid waste Khouribga city (Salama, Chennaoui,2024). Khouribga's case study reveals that a shortage of waste collection vehicles, limited human resources and inefficient urban planning cause poor solid waste collection. Similarly to the data above, Maniini and Muledane are experiencing the same thing happening in Khouribga. The data from the

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questionnaires support this, with a shortage of vehicles having a high mean of 3,06, highlighting it as a key challenge. These constraints impact solid waste collection's efficiency, reliability, and sustainability. Many developing cities struggle with limited waste collection vehicles, poor route planning and insufficient human resources, making it challenging to manage rising waste effectively.



Picture 6.3: Shortage of waste collection vehicles in Thulamela Local Municipality

Source: field date (2025)

From the observation, picture 6.3 effectively represents the shortage of waste collection vehicles in Thulamela Local Municipality. The trucks shown are part of the limited fleet tasked with covering the entire municipality, supporting the claim that the available cars are overused.

6. 2.3.3. Poor allocation of municipal resources

The respondents (8.8%) strongly disagreed that poor allocation of municipal resources is a key issue affecting waste collection. More than a quarter (26.1%) of respondents disagreed that poor resource allocation is a major problem. Approximately, 20.6% of respondents remained neutral, meaning they are uncertain or indifferent about this issue. Nearly one-third (28.6%) of respondents agreed that poor allocation of municipal resources is a factor in inefficient waste collection. About, 16.0% of respondents strongly agreed, meaning they view poor allocation of municipal resources as a major issue. A mean of 3.17 indicated that respondents lean slightly toward agreeing that inadequate allocation of municipal resources is an issue, but it is not the most pressing concern. A moderate standard deviation (1.231) means that responses are somewhat varied, indicating differences in perceptions across different areas. This indicated that

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while some communities experience inefficient municipal resource allocation, others do not.

The regression analysis tested whether poor allocation of municipal resources had a significant effect on perceptions of the effectiveness and sustainability of waste collection services. The unstandardised coefficient (B) was 0.012, and the standardised beta coefficient was 0.014, indicating a very weak positive relationship. This implies that increased perceptions of misallocated resources are slightly associated with increased concerns about poor waste collection, but the relationship is minimal. Statistically, the relationship was not significant, as the p-value was 0.851, well above the 0.05 threshold. The 95% confidence interval ranged from -0.118 to 0.143, which includes zero, confirming the insignificance of this variable in the regression model. Partial and semi-partial correlations (0.013 and 0.012, respectively) also reflect this weak predictive power.

Many South African municipalities are characterised by corruption and mismanagement of funds. In local municipalities like this, there is a weak budget, corruption, and lack of planning, often resulting in little funding for solid waste collection systems. Solid waste collection cannot expand to other areas like Maniini Tshikovha without proper funds to meet population demands. The municipality struggles to hire and train more solid waste collection workers. Limited trucks and fuel shortages have prevented the timely collection of solid waste, leading to uncollected waste in the community. Lack of maintenance funds for existing vehicles and equipment often break down and go unrepaired. In some scenarios, funds for solid waste management systems are misused and misallocated.

The municipality has operated waste management services with a financial deficit for the past few years. Refuse removal is a constitutional right per the Bill of Rights Chapter 2 and is one of the key basic services the Municipality is mandated to provide (Thulamela Municipality, 2024). Further , the Principal-Agent Theory explained the challenges that are faced by municipality in delivering the service. Municipal officials may misuse or misallocate budgets, directing funds to non-priority areas or inflating administrative costs. Households often lack insight into how municipal budgets are planned and spent, making it difficult to hold officials accountable. Solid waste

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management, especially in peri-urban areas, is not politically prioritised, meaning officials don't face consequences for poor service.

6.3.3.1. Budget constraints

The most significant factor identified by the respondents is budget constraints, with a mean of 4.58, which indicates strong agreement that limited budgets are a major challenge. A vast majority, 85.7%, strongly agreed with this factor, while 7.6% disagreed. The standard deviation of 1.133 reveals a moderate spread in the responses, indicating a fairly consistent recognition of budget limitations across the respondents. Lack of funding prevents the construction of solid waste collection points and recycling facilities in peri-urban villages.

The regression analysis evaluated the impact of budget constraints on perceptions of the effectiveness and sustainability of household solid waste collection. The unstandardised coefficient (B) was -0.045, and the standardised beta coefficient was -0.045, indicating a very weak negative relationship. This means that as perceptions of budget constraints increased, there was a slight decline in perceptions of waste collection effectiveness, although the influence was minimal. Statistically, this relationship was not significant, with a p-value of 0.629, well above the 0.05 threshold. The 95% confidence interval for B ranged from -0.228 to 0.138, which includes zero and reaffirms the insignificance of this factor within the regression model. Partial and semi-partial correlations were -0.034 and -0.031, indicating very low predictive strength.

Insufficient funds mean that the municipality cannot afford to purchase enough collection trucks and maintain existing ones. Peri urban areas have issues such as long distances, rough terrain and poor road conditions requiring vehicles. Budget constraints limit the ability to hire and train solid waste collection workers; this leads to inadequate service. Peri-urban villages suffer from poorly maintained roads that solid waste collection trucks cannot navigate. When there is limited funding, the municipality struggles to invest in road infrastructure. Solid waste collection programs require funding for awareness campaigns, training workshops and an incentives program to encourage proper solid waste disposal.

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	THULAMELA LOCAL MUNICIPALITY				
	TARIFFS FOR 2024/2025 FINANCIAL YEAR				
NATURE OF SERVICE	REMARKS				
			2024/2025	2025/2026	2026/2027
	Community Services-Waste Removal(041)				
General service for Residential	a) Refuse services per month		R 89	R 93	R 97
	b) Development fund i.r.o. all areas.				
	other than a. Per month				
	c) Extra ordinary Refuse				
	i. Garden refuse, per load		R 744	R 779	R 814
	ii. Building Rubble, per load		R 1 004	R 1 050	R 1 098
	d) Using of Landfill (Dumping), per ton		R 89	R 93	R 97
General Services for rural areas	a) Refuse services per month		R40	R 42	R 44
General service for Business & Government	a) Standard refuse container once a week per month		R 223	R 234	R 244
	i. Bulk container once a week, per month		R 4 182	R 4 374	R 4 576
	ii. Development fund i.r.o. Other than I above per month				
	b) Extra Ordinary Refuse				
	Garden refuse Per load		R 893	R 934	R 977
	i. Building Rubble per load		R 1 340	R 1 402	R 1 466
	c) Using of Landfill (Dumping) per tone		R 211	R 221	R 231
new vote	d)Using of Landfill per ton by other entities outside the municipal boundry		R 250	R 262	R 274
General service for Industrial site	a) Standard refuse container (once a week) per time		R 223	R 234	R 244
General service is Payable from the	b) Bulk container per week, per month		R 4 020	R 4 205	R 4 398
date of purchase whether there is					
development or not					

Figure 6.1: Tariffs for solid waste collection of Thulamela Local Municipality

Source: Thulamela Budget 2024/2025

The monthly refuse service fee for residential households is set to increase from R89 (2024/2025) to R97 (2026/2027). Rural residents, who are charged R40 per month (2024/2025) for refuse collection, may struggle with payment as fees increase. Limited infrastructure in rural areas and informal settlements means inadequate waste collection services. If budget constraints limit expansion efforts, these communities will continue to face waste accumulation issues. Addressing budget constraints through subsidies, better fee collection strategies and improved financial management is crucial for ensuring sustainable solid waste collection services.

Mutheu & Wambua (2024) (Thika) found that financial constraints meant that local authorities couldn't buy enough collection vehicles or hire enough workers. Chimbwete & Mbewe (2022) (Lilongwe) also noted that low municipal revenue was a barrier,

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especially in newer peri-urban areas. Both studies and your data reflect that insufficient funding results in poor infrastructure, few workers, and inconsistent services. No matter how well waste management is planned, it cannot function without money.

6.3.3.2. High transportation costs

In this study, high transportation costs were identified as a factor contributing to unsustainable waste collection, with a mean score of 3.07, which suggests that respondents generally see transportation costs as a moderate concern in waste collection. A moderate-to-high standard deviation (1.317) indicates that opinions on this issue vary significantly, likely due to differences in regional fuel prices, waste collection distances, and municipal budget structures. Approximately 15.5% of respondents strongly agreed that transportation cost affects solid waste collection and 30,2% of respondents agreed, this makes a total of 45,7% of respondents, nearly half of respondents believed high transportation costs are a key barrier to effective waste collection. About 16.2% of respondents were uncertain about its impact on solid waste collection because they live in areas with relatively efficient waste collection. A about 24.8% of respondents disagreed that high transport cost affects solid waste collection, and 13,4% disagreed, making a total of 38,2% of respondents. Indicating that some areas may have lower transportation expenses due to better road access.

The regression analysis examined whether high transportation costs significantly influenced perceptions of effective and sustainable waste collection. The unstandardised coefficient (B) was 0.055, and the standardised beta coefficient was 0.060, indicating a weak positive relationship. This suggests that perceptions of rising transportation costs were mildly associated with views of reduced service sustainability and effectiveness. However, this relationship was not statistically significant, with a p-value of 0.467, which is well above the 0.05 threshold. The 95% confidence interval for B ranged from -0.092 to 0.202, which includes zero and confirms the insignificance of the variable. The partial correlation was 0.047, and the semi-partial correlation was 0.042, indicating a minimal contribution to the overall regression model.

High transport costs have increased the financial responsibility of moving solid waste from scattered households in peri-urban areas to designated disposal facilities. The cost includes fuel, vehicle maintenance, labour and potential investment in specialised

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vehicles to navigate challenging terrain. Peri-urban villages lack compact layouts, meaning solid waste collection vehicles must travel long distances between collection points, increasing fuel consumption. Inadequate mapping and inefficient routes force vehicles to take a long to reach their destination. Without a GIS tool, unnecessary distance is added, escalating operational costs.

6.2.4. Environmental factors

Environmental factors, including topography, climate, and poor response to waste minimisation, affect waste collection efficiency. These factors can increase collection costs and complicate access, requiring adaptive planning and resilient infrastructure.

6.2.4.1. Poor response to waste minimisation

From Table 6.1, 10% of the respondents strongly disagreed with the poor response to waste minimisation. 19.3% of respondents also disagreed, meaning they acknowledged waste minimisation but did not see it as a major issue. 17.6% of respondents are neutral, indicating uncertainty or mixed perceptions about the role of waste minimisation. 31.1% of respondents believed that poor waste minimisation efforts contributed to waste collection inefficiencies, which is a significant number compared to others. 21.8% of respondents strongly agree, meaning they view poor waste minimisation as a significant challenge for waste collection. It has a mean of 3.42 and a standard deviation of 1.187. A mean value of 3.35 showed a lack of commitment to solid waste minimisation efforts. Limited recycling infrastructure and weak solid waste management policy enforcement and regulations contribute to unsustainable practices.

The regression analysis evaluated whether poor response to waste minimisation significantly influenced perceptions of the effectiveness and sustainability of waste collection. The unstandardised coefficient (B) was 0.025, and the standardised beta coefficient was 0.028, indicating a very weak positive relationship. This means that increased concerns about waste minimisation corresponded slightly with the perception of less effective waste services, but the impact was negligible. Statistically, this relationship was not significant, with a p-value of 0.707, far above the 0.05 benchmark. The 95% confidence interval ranged from -0.107 to 0.157, which included zero, reaffirming the statistical insignificance of the variable. In addition, the partial and

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semi-partial correlations were 0.026 and 0.024, respectively, further highlighting its weak contribution to the model. However, there were no multicollinearity issues tolerance was 0.697, and the Variance Inflation Factor (VIF) was 1.435, both indicating acceptable levels of variable independence in the regression model. Even though the regression model did not find poor waste minimisation to be a statistically significant factor, its practical implications are critical. Without strong waste reduction strategies, the municipality must manage larger waste volumes, increasing transport, operational, and landfill costs...

In Maniini and Muledane, there is a poor response to waste minimisation due to a lack of awareness, inadequate policy, poor enforcement and insufficient infrastructure. This has resulted in excessive solid waste generation and environmental pollution. Without a proper response to solid waste minimisation, households will continue to produce more solid waste, which will overburden the collection system. The more solid waste means more cost and transportation challenges for the municipality. This issue increased the reliance on non-sustainable solid waste disposal, such as open space disposal. Many households in peri-urban areas lack knowledge about the benefits of solid waste minimisation.

6.2.4.2. Non-compliance with environmental legislation

Non-compliance with environmental legislation has a mean score of 3.14 and a standard deviation of 1.88, which indicates that respondents lean toward agreement that non-compliance with environmental laws is a challenge. This is because many waste collection inefficiencies are caused by weak enforcement of regulations. A total of 46.3% of respondents believed that non-compliance with environmental laws is a significant challenge. This indicated widespread disregard for waste management policies, such as illegal dumping and a lack of proper solid waste segregation. A total of 35.7% of respondents believed that non-compliance is not a significant issue. This indicated that some areas may have better enforcement, or some respondents may not be fully aware of existing environmental laws. 18.1% of respondents remained neutral, suggesting they may be uncertain about compliance with environmental regulations.

The regression analysis tested whether non-compliance with environmental legislation significantly influenced perceptions of the effectiveness and sustainability of household

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solid waste collection. The unstandardised coefficient (B) was -0.028, and the standardised beta coefficient was -0.029, indicating a very weak negative relationship. This suggests that as perceptions of non-compliance increased, perceptions of waste collection sustainability decreased slightly, but the effect was minimal. The p-value was 0.697, which is far above the 0.05 significance threshold, indicating that the relationship is not statistically significant. The 95% confidence interval ranged from -0.169 to 0.113, which includes zero, further confirming the lack of significance. Partial and semi-partial correlations were -0.027 and -0.025, respectively both very low and indicating minimal predictive power in the model.

Illegal dumping and pollution due to weak enforcement mean municipal authorities fail to track where waste is disposed of. Residents resort to illegal dumping when collection is irregular. Fines for illegal dumping are either absent or not strictly applied. When environmental laws are not enforced, individuals and businesses do not feel obligated to follow proper waste disposal practices; many residents are unaware of solid waste disposal regulations. Households are not motivated to segregate waste or recycle because governments do not actively involve citizens in waste management efforts. Municipalities often struggle to enforce waste management laws due to limited resources and institutional weaknesses.

Namoun (2022) highlights that a lack of clear environmental standards for institutional waste management contributes to poor waste disposal in Pakistan. Similarly, in Muledane and Maniini, weak enforcement of environmental legislation has resulted in illegal dumping, poor waste segregation, and inefficient collection systems. Khan et al. (2022) describe household solid waste management as an emerging challenge in developing countries. This is also evident in South Africa, where many municipalities struggle to enforce waste disposal regulations. The findings from Jamshaid (2021), which highlight the increasing waste generation in institutions, are relevant to South Africa, where rising urban populations and limited regulatory enforcement have further burdened waste collection services.

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Picture 6. 4: Illegal dumping

Source: field data (2025)

from the observation, this image shows several piles of waste scattered around, a classic example of illegal dumping. The visible disregard for proper waste disposal practices reflects a failure in municipal management, where the absence of proper collection systems and monitoring encourages unlawful dumping. The poor enforcement of fines and regulations for such behaviour further perpetuates this issue, as highlighted by your study findings.

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Picture 6.5: Open space burning

Source: field data (2025)

The picture 6.5 above shows a different site where solid waste appears to have been burned in an open space. Open burning of waste is another consequence of inadequate waste management systems. Open burning also ties into the issue of non-compliance with environmental laws. Since many people are unaware of the harmful effects or feel no consequences for burning waste, it continues to happen.

6.3.4.1. Topography

Topography had a mean value of 3.45, suggesting that respondents generally perceive topography as a moderate concern in waste collection. A moderate standard deviation (1.220) indicates that while most respondents agree, opinions vary depending on the local topographic conditions of their area. About 23.1% of the respondents strongly agreed that topography affects solid waste collection, and 31.3% agreed, which makes up a total of 54,4%. This indicated that over half of the respondents believed that peri-urban terrain negatively affects waste collection services. Approximately 18.5% of respondents were not sure about whether topography affects solid waste collection, sometimes because they live in more accessible areas. About 21.0% of respondents disagreed that topography does not affect solid waste collection, and 5,9% strongly

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disagreed; this indicates that some areas did not experience topography challenges, especially in flatter areas.

The regression analysis tested whether topography significantly influenced perceptions of effective and sustainable household solid waste collection. The unstandardised coefficient (B) was 0.016, and the standardised beta coefficient was 0.018, indicating an extremely weak positive relationship. This suggests that topographical challenges were perceived to have a very minor association with the sustainability of waste collection, but the effect was negligible. Statistically, the result was not significant, with a p-value of 0.829, which is far above the 0.05 threshold. The 95% confidence interval ranged from -0.126 to 0.157, which includes zero, confirming the insignificance of the variable. The partial correlation was 0.017, and the semi-partial correlation was 0.015, indicating a very small influence on the model's outcome. Although not statistically significant, the practical implications of topography in waste collection planning are substantial. In hilly or low-lying areas, a lack of investment in road infrastructure or adapted collection vehicles often leads to exclusion.

In peri-urban villages around Thohoyandou, the slope in most places is steep and characterised by a lot of mountains. The landscape is varied and significantly affects infrastructure development, transportation and service delivery. Maniini and Muledane have steep slopes and hilly terrain with a lot of valleys, making it difficult for solid waste collection trucks to access certain areas. Households are forced to carry solid waste to collection points, which some households are too lazy to do. Fuel consumption is much higher in these hilly areas due to the difficulty in driving conditions. Collection routes take longer, which leads to high transportation and labour costs.

6.3.4.2. Climate

Climate is identified as a significant factor contributing to unsustainable waste collection, with a mean score of 3.14, which suggests that respondents generally view climate as a moderate concern in solid waste collection. A moderate standard deviation (1.250) indicates that while many respondents agree, opinions vary depending on local climatic conditions and how they experience solid waste collection issues. A small number of 14.3% of respondents strongly agreed that climate had an impact on the issue of solid waste collection, and 28.4 agreed, which makes a total of 42.7%. This shows

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that a significant portion of respondents acknowledge the negative impact of climate on waste collection. Approximately 15.5% of the respondents were uncertain about the challenges of climate change on solid waste, possibly because they live in areas with better drainage and road networks. About 27.3% of the respondents disagreed that poor solid waste is caused by climate, and 10,1% of the respondents strongly agreed, which makes a total of 37,3%. This indicates that some areas have not experienced major climatic impacts on waste collection, possibly due to better infrastructure.

The regression analysis assessed whether climate significantly influenced perceptions of the effectiveness and sustainability of household solid waste collection. The unstandardised coefficient (B) was -0.031, and the standardised beta coefficient was -0.034, indicating a very weak negative relationship. This implies that worsening climatic conditions slightly reduced perceptions of waste service effectiveness, but the effect was minimal. The relationship was not statistically significant, with a p-value of 0.672, well above the 0.05 threshold. The 95% confidence interval for B ranged from -0.171 to 0.110, which includes zero, confirming its insignificance in the regression model. The partial and semi-partial correlations were -0.030 and -0.027, respectively, both very low, indicating weak predictive influence. While not statistically significant, the practical implications of climate factors should not be overlooked, particularly in regions with poor drainage, limited infrastructure, or seasonal road inaccessibility.

Rising temperatures accelerate the decomposition of organic waste, which leads to unpleasant odours which attract flies. This not only affects the community's health but also affects the necessity of more frequent waste collection to mitigate these issues. Extreme weather events, such as flooding and storms, can overwhelm existing waste management systems. Leading to increased pollution and health hazards. Such events can also damage solid waste collection infrastructure.

6.2.5. Political factors

Political influences, such as poor service delivery, poor prioritisation of the services and Poor urban management and planning, hinder the solid waste collection service.

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6.2.5.1. Poor urban management and planning

A small number (9.2%) strongly disagreed that poor urban management and planning prevented solid waste collection. Approximately,16.0% of respondents disagreed, meaning they acknowledge some level of impact but do not consider it a major problem. 13.0% of respondents remained neutral, meaning they are uncertain about the issue. Nearly half (47.5%) of respondents agreed that poor urban management and planning contribute to waste collection inefficiencies. About 14.3% of respondents strongly agreed that poor urban management and planning are critical issues for waste collection. Poor urban management mean of 3.35 and a standard deviations of 1.290 shows moderate response variability. Poorly planned road networks, lack of designated collection points, and uncoordinated land use planning worsened solid waste collection difficulties.

The regression analysis examined whether poor urban management and planning significantly influenced the perception of effective and sustainable solid waste collection. The unstandardised coefficient (B) was -0.153, and the standardised beta coefficient was -0.160, indicating a weak negative relationship. This means that as respondents perceived urban management to be poor, they were more likely to view household solid waste collection services as ineffective and unsustainable. Crucially, this variable was statistically significant, with a p-value of 0.035, which is below the 0.05 threshold. The 95% confidence interval ranged from -0.296 to -0.011, and since it does not include zero, it confirms a significant negative effect. This implies that poor urban management and planning meaningfully predict perceptions of ineffective solid waste services. In terms of model stability, the tolerance value was 0.702, and the Variance Inflation Factor (VIF) was 1.424, indicating no multicollinearity issues and confirming that the variable's effect is reliably estimated within the model. This significant statistical relationship strengthens the practical insights derived from your fieldwork. The lack of integrated urban management strategies especially in informal peri-urban areas contributes to service inefficiencies.

Urban planning failed to integrate effective solid waste management, resulting in overloaded landfills, illegal dumping and poor sanitation service. Rapid urban expansion in peri-urban areas creates an informal planning pattern with narrow, unpaved roads that solid collection trucks find difficult to access. Poor spatial planning

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led to ineffective solid waste collection service. These two villages lack properly designated collection points, making disposal difficult. Thulamela Local Municipality, by law, lacks policies and enforcement that regulate solid waste collection. Solid waste collection service often receives low priority in the municipal budget, this causes a shortage of equipment and labour.

Adedibu & Okekunle (2019) (Ibadan) highlighted that fragmented planning and lack of coordination between urban management bodies resulted in poor waste service delivery. Isunju et al. (2020) (Kampala) Identified that uncoordinated urban growth and weak enforcement of planning regulations led to overwhelmed waste management systems. The findings and the literature show that waste services can't keep up with settlement expansion without integrated planning. This leads to service gaps, especially in peri-urban areas where growth is fast and unregulated.

6.2.5.2. Poor service delivery

13.0% of respondents completely reject the idea that poor service delivery is a major issue in waste collection. Nearly a quarter (24.4%) of respondents disagreed, meaning they did not see poor service delivery as a primary challenge in waste collection. Approximately 20.2% of respondents remained neutral, meaning they are either uncertain or indifferent about the role of poor service delivery in waste collection challenges. More than a quarter (28.6%) of respondents believed poor service delivery negatively impacts solid waste collection. A mean of 3.06 indicated that respondents lean slightly toward agreeing that poor service delivery is a problem, but it is not the most critical challenge. A moderate standard deviation (1.268) means that responses are somewhat varied, indicating differences in waste collection services across different areas. This suggests that while some communities experience serious waste collection issues, others receive relatively good service.

The regression analysis explored whether poor service delivery had a statistically significant influence on perceptions of household solid waste collection effectiveness and sustainability. The unstandardised coefficient (B) was 0.042, and the standardised beta coefficient was 0.047, suggesting a very weak positive relationship. This implies that as perceptions of poor service delivery increased, so did concerns over the ineffectiveness of solid waste collection, although the relationship was minimal. The p-value was 0.541, which exceeds the 0.05 threshold, meaning the relationship is not

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statistically significant. The 95% confidence interval ranged from -0.093 to 0.178, including zero, which further confirms the insignificance. Additionally, the partial correlation was 0.043, and the semi-partial correlation was 0.039, both reflecting weak influence in the model.

From the semi-structured interview, Thulamela officials admitted that solid waste does not follow a fixed schedule in these peri-urban villages, leading to solid waste accumulation in the residential areas. Some residential areas are not included in municipal solid waste collection plans households without access to solid waste collection resort to burning and dumping waste in rivers. Municipality does not have efficient complaint mechanisms, making it difficult for households to report missed collections and illegal dumping.

Furthermore, the White Paper on Environmental Management Policy (1998) emphasises the right to a healthy environment and reliable service delivery, including refuse removal. Calls for public participation in environmental governance and policy implementation. Inconsistent services directly violate this right and reduce public trust. Sustainable Development Goal 11 (Make cities inclusive, safe, resilient, and sustainable) Calls for regular, inclusive, and efficient municipal solid waste collection to reduce the environmental impact of cities. Poor scheduling undermines SDG targets and increases unregulated waste disposal.

Albert Hirschman's model explains how citizens respond to service failure. Exit, People silently withdraw or stop participating when services decline. Muledane and Maniini see this when households stop paying levies, dump illegally, or burn waste rather than engaging the municipality. Voice, citizens complain or protest in hopes of improving services. Community protests and service delivery complaints in local meetings are examples of using “voice” to demand better waste collection. Loyalty can delay exit and encourage voice. Some residents stay committed to the municipal system, still trying to work within it, but their loyalty can diminish if issues continue.

6. 2.5.3. Poor prioritisation of the service

Only 5.9% of respondents completely strongly disagree with the idea that poor prioritisation affects waste collection. Nearly a quarter (23.5%) of respondents disagreed that poor prioritisation is a key issue in waste collection. 17.6% of

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respondents remained neutral, meaning they are uncertain about whether poor prioritisation affects solid waste collection. A significant portion (39.1%) of respondents believed that poor prioritisation negatively impacts waste collection. 13.9% of respondents strongly agree that poor prioritisation is a major issue in waste management. The mean value is 3.32 and standard deviation is 1.150 which indicated that Solid waste collection did not receiving enough attention and is not treated as a critical public service.

The regression analysis evaluated whether poor prioritisation significantly influenced perceptions of the effectiveness and sustainability of waste collection services. The unstandardised coefficient (B) was -0.079, and the standardised beta coefficient was -0.079, indicating a very weak negative relationship. This means that as perceptions of poor prioritisation increased, perceptions of service effectiveness slightly declined, though the relationship was weak. However, the p-value was 0.314, which is above the 0.05 threshold, indicating that the relationship is not statistically significant. The 95% confidence interval for B ranged from -0.232 to 0.075, which includes zero and confirms the variable's lack of statistical significance. The partial and semi-partial correlations were -0.071 and -0.064, respectively, indicating weak predictive value in the model.

issues such as illegal dumping, pollution and public health risks are becoming widespread, worsening peri-urban conditions and creating long-term sustainability challenges. Municipality funds are often directed to road infrastructure, housing projects and administrative expenses, while solid waste collection receives minimal funding. Solid waste management strategies are developed but not implemented due to competing priorities. Municipalities often focus on visible urban development projects while failing to enforce solid waste disposal laws. According to Thulamela officials the municipality still uses outdated and inefficient solid waste collection methods due to a lack of investment in a smart solid waste management system.

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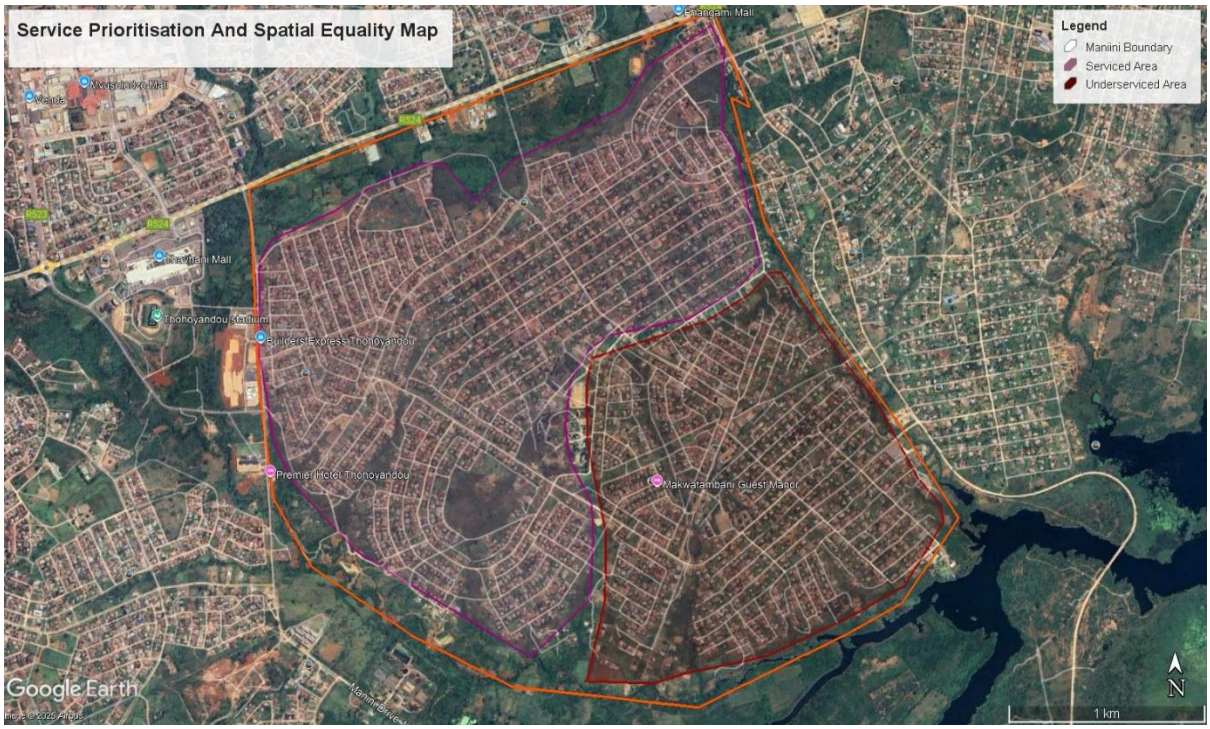

Figure 6.1: Service Prioritisation and Spatial Equality Map

Source: Mutwanamba (2025)

Figure 6.1 shows the Service Prioritisation and Spatial Equality Map, which depicts spatial disparities in service coverage within Maniini. The map highlighted that only portions of the village are serviced, while large areas, particularly on the periphery, such as Maniini Tshikovha, remain underserved.

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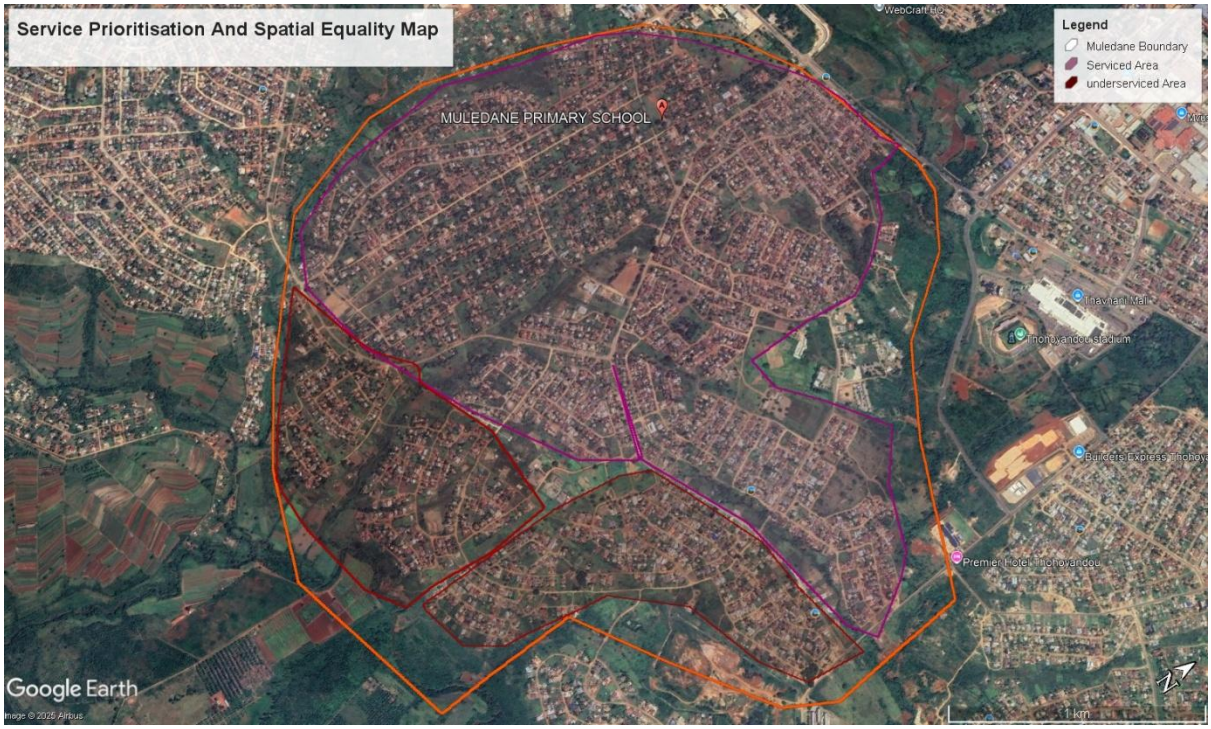

Figure 6.2: The Service Prioritisation and Spatial Equality Map for Muledane

Source:Mutwanamba (2025)

The figure 6.2 above provides visual evidence of disparities in the prioritisation of solid waste collection within the village. The map highlights two distinct zones: a serviced area, predominantly located in the northern and central parts of Muledane, and an underserviced area, concentrated in the southern and south-western sections. The underserviced zones, despite being densely populated, are excluded from regular municipal waste collection services, reflecting a clear case of spatial and service inequality.

6.3.5.1. Limited human resource

The issue of limited human resources also garnered considerable agreement, with a mean of 3.72, indicating that this factor is perceived as a high concern affecting sustainable waste collection. The standard deviation of 0.757 indicates low variability in responses, suggesting that respondents generally agree on the importance of human resource shortages in affecting solid waste collection. A high number 84% of respondents (81.1% agreed + 2.9% strongly agreed) believed that limited human resources negatively affect waste collection. Only 13.8% (13.0% disagreed + 0.8%

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strongly disagreed) believed this was not a significant problem. A low, neutral response (2.1%) indicated that most respondents have a clear opinion on this issue.

The regression analysis assessed whether limited human resources significantly influenced perceptions of waste collection effectiveness and sustainability. The unstandardised coefficient (B) was 0.241, and the standardised beta coefficient was 0.160, indicating a moderate positive relationship. This suggests that as perceptions of limited human resources increased, so did concerns that waste services were ineffective or unsustainable. Although the direction and strength of the relationship appear meaningful, the result was not statistically significant, with a p-value of 0.083. While this value is above the 0.05 threshold, it is close enough to suggest potential practical importance, especially in the context of service delivery constraints. The 95% confidence interval ranged from -0.031 to 0.513, which includes zero and therefore confirms the lack of statistical significance. From a multicollinearity perspective, the tolerance value was 0.474, and the VIF was 2.109. While these values remain within acceptable thresholds, they are on the higher end, which may reflect some overlap with related variables such as "shortage of vehicles" or "lack of equipment.".

In peri-urban villages with limited solid waste collection workers, garbage is not collected regularly, leading to overflow of solid waste bins and illegal dumping. Solid waste collection requires not only field workers but also urban and regional planners, environmental specialists and GIS analysts to design efficient collection routes and infrastructure placement. Many towns in South Africa municipality lack different specialised fields to implement and develop solid waste collection strategies. Due to staff shortages, the municipality struggles to conduct solid waste education campaigns, leading to poor household solid waste segregation and disposal practices.

6. 3.5.4. Poor planning

In Table 6.2 above, poor planning had a mean value of 2,54 and a standard deviation of 1,34. This indicates that respondents recognise it as a key challenge affecting sustainable solid waste collection. A mean score of 2.54 suggests poor planning is not perceived as a critical factor in waste collection inefficiencies. A high standard deviation (1.364) indicated that opinions are quite varied across different respondents. Only 34.1% of respondents (26.5% agreed + 7.6% strongly agreed) believed that poor

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planning negatively affects waste collection. A majority of respondents (56.7% strongly disagreed + disagreed) believed that poor planning is not a major issue. 9.7% of respondents are neutral, indicating some uncertainty or mixed opinions.

The regression analysis examined whether poor planning significantly influenced perceptions of the effectiveness and sustainability of solid waste collection. The unstandardised coefficient (B) was -0.026, and the standardised beta coefficient was -0.027, indicating a very weak negative relationship. This suggests that as the perception of poor planning increased, perceptions of the effectiveness of waste services slightly declined, but the effect was minimal. The result was not statistically significant, with a p-value of 0.714, well above the 0.05 threshold. The 95% confidence interval ranged from -0.177 to 0.124, which includes zero, confirming that this factor does not significantly predict waste collection performance in the regression model. The partial and semi-partial correlations were -0.025 and -0.023, respectively, indicating very limited influence.

Poor planning has led to a lack of integration of solid waste management into spatial planning, which has led to coordinated development with solid waste collection infrastructure. In these peri-urban villages, solid waste service is not evenly distributed due to income disparities. For example, Maniini (K, M) is well developed compared to Maniini (L, Tshikovha). Maniini (K, M) receive house-to-house and block collection, while Maniini (L, Tshikovha) do not receive solid waste collection at all. Thulamela Local Municipality has a few recycling centres for solid waste, and most recycling services are offered by private companies. Rapid urbanisation in Thohoyandou is not matching with available waste management infrastructure.

From 2.2.9 factors affecting…Inconvenient or Inadequate Facilities, Ebrahimi et al., 2021. Ebrahimi et al. also likely pointed out challenges such as limited funding for waste services, insufficient waste worker training, and weak enforcement of waste regulations. By analysing these issues, they underscore that technical fixes alone (trucks, bins, etc.) won't succeed without community engagement and strong institutional support. The respondents rated poor planning as a notable issue, indicating that uncoordinated or reactive waste management efforts contribute to inefficiencies.

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6.4. Summary of the findings

The findings presented in Chapter 6 identified a range of interrelated factors that hinder sustainable household solid waste collection in the peri-urban villages of Muledane and Maniini. Among the most critical barriers were budget constraints, limited human resources, and irregular collection schedules. Budgetary limitations affected the municipality's ability to procure collection vehicles, maintain equipment, and hire and train adequate personnel. These constraints directly contributed to inconsistent waste collection and the accumulation of uncollected waste, often resulting in illegal dumping. Irregular scheduling was reported by 76.1% of respondents as a major issue, generating public dissatisfaction, environmental risks, and health hazards. Additionally, other infrastructural and logistical challenges such as poor route planning, lack of equipment, narrow road networks, and topographical difficulties further complicated service delivery, particularly in informal and unplanned settlements.

Institutional and governance-related factors also emerged as significant obstacles. Weak coordination between municipal departments, insufficient policy enforcement, and inadequate integration of spatial planning frameworks such as those outlined in SPLUMA and the National Waste Management Act resulted in gaps between policy intent and on-the-ground implementation. Furthermore, behavioural issues such as poor household attitudes, non-compliance with environmental regulations, and low levels of public awareness and participation negatively influenced waste segregation and disposal practices. Regression analysis reinforced these findings by revealing that factors like population growth, poor service delivery, and ineffective urban management significantly affected perceptions of waste collection effectiveness, although no single variable emerged as a dominant predictor. These results underscore the complex and multifaceted nature of waste management challenges in peri-urban areas, pointing to the urgent need for integrated, well-resourced, and context-sensitive strategies that combine financial investment, community engagement, spatial planning, and stronger institutional capacity to enhance the sustainability of waste collection systems in Maniini and Muledane.

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Chapter 7: Possible Strategies for Sustainable Household Solid Waste Collection Practices in Thohoyandou Peri-Urban Areas

7.1. Introduction

This chapter draws from the insights presented in Chapters 2 and 4 to discuss informed strategies for improving household solid waste collection in Thohoyandou's town peri-urban areas. The literature review examined global best practices, spatial planning approaches, and challenges in managing waste in developing and developed regions. The methodology chapter outlined how data were collected and analysed to understand local practices, perceptions, and gaps in the current system. Together, these chapters provided a strong foundation for identifying strategic interventions. The strategies focus on enhancing service efficiency, sustainability, and inclusiveness. The aim is to ensure solid waste collection aligns with local needs and broader sustainability goals. The chapter proposed actionable solutions tailored to the Thulamela Local Municipality context by integrating theory and empirical evidence.

The study selected Maniini and Muledane as case study villages, where data were collected using structured questionnaires from 261 sampled households, with 238 responses successfully returned. The quantitative data were analysed using descriptive statistics (mean and standard deviation) and regression analysis, while the qualitative data were examined through thematic analysis

7.2. Possible Strategies for Sustainable Household Solid Waste Collection Practices in Thohoyandou Peri-Urban Areas

Table 7.1 presents targeted strategies to improve household solid waste collection in the peri-urban villages of Maniini and Muledane. Drawing on Chapter 5, it addresses the current uneven solid waste collection practices, including over-reliance on municipal services and lack of service in low-income zones. Chapter 6 highlighted key barriers such as poor route planning, irregular collection schedules, and a shortage of vehicles and human resources. The data also revealed socio-political issues like poor municipal resource allocation and non-compliance with environmental legislation. These negative factors indicate the need for structural reform and spatially aware interventions. The strategies include introducing income-based collection levies, formalising informal waste collectors, and investing in modern infrastructure.

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Community-based cleaning campaigns and education programmes are also proposed to raise awareness. These strategies promote inclusivity, equity, and sustainability. Each strategy is tailored to the spatial and socio-economic realities of the study area. The strategies are grouped into three categories: government approach, community action, and spatial planning practices.

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	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std. Deviation
Cleaning campaigns	2.1%	6.3%	3.8%	38.2%	49.6%	4.27	0.952
Implement policy and legislation	2.9%	0.4%	1.3%	5.9%	89.5%	4.79	0.758
Collection efficiency	1.7%	4.6%	3.8%	84.9%	5.0%	3.87	0.640
Landfilling	2.1%	18.5%	63.0%	13.9%	2.5%	2.96	0.714
Recycling	2.5%	57.1%	15.5%	23.1%	1.7%	2.64	0.920
Enhance Collection Infrastructure	45.4%	20.2%	10.9%	15.5%	8.0%	2.21	1.367
Public Engagement	25.6%	28.2%	11.8%	28.2%	6.3%	2.61	1.303
New technologies	8.0%	30.7%	24.4%	25.2%	11.8%	3.02	1.164
Invest in Training and Development	4.6%	17.6%	22.7%	38.7%	16.4%	3.45	1.100
Enhance Data Management	5.0%	16.4%	12.6%	39.5%	26.5%	3.66	1.179
More household solid waste equipment, e.g., Dustbins	3.8%	19.7%	10.5%	41.6%	24.4%	3.63	1.161
Reduce missed pickups	6.7%	20.2%	16.8%	36.6%	19.7%	3.42	1.205
Optimise Routes and Services	8.8%	22.3%	16.8%	34.0%	18.1%	3.30	1.246
Schedule Bulky Collection	9.7%	28.6%	16.0%	26.9%	18.9%	3.17	1.295
Empower Drivers	11.8%	25.2%	15.5%	29.4%	18.1%	3.17	1.311
Avoid electronic waste	7.6%	17.2%	19.7%	36.1%	19.3%	3.42	1.198
Please leave it to private companies and individual responsibility	4.2%	21.8%	12.2%	37.0%	24.8%	3.56	1.199
Rethink how peri-urban areas are designed and managed	7.1%	19.3%	16.0%	31.1%	26.5%	3.50	1.265

Table 7.1: Possible strategies for poor solid waste collection

Source: field data (2025)

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7.2.1. Government approach

The government plays a crucial role in establishing solid waste collection frameworks through policy development, infrastructure investment, and regulatory enforcement. Effective governance is necessary for creating sustainable collection systems.

7.2.1.1. Implementing policy and legislation

Table 7.1 above presents responses regarding how various strategies may improve solid waste collection. The data revealed different levels of agreement with each strategy, highlighting a range of approaches that respondents believed could enhance solid waste collection. The highest level of agreement was with implementing policy and legislation, with a mean score of 4.79, which means that the study indicates that respondents believed clear policies and strong enforcement can significantly improve solid waste collection systems. It is the highest among the strategies listed and has a low standard deviation of 0.758, indicating a strong consensus on the importance of policy and legislation. About 89.5% of the respondents strongly agreed that policy and legislation can change the issue of poor solid waste collection, and 5.9% of the respondents agreed, which makes a total of 95.5% who believe policy and legislation are an important step toward sustainable solid waste collection. Nearly 2.9% of respondents strongly disagreed that policy and legislation can improve solid waste collection, and 0.4% disagreed. This makes a total of 3.3% of respondents who did not believe because they feel that policies might not be enforced effectively, even if they exist. A small number of 1.3% of respondents were uncertain about implementing policies because they didn't know much about the policies regarding solid waste collection.

The regression analysis for implementing policy and legislation assessed whether the presence of strong legal and regulatory frameworks significantly influenced the perceived effectiveness and sustainability of household solid waste collection in peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.053, and the standardised beta coefficient was –0.035, indicating a very weak negative relationship. This meant that as support for policy implementation increased, there was a slight decline in the perception of collection effectiveness, although the effect was negligible. This relationship was found to be statistically insignificant, with a p-value of 0.645, which was well above the 0.05 threshold. The 95% confidence interval for B ranged

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from –0.279 to 0.173, further confirming the lack of statistical significance since the interval included zero.

Legal frameworks have to ensure that the roles and responsibilities of the local municipality authority and household are clearly defined on the issue of poor collection service. Illegal dumping needs to be penalised to reduce environmental pollution. Municipality needs to put more funds into waste reduction, recycling, and private participation rather than focusing on collection only. Thulamela Local Municipality should focus on regulating solid waste disposal, preventing littering, formalising solid waste collection services, and ensuring that all household waste has a collection service. South Africa has a strong policy framework, which includes the Waste Act; the municipality needs to focus more on this policy since it emphasises reducing, reusing, recycling, and disposing of. This will improve the current solid waste collection service. Thulamela Local Municipality, by law, needs to set guidelines for waste collection schedules and fines for illegal dumping. The by-law has to clearly define the role of solid waste generators, transportation, and landfill operation.

Case study of Mukono Municipality, from 2.4.3.2.2, Uganda: Household's willingness to pay for collection service (Namukuve, 2021; Muheirwe et al, 2023). The Mukono case study highlighted that income, gender, and satisfaction with current waste services influence household willingness to pay (WTP) to improve waste collection. It is recommended that the policy use the estimated WTP to set fair pricing and establish a structured, solid waste collection system. This underscores the importance of clear policies and regulations guiding sustainable solid waste management. The majority support implementing policies and regulations. A well-enforced waste management policy can provide legal frameworks for solid waste collection services. Policies can include solid segregation, formalised payment structures, and penalties for illegal dumping to improve compliance and efficiency.

7.2.1.2. Enhancing collection infrastructure

Enhancing collection infrastructure received the least support and has a mean of 2.21, indicating a general lack of enthusiasm for this measure, with a high standard deviation of 1.367, suggesting significant disagreement among respondents. A small number, 8.0% of the respondents, strongly agreed that enhancing infrastructure can improve

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solid waste collection, and 15.5% of respondents agreed that enhancing infrastructure is the right strategy for sustainable solid waste collection, which makes 24.5% of respondents believe that infrastructure enhancement is the right strategy for sustainable collection. Nearly 10.9% of respondents were neutral, which means they are uncertain about the impact of infrastructure improvements. Approximately 20.2% of respondents disagreed that infrastructure enhancement can improve solid waste collection because due to cost and maintenance expenses, 45.4% of respondents strongly disagreed that infrastructure enhancement is the solution which makes a total of 65.5% of respondents who did not support the idea of infrastructure this because of previous attempts to improve infrastructure have not been effective, residents may have lost trust in this approach.

The regression analysis for enhancing collection infrastructure assessed whether improvements in waste storage facilities, road access, and collection equipment influenced perceptions of the effectiveness and sustainability of household solid waste collection in the peri-urban villages of Thohoyandou. The unstandardised coefficient (B) was –0.042, and the standardised beta coefficient was –0.051, indicating a very weak negative relationship. This implied that increased support for improving infrastructure was slightly associated with a decline in the perceived effectiveness of current waste collection practices, although the effect was negligible. This relationship was not statistically significant, with a p-value of 0.578, which was well above the 0.05 significance threshold. The 95% confidence interval for B ranged from –0.191 to 0.107, including zero, and reinforcing that the relationship was statistically insignificant. Multicollinearity was not an issue, as the tolerance value was 0.526 and the Variance Inflation Factor (VIF) was 1.902, both within acceptable limits. This confirmed that enhancing collection infrastructure was a stable variable within the model...

A municipality can upgrade unpaved roads and create a designated access route for collection trucks. Department of solid waste management needs to work with the Department of planning and infrastructure to integrate waste collection needs into urban expansion plans. Thulamela Local Municipality has old trucks, there is a need to invest in modern and efficient solid waste collection trucks to increase collection frequency. Also introducing solid waste compaction technology to allow trucks to carry more than one waste trip. Working with traditional leaders to introduce community-based waste

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management committees to oversee collection activities. Enhancing collection infrastructure an important step in improving sustainable waste management in Muledane and Maniini. Without proper collection points, roads, storage facilities, and transportation solid waste will continue to pile up, leading to environmental and health risk.

Case study of Kisimu from 2.4.3.2.1, household solid waste (HSW) source separation practices on sustainable solid waste management in Kisumu City of Kenya (Onyango et al, 2024). Using a case study of Kisumu city, according to the study, the lack of a proper waste storage container is the key barrier that prevents effective waste separation at the household level. Without adequate infrastructure, households are less motivated to separate waste, leading to improper disposal methods.

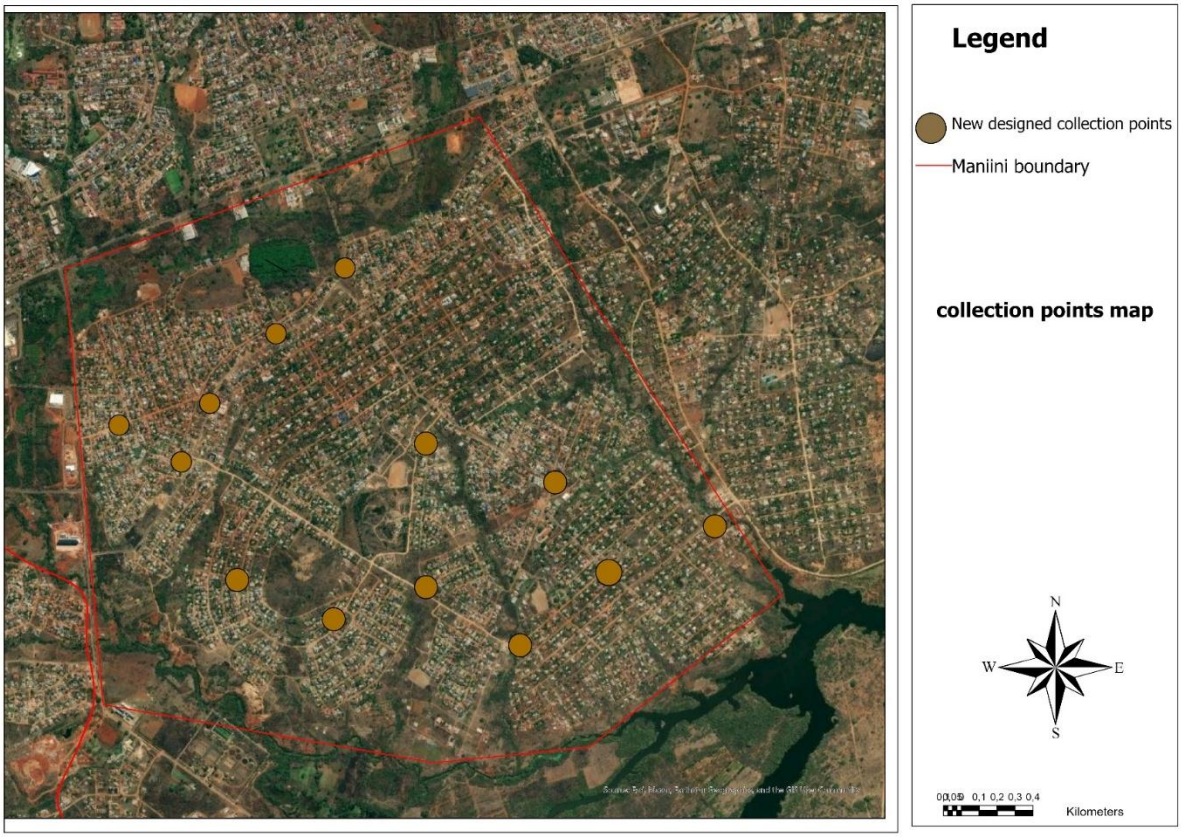

Figure 7.1: New proposed collection points map

Source: Mutwanamba (2025)

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As shown in Figure 7.1, the proposed collection points and newly designed waste collection systems are strategically distributed across different parts of Maniini. The placement of these collection points aims to improve service accessibility and reduce travel distances for households to dispose of their waste. Furthermore, spatial planning interventions are being proposed to enhance solid waste collection efficiency in Maniini. National Domestic Waste Collection Standards (2011) emphasises that Collection points must be accessible to all households without causing health or environmental risks, so the new proposed collection points are accessible to every household.

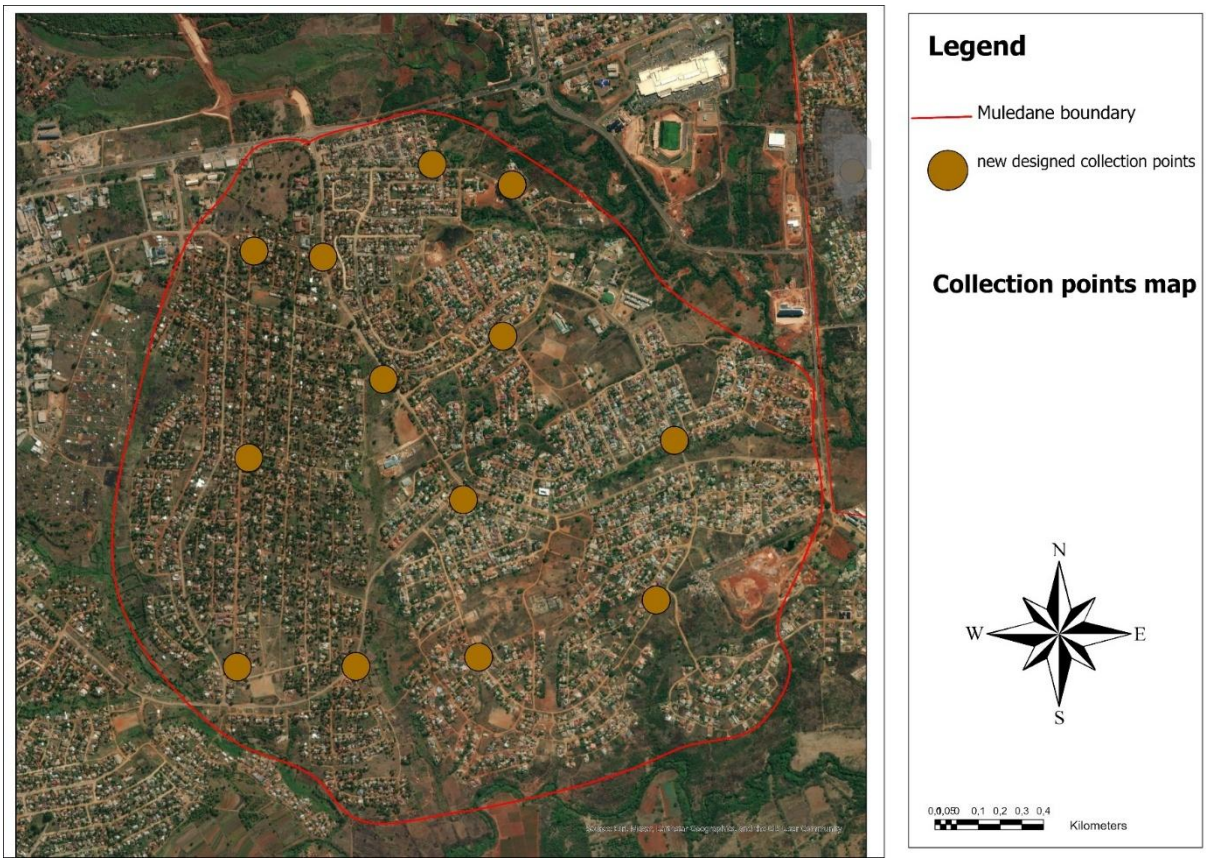

Figure 7.2: Muledane's newly designed household waste collection points

Source: Mutwanamba (2025)

The map above presents the spatial distribution of newly designed solid waste collection points within the boundary of Muledane, a peri-urban village in Thohoyandou. The placement of these points demonstrates a strategic effort to improve accessibility and service coverage across the settlement. The collection points are

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distributed to accommodate the medium-density residential areas and peripheral zones, addressing previous challenges of long travel distances and limited access to waste disposal infrastructure. The map serves as a visual tool to support spatial planning strategies and infrastructure redesign for inclusive and responsive service delivery.

7.2.1.3. Empowering drivers

Empowering drivers received a mean of 3.17, indicating that respondents moderately agreed that empowering waste collection drivers can improve solid waste management in peri-urban villages. The moderate mean suggests that driver empowerment is important, but measures like route optimisation and better waste infrastructure must be supported. A high standard deviation of 1.311 indicated that opinions were highly varied on whether empowering drivers would significantly improve waste collection. Some respondents strongly supported driver empowerment as a key strategy, while others may not see a direct connection between driver skills and waste collection efficiency. This variation suggests that different communities experience different service levels, possibly influenced by existing driver competence, working conditions, and collection reliability. About 29.4% of respondents agreed that drive empowerment is the solution to poor solid waste collection, and 18.1% of respondents strongly agreed with the importance of driver support, which makes a total of 47.5% of respondents have trust in this strategy because respondents believed that well-trained drivers could improve collection efficiency, reduce missed pickups, and enhance customer service. 15.5% of respondents were neutral due to a lack of awareness about drivers' challenges or uncertainty about how much empowerment will directly improve services. Approximately 25.2% of respondents disagreed that driver empowerment can improve solid waste collection, and 11.8% of respondents strongly disagreed that driver empowerment is not a practical solution. This is because respondents doubt that drivers alone can improve service efficiency without better policies and management support.

The regression analysis for empowering drivers investigated whether improving the working conditions, decision-making authority, and capacity of waste collection drivers influenced perceptions of the effectiveness and sustainability of solid waste collection in the peri-urban settlements of Thohoyandou. The unstandardised coefficient (B) was –0.059, and the standardised beta coefficient was –0.060, indicating a very weak negative relationship. This result implied that as support for empowering drivers

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increased, there was a slight decline in the perception of service effectiveness, although the relationship was minimal and likely not meaningful. The relationship was found to be not statistically significant, with a p-value of 0.448, exceeding the 0.05 threshold. The 95% confidence interval for B ranged from –0.214 to 0.096, which included zero, confirming that empowering drivers was not a statistically significant predictor in the regression model.

Equipping drivers with technical and professional skills improves their efficiency and ability to handle waste safely and effectively. Encourage cross-training where drivers learn skills such as vehicle maintenance and sorting. Solid waste collection is physically demanding, Thulamela Local Municipality must ensure better working conditions. It is important because it improves productivity. Municipality can also provide certificate programs to recognise skilled drivers and encourage career growth. Better working conditions are essential to improve drivers' performance and reduce health risks. Providing financial and non-financial rewards can motivate drivers to improve service delivery by introducing a bonus system for drivers with consistent on-time collection and low complaints.

7.2.1. 4. Investing in training and development

Investing in training and development received moderate support and had a mean of 3.45, suggesting that respondents moderately agreed that investing in training and development is an effective strategy for improving waste collection. The moderate score showed that respondents acknowledge training's importance but may not consider it a top solution for peri-urban waste collection issues. The standard deviation of 1.100 indicated some variability in responses, but the overall trend indicates that respondents see value in improving the skills of waste management personnel. Approximately 16.4% of respondents strongly agreed that investing in training and development will assist in improving the solid collection system, 38.7% of respondents agreed that investing in training and development will change the current situation, which makes a total of 55.1% of respondents believed that training and development would improve the solid waste collection system. About 22.7% of respondents were uncertain about its effectiveness. This is due to a lack of awareness of how training can improve solid waste collection operations. Nearly 17.6% of the respondents disagreed that training and development could not improve solid waste collection, 4.6% of the respondents

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strongly disagreed that investing in training and development could improve solid waste collection, which make a total of 22.2% of respondents who did not believe in the effectiveness of investing in training and development due to respondents believe that improving infrastructure or policy enforcement would have a more immediate impact than training.

The regression analysis for investing in training and development assessed whether improving the skills and capacity of waste management personnel and community members influenced the perceived effectiveness and sustainability of household solid waste collection in peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.055, and the standardised beta coefficient was –0.053, indicating a very weak negative relationship. This suggested that as perceptions in support of training and development increased, there was a slight decline in perceived effectiveness of waste collection, although the relationship was minimal. This relationship was not statistically significant, with a p-value of 0.499, which exceeded the 0.05 threshold for significance. The 95% confidence interval for B ranged from –0.215 to 0.105, and since this interval included zero, it confirmed that the relationship was statistically insignificant.

A well-trained workforce informed municipal officials, and an educated community can significantly enhance waste collection efficiency, recycling rate and the environment. Municipalities need to train solid waste collection workers for safety operations. Proper waste collection methods include lifting techniques and handling hazardous solid waste. Route optimisation training to ensure efficient waste pickups is important. Training should also focus on educating households on waste segregation at the source, as well as awareness campaigns on reducing plastic waste and promoting reusable materials. The Department of Waste Management should be trained to use GIS and GPS to provide the best collection service.

7.2.1.5. Avoiding electronic waste

Avoiding electronic waste garnered a mean of 3.42, indicating that respondents moderately agreed that avoiding electronic waste (e-waste) can improve solid waste management in peri-urban villages. The moderate mean suggests that some respondents recognise the dangers of improper e-waste disposal, but others may not view it as an

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immediate waste management concern. A high standard deviation of 1.198 indicates that opinions were highly varied on whether avoiding e-waste would significantly improve waste collection. Some respondents strongly support e-waste management efforts, while others may not see it as a major issue in their community. The high variation suggests that different areas experience different levels of e-waste problems, possibly influenced by access to proper disposal methods and awareness of the issue. About 19.3% of the respondents strongly agreed that avoiding electronic waste is the solution to the current problem, and 36.1% of respondents agreed that this strategy could improve poor solid waste collection because respondents understand that e-waste contains toxic substances that can pollute soil and water if not disposed of properly. Approximately 17.2% of respondents did not prioritise e-waste management, and 7.6% of respondents strongly disagreed that E-waste management can improve solid waste collection. This is because some people may not know that electronics contain harmful chemicals that require special handling. About 19.7% of the respondents were neutral; they are not deciding this because some respondents are unsure about the urgency of e-waste management, possibly due to a lack of information or a direct impact on their daily lives.

The regression analysis for avoiding electronic waste assessed whether strategies aimed at reducing the disposal of electronic items in the general waste stream influenced perceptions of the effectiveness and sustainability of household solid waste collection in the peri-urban villages of Thohoyandou. The unstandardised coefficient (B) was –0.066, and the standardised beta coefficient was –0.061, indicating a very weak negative relationship. This suggested that as support for avoiding electronic waste increased, perceptions of collection effectiveness slightly decreased, though the relationship was negligible. This relationship was not statistically significant, with a p-value of 0.421, which exceeded the 0.05 threshold. The 95% confidence interval for B ranged from –0.228 to 0.096, which included zero, confirming that avoiding electronic waste was not a significant predictor of perceived collection effectiveness in the model.

E-waste is a growing challenge in these two villages, old phones, computers, televisions, and batteries contain hazardous materials such as lead, mercury and cadmium, which can pollute the environment if not disposed of properly. Municipality need to encourage households to sell refurbished electronics. Raising awareness about

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repair instead of replacing old gadgets reduces E-waste. Most households do not understand the environmental harm caused by E-waste, so public education campaigns are needed to teach households about the dangers. This can change disposal habits.

7.2.1.6. Please leave it to private companies and individual responsibility

Leaving waste management to private companies and individual responsibility had a mean of 3.56, indicating that respondents were neutral or only slightly supportive of leaving waste management to private companies and individual responsibility instead of being fully managed by municipalities. The moderate mean suggests that some respondents support privatisation and personal responsibility, while others are sceptical about its effectiveness in peri-urban waste collection. A high standard deviation of 1.199 means respondents had widely different views on this approach. Some respondents strongly support privatisation, believing private companies can improve efficiency, while others believe waste management should remain a public service. The high variation suggests that different communities have different experiences with waste privatisation, possibly influenced by service reliability, affordability, and past privatisation attempts. About 24.8% of respondents strongly agreed that privatisation of solid waste collection could improve the current situation, and 37.0% of respondents agreed that this method could work, which makes a total of 61.8% of respondents who believed that private companies offer better efficiency, accountability, and service quality than municipal waste management. Nearly 12.2% of respondents were neutral, and this is because they were uncertain about the long-term effects of privatisation. Small number 4.2% of respondents strongly agreed that privatisation of waste collection can improve the current system, 21.8% of respondents reject the idea of privatisation of solid waste collection system, which makes a total of 26.0% of respondents who did not believe in privatisation of solid waste collection system this because Many households may not be able to afford private waste collection fees.

The regression analysis for the strategy of assigning solid waste management responsibility to private companies and individuals explored whether reducing municipal involvement in favour of privatisation and personal responsibility influenced perceptions of the effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban areas. The unstandardised coefficient (B) was –0.092, and the standardised beta coefficient was –0.072, indicating a weak negative relationship.

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This suggested that greater support for privatising waste services or shifting responsibility to households was associated with slightly lower perceptions of effective service delivery. This relationship was not statistically significant, with a p-value of 0.268, which was above the 0.05 significance level. The 95% confidence interval for B ranged from –0.256 to 0.071, and because this range included zero, it confirmed that the predictor was not statistically significant in influencing perceptions of waste collection effectiveness.

Private companies can profit from recycling waste to energy initiatives while improving the solid waste collection system. Households must pay a waste collection fee based on the waste they generate. Households that generate less waste pay lower fees. Leaving solid waste collection to private companies and individuals' responsibility can improve efficiency and reduce the municipality's cost.

Case study of Mbare form 2.4.3.3.1, Harare, Zimbabwe, Recycling of plastic waste and gives a general overview of the main environmental issues related to plastic disposal (Chipfunde F, 2023). The study in Mbare highlights the need for the Harare City Council to register waste collectors and recyclers and provide incentives through contract agreements. This indicates that involving private companies, community organisations, and informal waste collectors can enhance waste collection and recycling efforts. This shows that PPP can also work in Thulamela Local Municipality, as it was implemented in Mbare and became successful. From the semi-structured interview, the officials also suggest that by working with the private company, the solid waste collection service can improve.

7.2.2. Community actions

Community involvement is vital for successful solid waste collection. Initiatives like cleaning campaigns, recycling programs, and public awareness efforts empower residents to take responsibility for their waste.

7.2.2.1. Cleaning campaigns

Cleaning campaigns have a mean of 4.27, which indicated that most respondents agree or strongly agree that cleaning campaigns are an effective strategy for improving solid waste collection and a Standard Deviation of 0.952, which indicated low variation in responses, meaning most people share similar opinions The high proportion of strong

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agreement reflects the perceived effectiveness of community-driven initiatives in addressing waste management challenges. Nearly half of 49.6% of the respondents strongly agreed that cleaning campaigns are highly effective in poor solid waste collection. About 38.2% of respondents agreed, which brings 87.8% to support the idea of introducing cleaning campaigns. A small number of 3.8% of respondents were not sure about the effectiveness of cleaning campaigns. A small number of 6.3% of respondents disagreed that cleaning campaigns can improve solid waste, and 21% strongly agreed about campaigns. This is because some people are too lazy to clean, and it requires continuous maintenance. A small number of 3.8% of respondents did not decide that most people already have an opinion on cleaning campaigns.

The regression analysis for cleaning campaigns investigated whether the implementation of regular community-based clean-up activities significantly influenced the perceived effectiveness and sustainability of household solid waste collection in the peri-urban villages of Thohoyandou. The unstandardised coefficient (B) was –0.131, and the standardised beta coefficient was –0.109, indicating a weak negative relationship. This result suggested that as support for cleaning campaigns increased, perceptions of the effectiveness of solid waste collection slightly declined, although the effect was marginal and counterintuitive. The relationship was found to be statistically insignificant, as the p-value was 0.144, which exceeded the 0.05 threshold. Additionally, the 95% confidence interval for B ranged from –0.306 to 0.045, which included zero and further confirmed the absence of a statistically significant effect.

Clean campaigns are important since less solid waste will be generated, leading to municipal limits on collection services. Clean campaigns help remove waste from these areas and educate households on proper disposal methods. Schools, churches, and local organisations must regularly organise clean-up events. Households need to remember that cleaning campaigns act as short-term solutions while advocating for better municipal solid waste collection. Thulamela Local Municipality needs to engage with traditional leaders, wards councillors and community groups to promote public participation.

Case study of Kisumu City, Kenya: An effective measure to improve waste management levels and convert HSW into valuable materials is to separate sources instead of just burning or burying them (Chen, 2017). The study examined the existing

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household solid waste separation practices and their contribution to sustainable solid waste management in Kisumu City, Kenya. Source separation and recycling are important elements in SWM as both offer sustainable and effective solutions to mounting waste (Nadia et al., 2018). The main body of source separation is the community resident (Zhang & Wen, 2014). Thulamela Local Municipality has to prioritise a public engagement strategy to promote source separation, similar to Kisumu City. Incentivising waste separation practices through reward could further enhance participation.

7.2.2.2. Recycling

Recycling also garnered relatively low support, with a mean of 2.64, indicating that respondents were less convinced of its potential to improve waste collection. The standard deviation of 0.920 highlights a high degree of variability in opinions on the effectiveness of recycling as a waste management solution. A small number of 1.7% of the respondents agreed that recycling improves solid waste collection services, and 23.1% of respondents agreed about the effectiveness of solid waste collection services, which makes a total of 24.8% of the respondents who believe that recycling can change the current situation. Only 15.5% of respondents were uncertain about recycling. This is because households are not well-informed about recycling programs, and participation rates remain low. Over 57.1% of respondents disagreed that recycling is not the way to solve the issue of solid waste collection, and 2.5% of respondents strongly agreed, which makes a total of 59.6% of respondents who did not support this indicates significant challenges that preventing recycling from being widely adopted in peri-urban areas and plus municipality find expensive it needs a different type of infrastructure.

The regression analysis for recycling assessed whether the promotion and adoption of recycling practices influenced public perceptions of the effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The analysis produced an unstandardised coefficient (B) of 0.089 and a standardised beta coefficient of 0.073, indicating a weak positive relationship. This suggested that residents who supported or practiced recycling were slightly more inclined to perceive solid waste collection as more effective and sustainable. The p-value was 0.386, which was well above the 0.05 significance threshold, indicating that the relationship was not

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statistically significant. The 95% confidence interval ranged from -0.113 to 0.291, and since zero fell within this range, the regression did not confirm the effect statistically.

In addition, although recycling did not emerge as a statistically significant factor, it showed a practically meaningful positive trend. In peri-urban areas like Maniini and Muledane, limited access to recycling infrastructure and insufficient public awareness hinder recycling efforts. Therefore, it is recommended that the municipality invest in establishing recycling drop-off centres, educate communities about separating recyclables, and partner with informal waste pickers and recycling cooperatives. Strengthening recycling practices will not only reduce the volume of waste needing collection but also contribute to environmental sustainability and create local economic opportunities.

Setting community recycling drop-off points in Muledane and Maniini, where households can dispose of and sort recyclables, is an important step to take in order to implement recycling. Thulamela needs to organise local recycling competitions and rewards to encourage households to participate in recycling. Business owners need to sponsor recycling programs and create opportunities. By implementing better infrastructure, education programs, strong regulation and private sector engagement, Thulamela can boost the recycling rate, reduce collection costs and create a clean environment.

The cited statement by Tanveer (2023) and Zhang et al. (2022) highlights the global shift towards circular economy practices, which prioritise recycling, reusing, and reducing waste. Recycling is a fundamental circular economy approach, aiming to turn waste back into resources, thereby "closing the loop" in the waste supply chain. To effectively transition from linear production methods towards circular economy practices (as advocated by Tanveer, 2023; Zhang et al, 2022), significant improvements are necessary in recycling practices. Strategic spatial planning should consider developing accessible recycling infrastructure, increasing public engagement and awareness campaigns, and implementing supportive regulatory frameworks.

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7.2.2. 3. Public engagement

Public engagement also showed limited support, with a mean of 2.61, indicating that respondents generally did not strongly agree that public engagement is a highly effective strategy for improving solid waste collection. The standard deviation of 1.303 further illustrates the mixed views on the effectiveness of public participation in improving waste collection efficiency. Nearly 6.3% of the respondents strongly agreed that public engagement programs can improve poor solid waste collection, and 28.2% of respondents agreed about the effectiveness of public engagement, which makes a total of 34.5% of respondents believed that public engagement will improve solid waste collection. This is because some households believe that the collection of solids is not only the municipal responsibility but the responsibility of both households and the municipality. A small number of 11.8% of the respondents are not sure about the effectiveness of public engagement towards poor solid waste collection. This is because of a lack of information and exposure to successful engagement programs. Approximately 28.2% of the respondents disagree about the effectiveness of engagement programs, 25.6% of respondents strongly agree that public engagement can solve the issue of solid waste collection, which makes a total of 53.8% of respondents who do not believe public engagement is an effective solution of poor solid waste collection this is due to community programs past failures, leading to scepticism about future initiatives.

The regression analysis for public engagement explored whether involving residents in solid waste management decision-making and awareness activities influenced their perception of the effectiveness and sustainability of household waste collection in Thohoyandou's peri-urban areas. The unstandardised coefficient (B) was 0.045, and the standardised beta coefficient was 0.051, indicating a very weak positive relationship. This suggested that as public engagement increased, perceptions of waste collection effectiveness also slightly improved, though the effect was marginal.

The relationship was not statistically significant, with a p-value of 0.539, exceeding the 0.05 threshold. The 95% confidence interval for B ranged from –0.099 to 0.188, which included zero, thereby confirming the insignificance of this relationship in the regression model.

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Thulamela Local Municipality needs to set up a team to conduct door-to-door education programs to teach households about proper waste, separation and recycling. Organising waste management workshops to teach communities the challenges and solutions to poor solid waste. Municipalities can also organise monthly cleanups where households, businesses and municipal workers clean up public areas by educating households, improving communication, offering incentives and strengthening enforcement. Thulamela Local Municipality can build an active waste-conscious society.

2.2.1.3. Case study in Minamata City, Kumamoto Prefecture, Japan: Optimising the number and location of household waste collection sites by multi-maximal covering location model (Zhuo & Yan, 2022). The case study's Minamata model indicates that improving accessibility through an optimised collection site's location can boost participation and engagement. The Minamata case study proves that optimised collection points improve accessibility and encourage participation. Placing solid waste collection sites closer to households increases participation rates, making it easy for households to separate and dispose of solid waste properly.

7.2.3. Spatial planning practices

Spatial planning can significantly improve waste collection efficiency by optimising routes, improving infrastructure, and integrating solid waste collection into broader land-use planning. This approach ensures long-term sustainability and service reliability.

7.2.3.1. Collection efficiency

Collection efficiency had mean of 3.87 indicates that respondents moderately agreed that improving collection efficiency is an effective strategy for improving solid waste collection. The low standard deviation of 0.640 indicated that respondents generally agree on greater efficiency in waste collection processes. Over 84.9% of respondents strongly agreed that frequent collection can improve solid waste collection, and 5.0% of respondents agreed that collection efficiency is the solution, which makes up 89.9% of respondents who supported collection efficiency. A small number of 3.8% of respondents did not decide this due to having a clear opinion about solid waste collection efficiency. A small number of 4.6% of respondents disagreed that collection efficiency could improve the solid waste collection system, and 1.7% of respondents disagreed, which makes a total of 6.3% of respondents who did not see collection

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efficiency as important. Collection services are inefficient due to a lack of resources (e.g., trucks, workers), so people might not see much improvement happening.

The regression analysis for collection efficiency examined whether improvements in the regularity, reliability, and reach of waste collection services influenced the perceived effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban villages. The unstandardised coefficient (B) was 0.037, and the standardised beta coefficient was 0.021, indicating a very weak positive relationship. This result suggested that as collection efficiency improved, perceptions of solid waste collection effectiveness also increased slightly, although the effect was minimal. However, the relationship was not statistically significant, with a p-value of 0.789, which was substantially higher than the 0.05 threshold. The 95% confidence interval for B ranged from –0.234 to 0.307, and since it included zero, the result was statistically inconclusive.

Thulamela Local Municipality should set and communicate fixed collection days for each area. This can be done via SMS alerts, social media and community meetings. Using small solid waste collection vehicles and establishing community solid waste collection points where households can drop off solid waste for municipal pickup can work for the municipality and the household. Thulamela Local Municipality should invest in more solid waste trucks or partnerships with private companies to increase fleet capacity. Households should be encouraged to separate waste at source by using colour-coded bins, for example, green for organic waste, red for recyclable waste, and brown for general waste. Mobile websites and hotlines that allow households to report missed collections and overflow of waste bins. Public-private partnerships can help expand collection services by engaging private waste collection companies.

Case study of Mukono Municipality, from 2.4.3.2.2, Uganda: Household's willingness to pay for collection service. (Namukuve., 2021., Muheirwe, et al, 2023). Establishing efficient and affordable door-to-door collection, the Mukono case study emphasises that the estimated mean WTD guides policymakers in setting waste collection fees. If households are willing to pay, a well-structured door-to-door collection can be implemented to reduce dependency on informal disposal. The study data shows strong support for improving collection efficiency. Implementing a door-to-door system

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financed through reasonable household fees could enhance collection effectiveness, reduce illegal dumping and improve waste management in peri-urban.

7.2.3.2. Landfilling

In contrast, landfilling received a more mixed response, with a mean score of 2.96, indicating lower support compared to other strategies. The standard deviation of 0.714 indicates moderate variability in opinions, signalling that while some respondents see landfilling as a necessary solution, others may view it as an unsustainable option. A small number of 2.5% of respondents strongly agreed that landfilling can solve the issue of poor solid waste collection, and 13.9% of respondents agreed that landfilling is an effective strategy, which makes a total of 16.4% of respondents believed that landfilling is the solution. This is because it is a widely used waste disposal option and might be the only available solution in some areas. About 63.0% of respondents were in between; they did not know what to decide because maybe people do not know the meaning of landfill, which has the highest neutral response. The data shows that 18.5% of the respondents opposed the idea of landfills due to negative environmental pack, 2.1% of the respondents disagreed that landfilling is the solution to poor solid waste collection, which makes a total of 20.6% of respondents who did not believe that landfilling is the solution this is because landfills contribute to soil and water contamination.

The regression analysis for landfilling assessed whether reliance on landfill disposal had a measurable impact on the perceived effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was 0.033, and the standardised beta coefficient was 0.020, indicating a very weak positive relationship. This result suggested that increased support for landfilling was associated with a slight increase in the perception of effective waste collection, although the relationship was minimal. The association was not statistically significant, as the p-value was 0.774, which exceeded the 0.05 threshold. Additionally, the 95% confidence interval for B ranged from –0.191 to 0.256, further confirming that the relationship was statistically insignificant due to the inclusion of zero in the interval. There were no multicollinearity concerns, with a tolerance value of 0.855 and a Variance Inflation Factor (VIF) of 1.170, both within the acceptable range, indicating model stability.

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Thulamela needs to divert recyclable and organic solid waste to reduce solid waste volume. Introducing a solid waste transfer station where solid waste is sorted before being sent to landfills. Landfills produce methane gas, a powerful green gas, installing gas capture systems that can allow all methane to be used for energy production instead of being released into the environment.

Case study of Malaysian cities from 2.4.2.2., A Review of Future Household Waste Management for Sustainable Environment in Malaysian Cities (Cheng et al, 2022; Ebekozien et al, 2022). From the case study of Malaysia, it is evident that reliance on landfills leads to unsustainable waste disposal and environmental risk, including environmental hazards such as greenhouse gas emissions from decomposing organic waste, leading to climate-related disasters. Thulamela Local Municipality should avoid the strategy of landfills since it is dangerous to the environment.

7.2.3.3. New technologies

New technologies had a mean of 3.02, indicating that respondents were neutral or only slightly supportive of using new technologies to improve household solid waste collection. This score indicates that while some respondents value technological innovations, others may not be fully convinced or aware of their benefits. The standard deviation of 1.164 suggests that opinions on this recommendation were somewhat divided. Nearly 11.8% of respondents strongly agreed that new technologies can improve unsustainable solid waste collection, and 25.2% of respondents agreed with the idea of new technologies. This is because households see potential benefits of new technologies in the waste collection systems; the total of respondents who agree with the effectiveness of new technology is 37.1%. Approximately 24.4% of the respondents were uncertain that technology could improve solid waste collection due to limited knowledge about available technologies. From the data, 30.7% of respondents disagreed that new technologies can improve poor solid waste collection, and 8.0% strongly disagreed that new technologies will positively impact the current situation of solid waste collection. This is due to a lack of technical expertise in managing and maintaining these systems, which requires skilled workers, which may be lacking in rural municipalities like Thulamela Local Municipality.

The regression analysis for new technologies examined whether the adoption of modern innovations such as smart bins, GPS tracking, and waste-to-energy systems influenced

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perceptions of the effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban areas. The unstandardised coefficient (B) was –0.050, and the standardised beta coefficient was –0.051, indicating a very weak negative relationship. This suggested that as support for new technologies increased, perceptions of collection effectiveness slightly declined, although the effect was negligible. The relationship was statistically insignificant, with a p-value of 0.507, which was greater than the 0.05 threshold. The 95% confidence interval for B ranged from –0.197 to 0.098, which included zero, reinforcing the conclusion that the variable did not significantly predict perceptions of waste collection effectiveness.

Municipalities need to introduce bins with sensors, smart bins are equipment with sensors that detect waste levels and alert the collection authorities when they are nearly complete. The municipality will receive real-time data to ensure collection schedules match the waste generation. The introduction of GPS and GIS will help track solid waste collection vehicles in real-time. Data on bin fill levels, road conditions and population density will be used to create efficient collection points. Thulamela Local Municipality has to develop ways to implement waste-to-energy technology; waste-to-energy plants can be integrated with existing landfill sites to reduce waste volume and generation. New technologies will offer innovative solutions to solid waste management challenges in Muledane and Maniini. Adopting smart bins and sensors introduces promising technological solutions, but there is a need for assessment of the financial feasibility of municipality.

Fang et al. (2023), Yigitcanlar & Cugurullo (2020), and Goutam et al. (2021) highlight how artificial intelligence (AI) and robotics are transforming solid waste management, particularly in waste treatment plants. AI-driven solutions can increase operational efficiency and promote sustainable waste management practices. This aligns with the "New Technologies" strategy, which states that AI and robotics can optimise waste sorting, automate collection schedules, and improve recycling rates, making waste management more efficient and cost-effective. The study's moderate support for new technologies (3.02 mean score) indicates that respondents recognise the potential of AI-driven solutions but may have concerns about costs, implementation challenges, or lack of technical expertise. In Thulamela Local Municipality, where solid waste collection inefficiencies persist, integrating AI-powered route optimisation, smart waste bins, and

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automated sorting systems could enhance overall solid waste collection. The shift towards AI-powered waste management is aligned with global trends, but successful adoption will require investment in technology, workforce training, and supportive policies.

7.2.3.4. Enhancing data management

Enhancing data management had a mean of 3.66, the moderate mean showed that many respondents see potential benefits in tracking and analysing waste collection data, but some may not fully understand its direct impact. A high standard deviation of 1.179 indicated significant differences in opinions about data management. Some respondents strongly support data-driven decision-making, while others may not see its immediate impact on waste collection services. Approximately 26.5 % of the respondents strongly agreed that enhancing data management can improve solid waste collection, and 39.5% of the respondents agreed that enhancing data is an effective strategy, which makes a total of 66% of respondents believed that enhancing data management will improve household solid waste collection in peri-urban areas. . About 12.6% of the respondents were neutral, they did not know what to choose. This is because while data management is valuable, some people may believe that Thulamela Municipality lacks the financial or technological capacity to implement it effectively. A small number, 5.0% of the respondents, strongly disagreed about the effectiveness of enhancing data management, 16.4% of respondents disagreed that data management could improve the current situation in the Thohoyandou peri-urban area, which makes a total of 21.4% of respondents sceptical about the impact of data management on waste collection.

The regression analysis for enhancing data management assessed whether improving the collection, analysis, and use of waste management data influenced the perceived effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban areas. The unstandardised coefficient (B) was –0.004, and the standardised beta coefficient was –0.004, indicating an extremely weak negative relationship. This suggested that improvements in data management were associated with a slight decrease in perceived effectiveness, though the effect was negligible. The relationship was not statistically significant, with a p-value of 0.957, which was far above the 0.05 significance level. The 95% confidence interval for B ranged from –0.162 to 0.153, and

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the inclusion of zero further confirmed that the variable had no significant predictive power in the regression model.

This indicates limited awareness of how data-driven strategies can optimise waste management or doubts about implementation. By optimising collection routes, data from mapping can help reduce fuel consumption, labour costs, and collection time. Intelligent waste management systems can help track generation rates and predict peak waste disposal periods. Data analytics can help Thohoyandou Local Municipality determine where more bins or collection points are needed, preventing overflow and illegal dumping. Digital records can be used to track waste collection efficiency, ensuring contractors and municipal workers meet performance benchmarks. Historical data can help forecast waste trends, allowing for long-term infrastructure and policy planning.

Municipality can also develop a centralised waste management database, the database will have information about household waste generation, including weight, type and disposal pattern. Enhancing data management is essential for improving waste collection efficiency, monitoring illegal dumping and promoting recycling efforts in Muledane and Mannini. Thulamela Local Municipality can create a sustainable and efficient waste management system using digital tools, AI, and community engagement.

7.2.3.5. Providing more household solid waste equipment, such as dustbins

Providing more household solid waste equipment, such as dustbins, had a mean of 3.63, suggesting that respondents moderately agreed that providing more household solid waste equipment (e.g., dustbins, waste collection containers) can improve waste collection. A high standard deviation (1.161) indicated that respondents had mixed views on whether providing more solid waste equipment alone would significantly improve waste collection. The data shows that 41.6% of the respondents agreed that solid waste equipment can improve solid waste collection, and 24.4% strongly agreed that providing more solid waste is the solution. This makes a total of 66.0% of the respondents who trust that the provision of solid waste equipment could improve the solid waste collection system; this is due to respondents recognising that a lack of proper solid waste containers leads to littering, open dumping and poor household waste management. Nearly 10.5% of respondents were unsure about the impact of the

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provision of solid waste equipment. Approximately 19.7% of respondents disagree that this strategy can improve the quality of solid waste collection, 3.8% of respondents strongly disagree that that solid waste equipment is the solution to the current situation, which makes a total of 23.5% of respondents who disagreed this because Some respondents believe that providing equipment is expensive and not a sustainable long-term solution.

The regression analysis for the provision of household solid waste equipment, such as dustbins, examined whether improving access to proper waste storage containers influenced perceptions of the effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban settlements. The unstandardised coefficient (B) was –0.032, and the standardised beta coefficient was –0.035, indicating a very weak negative relationship. This suggested that support for increased equipment provision was slightly associated with reduced perceptions of collection effectiveness, although the relationship was minimal and likely not meaningful. The model revealed that this relationship was not statistically significant, with a p-value of 0.680, well above the 0.05 significance threshold. The 95% confidence interval for B ranged from –0.201 to 0.137, including zero, which confirmed the lack of statistical significance.

Providing durable standards for dustbins can significantly improve household solid waste storage and collection. Municipality can create awareness on how to use bins properly through workshops, and monitoring the usage of bins to prevent misuse or loss is very important. In areas where individual household collection is difficult, communal waste skips can serve as centralised collection points with regular emptying and maintenance to prevent offer flow of solid waste.

7.2.3. 6. Reducing missed pickups was considered important

Reducing missed pickups was considered important and had a mean of 3.42, which suggests that respondents moderately agreed that reducing missed waste pickups is an effective strategy for improving household solid waste collection in peri-urban villages. A high standard deviation of 1.205 indicated that respondents had mixed views on how significant missed pickups affect waste collection. Some respondents strongly support improving pickup consistency, while others may not see it as the primary waste management issue. About 36.6% of respondents agreed that reducing missed pickups

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can solve the issue of poor solid waste collection, and 19.7% of respondents strongly agreed that the strategy is the key improvement, which makes a total of 56.3% of respondents believed in the process this is because household recognises that consistent waste collection reduces environmental pollution, improves sanitation, and minimises illegal dumping. Approximately 16.8% of the respondents were neutral, which means they did not decide on this because they may not know the extent of missed pickups or their impact. Nearly 20.2% of respondents did not see missed pickups as a major problem, and 6.7% of the respondents strongly disagreed that reducing missed pickups can improve solid waste collection, which makes a total of 26.9% of the respondents who did not believe in this strategy.

The regression analysis for reducing missed pickups investigated whether improving the consistency and reliability of waste collection influenced perceptions of the effectiveness and sustainability of household solid waste services in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.040, and the standardised beta coefficient was –0.040, indicating a very weak negative relationship. This implied that as concerns about missed pickups increased, there was a slight decline in perceived service effectiveness, although the association was practically negligible. The p-value was 0.652, which exceeded the 0.05 threshold, confirming that the relationship was not statistically significant. The 95% confidence interval for B ranged from –0.224 to 0.143, and because this interval included zero, the variable was deemed not a significant predictor in the regression model. There were no multicollinearity concerns, with a tolerance value of 0.730 and a Variance Inflation Factor (VIF) of 1.370, indicating that this variable did not distort the regression model and was statistically stable.

This is because some residents may not directly experience missed pickups. Solid waste management authorities can increase and reduce delays by optimising collection routes and schedules. Municipality should consider nighttime to places where there is high daytime congestion. Increasing fleet capacity and workforce will improve service coverage and efficiency. Thulamela needs to hire more workers to speed up service delivery. Thulamela can also implement a vehicle maintenance schedule to reduce breakdown and collection delays. The Municipality should also consider private solid waste companies as temporary services during a crisis.

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7.2.3. 7. Optimising routes and services

Optimising routes and services had a mean of 3.30, indicating that respondents moderately agreed that optimising waste collection routes and services could improve solid waste management in peri-urban villages. A high standard deviation of 1.246 means respondents had mixed views on route and service optimisation effectiveness. Some respondents strongly support optimising routes to improve efficiency, while others did not see it as the main issue affecting waste collection. Nearly 18.1% of the respondents strongly agreed that route and service optimisation improves solid waste collection services, and 34.0% of respondents agreed that route and service optimisation is the key, which makes a total of 52.1% of respondents believed the implementation of this strategy can help is poor solid waste collection this is due to respondents recognise that efficient routing reduces missed pickups, minimises fuel costs, and speeds up collection services. About 16.8% of respondents did not decide this because most people don't a clear opinion on whether or not route optimisation is necessary. Approximately 22.3% of respondents disagreed that route optimisation contributes to sustainable solid waste collection, 8.8% of respondents strongly disagreed that route and service optimisation are the solutions which makes a total of 31.1% of respondents who didn't have faith in this strategy this because respondents believe if municipality struggles with basic collection issues, residents may doubt their ability to implement smart routing systems.

The regression analysis for optimising routes and services explored whether improvements in route planning and service delivery logistics influenced the perceived effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.019, and the standardised beta coefficient was –0.021, indicating a very weak negative relationship. This result suggested that as support for route and service optimisation increased, there was a negligible decrease in the perception of effective waste collection services. The relationship was not statistically significant, with a p-value of 0.831, well above the standard threshold of 0.05. The 95% confidence interval for B ranged from –0.199 to 0.161, which included zero, confirming the lack of statistical significance in the regression model. The variable demonstrated no multicollinearity issues, with a

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tolerance value of 0.734 and a Variance Inflation Factor (VIF) of 1.363, indicating that it did not destabilise the model.

Optimising waste collection routes in Maniini and Muledane needs efficient scheduling, smart technologies and active involvement by implementing GIS mapping, real-time monitoring, community engagement and data-driven decision-making. Thulamela Local Municipality can improve collection efficiency and promote sustainable waste management. The municipality can also develop a reporting system where drivers and collection teams can log in daily activities and report about their work. Case study of the city of Bragança from 2.4.1.2, Portugal, Solving a Capacitated Waste Collection Problem sing an Open-source Tool (Filipe A, 2022). Referring to this case study of Portugal, Braganca city shows how inefficiency increases when drivers determine manually, leading to resource wastage and increased cost. Implementing the Braganca optimisation tool in Thulamela Local Municipality can reduce collection costs while maintaining service delivery quality. Capacitated vehicle routing problem is used to model solid waste collection routes while considering vehicle capacity.

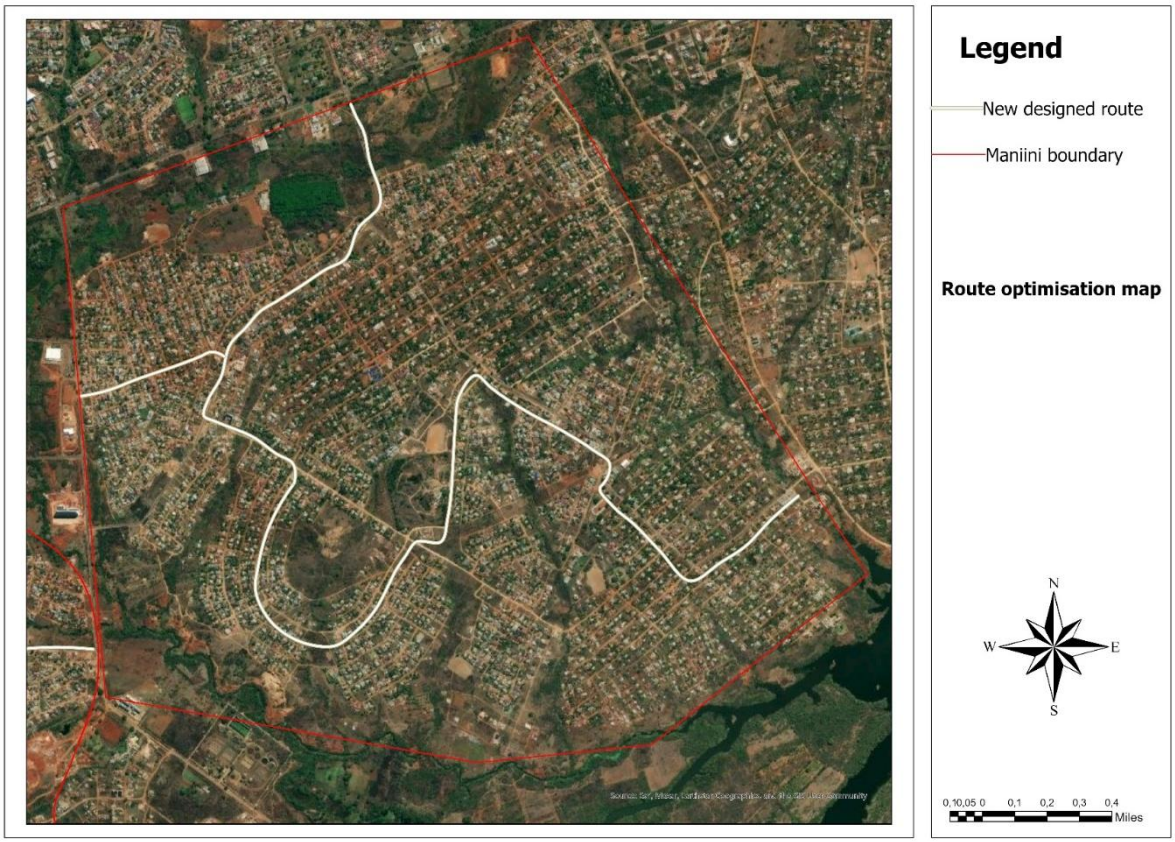

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Figure 7.3: Route Optimisation Map for Maniini

Source: Mutwanamba (2025)

Figure 7.3 illustrates the newly proposed waste collection routes within the Maniini village boundary. These routes were strategically developed to address previous inefficiencies in waste collection, such as long travel distances, missed households, and circuitous paths. The optimized layout ensures that service coverage is maximised with minimal resource use, thereby promoting sustainable and cost-effective waste management practices. This intervention reflects a spatial planning approach aimed at enhancing the operational efficiency of household solid waste collection systems in a peri-urban setting.

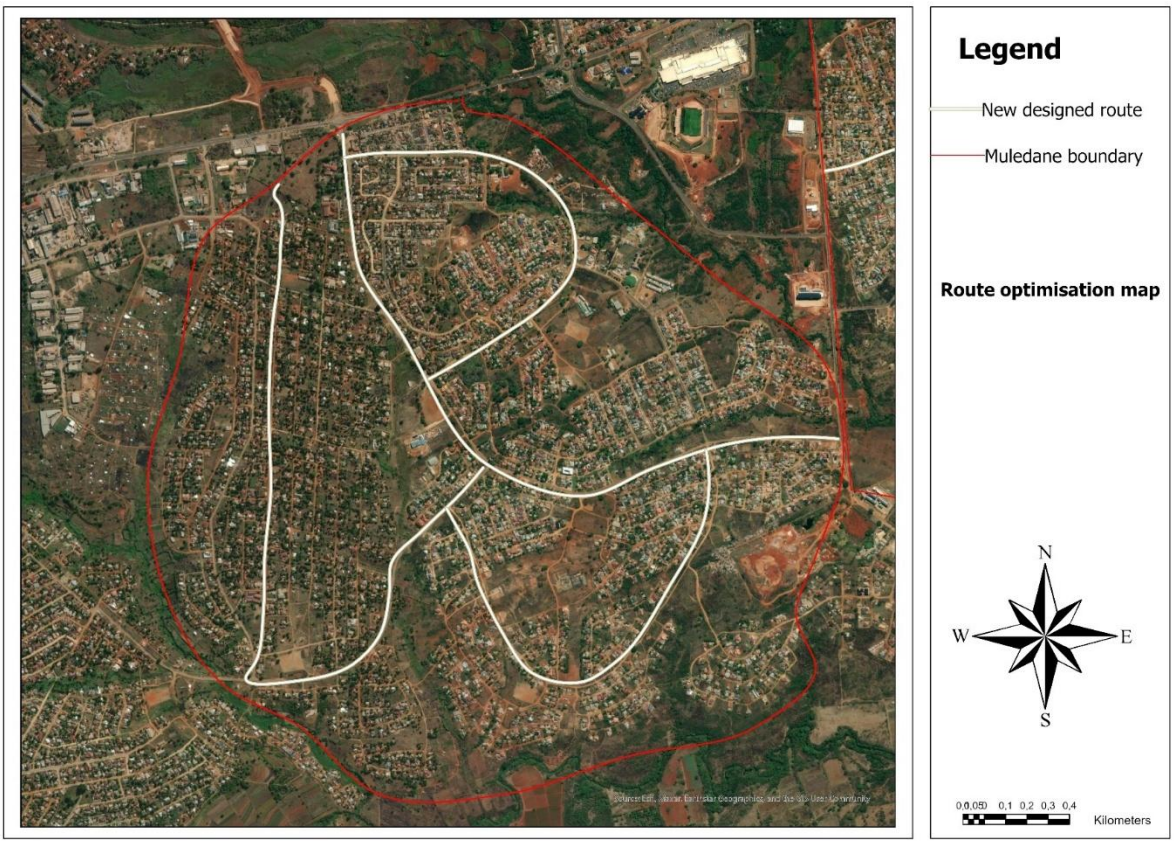

Figure 7.4: Route Optimisation Map for Muledane

Source: Mutwanamba (2025)

Figure 7.4 illustrates the optimised solid waste collection routes designed for Muledane village, as delineated by the red boundary. These routes were spatially configured to

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align with the settlement's road network and population distribution, ensuring that all key residential zones are accessed. The design aims to mitigate the previously identified challenges of irregular service, poor route coverage, and operational delays. By optimising the travel paths of waste collection vehicles, the strategy promotes improved service delivery, time efficiency, and fuel cost reduction, thereby contributing to more sustainable waste management practices in peri-urban environment.

7.2.3.8. Scheduling bulky collections

Scheduling bulky collections received a mean of 3.17, indicating that respondents moderately agreed that scheduling bulky waste collections (for large items like furniture, appliances, and construction debris) can improve solid waste management in peri-urban villages. A high standard deviation of 1.295 indicates respondents had divergent views on whether scheduling bulky waste collections would significantly improve solid waste management. Some respondents strongly supported the idea, while others did not consider it a major waste management concern. From the data, 18,9% of respondents strongly agreed that bulk collection could improve solid waste collection, and 26.9% of respondents agreed that the strategy is effective, which makes a total of 45.8% of the respondents who believed designated bulky waste collections could help reduce illegal dumping and improve waste disposal efficiency. About 16.0% of the respondents are unsure about its effectiveness because some believe that bulky waste collection requires extra resources, such as larger trucks and more workers, and is costly. Nearly 28.6% of the respondents disagreed that bulk collection can improve poor solid waste collection, and 9.7% of the respondents strongly agreed about the effectiveness of bulk collection, which makes a total of 38.3% of the respondents who do not believe in this strategy this is because Some may think that waste reduction and recycling programs should be prioritised over bulky waste collections.

The regression analysis for scheduling bulky collections assessed whether planned collection of large household waste items such as furniture, appliances, and yard debris influenced perceptions of the effectiveness and sustainability of solid waste management services in the peri-urban villages of Thohoyandou. The unstandardised coefficient (B) was 0.021, and the standardised beta coefficient was 0.025, indicating a very weak positive relationship. This implied that as support for scheduled bulky item collections increased, so did the perception of improved service effectiveness, albeit

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slightly. The p-value was 0.749, which exceeded the 0.05 threshold for statistical significance, confirming that the relationship was not statistically significant. The 95% confidence interval for B ranged from –0.104 to 0.146, which included zero, further affirming that this variable was not a significant predictor of perceived waste collection effectiveness. There were no multicollinearity concerns, with a tolerance value of 0.828 and a Variance Inflation Factor (VIF) of 1.208, indicating that the variable was statistically stable and did not interfere with the overall regression model.

Implementing structured bulk solid waste collection schedules can help manage these issues while improving waste diversion and recycling; for this strategy, the municipality must have equipped trucks and heavy trucks. Drop-off sites can serve as permanent collection points for large items. This will be achieved by installing a large container. Deploying staff or volunteers to guide proper waste sorting. For the bulk waste collection schedule to be successful, residents must be informed and actively involved. Municipality can tell people by distributing flyers and posters with collection dates and procedures to make the program successful, and sustainable bulk waste collection should be linked with existing solid waste plans.

7.2.3. 8. Rethinking how peri-urban areas are designed and managed

Lastly, rethinking how peri-urban areas are designed and managed received a mean of 3.50, indicating that respondents moderately agree that rethinking how peri-urban areas are designed and managed can improve solid waste collection. A high standard deviation of 1.265 indicates significant differences in opinions about this strategy. Some respondents strongly support urban planning reforms, while others may not see how spatial planning directly impacts waste management. About 26.5% of respondents strongly agree that rethinking peri-urban planning can change solid waste collection, and 31.1% of respondents agree that rethinking of peri-urban planning is important, which makes a total of 57.6% of respondents who think this strategy can work this is because respondents recognise that better urban design can improve waste collection routes, reduce illegal dumping, and encourage community-based recycling efforts. Nearly 16.0% of the respondents were neutral this is because respondents did not fully understand how urban planning affects waste management, highlighting the need for more public education on the topic. Approximately 19.0% of the respondents disagreed that rethinking of peri-urban planning it will not reduce the issue of poor solid waste

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collection, 7.1% of respondents strongly agreed that urban design could make changes which makes a total of 19.3% of respondents who did not agree that urban design can bring changes due to Redesigning peri-urban areas requires significant government investment, which may not be prioritised.

The regression analysis for rethinking how peri-urban areas are designed and managed assessed whether improved spatial planning, land-use management, and infrastructure design influenced perceptions of the effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban communities. The unstandardised coefficient (B) was –0.073, and the standardised beta coefficient was –0.068, indicating a weak negative relationship. This implied that greater support for spatial redesign and management reforms was slightly associated with reduced perceptions of collection effectiveness, though the relationship was not meaningful. The p-value was 0.352, which exceeded the 0.05 threshold, confirming that the relationship was not statistically significant. The 95% confidence interval for B ranged from –0.228 to 0.083, which included zero and further reinforced the conclusion that this strategy was not a statistically significant predictor of perceived service performance.

To improve solid waste collection in Muledane & Maniini, peri-urban areas must be designed and managed sustainably. This requires a shift from reactive waste collection to proactive waste planning. Solid Waste collection infrastructure must be integrated into urban planning and population expansion. Smart technologies improve efficiency and data tracking, and also strong governance and public participation ensure long-term success. The strategies most strongly supported by respondents include implementing policy and legislation, cleaning campaigns, and collection efficiency, while landfilling, recycling, and enhancing collection infrastructure received less enthusiasm. The data underscores the importance of policy-driven and efficiency-focused interventions in improving solid waste collection, with more mixed opinions on technological and infrastructural solutions.

Case of Lesotho from 2.4.3.3.2, Maseru the use of geospatial techniques plays a crucial role in solid waste management. (MSW (Makhosi, 2021). The case study found out that the Tsoane dumpsite was unsuitable, indicating the need for better planning and location of waste disposal sites. Similarly, the strategies to rethink peri-urban area management focuses on urban planning improvements, ensuring that waste

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management infrastructure is properly integrated into city development. The Maseru case study's mention of policy gaps regarding waste collection points location aligns with the need for better planning in peri-urban areas to ensure accessibility and efficiency. Both Maseru and this strategy emphasise the need for scientific and driven approaches to waste management. Maseru case study have highlighted urban planning and infrastructure improvements as critical factors ineffective.

7.3. Measures to improve the efficiency of solid waste collection

Table 7.2. Below are responses to the question of what measures may improve solid waste collection efficiency. The results highlighted several initiatives, with varying degrees of support from the respondents.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	mean	Std. Deviation
Municipal solid waste collection fee levy	4.6%	0.0%	0.8%	2.9%	91.6%	4.77	0.867
Formalising solid waste collectors	0.8%	5.9%	2.9%	87.8%	2.5%	3.85	0.588
Solid waste to energy	0.8%	12.6%	67.6%	13.9%	5.0%	3.10	0.702
Recovery of recyclable materials	4.6%	55.5%	13.9%	20.6%	5.5%	2.67	1.029
Policies and Legislation Advocacy	50.0%	19.3%	8.4%	14.3%	8.0%	2.11	1.367
Community engagement	29.0%	25.6%	13.4%	25.6%	6.3%	2.55	1.314
Green Certification	3.4%	24.8%	26.5%	32.4%	13.0%	3.27	1.077
Public Health and Safety	1.7%	12.6%	18.9%	43.7%	23.1%	3.74	1.006

Table 7.2. Measures to improve the efficiency of solid waste collection

Source: field data (2025)

7.3.1. Municipal solid waste collection fee levy

The most strongly endorsed measure is the municipal solid waste collection fee levy, with an overwhelming amount reflected in the mean score of 4.77, the highest among the factors listed, and a low standard deviation of 0.867, indicating a high level of consensus among respondents. The majority, 91.6% of the respondents, strongly agreed that waste collection levies can improve solid waste collection, and 2.9% of the

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respondents agreed, which makes a total of 91.6% of respondents who believed that it would enhance the efficiency of waste collection. A small number of 4.6% of respondents disagree that the collection of levies can improve solid waste collection; there is no opposition at the "Disagree" level, meaning no one thinks it is outright ineffective. 0.8% of the respondents were unsure whether the collection fee would improve the service.

The regression analysis for the municipal solid waste collection fee levy investigated whether the introduction of waste collection charges influenced the effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was 0.029, and the standardised beta coefficient was 0.022, indicating a very weak positive relationship. This suggested that as perceptions in favour of the fee levy increased, there was a slight rise in the belief that waste collection practices were effective and sustainable. However, this relationship was minimal. The p-value was 0.821, which exceeded the 0.05 significance level, confirming that the relationship was not statistically significant. Furthermore, the 95% confidence interval for B, ranging from –0.225 to 0.283, included zero and reinforced the conclusion that the variable did not significantly predict waste collection effectiveness.

The goal is to establish a financially stable, sustainable, solid waste collection system. This will ensure regular and effective solid waste collection, reducing illegal dumping and promoting environmental sustainability. Levies should be based on income levels to avoid overburdening low-income households; every household will be covered with the service because they will be paying for it. When every household is paying, the financial status of the municipality will increase. Municipality should consider the idea of those who earn more money paying high fees. Municipality needs to utilise money sustainably. Public campaigns for educating households on the importance of paying collection fees are significant.

Similarity in Pune (Bhat & Deshpande, 2021), residents pay a fee to support ward-level collection hubs. These fees make waste collection more regular and better managed. Like in the study, community support for fee systems helped fund infrastructure and services. Both cases show that when people contribute money, waste services become

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more efficient. The fee creates accountability, encourages service quality, and ensures sustainability. These two peri-urban and Pune residents both see this as a positive, workable solution. Furthermore, in linking with Principal-Agent Theory, the community (the principal) delegates waste collection responsibility to the municipality (the agent). The municipality is held accountable by charging fees because citizens expect performance in exchange for payment. Transparency and performance monitoring are easier residents demand better service since they are financially involved. This helps close the "accountability gap" often seen in poorly funded municipal systems.

7.3.2. Formalising solid waste collectors

From the data below the mean value of 3.85 and the low standard deviation of 0.588 suggest strong agreement and consistency in responses, indicating that formalising this sector is important for enhancing collection efficiency. About 87.7% of respondents agreed that the majority support the idea of formalising waste collectors, showing a strong trust in its benefits, and 2.5% of respondents strongly agreed, which makes a total of 87.8% of respondents who were in support of solid waste collectors can improve the current situation of solid waste collection. A small number of 2.9% of respondents are unsure; maybe this is because of a lack of knowledge. Nearly 5.9% of respondents disagreed that formalised waste collectors will not improve solid waste collection, and 0.8% strongly disagreed.

The regression analysis for formalising solid waste collectors aimed to determine whether integrating informal waste pickers into the formal municipal system had a significant effect on the perceived effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.163, and the standardised beta coefficient was –0.084, indicating a weak negative relationship. This suggested that as perceptions favouring the formalisation of waste collectors increased, there was a slight decrease in the perceived effectiveness of the current collection practices. However, this relationship was not strong. Importantly, the p-value was 0.374, which was well above the 0.05 significance threshold. This indicated that the relationship between formalisation and waste collection effectiveness was not statistically significant. The 95% confidence interval for B ranged from –0.523 to 0.197, and because this interval included zero, it further

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confirmed that formalising waste collectors did not significantly impact the effectiveness of solid waste services within the model.

In local municipalities around South Africa, informal solid waste collectors play an important role in solid waste collection and recycling. However, their work is often unregulated, and they receive a low salary of R2500 (USD125) per month. The integration of informal waste pickers into municipal systems is very important. It improves the efficiency of solid waste collection services. More waste pickers should be hired. By doing this, the unemployment rate will decrease. The Department of Labour in South Africa needs to promote dignity and fair wages for waste pickers who are often exploited and work under a harsh condition. Municipalities must train waste collectors in safety procedures, recycling techniques, and separation. Protective gloves, boots, and masks are important to improve working conditions.

The New Urban Agenda (NUA 2016) Supports decentralised, people-centred waste management, emphasising worker protection and community participation. Encourages municipalities to decentralise waste management decisions, giving voice to grassroots actors like informal waste workers. Department of Labour & Basic Conditions of Employment Act states that all workers, including informal ones, should enjoy safe working conditions, fair wages, and labour rights. Many informal waste collectors earn as little as R2,500/month with no protective gear. Formalisation aligns their treatment with national labour policies.

7.3.3. Solid waste to energy

On the other hand, solid waste to energy received a mixed response; the mean of 3.10 suggests that while it is seen as a potential improvement, it does not garner as much enthusiasm as other measures. The standard deviation of 0.702 indicated a moderate opinion spread, signalling that some respondents may had reservations about its effectiveness. Approximately 67.6% of the respondents were uncertain whether solid waste to energy can solve the problem of solid waste collection. About 13.9 of the respondents agreed that solid waste to energy had a potential benefit, and 5.0% strongly agreed, which makes a total of 18.9% agreeing. Nearly 12.6% strongly disagreed due to environmental or cost concerns, and 0.8% of the respondents strongly disagreed.

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The regression analysis for the solid waste to energy (WTE) strategy investigated whether the conversion of waste into usable energy sources influenced the perceived effectiveness and sustainability of household solid waste collection in the peri-urban villages of Thohoyandou. The unstandardised coefficient (B) was –0.099, and the standardised beta coefficient was –0.061, indicating a very weak negative relationship. This result suggested that as support for waste-to-energy initiatives increased, there was a slight decline in perceptions of current collection effectiveness, though the relationship was not substantial. The p-value was 0.394, which exceeded the 0.05 significance level, indicating that the relationship was not statistically significant. The 95% confidence interval for the unstandardised coefficient ranged from –0.327 to 0.129, which included zero, further reinforcing the insignificance of the relationship between the waste-to-energy strategy and perceived effectiveness of solid waste collection services.

Solid waste to energy is the process of converting non-recyclable solid waste into usable energy such as electricity, heat, and fuel. The approach can help per-urban villages address the issue of poor solid waste collection and simultaneously generate energy. Collaboration with energy companies and environmental organisations to finance the project is an important step to initiate the energy project. The municipality needs to seek government grants and incentives for renewable energy initiatives and conduct feasibility studies to assess the type and volumes of waste generated in the municipality. This will determine the most sustainable waste-to-energy technology based on the available waste composition. Conducting awareness campaigns to educate households about solid waste energy is very important.

Sustainable Development Goals (SDG 13 – Climate Action & SDG 12 – Responsible Consumption and Production). Promote clean energy solutions and sustainable waste disposal systems. Encourage innovative methods to reduce environmental impact and promote circular economies. Solid waste to energy provides a dual solution—reducing landfill pressure and generating energy in line with climate goals. The New Urban Agenda (NUA, 2016) encourages cities to adopt zero-landfill targets and supports converting waste to energy when recycling is not possible. WTE aligns with the agenda's focus on resource-efficient urban management, particularly for fast-growing peri-urban areas. Linking with Lefebvre's Spatial Triad, WTE facilities reflect forward-

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thinking planning where waste systems are tied into the urban energy landscape. It's a space designed for a dual purpose: disposal and production. In peri-urban areas, where waste piles up due to poor collection, WTE offers a spatial solution that removes and repurposes waste from the environment. Communities may resist or support WTE based on how it's introduced. Awareness, education, and transparency shape whether they see it as progressive or dangerous.

7.3.4. Recovery of recyclable materials

The recovery of recyclable materials had a mean of 2.67, indicating that it is seen as less critical for improving efficiency. The standard deviation of 1.029 shows moderate variability, pointing to differing views on the importance of recycling in improving waste collection efficiency. Approximately 20.6% of the respondents agreed, and a total of 21% of the respondents believed that improving recycling efforts would significantly enhance waste collection efficiency. Nearly 13.9% of the respondents were unsure or indifferent about the impact of recycling on waste management. Approximately 55% of the respondents disagreed that recovery of recyclable materials improves solid waste collection, and 4.6% of the respondents disagreed. Municipality needs to introduce household-level waste sorting bins; the bins should include organic, recyclable, and non-recyclable.

The regression analysis for the recovery of recyclable materials explored whether increasing recycling efforts influenced the perceived effectiveness and sustainability of household solid waste collection in the peri-urban communities of Thohoyandou. The unstandardised coefficient (B) was –0.018, and the standardised beta coefficient was –0.017, indicating an extremely weak negative relationship. This suggested that as support for recycling measures increased, there was a negligible decline in perceived effectiveness of current waste collection practices. The relationship was statistically insignificant, with a p-value of 0.838, far exceeding the 0.05 threshold. Furthermore, the 95% confidence interval for the B value ranged from –0.197 to 0.160, which included zero and confirmed that the effect of recycling efforts on perceptions of collection effectiveness was not statistically meaningful. Multicollinearity was not a concern, as the tolerance value was 0.645 and the Variance Inflation Factor (VIF) was 1.550, both of which were within acceptable ranges. These values indicated that the variable was stable within the model and did not distort the regression output.

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Implementing mandatory recycling policies that require households to separate their waste. Municipalities should provide financial incentives such as subsidies for those engaging in recycling. Partnerships with private recycling companies will allow the municipality to create a structural system for waste recovery. Conducting the awareness campaigns will educate the households about the benefits of recycling.

Case study of Malaysian cities : A Review of Future Household Waste Management for Sustainable Environment in Malaysian Cities (Cheng, K.M; et al.; 2022). The Malaysian case study confirms that poor recycling rates and overreliance on landfills lead to environmental and financial burdens. By looking at Table 7.1. it indicates that recovery of recyclable materials is strongly supported in these two villages, showing a need for better infrastructure and legislation by adopting lessons from lessons such as improving recycling infrastructure, policy-driven incentives and behavioural change campaigns. Thulamela Local Municipality can enhance its waste recovery system and reduce land dependency.

7.3.5. Policies and Legislation Advocacy

Policy and legislation advocacy received the lowest level of support, with a mean of 2.11. This indicates that respondents were less confident that advocacy for policies and legislation would significantly impact waste collection efficiency. The standard deviation of 1.367 reflected a high level of disagreement, further emphasising the lack of consensus on this factor. Approximately 50.0% of the respondents strongly disagreed that policies and legislation are important to improve solid waste collection, and 19.3% disagreed about the issue, with a total of 69.3% disagreeing significantly. The majority of this indicates that respondents do not trust policy enforcement or see it as ineffective in improving solid waste management. Nearly 14.3% of the respondents agreed that policy enforcement is a solution to poor solid waste collection, and 8.0% of the respondents strongly agree, which makes a total of 23.3% of the respondents indicating that a small number of household members believed that policy and legislative advocacy could contribute to better waste collection practices. About 8.4% of respondents were uncertain about the role of policies in the waste collection system.

The regression analysis for policies and legislation advocacy examined whether promoting policy frameworks and legal enforcement influenced perceptions of the

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effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban areas. The unstandardised coefficient (B) was –0.028, and the standardised beta coefficient was –0.034, indicating a very weak negative relationship. This result implied that stronger perceptions of policy advocacy were associated with a marginal decrease in perceived collection effectiveness, although the effect was practically insignificant. The model revealed that this relationship was not statistically significant, with a p-value of 0.682, which was far above the standard threshold of 0.05. The 95% confidence interval for B ranged from –0.163 to 0.107, encompassing zero, and reinforcing the lack of statistical significance. Municipality and private service providers must adhere to waste collection policies and regulations. Most waste collectors operate informally, policies can help integrate them into formal waste collection systems to improve service delivery. Municipalities need to implement policies on illegal dumping and improper waste disposal.

7. 3.6. Community engagement

Community engagement had a mean of 2.55 and a standard deviation of 1.314, indicating variability in opinions. However, the overall trend leans toward scepticism. The municipality needs to solve problems regarding the issue of solid waste collection. About 29.0% of respondents strongly disagreed that community engagement is an effective way to improve waste collection, and 25.6% disagreed that community engagement is a key solution, which makes a total of 54.6% of respondents who believed that community engagement is not a solution. Nearly 13.4% of respondents did not decide. Community workshops and public meetings are important because households will learn more about the importance of proper waste disposal.

The regression analysis for community engagement assessed whether increased involvement of residents in waste management activities had any measurable impact on the perceived effectiveness and sustainability of household solid waste collection in peri-urban Thohoyandou. The unstandardised coefficient (B) was –0.032, and the standardised beta coefficient was –0.037, indicating a very weak negative relationship. This suggested that greater support for community engagement was associated with a minor decline in the perception of waste collection effectiveness, although this association was marginal and not meaningful. The relationship was statistically insignificant, with a p-value of 0.649, which exceeded the 0.05 level of significance.

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The 95% confidence interval for B ranged from –0.170 to 0.106, which included zero, confirming the non-significance of the predictor variable within the regression model.

Municipalities need to consider making radio and social media advertisements to spread awareness of solid waste management. Introducing school-based programs that allow children to learn more about recycling and waste reduction. Encouraging the community's to-do cleanup program, where the community members can volunteer to clean up illegal dumping. Youth and women's groups should be encouraged to participate in recovery projects that create employment. Municipalities need to implement waste rewards programs, where households receive incentives for recycling, motivating residents to maintain a clean environment. Install solid waste bins in strategic locations with clear labelling and non-recyclable waste.

SPLUMA (2013) promotes spatial justice and public participation in spatial planning processes, especially in marginalised areas. Community involvement in planning for waste collection routes, bin placement, and cleanup initiatives fulfils SPLUMA's call for inclusive governance. Additionally, Lefebvre's Spatial Triad has a dimension: Lived Space (Representational Space). Their perception of how space is managed shapes community beliefs, behaviours, and values. When residents are invited to participate in planning or clean-up, they feel more connected to their space and are more likely to keep it clean. Perceived Space (Spatial Practice), Waste is generated and discarded daily. Engaging people in how waste moves and where it ends up changes everyday habits (e.g., illegal dumping, burning). Conceived Space, when communities are not involved in formal plans, their lived realities are often ignored, resulting in ineffective strategies.

7.3.6. Green Certification

Green certification has a mean value of 3.27. This indicated moderate agreement, with a standard deviation of 1.077, showing some variability in respondents' views on the role of environmental certification in waste collection practices. Approximately 32.4% of respondents agreed that the majority of the households support green certification as a strategy for improving solid waste collection efficiency, and 13.0% of respondents agreed, believing it can significantly contribute to better collection service, which makes a total of 45% of respondents. A small number of 3.4% of respondents strongly

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disagreed that green certification is the solution, and 24% are sceptical about its effectiveness, which makes up 28.2% of the respondents who did not believe in the idea. Approximately 26.5% of respondents were neutral, indicating limited awareness or mixed opinions. Green certifications reduce environmental pollution by certified waste collection programs, lowering illegal dumping.

The regression analysis for green certification assessed whether promoting environmentally responsible practices through certification had a measurable impact on the perceived effectiveness and sustainability of household solid waste collection in Thohoyandou's peri-urban communities. The unstandardised coefficient (B) was 0.110, and the standardised beta coefficient was 0.104, indicating a weak positive relationship. This suggested that as support for green certification increased, so too did the perception that current waste collection practices were more effective and sustainable, though the relationship remained modest. Despite the positive direction, the relationship was not statistically significant, with a p-value of 0.175, which exceeded the 0.05 threshold. The 95% confidence interval for the B value ranged from –0.049 to 0.269, including zero, and therefore reinforcing the insignificance of the relationship in statistical terms. The analysis also confirmed that the variable did not pose multicollinearity concerns, as the tolerance value was 0.737 and the Variance Inflation Factor (VIF) was 1.357, both well within accepted standards for model stability..

Certification encourages households to engage in sustainable waste management. Green certification ensures that solid waste follows international and national environmental standards. Municipalities and companies must adopt green waste management strategies to gain recognition and community trust. Establishing a local certification body to assess solid waste collection service-based criteria. Implementing a green household certification program for households that perfectly separate solid waste and participate in recycling. Municipalities can launch community workshops and training sessions to educate people about the importance of green certification. The Department of Education and universities should integrate sustainable education into their curriculum.

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7.3.8. Public Health and Safety

Finally, public health and safety had a mean of 3.74 and a standard deviation of 1.006, suggesting a high degree of agreement and consistency, highlighting the importance of public health and safety considerations in enhancing waste collection efficiency. About 43.7% of respondents agreed that it supports public health and safety as an essential factor in waste collection efficiency, and 23.1% of respondents believed in its importance, which makes a total of 66.8% of respondents agreeing. Approximately 1.7% of respondents strongly agreed to prioritise public health and safety in waste management, and 12.6% disagreed because they did not see public health and safety as a key concern for waste collection efficiency, which makes a total of 14.3% of respondents who did not believe. Nearly 18.9% of respondents were uncertain about public health and safety because of a lack of direct awareness of waste-related health risks.

The regression analysis for public health and safety examined whether prioritising health and safety concerns influenced the perceived effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.118, and the standardised beta coefficient was –0.104, indicating a weak negative relationship. This suggested that as emphasis on public health and safety increased, there was a slight decrease in the perception that waste collection was effective and sustainable, although this association was minimal. The p-value was 0.163, which exceeded the standard 0.05 threshold, indicating that the relationship was not statistically significant. The 95% confidence interval for B ranged from –0.284 to 0.048, which included zero, further confirming that public health and safety did not significantly predict the dependent variable within the regression model.

Public health is important because it enhances overall community well-being, cleans streets, and adequately manages waste to create a healthier living environment. Providing protective clothing can reduce health risks for solid waste workers. Implementing training programs on handling hazardous waste is very important. Municipalities must strengthen policies and regulations to prevent illegal dumping and open space burning. Local governments must impose fines and penalties for those not comply with solid waste disposal regulations.

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7.3. Negative impacts of current solid waste collection practices

Table 7.3. below provides an analysis of how respondents view the negative impacts of current solid waste collection practices on the environment, health, and safety

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	Mean	Std. Deviation
Environment	5.5%	15.5%	9.2%	42.0%	27.7%	3.71	1.185
Health	8.8%	2.9%	0.8%	10.1%	77.3%	4.44	1.227
Safety	2.9%	6.3%	5.9%	80.3%	4.6%	3.77	0.757

Table 7.3: Negative impacts of current solid waste collection practices

Source: field data (2025)

7.3.1. Environment

For the environment, the mean score is 3.71, indicating that solid waste collection practices negatively impact the environment. The standard deviation of 1.185 indicates moderate variability in responses, showing that while the majority recognise a negative environmental impact, there are also a notable number of neutral or disagreeing respondents. About 27.7% of the respondents strongly agreed that the current collection practice is negatively affecting the environment, 42.0% of the respondents agreed to issue of the environment being affected, which makes a total of 69.7% of the respondents who believed that the current system is affecting the environment indicating concerns over pollution, poor waste disposal, and ecological damage. Nearly 9.2% of the respondents were neutral; they were unsure of the option to choose because of different levels of exposure to waste-related pollution. Approximately 15.5% of

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respondents disagreed that the current system impacts the environment, and 5.5% strongly disagreed, which makes a total of 21% of respondents who do not see environmental harm, indicating that a small group of people believe solid waste collection is effective.

The regression analysis for the environmental factor explored whether concern for environmental protection influenced perceptions of the effectiveness and sustainability of household solid waste collection in the peri-urban settlements of Thohoyandou. The unstandardised coefficient (B) was –0.058, and the standardised beta coefficient was –0.049, indicating a very weak negative relationship. This suggested that as concern for environmental impacts increased, there was a minor decline in the perception of effective waste collection services, though the relationship was negligible. The p-value was 0.526, which was above the conventional threshold of 0.05, confirming that the relationship was not statistically significant. The 95% confidence interval for B ranged from –0.239 to 0.123, which included zero, further confirming that environmental concern was not a significant predictor of perceived waste collection effectiveness in the regression model. There were no multicollinearity issues, as the tolerance value was 0.694 and the Variance Inflation Factor (VIF) was 1.441, both of which were within acceptable statistical ranges, indicating that the model was stable.

The majority of peri-urban areas lack formalised waste collection systems, leading to illegal dumping, soil contamination, and water pollution. The table does not indicate overwhelming concern for environmental issues, which could imply limited awareness and implementation of recycling initiatives. The National Environmental Management Act (NEMA, 1998) states that any person (including municipalities) must take reasonable steps to prevent pollution and environmental degradation. Thulamela Municipality has a legal obligation to implement waste systems that reduce environmental impact. Failure to do so violates the "duty of care" principles outlined in NEMA. The Basel Convention (1989) focuses on the safe handling of hazardous and household waste to protect ecosystems. Many types of household waste in Muledane and Maniini (e.g., batteries, e-waste, plastics) contain harmful substances. The absence of regulated collection means environmental risks go unmitigated.

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7.3.2. Health

Regarding health, a mean score of 4.44 indicates a strong perception that current solid waste collection practices negatively impact health, with a low standard deviation of 1.227, indicating moderate variation, meaning some respondents had different experiences with waste-related health problems. The majority, 77.3% of the respondents, strongly agreed that the current system affects health, and 10.1.% of the respondents agreed, which makes a total of 87.4% of respondents believe that solid waste collection is a major health issue, likely due to disease outbreaks, pests, and contamination of water sources. Nearly 0.8% of the respondents were uncertain about the issue. Small number of 2.9% of respondents disagree that the current collection system is not effective, and 8.8% of respondents strongly agreed that the current system is effective, which makes a total of 11.7% of respondents who did not see waste collection as a health hazard, possibly in areas where waste collection is better controlled.

The regression analysis for the health factor investigated whether concerns about public health risks associated with poor waste management influenced perceptions of the effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.051, and the standardised beta coefficient was –0.046, indicating a very weak negative relationship. This implied that heightened concern for health impacts was slightly associated with lower perceptions of service effectiveness, though the relationship was minor and not practically significant. The p-value was 0.559, which was above the 0.05 threshold, indicating that the relationship was not statistically significant. Additionally, the 95% confidence interval for B ranged from –0.224 to 0.122, and the inclusion of zero confirmed that the health variable was not a significant predictor in the regression model. There were no multicollinearity concerns, as the tolerance value was 0.696 and the Variance Inflation Factor (VIF) was 1.438, suggesting model stability and no redundancy with other predictors.

Uncollected waste creates breeding grounds for bacteria, viruses, and fungi, increasing the risk of diarrhoea, cholera, typhoid, and respiratory infections. Rotting food and organic waste attract flies and cockroaches, which transmit diseases. Stagnant waste and clogged drains become ideal breeding sites for mosquitoes, leading to malaria and

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dengue fever outbreaks. Burning of waste, often done in areas with irregular collection services, releases toxic fumes, leading to asthma, lung infections, and chronic respiratory diseases. Dust and decomposing waste contribute to poor air quality, affecting people with allergies and lung conditions. Linking with the Lefebvre's Spatial Triad, residents walk past, live near, or interact with overflowing bins and waste piles in daily life. Health risks become embedded in daily routines. Residents begin to associate certain streets, corners, or yards with sickness, neglect, and poverty due to waste exposure. Municipal waste management plans often ignore health risk zones, especially in informal or peri-urban areas. Planners design systems that don't reflect actual health vulnerabilities on the ground.

7.3.2. Safety

For safety, the mean score is 3.77, indicating a strong belief in solid waste-related safety issues. The relatively low standard deviation of 0.757 suggests strong agreement and consistency in responses, indicating that safety concerns are widely recognised. 4.6% of the respondents strongly agreed that the current collection service affects the safety of the household, 80.3 of the respondents agreed that safety is being affected by the current collection service, and make total of 84.9% of respondents acknowledged safety risks, such as blocked roads, waste fires, and physical hazards from uncollected garbage. A small number, 5.4% of the respondents, were unsure whether safety is being affected by the solid waste collection system. Approximately 6.3% of respondents disagreed that the currency system affects safety, and 2.9% of respondents strongly agreed that the current system does not affect safety, which makes a total of 9.2% of respondents did not view waste collection as a safety concern, suggesting that some areas might have better waste handling systems.

The regression analysis for the safety factor assessed whether concerns about physical safety and exposure to hazardous conditions influenced perceptions of the effectiveness and sustainability of household solid waste collection in the peri-urban areas of Thohoyandou. The unstandardised coefficient (B) was –0.094, and the standardised beta coefficient was –0.075, indicating a weak negative relationship. This suggested that increased concern for safety was slightly associated with lower perceptions of collection effectiveness, although the relationship was weak and not practically meaningful. The p-value was 0.279, exceeding the 0.05 significance level, which

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confirmed that the relationship was not statistically significant. The 95% confidence interval for B ranged from –0.265 to 0.076, which included zero, reinforcing that safety was not a statistically significant predictor in the model.

In the case study of Soweto from 2.4.3.3.2, the illegal dumping of waste is one of the significant causes of land degradation, which presents a problem for the global environment for both the developed and developing worlds (Sibongiseni, 2020). The Soweto, South Africa case study highlights how illegal dumping contributes to environmental degradation, health risks, and financial burdens on municipalities. The study's findings align closely with the survey results on spatial planning strategies in Thohoyandou, particularly regarding the environmental, health, and safety impacts of poor waste collection. The Case Study of Soweto highlights that the Illegal dumping of building rubble and domestic waste leads to groundwater and air pollution, increasing greenhouse gas emissions. The results from the study indicate a similar situation where illegal dumping remains a concern. Mapping and monitoring illegal dumps (as suggested in the Soweto study) could help these two villages prevent environmental damage. Soweto Case Study indicates that waste accumulation contributes to the spreading of diseases, airborne contaminants, and exposure to hazardous materials. Comparing it with the study health has the highest mean value, indicating that most respondents believe improved waste collection negatively affects public health. Poor waste collection exposes communities to vector-borne diseases, contaminated water, and respiratory illnesses, similar to findings in Soweto. Implementing remote sensing

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and machine learning technologies to detect illegal dumps could reduce health risks in Thohoyandou.

Figure 7.5: Illegal dumping hotspots in Maniini
Source: Mutwanamba (2025)

Figure 7.5 illustrates the distribution of illegal dumping sites within Maniini. The spatial distribution highlights a widespread occurrence of illegal dumping across the village, with a notable concentration near environmentally sensitive areas such as rivers and wetlands. The proximity of illegal dumping to these natural resources poses significant environmental risks, including water pollution and degradation of wetland ecosystems. This pattern suggests gaps in formal solid waste collection services, inadequate collection infrastructure, and lack of environmental awareness among residents. The map supports the identification of critical areas requiring urgent intervention to enhance sustainable solid waste collection practices.

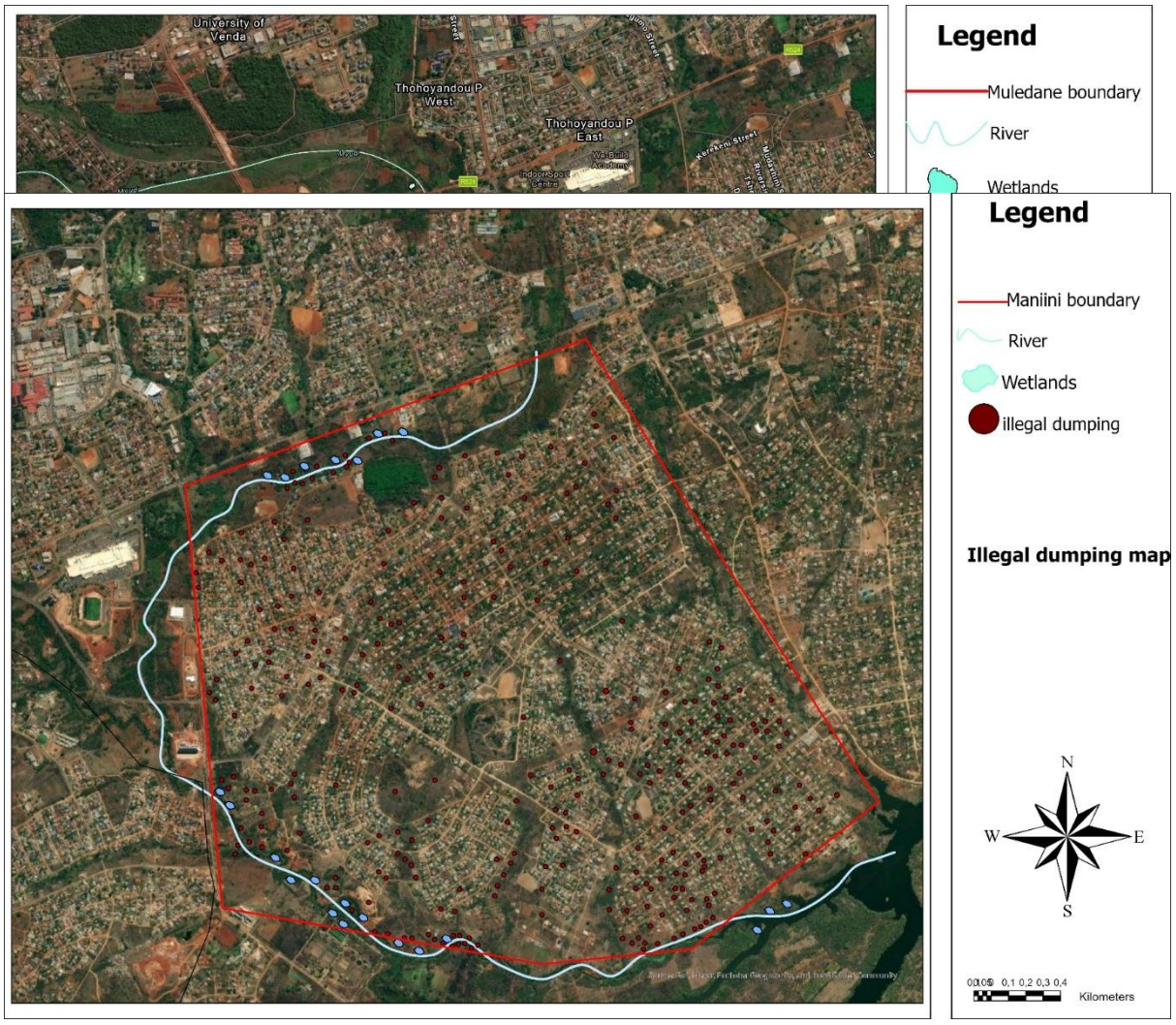

Figure 7.6: Illegal dumping map for Muledane

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Source: Mutwanamba (2025)

Figure 7.6 shows the distribution of illegal dumping sites within Muledane, delineated by the red boundary. The proximity of dumping sites to natural ecosystems such as rivers and wetlands poses severe environmental risks, including contamination of water sources and degradation of sensitive habitats. The spatial pattern of illegal dumping in Muledane highlights critical service delivery gaps, including insufficient waste collection infrastructure and low community awareness regarding proper waste disposal practices.

7.4. hypothesis testing

The study set out to test three hypotheses regarding the effectiveness of spatial planning strategies and their relationship to sustainable household solid waste collection in the peri-urban villages of Thohoyandou, specifically Muledane and Maniini. The hypothesis testing was based on the findings from Chapters 5, 6, and 7.

H_0 (Null Hypothesis): *Spatial planning strategies have no significant effect on the sustainability of household solid waste collection practices in peri-urban villages of Thohoyandou.*

To test this hypothesis, multiple regression analysis was performed using spatial planning indicators such as accessibility of collection points, route planning, land use structure, and settlement layout. The analysis revealed that although spatial factors such as road network design, illegal dumping locations, and accessibility to waste collection points were discussed as critical from a practical perspective, their statistical influence on perceptions of collection effectiveness was weak. For example, the regression results for factors like poor route planning ($B = 0.132$, $p = 0.239$) and topography ($B = 0.016$, $p = 0.829$) were not statistically significant. These findings suggest that spatial factors alone do not have a statistically measurable effect on the perceived sustainability of waste collection practices in these villages. Thus, the null hypothesis cannot be rejected based on the regression results alone.

H_1 (Alternative Hypothesis*): Spatial planning strategies play a significant role in enhancing sustainable household solid waste collection practices in peri-urban villages of Thohoyandou.*

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Despite the statistical insignificance of most spatial variables in the regression model, descriptive findings from the study support the practical importance of spatial planning. Respondents cited infrastructure challenges, inaccessible collection points, and poor land use planning as major contributors to inefficiencies in waste management. Moreover, the study emphasised the role of spatial planning in designing efficient service delivery networks, improving accessibility, and reducing environmental degradation. Spatial planning was also found to be central in shaping long-term sustainability, even if not reflected as statistically significant in isolation. Therefore, while the regression does not confirm H_1, the integrated interpretation of descriptive, spatial, and thematic analysis supports the practical relevance of spatial planning strategies. Hence, this hypothesis remains plausible when considering qualitative evidence.

H_2 (Competing Alternative Hypothesis): *The effectiveness of household solid waste collection in peri-urban villages of Thohoyandou is primarily influenced by governance policies and financial resources rather than spatial planning strategies.*

Statistical evidence strongly supports H_2. Regression analysis revealed that governance-related and economic variables such as poor payment of property levies ($B = -0.151$, $p = 0.025$) and poor allocation of municipal resources ($B = -0.106$, $p = 0.194$) had a stronger influence on perceptions of waste collection effectiveness than spatial factors. The significant p-value for property levies demonstrates that financial capacity and institutional governance are more critical determinants in sustaining waste management systems. Additionally, limited human resources, irregular scheduling, and non-compliance with environmental legislation were frequently cited as primary challenges affecting service delivery. This reinforces the conclusion that governance and funding structures are central to improving solid waste management outcomes.

Conclusion of Hypothesis Testing: Based on the quantitative and qualitative findings, the study fails to reject the null hypothesis (H_0) and does not statistically confirm the alternative hypothesis (H_1). However, it accepts the competing hypothesis (H_2) as the most supported explanation. While spatial planning strategies are important, the data indicate that governance effectiveness and financial resources exert a stronger influence

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on the sustainability and efficiency of household solid waste collection in the peri-urban villages of Thohoyandou.

7.5. Summary of the research findings

Chapter 7 summarised the key strategies proposed to improve sustainable household solid waste collection in the peri-urban villages of Muledane and Maniini in Thohoyandou. Drawing on data from earlier chapters and integrating both community perspectives and best practices from literature, the findings revealed a broad consensus among respondents on the importance of several critical interventions. These included implementing and enforcing waste management policies and legislation, introducing municipal waste collection levies, and conducting community-based cleaning campaigns. These strategies were seen as essential for improving accountability, enhancing service efficiency, and fostering environmental stewardship.

There was strong support for formalising the roles of informal waste collectors, suggesting a need for their integration into the formal system with appropriate regulation, remuneration, and recognition. Although strategies like recycling initiatives and investment in new technologies received moderate backing, concerns about cost, awareness, and implementation capacity were evident. Additionally, the findings highlighted persistent challenges such as public health risks, safety hazards, and environmental degradation caused by inconsistent collection, lack of infrastructure, and low public participation in waste reduction efforts.

Regression analysis revealed that spatial planning strategies, although conceptually significant, had no statistically meaningful impact on the perceived effectiveness or sustainability of solid waste collection in the studied villages. The model explained only 10.7% of the variance, indicating that other factors particularly governance policies, financial resources, and institutional capacity played a more influential role in shaping outcomes. These results confirm that while spatial planning is important, its current application in Thohoyandou's peri-urban areas is insufficient without complementary interventions that address structural, financial, and governance-related gaps. The chapter concludes by highlighting the need for integrated, community-responsive, and

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policy-aligned strategies to address the complex challenges facing sustainable solid waste collection in Maniini and Muledane.

Chapter 8: Summary Of Findings, Recommendations, And Conclusions

8.1. Introduction

This chapter provided a synthesis of the research findings. It presented key conclusions and actionable recommendations aimed at improving sustainable household solid waste collection practices in the peri-urban villages of Muledane and Maniini in Thohoyandou. The aim of this research was to investigate and develop spatial planning strategies that can enhance sustainable household solid waste collection practices in peri-urban villages of small towns, using Thohoyandou in the Thulamela Local Municipality as a case study. Grounded in the challenges identified in Maniini and Muledane villages, the study sought to address the spatial and infrastructural inequalities that limit effective service delivery. The problem statement was "*Current household solid waste collection practices in Thohoyandou peri-urban are not effective nor sustainable solid waste collection strategies"*. This study was guided by three core objectives, which were clearly stated in chapter 1(1.4). The research findings have highlighted the complex and multifaceted nature of household solid waste collection in peri-urban areas. The study revealed gaps between planning intentions and actual service implementation and challenges related to accessibility, collection frequency, and waste segregation. The study also answered key research questions which were clearly stated in chapter 1 (1.5).

The research was conducted in Muledane and Maniini, two fast-growing peri-urban villages within Thulamela Local Municipality in Thohoyandou, Limpopo Province, South Africa. These villages are characterised by dispersed settlements, limited road infrastructure, and inadequate municipal services. Dependent variable: Perceived effectiveness and sustainability of household solid waste collection practices.

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Independent variables: Demographic (age, gender, income), socio-economic (education, occupation), infrastructural (road access, equipment availability), spatial (settlement patterns), and health/environmental factors. A mixed-methods approach was employed, combining household surveys, key informant interviews, spatial mapping, and field observations. Statistical analysis (descriptive and regression) was used alongside GIS to examine spatial factors affecting solid waste collection. This chapter is structured into five main sections: a summary of findings, recommendations for practice and policy, knowledge contributed, suggestions for future research, and a concluding reflection.

8.1. Summary of findings

8.1.1. Characterisation of Household Solid Waste Collection Practices

The study revealed that household solid waste collection practices in the peri-urban villages of Maniini and Muledane were largely inconsistent, irregular, and ineffective. Solid waste was predominantly generated from domestic sources such as food waste, plastics, paper, and other household materials. The findings showed that most households did not receive regular municipal solid waste collection services, and a significant proportion relied on self-disposal methods, including illegal dumping and open burning. Solid Waste collection was found to be ineffective, with many respondents indicating that solid waste was collected either irregularly or not at all.

Furthermore, the methods of collection varied across the study areas. While some households were reached by municipal trucks, others were served by private or informal collectors, often lacking proper coordination. The frequency of collection was low, and in some cases, waste was collected weekly or only during specific periods. Access to designated solid waste collection points was limited, with poor road infrastructure and scattered settlement patterns further complicating service delivery.

The literature established that solid waste collection in peri-urban areas of developing countries is often challenged by poor infrastructure, informal settlements, and limited institutional capacity (World Bank, 2020; Fadugba et al., 2022). In both Muledane and Maniini, these realities were confirmed, even though to different extents. In Muledane, spatial fragmentation, poor access roads, and informal housing layouts complicated collection schedules and routing. Maniini, while also facing challenges, showed

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comparatively better connectivity and coordination in collection activities due to its closer proximity to town and slightly more formal layout.

In terms of solid waste handling, many households lacked access to standardised waste storage containers, such as municipal dustbins, leading to improper waste storage practices. The spatial analysis indicated that areas with poor road connectivity were less likely to be served, highlighting the direct impact of spatial planning constraints on solid waste service accessibility. The community also demonstrated low levels of recycling and limited awareness of proper waste separation techniques. Overall, the current household solid waste collection practices were found to be fragmented, inefficient, and largely unsustainable, necessitating spatial planning interventions to enhance service delivery and environmental management in the study areas.

8.1.2. Factors that impede sustainable household solid waste collection

The study identified a range of interrelated factors that hindered the sustainability of household solid waste collection in the peri-urban villages of Maniini and Muledane. Based on qualitative and quantitative findings, these factors were categorised under the STEEP framework: Social, Technological, Economic, Environmental, and Political dimensions.

Socially, limited public awareness and low levels of community participation in waste management significantly constrain sustainable practices. Residents lacked knowledge about recycling, waste sorting, and the environmental impacts of improper disposal. Informal settlement patterns and high population growth further exacerbated the challenge by increasing solid waste volumes in unplanned areas where services were difficult to deliver.

Technologically, the municipalities faced infrastructure limitations such as a shortage of appropriate solid waste collection equipment and vehicles. Poor route planning and the absence of technological systems for real-time monitoring and efficient scheduling contributed to delays and missed pickups.

Economically, budget constraints, poor allocation of municipal resources, and inadequate payment of property levies were identified as critical impediments. The

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limited financial capacity of local authorities affected their ability to provide consistent and widespread waste collection services, particularly in low-income peri-urban zones.

Environmentally, poor road networks, difficult terrain, and climate-related factors such as heavy rains created accessibility issues for waste collection trucks. Illegal dumping and open burning were common, posing risks to both public health and environmental quality. Topographical barriers made certain areas hard to reach, leading to service disparities.

Politically and institutionally, weak policy implementation, poor enforcement of waste regulations, and a lack of integration between spatial planning and waste management policies undermined coordinated efforts. The absence of planning frameworks that addressed the unique challenges of peri-urban areas resulted in service inefficiencies. Furthermore, insufficient interdepartmental collaboration and a lack of stakeholder engagement weakened governance structures responsible for service delivery.

Collectively, these factors revealed that sustainable household solid waste collection in the study areas was hampered by both structural and systemic challenges. The findings underscored the need for integrated, spatially informed, and community-inclusive solutions to improve long-term sustainability in peri-urban waste management. Consistent with the literature, factors impeding sustainable collection were both systemic and spatial. These included poor route planning, inadequate equipment, limited human resources, and budgetary constraints (Nkweauseh et al., 2023). In Muledane, the irregular layout and longer distances between households presented physical barriers to collection, while in Maniini, although spatial planning was slightly more integrated, the challenges were largely administrative, including scheduling inefficiencies and poor community engagement. Regression analysis further revealed that factors such as infrastructure availability and awareness levels had limited statistical impact, confirming earlier findings from the literature that spatial planning, while necessary, must be supported by institutional and community-based strategies to be effective (Zhao et al, 2023).

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8.1.3. Proposed Strategies and Stakeholder Preferences

The findings in Chapter 7 indicated that a range of spatial planning strategies were proposed to enhance the sustainability and effectiveness of household solid waste collection in the peri-urban villages of Thohoyandou, specifically Maniini and Muledane. These strategies emerged from both empirical data and stakeholder input, reflecting practical and context-specific solutions. Key proposed strategies included the clustering of households to allow for more efficient and cost-effective solid waste collection routes. This approach aimed to reduce service fragmentation caused by scattered settlement patterns. Another major strategy was the improvement of access roads, especially in hard-to-reach areas, which had previously hindered solid waste collection vehicles from operating consistently.

Stakeholders also emphasised the integration of solid waste collection systems into local spatial development frameworks (LSDFs) and IDPs. This was seen as essential for aligning service delivery with land use planning and ensuring long-term sustainability. Furthermore, the use of GIS and other spatial data tools was proposed to support better decision-making in route planning, service coverage analysis, and infrastructure investment. In terms of institutional roles, the findings showed that stakeholders preferred a multi-stakeholder approach involving the municipality, private sector, and community members. There was strong support for increasing community participation, with residents expressing willingness to be involved in solid waste sorting, awareness campaigns, and monitoring illegal dumping. Education programs were also proposed to promote recycling, composting, and proper waste storage. Municipal officials favoured strategies that would improve resource allocation and interdepartmental coordination, while community members preferred practical, low-cost solutions that could be implemented without extensive delays. The informal solid waste sector was also recognised as a valuable player, and stakeholders proposed that it be integrated into the formal system through training and support.

Findings underscored the need for integrated strategies combining spatial planning tools (e.g., GIS-based route optimization) with inclusive stakeholder engagement. Literature emphasizes proactive planning, community involvement, and enforcement as pillars for sustainable systems (Ghosh, 2022). Both villages expressed preferences

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for improved municipal support, more frequent collection, and formal recognition of informal collectors. Interestingly, residents in Muledane advocated for the clustering of households and road upgrades, while Maniini stakeholders prioritised the provision of bins and improved collection timetables. These priorities reflect village-specific spatial realities and suggest the need for location-sensitive interventions. Overall, the proposed strategies and stakeholder preferences emphasised the need for inclusive, spatially-informed, and participatory approaches to solid waste collection. The combination of infrastructure development, institutional reform, and public engagement was seen as critical to achieving sustainable and equitable waste collection in peri-urban areas.

8.2. Recommendations

Based on the empirical findings and analysis conducted in this study, several recommendations are proposed to enhance the sustainability and effectiveness of household solid waste collection in the peri-urban villages of Muledane and Maniini in Thohoyandou. These recommendations are guided by the gaps identified in solid waste collection practices, barriers to sustainability, and community perspectives on potential solutions.

8.2.1. Implement policy and legislation

While South Africa has progressive national frameworks like the National Environmental Management: Waste Act (2008) and SPLUMA, implementation at the local level remains weak. The Thulamela Local Municipality needs to adopt local by-laws that clearly articulate responsibilities for waste generators, collectors, and regulators. Enforcement mechanisms should include penalties for illegal dumping and improper disposal. Public officials and solid waste collection personnel should receive training on policy enforcement. The success of waste governance depends on the consistent and visible application of rules, which fosters community trust and compliance. The municipality needs to revise local by-laws that align with national legislation but are tailored to the unique context of peri-urban villages. These by-laws should define the responsibilities of households (e.g., segregation, proper storage, fee payment), Set clear standards for solid waste collectors, including registration, safety compliance, and areas of operation, establish penalties for illegal dumping, littering, and non-compliance, and conclude zoning for solid waste infrastructure in line with spatial planning goals.

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8.2.2. Municipal solid waste collection fee levy

A major finding was the strong public support (over 90%) for introducing a municipal waste collection levy. A tiered fee structure where wealthier households and businesses pay more can generate sustainable revenue while ensuring affordability for low-income households. These funds should be ring-fenced and transparently used for improving collection services, buying equipment, and supporting public education campaigns. Community consultations should precede implementation to explain the purpose of the fee and build buy-in. To ensure fairness and inclusivity, the waste fee system should follow a tiered or progressive model, where low-income households pay reduced or subsidised rates and high-income households and businesses pay higher fees based on income or waste volume. This ensures that no household is excluded due to poverty, while wealthier users contribute proportionately.

8.2.3. Formalizing solid waste collectors

Informal waste collectors currently contribute significantly to waste recovery and recycling, yet they operate without legal protection, equipment, or fair pay. Formalising this workforce through registration, training, and integration into municipal services would improve service coverage and worker dignity. Providing them with PPE (gloves, boots, uniforms), ID cards, and health coverage can also reduce occupational hazards. The Department of Labour and municipal authorities should collaborate on establishing guidelines and partnerships with the study, which revealed strong public support for formalising solid waste collectors, with 87.8% of respondents agreeing that formalisation would improve waste collection efficiency. This highlights a major opportunity for municipalities to professionalise, support, and integrate this workforce into the formal waste management system.

8.2.4. Collection efficiency

Many households reported that irregular or infrequent waste collection contributes to illegal dumping and health hazards. To address this, the municipality should establish fixed collection days supported by SMS alerts, local radio announcements, and social media updates. Investing in smaller, agile collection vehicles will improve access in informal settlements and areas with narrow roads. Hiring more collection staff and enhancing training can reduce missed pickups and improve reliability. Thulamela Local Municipality, particularly in peri-urban villages of Muledane and Maniini, investing in efficient, equitable, and consistent waste collection practices is essential for achieving

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sustainable development and environmental justice. Investment in infrastructure, such as road upgrades and designated collection points, is essential in both villages but more urgent in Muledane.

8.2.5. cleaning campaigns

Public attitudes toward solid waste disposal directly impact the success of any collection system. Many respondents showed limited trust in community involvement, which suggests a gap in awareness or past engagement failures. The municipality should revive community engagement through education campaigns in schools, churches, and local forums. Clean-up drives, school recycling competitions, and rewards for responsible households can encourage ownership. Traditional leaders and ward councillors should be key allies in promoting behavioural change. Cleaning campaigns are a low-cost, high-impact strategy that fosters community involvement, raises environmental awareness, and visibly improves the cleanliness of peri-urban areas. When paired with education, enforcement, and consistent waste collection, these campaigns can shift public attitudes and promote a culture of environmental stewardship.

8.2.5. Recycling

Recycling received low support despite the known environmental benefits, likely due to a lack of infrastructure and awareness. Introducing colour-coded bins at household and community levels (e.g., green for organic, red for recyclables, black for general waste) can make separation simple and visual. Municipal regulations can also make separation mandatory. Financial incentives like discounts or rewards for compliant households and partnerships with recycling companies can boost participation. Recycling hubs or drop-off points should be easily accessible. Although recycling is underutilised and undervalued in Thohoyandou's peri-urban areas, it can transform solid waste collection practices. Through targeted education, infrastructure investment, and community-based incentives, recycling can become a viable strategy to reduce solid waste, protect the environment, and support economic empowerment. Integrating recycling into the broader waste collection system will be essential for achieving long-term sustainability in Muledane and Maniini.

8.2.6. New technologies

Infrastructure such as dustbins, transfer stations, access roads, and dedicated storage areas is essential for efficient collection. Currently, infrastructure gaps lead to open

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dumping and inefficiencies. The municipality should invest in modern collection trucks, compactors, and waste containers. Technologies like GPS tracking of trucks, mobile reporting apps, and smart bins with sensors (to detect when full) can improve responsiveness and transparency. The municipality could pilot such innovations in high-density zones before scaling. Adopting new technologies offers immense potential for improving waste collection efficiency, responsiveness, and community engagement in Thulamela's peri-urban areas. Though initial investment and training are needed, these systems can reduce long-term costs, strengthen data management, and help the municipality build a more adaptive and future-proof waste management system. Introducing technologies gradually through pilot programs and public-private partnerships is a strategic pathway toward modernising service delivery in Muledane and Maniini.

8.2.7. Rethink how peri-urban are designed and managed

A data-driven approach to solid waste collection allows municipalities to identify service gaps, allocate resources, and measure progress. The municipality should develop a centralised digital solid waste database, tracking information such as bin locations, waste volumes, collection times, missed pickups, and citizen complaints. This data can be used for route optimisation, contractor performance reviews, and strategic planning. Annual public reports on waste collection performance can also improve transparency and accountability.

8.2.8. Address Environmental, Health, and Safety Concerns

The study found strong public concern about the impact of poor waste practices on health and safety. Solid waste accumulation contributes to respiratory issues, vector-borne diseases, and contaminated water sources. The municipality should prohibit the open burning of waste and illegal dumping through strict enforcement. Solid waste collectors must be protected with proper gear and vaccinated against occupational diseases. Community education on the health impacts of poor disposal can also encourage proper behaviour. Addressing environmental, health, and safety concerns is critical for improving the quality of life in peri-urban areas.

8.3. Knowledge contributed

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This study has contributed new empirical, methodological, and theoretical knowledge to the field of spatial planning and solid waste collection in peri-urban contexts, with a specific focus on Maniini and Muledane villages within Thulamela Local Municipality, South Africa. The research revealed that while spatial planning frameworks and legislation exist at the national and local levels, their application in peri-urban areas is limited and often disconnected from actual service delivery challenges. This highlights a critical gap between policy design and practical implementation, especially in rapidly urbanising rural-urban fringe settlements.

Through a mixed-methods approach combining GIS mapping, descriptive statistics, and regression analysis, the research established that spatial planning strategies alone do not significantly predict or improve the sustainability and effectiveness of household solid waste collection. Instead, factors such as financial resources, institutional capacity, governance quality, public awareness, and infrastructural readiness played a more decisive role. This insight shifts the focus from spatial planning as a standalone tool to one component of a broader, integrated solid waste collection system that requires cross-sectoral collaboration. In addition, it fills a gap in empirical data for under-researched peri-urban areas and offers a replicable framework for other municipalities facing similar service delivery challenges.

8.4. Recommendations for future research

Future research should explore the role of governance, institutional capacity, and political will in shaping waste management outcomes in peri-urban areas. While this study focused on spatial planning strategies, the regression analysis revealed that other factors outside of spatial planning may have a greater influence on collection efficiency and sustainability. Investigating how municipal leadership, budget allocation, and policy enforcement affect service delivery could offer a more comprehensive understanding. And the other thing is that , research into community-based waste management models and the integration of informal waste collectors would be useful. Understanding how local cooperatives, youth groups, or women-led initiatives contribute to waste collection and recycling could help design more inclusive and participatory systems. Future studies should adopt multidisciplinary approaches combining spatial planning, environmental science, public health, and governance to advance sustainable waste management in South African peri-urban contexts.

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8.5. Conclusion

Drawing from empirical data and supported by relevant theories such as the principal-agent Theory and Lefebvre's triad of space, the research has revealed that while spatial planning frameworks exist, their practical application remains weak and fragmented, especially in peri-urban contexts. Poor infrastructure, irregular collection schedules, low community participation, and limited municipal capacity have all contributed to unsustainable waste collection practices. In conclusion, the study takes the position that sustainable household solid waste collection in peri-urban contexts requires a shift from fragmented, reactive practices towards an integrated, proactive approach. This must combine effective spatial planning with strong governance, financial investment, inclusive community engagement, and consistent policy implementation. Ultimately, achieving sustainability in Muledane and Maniini contributes not only to local service delivery improvements but also aligns with broader environmental and public health objectives in the face of global waste challenges. In light of the projected global rise in municipal solid waste, as highlighted in the beginning of this study, it becomes imperative that sustainable household solid waste collection in peri-urban areas such as Muledane and Maniini not only addresses local spatial and governance challenges, but also contributes meaningfully to global efforts aimed at mitigating the environmental and public health impacts of unchecked waste growth.

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Appendix 1: Formular to determine sample size

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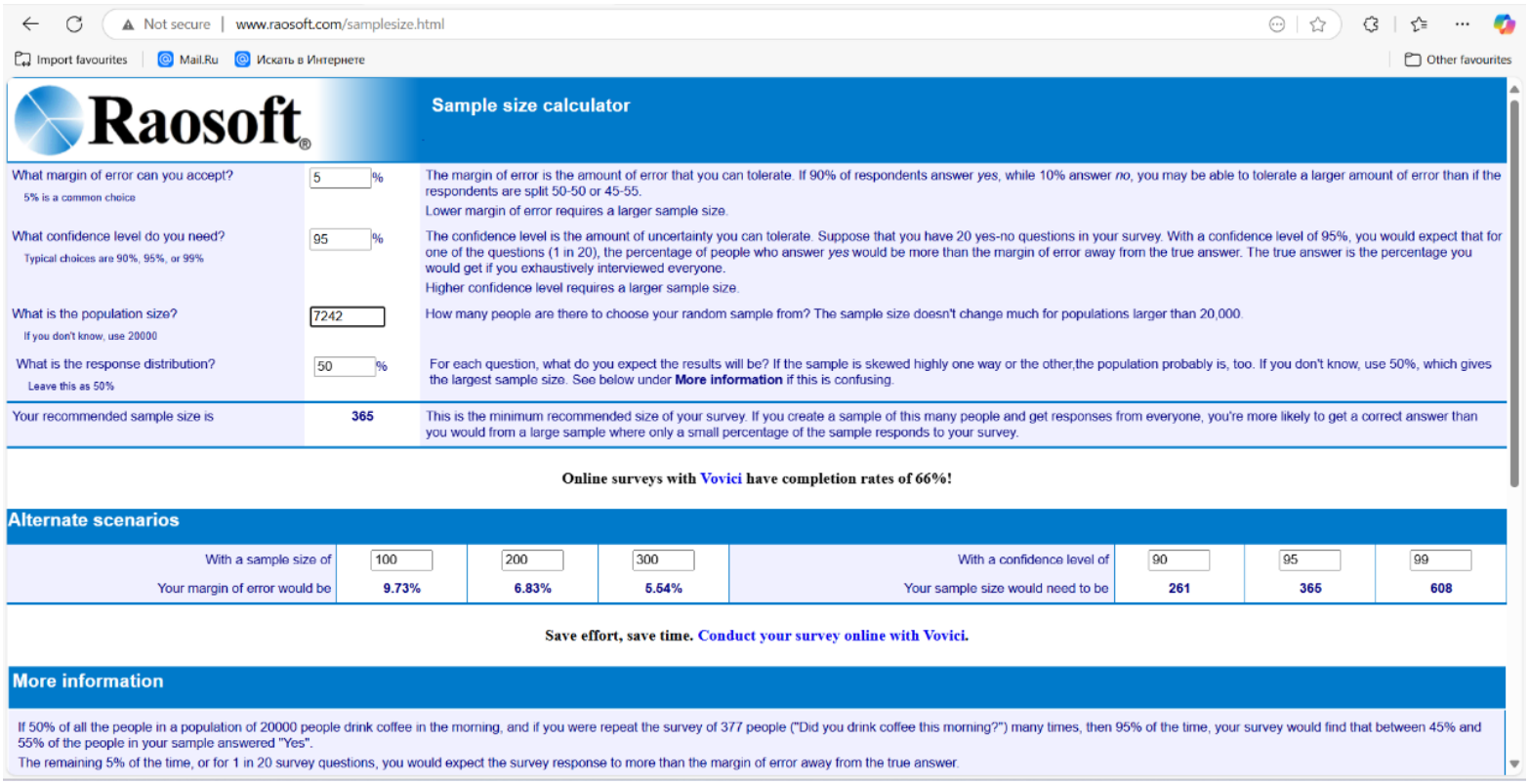

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Import favourites | Mail.Ru | Искать в Интернете | Other favourites

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Sample size calculator

What margin of error can you accept? 5% is a common choice	5 %	The margin of error is the amount of error that you can tolerate. If 90% of respondents answer *yes*, while 10% answer *no*, you may be able to tolerate a larger amount of error than if the respondents are split 50-50 or 45-55. Lower margin of error requires a larger sample size.
What confidence level do you need? Typical choices are 90%, 95%, or 99%	95 %	The confidence level is the amount of uncertainty you can tolerate. Suppose that you have 20 yes-no questions in your survey. With a confidence level of 95%, you would expect that for one of the questions (1 in 20), the percentage of people who answer *yes* would be more than the margin of error away from the true answer. The true answer is the percentage you would get if you exhaustively interviewed everyone. Higher confidence level requires a larger sample size.
What is the population size? If you don't know, use 20000	7242	How many people are there to choose your random sample from? The sample size doesn't change much for populations larger than 20,000.
What is the response distribution? Leave this as 50%	50 %	For each question, what do you expect the results will be? If the sample is skewed highly one way or the other,the population probably is, too. If you don't know, use 50%, which gives the largest sample size. See below under **More information** if this is confusing.
Your recommended sample size is	**365**	This is the minimum recommended size of your survey. If you create a sample of this many people and get responses from everyone, you're more likely to get a correct answer than you would from a large sample where only a small percentage of the sample responds to your survey.

Online surveys with Vovici have completion rates of 66%!

Alternate scenarios

With a sample size of	100	200	300	With a confidence level of	90	95	99
Your margin of error would be	**9.73%**	**6.83%**	**5.54%**	Your sample size would need to be	**261**	**365**	**608**

Save effort, save time. Conduct your survey online with Vovici.

More information

If 50% of all the people in a population of 20000 people drink coffee in the morning, and if you were repeat the survey of 377 people ("Did you drink coffee this morning?") many times, then 95% of the time, your survey would find that between 45% and 55% of the people in your sample answered "Yes".
The remaining 5% of the time, or for 1 in 20 survey questions, you would expect the survey response to more than the margin of error away from the true answer.

Appendix 2: Questionnaires Survey In Maniini And Muledane

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QUESTIONNAIRES SURVEY IN MANIINI AND MULEDANE

My name is Mutwanamba Pfariso with student number (19003408), a Master's student in Urban and Regional Planning in the Faculty of Science, Engineering and Agriculture at the University of Venda. I am undertaking research titled '***Spatial planning strategies to improve sustainable household solid waste collection practices in peri-urban villages of small towns: A case study of Thohoyandou in Thulamela local Municipality, South Africa.***'. I am humble asking for your participation by completing this questionnaire. The data collected through this questionnaire will be only used for the purpose of the study and information to be collected will be treated with highly confidentiality. Your participation is voluntary, and you are free to withdraw at any time.

N.B. Participation in this questionnaire survey is voluntary. The results of this research are for

statistical purposes only and will be treated with hight confidentiality

Instruction: Please complete the following questions by ticking [√] or [X] cross on your response.

SECTION A: DEMOGRAPHIC INFORMATION

1. Gender	1. Male	
	2. Female	

2. Age	1. 18-25		2. 26-35	
	3. 36-45		4. 46-55	
	5. 56+			

3. Level of education	1. Below matric		2. Matric	
	3. Certificate/Diploma		4. Degree/Postgraduate	

4. Occupational status	1. Employed		2. Unemployed	
	3. Retired		4. Self employed	

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5. Level of income	1. R0-R500		2. R600-R1500	
	3. R1600-R3500		4. R3600-R5000	
	5. R5100 and above			

6. Place of residence	1. Maniini		2. Muledane	

7. How many people live in your household?	1		2		3		Other specify	

SECTION B: CHARACTERISING THE CURRENT HOUSEHOLD SOLID WASTE COLLECTION PRACTICES IN MULEDANI AND MANINI.

8. for household solid waste collection?
(please tick or cross the relevant boxes)

(1) Municipality		(2) Household		(3) Private		(4) Not Applicable	

9. How often are the following solid waste collection methods are commonly used in your area for household solid waste collection?
(please tick or cross the relevant boxes)

Likert scale	(1) Never	(2) Rarely	(3) Sometimes	(4) Often	(5) Always
Wheelbarrows					
Manual tricycles					
Motor tricycles					
Taxis					
Mini-compact trucks					
Large compact or dump trucks to long trailers					

10. How often is household solid waste collected?
(please tick or cross the relevant boxes)

1. Once a week		2. Once in a month		3. Not collected at all	

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4. Twice a week		5. Twice in a month			

11. Who is responsible for the provision of solid waste bag?
(please tick or cross the relevant boxes)

(1) Municipality		(2) Household		(3) Private		(4) Not Applicable	

12. How is the household solid waste collected in your area?
(please tick or cross the relevant boxes)

(1) House to house		(2) Block collection		(3) Delegated Service		(4) Curbside	

13. To what extent do you agree or disagree with the following?
(please tick or cross the relevant boxes)

Likert scale	(1) Strongly Disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly Agree
1. There are sufficient designated solid waste collection points					
2. Solid waste collection points located at reasonable distance					
3. Household Waste is collected timeously					

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4. The current household solid waste collection practices are effective and sustainable					
5. Health problems due to household solid waste					

14. Which waste products do you think forms the bulk of your household solid waste?
(please tick or cross the relevant boxes)

Likert scale	(1) Strongly Disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly Agree
1. Plastic asnd rubber					
2. Glass and mentals					
3. Paper and cardboard					
4. Yard trimmings					
5. Food leftovers					

15. Normally, at which times is household solid waste collected in your area?
(please tick or cross the relevant boxes)

(1) Morning (08h00-11h30)		(2) Mid-day (12h00-14h30)		(3) Evening (14h30-18h30)		(4) After (18h30)	

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16. To what extent does your household use the following waste storage options to store household solid waste?
(please tick or cross the relevant boxes)

Likert scale	(1) Strongly Disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly Agree
1. Plastic bags					
2. Plastic container					
3. Metallic container					

SECTION C: FACTORS IMPEDING SUSTAINABLE HOUSEHOLD SOLID WASTE COLLECTION PRACTICES IN MULEDANE AND MANINI

17. Do you agree or disagree that the following factors contribute to the unsustainable solid waste collection practices in your area?
(please tick or cross the relevant boxes)

Likert scale	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly agree
1. Budget constraints					
2. Limited human resources					
3. shortage of waste collection vehicles					
4. Lack of equipment					
5. Poor response to waste minimisation					
6. Poor planning					
7. Poor allocation of municipal resources					

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8. Poor service delivery					
9. Poor prioritisation of the solid waste collection service					
10. Poor property levies					
11. Topography					
12. Climate					
13. Poor route planning					
14. Narrow road networks					
15. High Transportation costs					
16. Lack of awareness					
17. Lack of Infrastructure					
18. Population Growth					
19. Irregular scheduling					
20. Non-compliance with environmental legislation					
21. Poor urban management and planning					

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22. Household attitudes					

SECTION D: RECOMMENDATIONS FOR SUSTAINABLE HOUSEHOLD SOLID WASTE COLLECTION

18. To what extent do you think that the following may improve the efficiency of solid waste collection?
(please tick or cross the relevant boxes)

Likert scale	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly agree
1. Municipal solid waste collection fee levy					
2. Formalizing solid waste collectors					
3. Solid waste to energy					
4. Recovery of recyclable materials					
5.					
6. Policies and Legislation advocacy					
7. Community engagement					
8. Green certification					
9. Public Health and Safety					

19. To what extent do you strongly disagree or strongly agree that the use of the following recommendations can improve solid collection?
(please tick or cross the relevant boxes)

Likert scale	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly agree
1. Cleaning campaigns					
2. Implement policy and legislation					

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3. Collection efficiency					
4. Landfilling					
5. Recycling					
6. Enhance Collection Infrastructure					
7. Public Engagement					
8. New technologies					
9. Invest in Training and Development					
10. Enhance Data Management					
11. More household solid waste equipment e.g. Dustbins					
12. Reduce missed pickups					
13. Optimize Routes and Services					
14. Schedule Bulky Collection					
15. Empower Drivers					
16. Consider Fleet Electrification					
17. Avoid electronic waste					
18. Leave it to private companies and					

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individual responsibility					
19. Rethink how peri-urban are designed and managed					

23. To what extent do you think that the current solid waste collection practices negatively impact the following?
(please tick or cross the relevant boxes)

Likert scale	(1) Strongly disagree	(2) Disagree	(3) Neutral	(4) Agree	(5) Strongly agree
1. Environment					
2. Health					
3. Safety					

24. What do you think household may do to improve solid waste collection practices?

25. What do you think the municipality may do to improve current solid waste collection practices?

26. What other issues would like to bring to the attention of the researcher?

THANK YOU FOR PARTICIPATION!!!!

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Appendix 3: Semi-structured interview guide

SEMI-STRUCTURED INTERVIEW GUIDE FOR KEY STAKEHOLDERS AND OFFICIALS FROM THULAMELA LOCAL MUNICIPALITY

My name is Pfariso Mutwanamba with student number (19003408), a Master's student in Urban and Regional Planning in the Faculty of Science, Engineering and Agriculture at the University of Venda. I am undertaking research entitled '***Spatial planning strategies to improve sustainable household solid waste collection practices in peri-urban villages of small towns: A case study of Thohoyandou in Thulamela local Municipality, South Africa.'*** This interview is targeted at Thulamela Local Municipality and key stakeholders.

Motivation

I am humble requesting your assistance in participating in this interview. Your responses will be only used for the purpose of the study and information to be collected

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will be treated with highly confidentiality. Your participation is voluntary, and you are free to withdraw at any time.

I confirm that I have read and understand the information above I agree to take part in this study.

Yes ☐ or No ☐

SEMI-STRUCTURED QUESTIONS:

SECTIONA A: BACKGROUND INFORMATION

1. Age	1. 18-25		2. 26-35	
	3. 36-45		4. 46-55	
	5. 56+			

2. Level of education	1. Below matric		2. Matric	
	3. Certificate/Diploma		4. Degree/Postgraduate	

3. Place of residence	1. Maniini		2. Muledane	

4. How long have you been in this leadership position

_____

SECTION B: CHARACTERISING THE CURRENT HOUSEHOLD SOLID WASTE COLLECTION PRACTICES IN MULEDANI AND MANINI.

1. What kind of solid waste collection strategy is used in your area?
2. Are solid waste collection strategy used working?
3. How often solid waste is collected in Maniini and Muledane ?
4. At what time solid waste is collected?
5. What do you think is the main contributor to poor solid waste collection practices?
6. Is municipality providing enough vehicle for solid waste collection?
7. How many do collection point do you have in your village?

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SECTION C: FACTORS IMPEDING SUSTAINABLE HOUSEHOLD SOLID WASTE COLLECTION PRACTICES IN MULEDANE AND MANINI

1. What are the main concerns regarding the issue i.e. pollution, health impacts, etc?
2. Do community practice recycle of solid waste?
3. Any challenges encountered in collection of solid, i.e. the collection point are too far, unavailability of solid waste bag, etc?
4. What is the current system for solid waste collection?
5. What role do you think the communities can play to address the issue?

SECTION D: RECOMMENDATIONS FOR SUSTAINABLE HOUSEHOLD SOLID WASTE COLLECTION

1. Do you think that there should be an improvement from Pikitup as the appointment entity to manage solid waste? If so, please explain

2. How can community assist with the issue of solid waste collection?

3. Possible measures and required intervention to address the issue.
4. Any further information you would like to share?

Appendix 4: Observation checklist

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University of Venda

Faculty of Science, Engineering and Agriculture

Department of Urban And Regional Planning

Topic: Spatial planning strategies to improve sustainable household solid waste collection practices in peri-urban villages of small towns: A case study of Thohoyandou in Thulamela local Municipality, South Africa.

OBSERVATIONAL CHECKLIST FOR SOLID WASTE COLLECTION IN MULEDANE AND MANIINI

CHECKLIST	COMMENTS
1. Municipal bins in each village.	Few municipal bins
2. Solid waste containers appropriate for use (for example, food waste containers should have lids).	The solid waste containers are open and doesn't have lids
3. Solid waste containers in good condition.	No they are not in good conditions.
4. Solid waste containers emptied regularly.	No they are not regularly emptied.
5. Availability of collection points.	Few collection Points
6. Solid waste storage areas free from odours, contaminants.	Most of the solid waste storage are full of odours.
7. Municipal posters discouraging and warning residents about the negative effects of littering.	No poster available.
8. Are they any EPWP people for solid wastes collection.	Few collection workers are available
9. Household solid waste on streetside.	yes they are on the street
10. Bins provided for refuse removal.	yes they are but few

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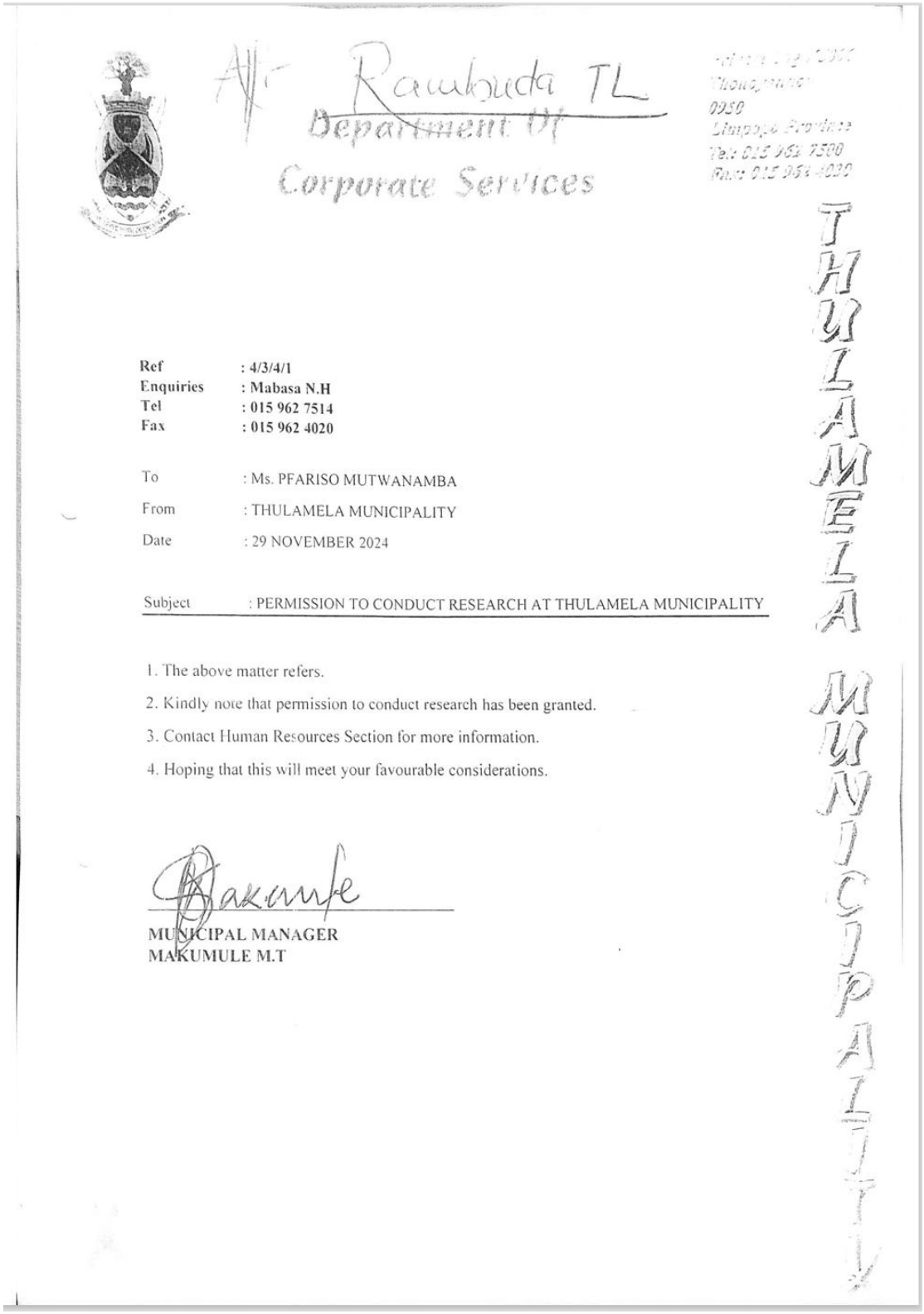
Appendix 5: permission to conduct research in Thulamela Local Municipality



Att Ramukuda TL
Department Of
Corporate Services

0950
Limpopo Province
Tel: 015 962 7500
Fax: 015 962 4020

THULAMELA MUNICIPALITY

Ref : 4/3/4/1
Enquiries : Mabasa N.H
Tel : 015 962 7514
Fax : 015 962 4020

To : Ms. PFARISO MUTWANAMBA
From : THULAMELA MUNICIPALITY
Date : 29 NOVEMBER 2024

Subject : PERMISSION TO CONDUCT RESEARCH AT THULAMELA MUNICIPALITY

1. The above matter refers.
2. Kindly note that permission to conduct research has been granted.
3. Contact Human Resources Section for more information.
4. Hoping that this will meet your favourable considerations.

Makumule

MUNICIPAL MANAGER
MAKUMULE M.T

Appendix 6: Requisition to conduct research in Thulamela Local Municipality

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THULAMELA MUNICIPALITY
RECEIVED
2024 -11- 07
REGISTRY
PRIVATE BAG X5066 THOHOYANDOU 0950
LIMPOPO PROVINCE

FACULTY OF SCIENCE, ENGINEERING AND AGRICULTURE
Department of Urban and Regional Planning

To Thulamela Local Municipality
Private Bag X5066
Thohoyandou
0950

Subject: Request for permission to conduct academic research in Thulamela Local Municipality

Dear Sir/Madam

Ms Pfariso Mutwanamba (Student number 19003408) from the Department of Urban and Regional Planning in the Faculty of Science, Engineering and Agriculture at The University of Venda wishes to undertake research in your municipality. The project is titled "Spatial planning strategies to improve sustainable household solid waste collection practices in peri-urban villages of small towns: A case study of Thohoyandou in Thulamela local Municipality, South Africa". It will be greatly appreciated if you grant her permission to conduct her research and engage with other municipal officials at Thulamela Local Municipality.

Yours faithfully

Ingwani

Dr Emaculate Ingwani

Private Bag X5050, Thohoyandou, 0950 . Limpopo Province . South Africa
Telephone (015 962 8635 . Fax (015) 962 8597 Cell: 073 519 1522
Email: emaculate.ingwani@univen.ac.za
Website: www.univen.ac.za

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Appendix 7: Project registration

ETHICS APPROVAL CERTIFICATE

ETHICS APPROVAL CERTIFICATE

FACULTY OF SCIENCE, ENGINEERING AND AGRICULTURE
RESEARCH ETHICS COMMITTEE

NAME OF RESEARCHER/INVESTIGATOR: MUTWANAMBA P

STAFF/STUDENT NO: 19003408

PROJECT TITLE: Spatial planning strategies to improve sustainable household solid waste collection practices in peri-urban villages of small towns: A case study of Thohoyandou in Thulamela local Municipality, South Africa.

ETHICAL CLEARENCE NO: FSEA/24/URP/50

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr. E Ingwani	University of Venda, Urban and Regional Planning	Supervisor
Prof J Chakwizira	University of Venda, Urban and Regional Planning	Co-Supervisor

Type: **MSc research**

Risk: **Minimal risk to humans, animals, or environment (Category 1)**

Approval Period: **March 2025 – March 2026**

The Faculty Research Ethics Committee (FREC) of the Faculty of Science, Engineering and Agriculture hereby approves your project as indicated above.

University of Venda

PRIVATE BAG X5050, THOHOYANDOU, 0950, LIMPOPO PROVINCE, SOUTH AFRICA
TELEPHONE (015) 962 8394/8107. FAX (015) 962 8000
"A quality driven financially sustainable, Comprehensive University"

Appendix 8: Proof of registration

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PROOF OF REGISTRATION

To Whom It May Concern

30-Jan-2025

It is hereby confirmed that the under mentioned person is a registered student at University of Venda PRODI41.

Student Number: 19003408
Student ID Number: 0103260748084
Name: PFARISO MUTWANAMBA
Registered for Period: 06-Jan-2025 - 31-Dec-2025
Study Level: 2ND YEAR
Qualification: ESMURP MASTER OF URBAN AND REGIONAL PLANNING
Offering Type : MASTERS (SUCCESIVE) FULL TIME

Subject	Description	Qual.	Class Group	Exam Year	Exam Month	Registration Date	Cancel Date	Stats Credits		Amount
URP6390	H3 MASTERS STUDENTS RESEARCH AND DISSERTATION 6390	ESMURP	A	2025	11	30-Jan-2025		0.333		19640.00
									Subtotal:	19640.00
							Credit Total:	0.333	Total:	19640.00

Outstanding Balance: -94768.00

NB. The costs reflected in this document apply only to the current academic year's registration and do not constitute a financial statement of account. Registration fees, SRC levies, and residence costs are not included here but will appear on the financial statement of account.

DR. J.J BALOYI
UNIVERSITY REGISTRAR

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30-Jan-2025
P/BAG X5050, THOHOYANDOU, 0950

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Appendix 9: proof of language editor report

Language Editing Report

Date: 6 May 2023

To whom it may concern.

This letter serves to confirm that I, B N Rumutsa proofread and edited a dissertation titled: **"Spatial Planning Strategies to Improve Sustainable Household Solid Waste Collection Practices In Peri-Urban Villages Of Small Towns: A Case Study Of Thohoyandou In Thulamela Local Municipality, South Africa."**, by **Mutwanamba Pfariso** (Student Number, **19003408**), to be submitted to the Department of Urban and Regional Planning, Faculty Of Science, Engineering And Agriculture, University of Venda.

I carefully read through the dissertation, focusing on language and grammatical construction errors that needed corrections to the best of my ability. Neither the dissertation content nor the author`s intentions were altered in any way during the editing process.

Yours sincerely



Dr B. N Rumutsa
(Language editor)

Email: nyeverwai@yahoo.com

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Appendix 10: Turnitin report

Mutwanamba P 19003408 first Draft.docx

ORIGINALITY REPORT

10%	5%	8%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Ndlovu, Nonduduzo. "Influence of Governance Institutions on Households' Willingness to Pay for Improved Solid Waste Management in the Peri-urban Settlements of Matsapa Swaziland", University of Pretoria (South Africa), 2023 Publication	1%
2	Submitted to University of Newcastle Student Paper	1%
3	hdl.handle.net Internet Source	1%
4	Submitted to University College London Student Paper	<1%
5	Stroud, Jeanine. "The Relationship Between Followers' Perceptions of Leader's Emotional Intelligence and Followers' Psychological Safety, Gender, and Tenure.", Walden University Publication	<1%
6	stmlportal.net	

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Appendix 11: Chapter 5 regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1,641	1,130		1,453	,148	-,586	3,868					
	Gender	,082	,172	,035	,476	,635	-,257	,421	-,040	,033	,029	,668	1,496
	age	-,036	,061	-,042	-,599	,550	-,156	,083	-,084	-,042	-,036	,741	1,349
	Level of education	,123	,070	,132	1,746	,082	-,016	,262	,049	,121	,105	,636	1,572
	Occupational status	-,005	,066	-,005	-,082	,934	-,135	,124	-,079	-,006	-,005	,829	1,206
	Level of income	-,087	,064	-,108	-1,363	,174	-,213	,039	-,076	-,095	-,082	,577	1,732
	Place of residence	-,328	,249	-,143	-1,318	,189	-,818	,162	,045	-,091	-,080	,309	3,233
	How many people live in your household?	,035	,062	,036	,557	,578	-,088	,157	,062	,039	,034	,872	1,147
	Who is responsible for household solid waste collection?	,148	,134	,162	1,101	,272	-,117	,412	-,033	,077	,066	,168	5,952
	Wheelbarrows	,067	,051	,098	1,319	,189	-,033	,168	,093	,091	,080	,661	1,512
	Manual tricycles	,034	,087	,030	,393	,695	-,138	,207	,070	,027	,024	,622	1,607
	Motor tricycles	-,058	,103	-,045	-,569	,570	-,261	,144	,063	-,040	-,034	,573	1,745
	Taxis	,040	,082	,036	,487	,626	-,121	,201	,100	,034	,029	,652	1,534
	Mini-compact trucks	-,078	,061	-,093	-1,265	,207	-,198	,043	-,049	-,088	-,076	,671	1,490
	Large compact or dump trucks to long trailers	-,019	,076	-,027	-,249	,804	-,170	,132	,063	-,017	-,015	,317	3,155
	How often is household solid waste collected?	,131	,106	,122	1,240	,216	-,077	,339	,058	,086	,075	,373	2,681
	Who is responsible for the provision of solid waste bag?	-,236	,142	-,256	-1,665	,098	-,516	,044	-,106	-,115	-,100	,154	6,487
	How is the household solid waste collected in your area?	-,139	,116	-,164	-1,201	,231	-,367	,089	-,182	-,083	-,072	,196	5,110
	There are sufficient designated solid waste collection points	,070	,062	,117	1,129	,260	-,052	,192	,163	,078	,068	,338	2,954
	Solid waste collection points located at reasonable distance	-,073	,109	-,070	-,664	,507	-,288	,143	,124	-,046	-,040	,328	3,050
	Household Waste is collected timeously	,288	,074	,271	3,910	<,001	,143	,434	,340	,263	,236	,757	1,321
	Health problems due to household solid waste	,115	,056	,139	2,068	,040	,005	,224	,150	,143	,125	,808	1,238
	Plastic and rubber	,026	,061	,035	,427	,670	-,094	,146	,127	,030	,026	,549	1,821
	Glass and mentals	,141	,092	,126	1,539	,125	-,040	,322	,085	,107	,093	,542	1,844
	Paper and cardboard	-,025	,082	-,020	-,299	,765	-,186	,137	-,067	-,021	-,018	,823	1,214
	Yard trimmings	-,054	,066	-,057	-,811	,418	-,185	,077	-,046	-,056	-,049	,725	1,380
	Food leftovers	,090	,072	,090	1,250	,213	-,052	,233	,091	,087	,075	,707	1,414
	Normally, at which times is household solid waste collected in your area?	-,066	,112	-,069	-,593	,554	-,287	,154	-,125	-,041	-,036	,269	3,717
	Plastic bags	-,039	,051	-,059	-,764	,446	-,138	,061	-,020	-,053	-,046	,612	1,634
	Plastic container	,047	,080	,044	,592	,554	-,110	,204	,020	,041	,036	,666	1,502
	Metallic container	-,022	,056	-,026	-,398	,691	-,132	,087	-,079	-,028	-,024	,832	1,202

a. Dependent Variable: The current household solid waste collection practices are effective and sustainable

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Appendix 12: Chapter 6 regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	3,942	1,207		3,265	,001	1,562	6,322					
	Municipal solid waste collection fee levy	,029	,129	,022	,226	,821	-,225	,283	-,036	,016	,015	,447	2,240
	Formalizing solid waste collectors	-,163	,183	-,084	-,891	,374	-,523	,197	-,067	-,062	-,059	,485	2,061
	Solid waste to energy	-,099	,116	-,061	-,854	,394	-,327	,129	-,052	-,059	-,056	,848	1,179
	Recovery of recyclable materials	-,018	,090	-,017	-,204	,838	-,197	,160	,010	-,014	-,013	,645	1,550
	Policies and Legislation advocacy	-,028	,068	-,034	-,411	,682	-,163	,107	,004	-,029	-,027	,638	1,567
	Community engagement	-,032	,070	-,037	-,456	,649	-,170	,106	,022	-,032	-,030	,658	1,521
	Green certification	,110	,081	,104	1,361	,175	-,049	,269	,091	,094	,089	,737	1,357
	Public Health and Safety	-,118	,084	-,104	-1,400	,163	-,284	,048	-,113	-,097	-,092	,778	1,286
	Cleaning campaigns	-,131	,089	-,109	-1,468	,144	-,306	,045	-,177	-,102	-,096	,780	1,282
	Implement policy and legislation	-,053	,115	-,035	-,461	,645	-,279	,173	-,033	-,032	-,030	,740	1,351
	Collection efficiency	,037	,137	,021	,268	,789	-,234	,307	-,010	,019	,018	,727	1,376
	Landfilling	,033	,113	,020	,287	,774	-,191	,256	-,026	,020	,019	,855	1,170
	Recycling	,024	,107	,019	,224	,823	-,187	,235	,061	,016	,015	,575	1,739
	Enhance Collection Infrastructure	-,042	,075	-,051	-,558	,578	-,191	,107	,073	-,039	-,037	,526	1,902
	Public Engagement	,045	,073	,051	,615	,539	-,099	,188	,108	,043	,040	,624	1,603
	New technologies	-,050	,075	-,051	-,664	,507	-,197	,098	,010	-,046	-,044	,740	1,351
	Invest in Training and Development	-,055	,081	-,053	-,678	,499	-,215	,105	-,026	-,047	-,045	,698	1,433
	Enhance Data Management	-,004	,080	-,004	-,054	,957	-,162	,153	-,073	-,004	-,004	,629	1,589
	More household solid waste equipment e.g. Dustbins	-,026	,076	-,027	-,345	,730	-,177	,124	-,125	-,024	-,023	,714	1,401
	Reduce missed pickups	-,071	,073	-,075	-,962	,337	-,215	,074	-,120	-,067	-,063	,714	1,400
	Optimize Routes and Services	-,067	,073	-,073	-,922	,358	-,210	,076	-,071	-,064	-,061	,684	1,463
	Schedule Bulky Collection	,081	,072	,092	1,117	,265	-,062	,224	,105	,077	,073	,634	1,577
	Empower Drivers	,059	,069	,067	,844	,400	-,078	,195	,115	,059	,055	,675	1,481
	Consider Fleet Electrification	,009	,069	,011	,135	,893	-,127	,146	,076	,009	,009	,705	1,418
	Avoid electronic waste	,043	,074	,045	,572	,568	-,104	,189	,099	,040	,038	,702	1,425
	Leave it to private companies and individual responsibility	,064	,077	,067	,824	,411	-,089	,216	,014	,057	,054	,652	1,535
	Rethink how peri-urban are designed and managed	-,038	,067	-,042	-,561	,575	-,170	,095	-,090	-,039	-,037	,771	1,298
	Environment	,002	,070	,002	,032	,975	-,136	,140	-,009	,002	,002	,814	1,229
	Health	-,058	,081	-,062	-,714	,476	-,217	,102	-,010	-,050	-,047	,566	1,765
	Safety	,162	,133	,108	1,222	,223	-,100	,424	,083	,085	,080	,553	1,808

a. Dependent Variable: The current household solid waste collection practices are effective and sustainable

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Appendix 13: Chapter 7 regression analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	3,942	1,207		3,265	,001	1,562	6,322					
	Municipal solid waste collection fee levy	,029	,129	,022	,226	,821	-,225	,283	-,036	,016	,015	,447	2,240
	Formalizing solid waste collectors	-,163	,183	-,084	-,891	,374	-,523	,197	-,067	-,062	-,059	,485	2,061
	Solid waste to energy	-,099	,116	-,061	-,854	,394	-,327	,129	-,052	-,059	-,056	,848	1,179
	Recovery of recyclable materials	-,018	,090	-,017	-,204	,838	-,197	,160	,010	-,014	-,013	,645	1,550
	Policies and Legislation advocacy	-,028	,068	-,034	-,411	,682	-,163	,107	,004	-,029	-,027	,638	1,567
	Community engagement	-,032	,070	-,037	-,456	,649	-,170	,106	,022	-,032	-,030	,658	1,521
	Green certification	,110	,081	,104	1,361	,175	-,049	,269	,091	,094	,089	,737	1,357
	Public Health and Safety	-,118	,084	-,104	-1,400	,163	-,284	,048	-,113	-,097	-,092	,778	1,286
	Cleaning campaigns	-,131	,089	-,109	-1,468	,144	-,306	,045	-,177	-,102	-,096	,780	1,282
	Implement policy and legislation	-,053	,115	-,035	-,461	,645	-,279	,173	-,033	-,032	-,030	,740	1,351
	Collection efficiency	,037	,137	,021	,268	,789	-,234	,307	-,010	,019	,018	,727	1,376
	Landfilling	,033	,113	,020	,287	,774	-,191	,256	-,026	,020	,019	,855	1,170
	Recycling	,024	,107	,019	,224	,823	-,187	,235	,061	,016	,015	,575	1,739
	Enhance Collection Infrastructure	-,042	,075	-,051	-,558	,578	-,191	,107	,073	-,039	-,037	,526	1,902
	Public Engagement	,045	,073	,051	,615	,539	-,099	,188	,108	,043	,040	,624	1,603
	New technologies	-,050	,075	-,051	-,664	,507	-,197	,098	,010	-,046	-,044	,740	1,351
	Invest in Training and Development	-,055	,081	-,053	-,678	,499	-,215	,105	-,026	-,047	-,045	,698	1,433
	Enhance Data Management	-,004	,080	-,004	-,054	,957	-,162	,153	-,073	-,004	-,004	,629	1,589
	More household solid waste equipment e.g. Dustbins	-,026	,076	-,027	-,345	,730	-,177	,124	-,125	-,024	-,023	,714	1,401
	Reduce missed pickups	-,071	,073	-,075	-,962	,337	-,215	,074	-,120	-,067	-,063	,714	1,400
	Optimize Routes and Services	-,067	,073	-,073	-,922	,358	-,210	,076	-,071	-,064	-,061	,684	1,463
	Schedule Bulky Collection	,081	,072	,092	1,117	,265	-,062	,224	,105	,077	,073	,634	1,577
	Empower Drivers	,059	,069	,067	,844	,400	-,078	,195	,115	,059	,055	,675	1,481
	Consider Fleet Electrification	,009	,069	,011	,135	,893	-,127	,146	,076	,009	,009	,705	1,418
	Avoid electronic waste	,043	,074	,045	,572	,568	-,104	,189	,099	,040	,038	,702	1,425
	Leave it to private companies and individual responsibility	,064	,077	,067	,824	,411	-,089	,216	,014	,057	,054	,652	1,535
	Rethink how peri-urban are designed and managed	-,038	,067	-,042	-,561	,575	-,170	,095	-,090	-,039	-,037	,771	1,298
	Environment	,002	,070	,002	,032	,975	-,136	,140	-,009	,002	,002	,814	1,229
	Health	-,058	,081	-,062	-,714	,476	-,217	,102	-,010	-,050	-,047	,566	1,765
	Safety	,162	,133	,108	1,222	,223	-,100	,424	,083	,085	,080	,553	1,808

a. Dependent Variable: The current household solid waste collection practices are effective and sustainable

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