DEVELOPING A PEOPLE CENTRED FRAMEWORK FOR SOLID WASTE MANAGEMENT IN INFORMAL SETTLEMENTS WITHIN TSHWANE AND JOHANNESBURG METROPOLITAN MUNICIPALITIES

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A dissertation submitted to the Department of Geography and Environmental Sciences, University of Venda, in fulfilment of the requirements for the degree of the Master in Environmental Sciences

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DECLARATION

I, **Ethinah Sibanda** with student number 11584253 hereby declare that this masters research report titled 'Developing People Centred Framework for Solid Waste Management In Informal Settlements within Tshwane and Johannesburg Metropolitan Municipalities': as my own except where sources are otherwise cited and acknowledged in the references. This work has not in any way in whole or part previously been submitted for a degree in any university

Signature….  ……. Date……

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ABSTRACT

An increase in population and migration to urban centres remains a threat to effective solid waste management mostly in developing countries. Informal settlements usually do not have effective waste collection system as they are often not planned residential areas. This study investigated the waste collection systems in two informal settlements intending to proffer a more robust waste management system in the informal settlement. This study is based on public participation in solid waste management in the Kya Sand and Mooiplaas informal settlements in Gauteng Province. Questionnaires were distributed to the residents of the Kya Sand and Mooiplaas informal settlements. For each community, 200 questionnaires were distributed to respondents, but only 150 people responded in Mooiplaas and 153 in Kya Sand were retrieved. Questionnaires were distributed to respondents using systematic random sampling, participants were randomly selected, and municipal officials from waste management departments were also selected for interviews. In addition, two members of the municipal committee per informal settlement were interviewed. Solid wastes were identified, collected, weighed and separated. The waste generated in the study areas was hand sorted into three different categories using the standard method ASTM D5231-92 into recyclables, compostables, and non-recyclable wastes (ASTM, 2008). The study results showed that the residents of the two informal settlements generated 0.3 kg average of waste per capita per day. The data showed that the average percentage for all the recyclable and compostable waste in Kya Sand and Mooiplaas informal settlements was 55% and 56%, respectively. Food waste recorded the most waste type, accounting for more than 50% of the total waste generated. Approximately 70% of the waste types reported in all settlements could be recycled, reused, or composted. A solid waste management framework was proposed that can be applied in the two informal settlements, as well as other informal settlements in developing countries, to achieve sustainable solid waste management.

Keywords: Informal settlement, public participation, solid waste, waste management, framework, sustainable, environment, household, recycle.

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ASTM	America Society for Testing and Materials
CTMM	City of Tshwane Metropolitan Municipality
CJMM	City of Johannesburg Metropolitan Municipality
CSIR	Council for Scientific and Industrial Research
CoJ	City of Johannesburg
CoJIWMP	City of Johannesburg Integrated Waste Management Plan
DEA	Department of Environmental Affairs
EMCA	Environmental Management and Coordination Act
ISWM	Integrated Solid Waste Management
IDP	Integrated Development Plan
JMPD	Johannesburg Metropolitan Police Department
MSW	Municipal Solid Waste
NGO	Non-Governmental Organisations
NEMA	National Environmental Management Act
SPSS	Statistical Package for Social Science
SWM	Solid Waste Management
SWOT	Strength, Weakness, Opportunities and Threats
SW	Solid Waste
TB	Tuberculosis
3R's	Re-use, Reduce and Recycle
USEPA	United States Environmental Protection Agency

CHAPTER 1 : INTRODUCTION

1.1 Background of the Study

Growing populations and economic development have increased resource consumption and waste generation (Haywood et al., 2021). According to Zandamela (2016), the rise in urbanisation due to migration from rural areas has caused the proliferation of informal settlements. The management of waste in urban areas across the globe remains a challenge because not only is there large quantity of waste generated but also the variety of types and components of waste produced. Moreover, factors such as lifestyle, demographic, economy, geology, season and lifestyle also contribute to the type of waste produced (Senzige et al., 2014). Poor collection of waste is also a contributing factor to poor management of waste in informal settlements, this is caused by poor access roads and poor spatial planning (Haywood et al., 2021 & Omollo 2019).

Fattah & Walters (2020) noted that informal settlements have always had a negative image of the people who live there. They are often described as undisciplined, dangerous, and uncontrollable. However, this is not always the case, as studies show that slum dwellers are ordinary people living in extraordinary circumstances due to the hardships of life. As a result of their social stigma, they are generally associated with waste. Solid waste refers to a wide range of trash and debris (e.g., bottles, compost, magazines, food scraps, clothing, garden waste, cans, newspapers and construction residual) that come from households and may contain hazardous materials such as medicines, solvents, paints, batteries, and cleaning products (Rambuda, 2020). Chen & Christensen (2010) also supports Rambuda's (2020) idea as he also described solid waste (SW) as wastes generated by anthropogenic activities and animals that are discarded in the environment as unwanted and useless.

There is a great concern of rapid increase of informal settlements in developing countries as it negatively affects the standard of life and the environment (Phala & Gumbo, 2016). In urban South Africa, it has been noticed that the population in the informal settlements is increasing. The challenges associated with management of solid waste in informal settlements stem such as households do not have knowledge on how to properly manage their waste as others use their own sources like small pits, they dispose waste inside those pits and burn the contents when the pits are full and some dispose waste along the streets and nearby streams thereby disabling the government to consistently control, manage and dispose of solid waste (Ngema 2020)

Worldwide, the solid waste management challenge is leading in environmental issues because the production of volumes of solid waste is part of the society. They often use disposal

methods that are harmful to human health and damaging the environment.as they rely more on non-degradable materials (Mwangi, et al., 2021). It has been observed that informal settlements are becoming integral part of cities (Olumuyiwa, 2016a). Developing countries are facing challenges of increasing informal settlements and urban informality & Elsayed, 2017). Zandamela (2016) also noted that informal settlements are categorised by residents with low-income profiles who lack the financial resources and urban infrastructure to meet their needs. Illegal waste dumping close to roads, paths, water sources and residents is a common feature in most informal settlements and affects healthy living standard (Haywood et al., 2021). However, there is a need to manage SW in these settlements.

Solid waste sources are mainly business waste, building and demolition waste, and garden refuse, the health of people living predominantly in low-income communities ((Haywood et al., 2021). The management of solid waste is way behind when compared to the production rate of solid waste. Consequently, disposal is becoming a challenge (Department of Environmental Affairs (DEA), 2018). The growth of the urban population has resulted in the increased generation of solid waste that exceeds the capacity of available waste disposal systems. As a result, alternative methods of handling and disposing of these wastes are required.

Rambuda (2020) confirmed that respondents in particular informal settlements in Ekurhuleni Municipality, South Africa reported that, infrequent collection of waste, small waste collection containers and non-collection of wastes on rainy days are the major challenges linked with management of solid waste within their settlement. More so, there is a rise on ineffective removal of waste (De Jager & Maserumule, 2021). However, Mwangi, et al., (2021) reported that garbage is usually scattered on open space available and along path ways and this is often associated with the production of disease vectors, especially rats and flies. The pathogens in the garbage and the disease vectors that breed in it pose a serious health hazard, and uncollected garbage often clogs sewers, which then become stagnant ponds (Sinthumule & Mkumbuzi, 2019).

There are studies which have focused on current practices and challenges from SW. For example, Rambuda (2020) studied household waste management operation in Ivory Park informal settlement in Ekurhuleni Municipality and Haywood et al., (2021) studied Waste disposal practices in low-Income Settlements of South Africa but they did not consider community perceptions of how best to dispose of waste. Recycling in informal settlements can be considered and includes pickers in the informal waste, who can potentially merge and be involved in formal community waste management structures (Nassar & Elsayed, 2017). Informal waste pickers see recycling as a survival strategy for themselves, as they are among low-income urban dwellers who have found a new source of survival in this way (Simelane &

Mohee, 2015). Planners and developers in informal settlements have experienced challenges with sustainable development (Nassar & Elsayed, 2017).

This study aims to understand the existing implementations of household solid waste management in informal settlements. It also examines the framework for SWM in the Kya Sand and Mooiplaas informal settlements in the Johannesburg and Tshwane metropolitan areas. Furthermore, the current participation status and possible methods to improve SWM public participation will be discussed in the current study.

1.2 Statement of Problem

Mazinyo & Nel (2018) indicated that the poor participation of the community is the main factor contributing to insufficient waste collection and management in informal settlements hence community participation has been found to be part of the solution to this problem in South Africa. According to Sinthumule & Mkumbuzi (2019), South African townships are also facing similar waste management challenges when compared to other African developing countries, such as Zimbabwe (Chigwenya & Simbanegavi 2021). Environmental pollution is also influenced by uncollected waste, improper collection, and disposal of waste (Local Government Management Board, 1994). The increase in waste quantity is also influenced by manufactured products that don't decompose easily (Omollo, 2019). Both urban and rural areas have waste management and improper disposal which affects the environment negatively (Kenobi, 2015).

According to Chadar & Chadar (2017), there are environmental and health impacts triggered by SW if not properly managed. The environmental impacts include the following: Leachate from landfills seeps into the soil and contaminates groundwater. While animals scatter waste dumped by the roadsides severely affecting the atmosphere. When waste products such as plastics and rubber are burned, noxious fumes pollutants are deposited into the atmosphere. The environment is polluted with odour from organic solid waste during decomposition. This also includes the impact on water quality due to weed growth and decomposition of wastes and low quantity of oxygen provision for aquatic organisms as a result of eutrophication (Palmer Development Group, 1996).

Ngema (2020) pointed out that uncontrolled municipal waste burning and improper dumping contributes to worsening climate change and air pollution. Decomposition of organic waste in landfills produces greenhouse gases, uncollected waste can impede storm water runoff, which can lead to flooding, and it can also cause high algae production in rivers and degrade water and soil quality (Alam & Ahmade, 2013).

The contamination of water supply by pathogens from solid waste has the potential to cause health implications such as hepatitis, jaundice, cholera and gastrointestinal diseases. Malaria and plague are likely to be a result of waterlogging caused by blocked drains and gullies by solid waste which promotes breeding of mosquitos. Due to the non-collection, illegally dumped solid wastes are sometimes scattered by domestic animals such as dogs, goats and other stray animals. Also children also scavenge from such wastes (Omollo, 2019), therefore children might suffer from physical injuries and infectious diseases from uncollected waste from the residents.

Improper waste disposal also leads to socioeconomic problems since there is a lack of waste collection points and disposal services in informal settlements (Phala & Gumbo, 2016). According to Zandamela (2016) informal settlements are mostly located near dumping sites. The uncontrolled solid waste piles lying around uncovered, produce bad odours which are likely to threaten human health, reducing property values in the neighbourhood and it doesn't attract residential developers (DEA, 2012; Yadav, 2018). It has been observed that most informal settlements find it difficult to attract tourists and investors for official businesses. As a result, the standard of living in these areas is often poor and opportunities for jobs and business are lost (Mathee et al., 2000). Langas in Eldoret city Kenya is an informal settlement experiencing environmental degradation resulting from domestic waste management issues (Omollo, 2019

According to Nkosi (2014), regardless of waste management services offered by the municipalities, the residents are still facing problems of illegal dumping of waste along streets and open spaces. Most studies have shown that the local authorities in most countries are responsible for solid waste management. However, the Council for Scientific and Industrial Research (CSIR) (2011) reported on local municipal waste management which indicated unpleasant performance on the service delivery.

According to the City of Johannesburg Integrated Waste Management Plan (CoJIWMP) (2011), the CoJ has introduced Waste Act that s more focused on waste minimisation for the current informal settlements and the provision of new settlements sites. In Alexandra, South Africa households use small hand-dug pits behind their yards for waste disposal and burning of the waste when full (Phala & Gumbo, 2016). Informal settlements have shown that the government is not doing enough since the informal settlements are still seen as unclean and heavily polluted. There is a need to improve on the current waste management practices, re-model waste management plans and implement recycling, which will require the training of the residents. The current study is determined to develop a plan for waste management that will be suitable for informal settlements worldwide.

In both informal settlements waste management is insufficiently managed, during the site visit the environment on both sites where dirty hence the government need to adopt other avenues, such as involvement of the community.

1.3 Motivation

According to Mitlin and Satterthwaite (2013), there is a significant number of people in the developing countries' cities that reside in informal settlements. Urban informal settlements in most developing countries have high population percentage. This research intends to establish a concept of the people-centred framework on solid waste management for two informal settlements in the Gauteng Province.

The development of a framework in an informal settlement is imperative since the informal settlements are facing more environmental challenges. The environments at Kya Sand and Mooiplaas informal settlements are not healthy at all as observed during site visit. These two settlements are dirty, while inadequate attention is being provided to these areas regarding solid waste management. The study by Olumuyiwa (2016b) indicated that the Pikitup waste collection service does not cover the whole settlement leaving other parts of the area dumping their waste in open spaces available mostly streams and rivers. Informal settlements residents tend to suffer causing implications to human health and harm to the environment as a result of solid waste piles found in the surrounding surface water sources, roadsides, and open spaces. Informal settlements have been mostly associated with inadequate local municipality services which SWM is among the list (Nassar & Elsayed, 2017). Therefore, there is a need to manage solid waste efficiently to reduce some negative health effects on the residents of the area.

This research intends to improve on how best the residence and the municipality can manage the solid waste effectively and keep the environment around the informal settlements clean. Figure 1.1 displays the current methods used in solid waste management are not adequate because the areas are still seen as dirty. Therefore, there is a need to explore other avenues which include the involvement of all the role players in the most effective management of solid waste in these two informal settlements. With the involvement of community-based approaches, much can be improved because the people on the ground level are the ones who know better about the background of the area and the historical issues on SWM within their community and this gives a better understanding to the decision-makers from the government on how best to attend to the issue of SWM in these two informal settlements in Gauteng.

Figure 1.1: The illegal dumping of waste alongside the streets at Kya Sand and Mooiplaas (source: Author 2020)

informal settlements because there is a lack of knowledge of waste streams in South African informal settlements. It is very important to do an assessment of household solid waste composition so that one can know which type of waste could pose risk to the environment. Furthermore, assessment of waste stream has a good impact during decision making on the solid waste plan (three Rs) towards the city since investment is based on these main ingredients (Gawaikar & Deshpande 2006). According to Tsheleza et al., (2022) proper understanding of household waste generation, waste management behaviour and household perceptions with regards to reuse, recycle and reduction is very important in addressing efficiency of waste and informing waste management authorities.

1.4 Objectives

1.4.1 Main Objective

To investigate solid waste management in Kya Sand and Mooiplaas informal settlements and to propose a more efficient framework for solid waste management in the informal settlements.

1.4.2 Specific Objectives

i. To examine the quantity and types of solid waste generated in Kya Sand and Mooiplaas informal settlements.
ii. To examine the municipality's approach to solid waste management in informal settlements.
iii. To compare and contrast the perceptions of Kya Sand and Mooiplaas informal settlement residents concerning solid waste management.
iv. To develop a community-based framework for the management of solid waste in informal settlements of metropolitan cities.

1.5 Research Questions

i. What type of solid waste is generated in the study area and quantity?

ii. What is the municipality's major approach towards solid waste management in informal settlements?

iii. What are the perceptions of the public from the two communities concerning solid waste management in the study area?

iv. What approach will be more efficient in solid waste management of the study area?

1.6 Organization of dissertation

- This research is structured into five parts in which each segment provides distinct and separate data. Provided below is the summary of the chapters in this research report.
- Chapter 1- concisely examines the background to solid waste management in informal settlements. It also presents the problem statement and the specific objectives of the study.
- Chapter 2 - literature review of waste management issues, including the causes and impacts of poor solid waste management in informal settlements, including the sustainable practices of solid waste management.
- Chapter 3 - outlining the methodology used to acquire data for this study, and the description of the study area, techniques used to analyse the collected data.
- Chapter 4 - presents and discusses the results obtained from field observations, questionnaire surveys, and key informant interviews.
- Chapter 5 - review of results, specific objectives, and concluding recommendation remarks.

1.7 Output from the study

The contribution of this study to the body of knowledge was drafted into three distinct papers to be published in an accredited journal. The three articles that are listed below are currently drafted and are at the manuscript stage.

- Perception and knowledge of residents in informal settlements on littering and Solid Waste Management (Journal of the Environmental Planning and Management).
- Solid waste generation, measurement, and characterisation in the Mooiplaas and Kya Sand Informal Settlements (International Journal of Environmental and Waste Management).
- Solid waste management; a way forward to sustainable waste management practices in informal settlements (The Journal of Environment & Development).

CHAPTER 2 LITERATURE REVIEW

Solid waste management and potential recycling require a thorough understanding of waste and its properties. This chapter discusses solid waste management challenges and provides a summary of the literature assessment on informal solid waste management. This part conceptualizes and reviews solid waste management theories and attitudes in general. The literature enables an understanding of approaches used to manage solid waste and identifies research gaps that must be addressed to achieve sustainable SWM objectives.

2.1 Community Participation

Community involvement, according to Nkosi (2014), is a method focused on collaboration and partnership between community members, NGOs, community-based organizations, and the municipality. According to Mazinyo & Nel (2018) establishing a community-based participatory model as an alternative to the current waste management framework can help to promote a more sustainable approach to trash disposal, with the primary goal of allowing waste separation at the source.

According to Omollo (2019), lack of Community Based Organisation's participation in SWM could easily indicate why households do not recognise them as potential partners in environmental management. However a fruitful SWM systems need the involvement of a diversity of stakeholders such as municipalities, decision makers, and technical supporters (Diaz & Otoma, 2012). Also local residents are very important in SWM and the decision making process (Garnett & Cooper, 2014). In this regard, community participation in developing countries is seen as a positive driver of SWM. The functions and structure of community participation in SWM are established on the attitudes of people and performance patterns, which are formed by local social and cultural settings (Kubanza & Simatele, 2019). In actuality, they are multi-faceted, and the SWM decision has a positive or negative impact on them.

The identification of participating stakeholders, according to Muranga (2014), is a critical step in participative decision-making. That is why, in any community-based initiative, the first priority is to incorporate all stakeholders who will be impacted by the decisions and project in the planning and implementation process. Households not included in the initiatives may object to the changes being implemented, such as publicly dumping unsegregated rubbish in light of door-to-door collecting operations. According to Tsheleza et. al (2022) indicated studies relating to the role of community participation in SWM in South African cities have not been fully explored has been undermined both in research and practical implementation.

As a result, participation throughout waste management and disposal procedures may be a missing component in a prospective solution for better solid waste management. Even in parts of recycling behaviour, significant research efforts have been dedicated toward public participation, for example, in the city of Johannesburg, informal waste pickers are playing an important role in recycling and SWM (Kubanza & Simatele, 2019). Such community engagement has environmental and economic benefits by contributing to environmental sustainability and job creation. The Department of Environmental Affairs estimated in 2016 number of waste pickers in South African cities ranging between 18 000 and 100 000, this shows that community members are already involved in SWM in their areas. Therefore, it is crucial for South African decision-makers to recognize the community participation as a approach for SWM and sustainable waste reduction to increase its effectiveness (Scheinberg, 2012).

Such studies have yielded intriguing results in favour of public participation in solid waste management. Residents residing close to the dump sites face more health and environmental hazards. According to Njoku et al. (2019) people who live near the waste sites have indicated that scents from the facility have contaminated the air quality and reported illnesses such as flu, eye discomfort, and physical weakness, as well as apprehension about their health in the future.

According to Muranga (2014), the community is a key stakeholder in SWM, and the extent to which they participate determines the success of recycling and solid waste management in general. The expenses of garbage collection, transportation, and disposal are considerable; but, by including communities in waste management, many of these costs can be lowered. In some ways, this demonstrates a long-term waste management model. For example, in Dhaka, where community-based solid waste management and composting projects were developed, many of these expenses were decreased (UNEP, 2005). These operations were able to save municipalities money on collection costs while also reducing the need for landfills.

According to Abazeri (2014), a participatory waste management method based on community empowerment and the integration of environmental processes can lead to a long-term waste management system. The majority of South African inhabitants, according to the Department of Housing (2000), comprehended the idea of waste management. It was discovered during interviews with residents of formal and informal settlements in Johannesburg's west and Pretoria's Mandela Village. It was also highlighted at Emondlo in northern KwaZulu-Natal and Phuthaditjhaba in the Free State that a regular pickup service and suitable on-site storage facilities were needed. Most communities have also asked for assistance in educating and assisting them in grasping the fundamental concepts of trash management.

Stakeholders must be notified from the start when developing local SWM strategies; their input is crucial in determining the location of facilities such as SW transfer stations, as they are the ones that generate waste. Also emphasized that public awareness about the health risks of uncontrolled solid waste should be raised among the general public (Kubanza et.al 2022). Lack of waste management awareness, inadequate public education, and improper waste management facilities were highlighted as barriers to poor MSW separation in a case study in Shanghai, China (Zhang et al., 2012).

According to Muranga (2014), most individuals irresponsibly dispose of garbage with little regard for the immediate consequences, and in some cases, people just do not consider the complexity of the waste problem and who would ultimately bear the brunt of the consequences. The public appears to believe that it is the municipality's responsibility to ensure proper trash management at no additional cost to the people. Community involvement in all activities associated to waste management are fundamental and un-ignorable. It is difficult to implement any suggested waste management strategy without community support because they are the waste generators and they know their habits towards waste. If there is a proposal for waste sorting, there will be a need to involve the community members because sorting needs to be done at the source it can be too complicated because the community can at least sort the waste at the source (Muranga, 2014).

According to studies conducted in Nairobi, negative perceptions of waste and waste handling have a significant impact on civil society commitment because households and businesses regard them as criminals and poor people who are treated harshly, particularly when charged for SWM because most of them are unwilling to pay for the service. Stakeholder commitment was influenced by delays in garbage collection from collection centres, as several households, traders, and SMEs indicated no interest in paying for the service because waste was not collected on time and often sat in estates open-air collecting centres for weeks (Muranga, 2014). Stakeholders must be presented multiple perspectives on what has to be put in place for the SWM system to function properly. Equal treatment, transparency, and information exchange were suggested as elements of a sustainable SWM system.

Municipalities must ensure that they have the proper institutional arrangements in place to provide sustainable waste management services, taking into account the importance of partnerships. According to Kubanza et al (2020), measures to solve waste management problems frequently entail the hiring of community members. As a result, community participation and environmental education are proposed as ways to ameliorate this situation in general. The benefits of community participation, according to Marais & Ntema (2012), are often linked to increased efficiency on SWM because they have a better understanding of

community needs, resulting in better planning, better cost recovery after project completion, skills transfer, better resource use, and a higher degree of affordability. The success of the MSW management system is determined by social, economic, and psychological aspects such as public engagement, legislation, and public attitude and behaviour, in addition to technical innovation. As a result, academics must comprehend, plan, and assess MSW management in terms of social dimensions (Jing and Hipel 2016).

2.2 What is Waste?

Waste is defined as any matter, whether gaseous, liquid, or solid, originating from any residential, commercial, or industrial area that has no further fundamental or commercial value, according to the Department of Housing (2000). Waste is defined by UNEP (2005) as objects that are abandoned or intended to be disposed of under national law. A substance that a person thinks useless is also referred to as waste (Mugambwa, 2009). The definition of waste is usually determined by the type of trash being considered, which might include municipal waste, hazardous waste, and technological waste.

Municipal solid waste (MSW) is defined by Abazeri (2014) as solid trash created in a community, excluding industrial and agricultural garbage. Trash storage, source segregation, primary waste collection to a communal waste bin or transfer station, street sweeping, transfer to a landfill or disposal site, and recyclables management are all examples of conventional waste management systems as Figure 2.1. Solid waste, according to Kirunda (2009), is garbage that is not distinguishable from municipal waste. The State of the Environment Report for Uganda (NEMA, 2007:275) described SW as “organic and inorganic waste products created by households, commercial, institutional and industrial activities that have lost value in the sight of the initial consumer.

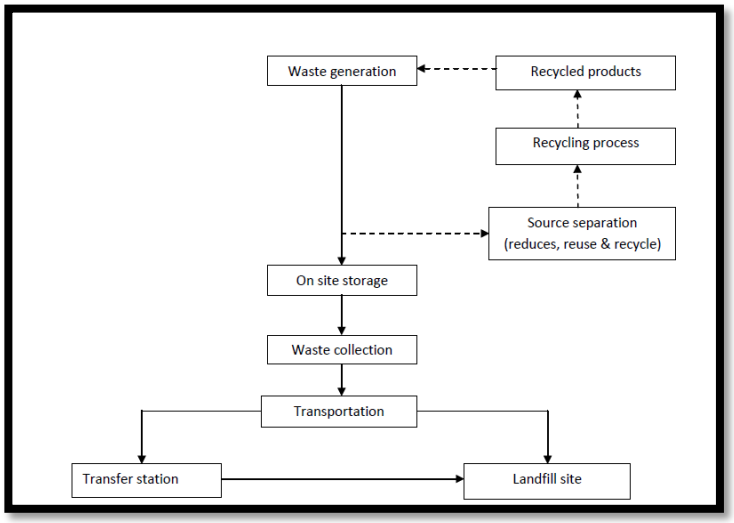

Figure 2.1: Waste Management Process (source, Kirunda 2009)

Solid waste should be managed in an environmentally responsible manner from generation to disposal, and waste management strategies should include a holistic approach that includes each of the functional components outlined above. Nkosi (2014) backed this up by emphasizing that the 3Rs strategy should begin at the site of waste generation in order to reduce the volume of waste disposed of to landfills.

- **Inert waste** is considered as not having negative environmental effects unless it is disposed of in an unacceptable or unsustainable/illegal way, these include cover soil, rubble, and tyres.
- **General waste** can be detrimental when the goods' disintegration has negative impacts, those include household, commercial, garden garbage, and harmless industrial wastes.
- **Special waste** contains wastes that, due to their concentration, quantity, or physical, chemical, or infectious qualities, may cause environmental deterioration. Before final disposal, such trash must be properly treated, stored, and transported.

2.3 Integrated Solid Waste Management (ISWM)

Integrated solid waste management (ISWM) is described by Leblanc (2017) as the selection and application of appropriate management programs and strategies to meet waste management goals and objectives. ISWM, according to the United States Environmental Protection Agency (USEPA), encompasses waste source reduction, recycling, waste combustion, and landfills. These exercises could be carried out in a hierarchical or participatory manner. MSWM is a complex system with interconnected aspects and difficulties. As a result, integrated management is critical for achieving the long-term goal of sustainable development (Achillas et al., 2011). The DEA guideline, however, emphasizes waste reduction as the first choice, followed by re-use, recycling and composting, energy recovery, and disposal as the last alternative, as illustrated in Figure 2.2.

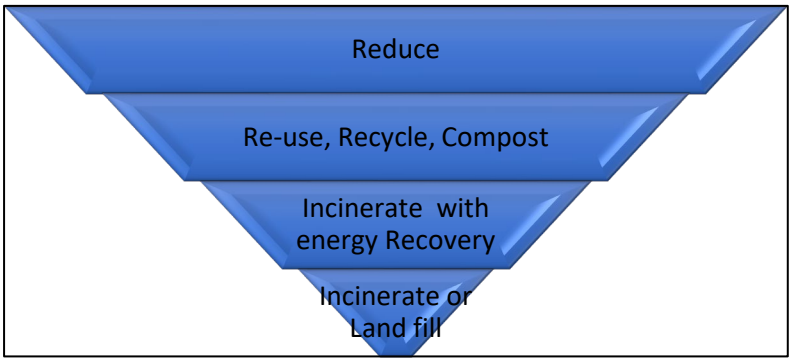

Figure 2.2: Waste management hierarchy (source, Author 2019)

a. **Waste Prevention** sometimes known as source reduction, is the process of decreasing garbage by not generating it during the design, manufacture, procurement, or usage of

materials and products in order to limit the amount of discarded waste (USEPA, 2002). The ideal method of municipal solid waste management is waste prevention. Many states in the United States of America (USA) have increasingly engaged in innovative ventures towards solid waste reduction, according to USEPA (1998). Source reduction involves reuse activities and is an approach with the potential to use resources efficiently. Because of the various advantages it presents, many states in the United States of America (USA) have increasingly engaged in innovative ventures towards solid waste reduction. Because the materials are totally diverted from disposal facilities and require no municipal infrastructure, grass recycling and backyard composting are considered "means of source reduction or waste avoidance" (USEPA, 2002).

b. **Recycling, Re-use,** s the process of reusing materials that would otherwise be discarded and converting them into valuable resources, which reduces greenhouse gas emissions by diverting garbage from landfills. Recycling will help limit the consumption of new resources, such as paper, aluminium, glass, steel, and plastic so contributing to sustainable development (Rambuda, 2020). This approach has the potential to convert a vast volume of garbage into usable products. Waste materials can possibly go through numerous cycles of use using these procedures, saving raw materials and energy in the process.

c. **Composting** is the decomposition of biodegradable waste like food waste and plant material, into compost. Compost is used as a nutrient supplier on plants (USEPA, 2002). This means that chemical fertilizers will be used less frequently, and composting will help to minimize greenhouse gas emissions from solid waste.

d. Combustion is the controlled burning of waste to limit the amount of waste that must be disposed of in landfills while also generating electricity. For garbage that cannot be avoided or repurposed, combustion can be used. There is also a component of offering safer disposal techniques, such as upgrading incinerator and landfill design and management (USEPA, 1993b). "While the combustion process can produce harmful air emissions, they can be managed by adding control devices in combustors such as acid gas scrubbers and fabric filters" (USEPA, 2002).

e. **Landfilling** when compared to the uncontrolled dumping of solid waste, is a safer way of waste management. Poor waste management can result in human health issues as well as environmental damage, necessitating the creation of dedicated trash disposal areas (landfills) where waste cannot be recycled or composted. A typical landfill is constructed

in such a way that it protects groundwater from contamination while also preventing fires caused by methane emission (Kirunda2009).

2.4 Informal Settlements in South Africa

Hoornweg and Bhada-Tata (2012) defined informal settlements as ones that were not planned by the government not have formal authorisation to exist. According to Srinivas (1991, informal settlement are areas occupied by low income earning people in urban cities hence they are forced to build temporary shelter on vacant land either private or public owned. MSW is rapidly increasing in South Africa as a result of population increase, urbanization, and economic activities, according to Haywood et al (2021), but municipal service delivery is trying to keep up. The rapid development of informal settlements in open spaces and along the riverbanks poses problems for environmental pollution and human health. Informal Settlements are formed of communities living in temporary shelters made of cheaper and improper building material and some are properly built with proper material but in the absence of law and have been not substantially planned and have been developed on land that is not designated for housing in the city's master plan. Although the buildings may appear to be in decent shape, they may be environmentally or socially unsafe and lack basic amenities and utilities (Nassar & Elsayed, 2017). In informal settlements, many mounts of solid garbage can be seen along roadsides, rivers, and other open spaces, posing serious health and environmental risks. Informal settlements, according to Puling (2004), are dense settlements comprised of communities housed in self-constructed shelters under informal conditions, or can be broadly described as housing erected unconventionally. In most circumstances, such settlements include:

- Lack of basic infrastructure and services for the collection and proper waste disposal of solid and liquid waste, resulting in health infections in humans.
- Congested and cramped living conditions,
- Insufficient water supply.
- The majority of dwellings are self-built by the family who live there, utilising temporary construction materials.
- The settlements are unlawful.
- The villages lack essential services such as reliable water supply, electricity, and waste management.
- They are usually occupied by individuals who are poor
- Squatting implies the illegally occupation of land or dwellings.
- Unplanned settlements, whose occupants are typically entitled to the particular land and which may be subdivided into backyard shacks.
- Outbuildings are structures made of standard materials that are used in unusual ways, such as garages, sheds, or backyard rooms.

2.4.1 Managing Waste in Informal Settlements

According to Kubanza et. Al (2020), informal settlements are diverse and unique, necessitating waste management solutions that are unique and relevant to the setting. It is governed by the availability and type of on-site storage facilities, as well as the quality of other services (particularly roads) (Palm & Loots, 1991). Communal collection and on-site garbage storage containers are frequently employed in areas where basic road services are unavailable. These are carefully located to allow for simple access and to serve the greatest number of houses possible (Municipal Engineer, 1998). Community attitudes and the resulting cooperation, which needs the introduction of public awareness, are other complementary and vital components that waste management in such places depends on (Tsheleza, et al 2022). In informal settlements, open dumps are frequently used for garbage disposal, resulting in leachate contamination of soil and water resources, as well as odours and fires.

According to Abazeri (2014), solid waste management is regarded a basic public necessity in India and is given via the supply of trash disposal containers, transportation, and disposal of waste material, whether separated or not. Despite the fact that the municipality does not technically recognize the informal trash sector in many circumstances, the workers play an important role in municipal garbage management. According to Jing & Hipel (2016), waste collection by the informal sector is more widespread in the global south, where 2% of the population in Asian and Latin American cities rely on waste pickup for subsistence.

According to Aparcana (2017), the positive contribution of the informal waste pickers in the informal settlement sector is reflected in their financial contribution to the formal waste management sector. Several studies have found that informal waste activities. Reduce the cost formal waste management systems. The amount of waste that has to be collected by the formal sector is reduced, resulting in lower labour, transportation, and infrastructure expenses. Many recyclables are recovered and processed in the informal sector before or after municipal waste is collected or disposed of; waste pickers gather and classify recyclables, which are then sold to a chain of waste dealers and recycling facilities. The majority of MSW is sent to landfills or open dumps once it has been collected, where it is disposed of and bulldozed over or covered with material (Abazeri 2014).

Informal settlements have been linked to societal issues, including poverty, illiteracy, and crime. Not to mention the lack of local services, particularly in the areas of healthcare, education, and youth facilities. While this impression is partially true in reality, it stigmatizes all informal residents, affecting their sense of belonging, citizenship, and social inclusion (Nassar & Elsayed, 2017).

2.5 Current waste Management practices in Tshwane and Johannesburg Metropolitan Municipalities

Simatele et al (2017), pointed out that waste pickers play a crucial role in municipal MSW management, and recyclables expected at Maningi Recycling dealer are from informal waste pickers When the Pikitup waste collectors go on strike, the informal waste pickers benefit because they are able to gather more recyclables, according to one of the waste pickers who sells his rubbish to Far Point Recycling Plant. According to research, the informal trash sector is critical to municipal solid waste management in Johannesburg, notably in terms of collection and recycling. The findings of this study revealed that the informal solid waste sector in Johannesburg is not only for the urban poor, but is also closely linked to formal enterprises through casualization, with circuitry that reaches nationwide and beyond in entrenched hierarchies. According to Tshwane IDP (2017/2018), they remove trash from official and informal neighbourhoods on a weekly basis. The city aspires to reduce the amount of garbage sent to landfills per inhabitant by 10%, although this is contingent on the availability of financing to implement additional waste reduction programs. At the moment, the city diverts 5% of waste from landfills. The city hopes to expand its waste diversion program to include homeowners in order to achieve a 10% reduction in waste going to landfills. Due to budget constraints, only a few programs will be offered in 2019/20. These services are provided at informal waste collection locations through the distribution and collection of plastic waste bags and skips (Tshwane IDP, 2017/18).

2.5.1 Solid Waste Management Legislation in South Africa

According to Nkosi (2014), South African legislation assures effective and efficient solid waste management see Figure 2.3 below, and Act 108, chapter 2, section 24 of the South African Constitution establishes citizens' rights to a healthy environment and the right to protect the environment. The constitution serves as an overarching law that must be followed by every laws. According to IWMPCJ, local government is responsible for ensuring the provision of sustainable services to communities as well as the promotion of a safe and healthy environment. Solid waste collection and disposal is designated as a local government responsibility in Part B of Schedule 5 of the constitution. The National Environmental Management Act (Act 107 of 1998), the National Environmental Management: Waste Act No. 59 of 2008, and the National Water Act (Act 36 of 1998) are only a few of the MSW laws that

ensure the success of solid waste management.

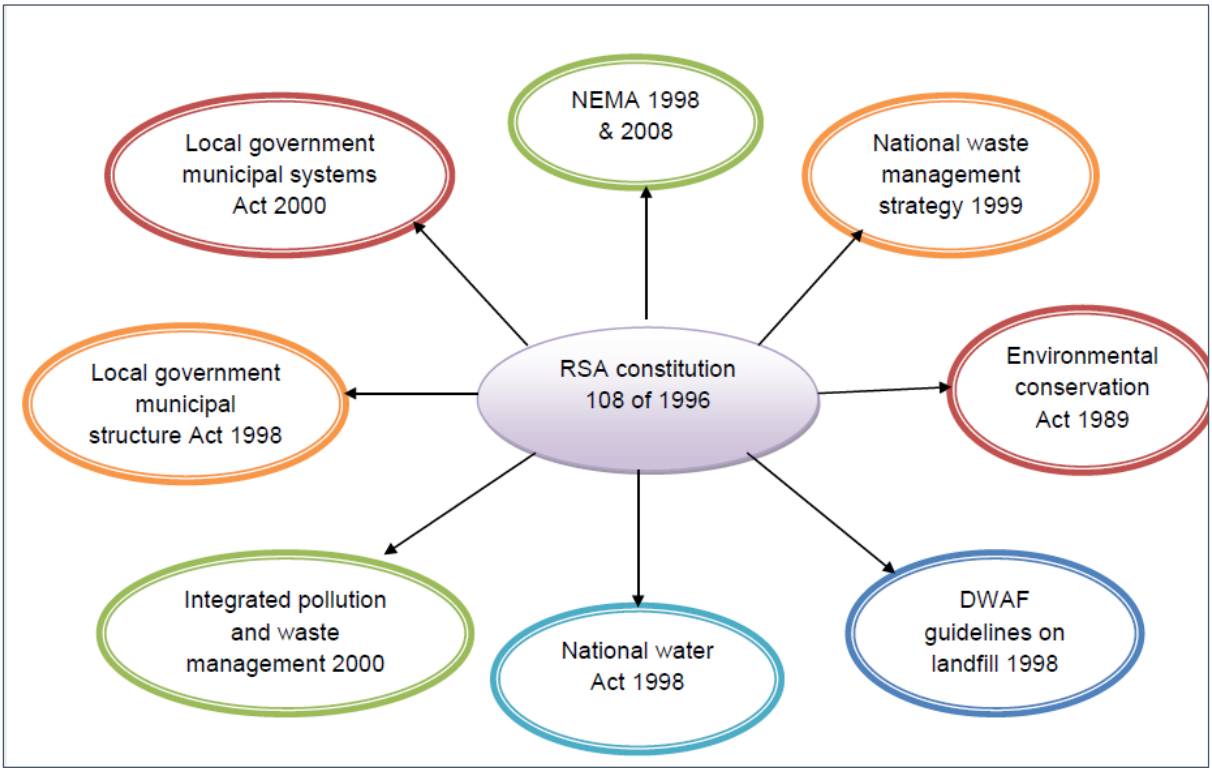

Figure 2.3: Legislation Governing Waste Management in South Africa (source: Nkosi 2014)

Efforts to enhance waste management have not solely relied on government activities, but also on the establishment of legislation and policies, as well as public and academic institutions' attention (Puling, 2004).

Despite the existence of laws to regulate waste management, according to Abazeri (2014), workers are still not fully empowered to regulate collection services; because there are no penalties for households that do not segregate waste, waste pickers are not allowed to refuse door-to-door services to defaulters. As a result, full compliance has yet to be achieved.

2.6 Solid Waste Management Challenges

Manufactured products frequently contain components that are difficult to degrade, such as plastics, resulting in uncontrollable waste amounts. According to Kirunda (2009), no effort is made to reduce packaging in an environmentally beneficial manner. The manufacturers do not bother to give the end-user any information on how to properly manage the garbage.

Because developing countries may not always have enough infrastructure and resources for waste management, some garbage will be piled up or incorrectly disposed of (UNEP, 2005). Because many individuals lack environmental understanding, they believe trash management is the government's responsibility. Waste management practices need to be given more

attention since, if not done properly, they can have harmful consequences for human health and the environment (Rambuda, 2020).

.2.6.1 Environmental and Health Implications of Solid Waste

2.6.1.1 Health Hazards

Waste management is essential for improving environmental and health). Non-collection, inappropriate collection, and inadequate approaches to garbage collection and disposal have negative environmental and health consequences, leading to contamination of land, air, and water (Kubanza et, al 2020). Direct health concerns, according to Alam & Ahmade (2013), are primarily a problem for workers in this industry, who must be safeguarded from trash contact as much as feasible. The primary health dangers for the general populace come from the breeding of disease vectors, especially flies, mosquitoes, and rodents. Children are at risk of infections including malaria, diarrhoea, and gastroenteritis as a result of this. Uncollected waste and incorrect collection also have direct consequences, such as physical damage to children (Zandamela, 2016).

2.6.1.2 Environmental Implications

According to Chadar & Chadar (2017), inappropriate treatment and transportation of solid waste can damage the air, water, and soil. The following are some of the negative effects on health and the environment:

- Leachates from discarded wastes penetrate into the soil and contaminate subsurface water.
- Scavengers and stray animals raid the roadside debris and scatter the waste across a vast area, having a negative effect on the environment.
- When garbage like plastic and rubber is burned, poisonous gases are released into the atmosphere.
- When organic solid waste decomposes, it emits an intolerable odour.
- A major environmental problem is a gas produced by decaying rubbish, which exacerbates the greenhouse gas impact and contributes to climate change (Alam & Ahmade, 2013).

Additionally, there are potential health environmental implications on aquatic life as a result of dirty water caused by weed growth, trash degradation, and lower oxygen availability for aquatic organisms owing to eutrophication (Nwaopani, 2015).

2.7 Sustainable Waste Management in an informal settlement

2.7.1 Solid Waste collection

Implementing an effective municipal solid waste management system is a difficult undertaking in any country, but particularly in developing countries (Elsaid & Aghezzaf, 2015). According

to Omollo (2019), solid trash collection facilities are frequently used to deliver garbage services to places that are inaccessible to motor vehicles; nonetheless, most studies have found that most places in informal settlements are inaccessible. CoJ (2011) added to this by stating that Pikitup provides rubbish collection services in most of the informal residential and business areas Each formal settlement family receives one 85-liter plastic bin, however certain informal communities do not receive plastic bins; nonetheless, bulk containers are put outside the informal settlements due to the lack of vehicle access to these regions (CoJ, 2011). To ensure that the environment is clean, there is a need for frequent collection, a dedication to cleaning up, and community participation. In most growing urban areas, waste is collected either sorted or unsorted. Unsorted waste is particularly expensive since sorting is required to choose recoverable and reusable commodities such as plastics, paper, metal, and glass (Elsaid & Aghezzaf, 2015). Previous research has found that improving access roads, having sufficient waste management facilities, and having adequate human resources can all help the waste management system work better (Elsaid & Aghezzaf, 2015).

2.7.2 Waste management community awareness/Environmental Education

According to Omollo (2019), in order for SWM efforts to be considered successful, citizens must be involved and participate. As a result, SWM can only be effective if key stakeholders are fully informed about the various activities and policies aimed at clearing the environment of solid waste defined environmental. In Southern Africa, an increasing number of waste management workshops, seminars, and conferences are concluding that education and awareness are necessary and should be considered (Stevens, 1994). Waste minimisation, recycling, composting, and job creation through community activities can all benefit from environmental education and community participation (the United States Environmental Protection Agency 1998). According to Rambuda (2020), as part of public consultation process, various programs are implemented in communities and schools, including educational awareness, clean-up campaigns against illegal dumping and littering, and the use of art and posters to communicate waste management messages (CoJ, 2011 & Simatele et al, 2017). Despite awareness programs in some areas of the city, trash and unlawful dumping continue to be a problem.

2.7.3 Waste stream assessment

To properly manage waste in terms of collection, transportation, and processing, one must first understand the type and amount of waste generated by the community. Because municipal solid waste is diverse and continually changing, it is necessary to understand its composition so that the waste handler may decide how to treat it. Many different waste type and household products can end up posing risk to the environment and human health. An

evaluation of home solid waste is needed to acquire information on the waste composition, which can aid in proper decision-making (Tsheleza et al., 2019).

The waste stream assessment exercise, according to Tsheleza et al (2022), reveals numerous parameters that indicate the solid waste contents in an informal settlement. The majority of research undertaken in informal settlements have revealed that kitchen garbage is the most prevalent type of waste in terms of mass-produced waste. Tsheleza et al. (2019) further support the idea that food waste is the most prevalent sort of garbage reported across all investigated households, followed by plastic and finally paper, indicating that waste recycling has a lot of potential.

2.7.4 Compliance monitoring and enforcement of Waste Management By-laws

According to the City of Johannesburg (2011), the Johannesburg Metropolitan Police Department is in charge of waste management compliance and enforcement (JMPD). However, because the chosen officials lack the necessary skills to implement these By-laws, the City of Johannesburg is in charge of compliance and enforcement (CoJ, 2011). By reducing the spread of illness caused by unregulated dumping sites, sustainable solid waste management methods help to improve public health outcomes (Mathee et al., 2000). Municipal waste management bylaws are still difficult to enforce and monitor.

Despite all of the efforts and initiatives done to address the issue, domestic solid waste management remains a challenge in many developing nations, according to Rambuda (2020). Population expansion, lack of capacity within local government, and lack of finance for solid waste services are all significant causes. Municipalities have created solid waste management policies, rules, and bylaws to help with solid waste management in the city, and various programs such as community educational awareness and cleanliness campaigns have been implemented. However, solid waste collection services are inequitable, and littering and unlawful disposal continue.

Finally, this chapter looked at solid waste management from its origin to its final disposal stage. Residents of informal settlements were also held responsible for sustainable garbage management, as evidenced by local and international case studies. In view of the foregoing, the current waste management system has flaws. Municipalities lack defined layouts for waste separation from generation through final disposal, as well as segregation facilities. As a result, an appropriate waste management system is required.

CHAPTER 3 : METHODOLOGIES

The methods employed in this study is presented in this chapter. It also shows where the research areas are (Kya Sand and Mooiplaas informal settlements). It goes on to detail the research strategy as well as the analysis of the obtained data.

3.1 Study Areas

The research was conducted in two informal settlements, situated in the Gauteng Province but in different local municipalities. In the Gauteng province, Kya Sand is under the authority of the City of Johannesburg Metropolitan Municipality (CJMM), while Mooiplaas is under the jurisdiction of the City of Tshwane Metropolitan Municipality (CTMM) (Figure 3.1 and 3.2) and Figure 3.3 for the overall map.

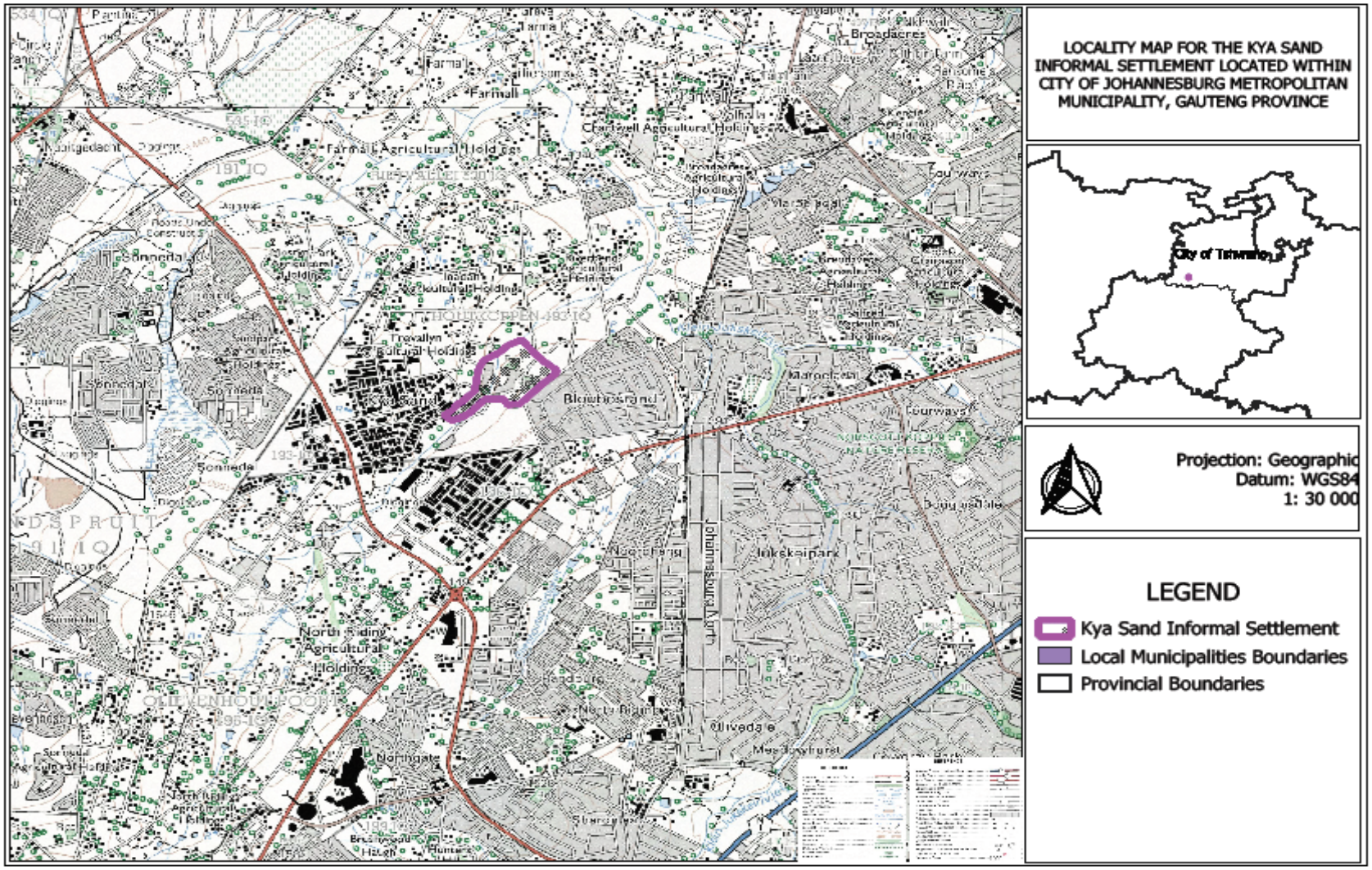

Figure 3.1: Locality Map for Kya Sand Informal Settlement (source, Author2021*)*

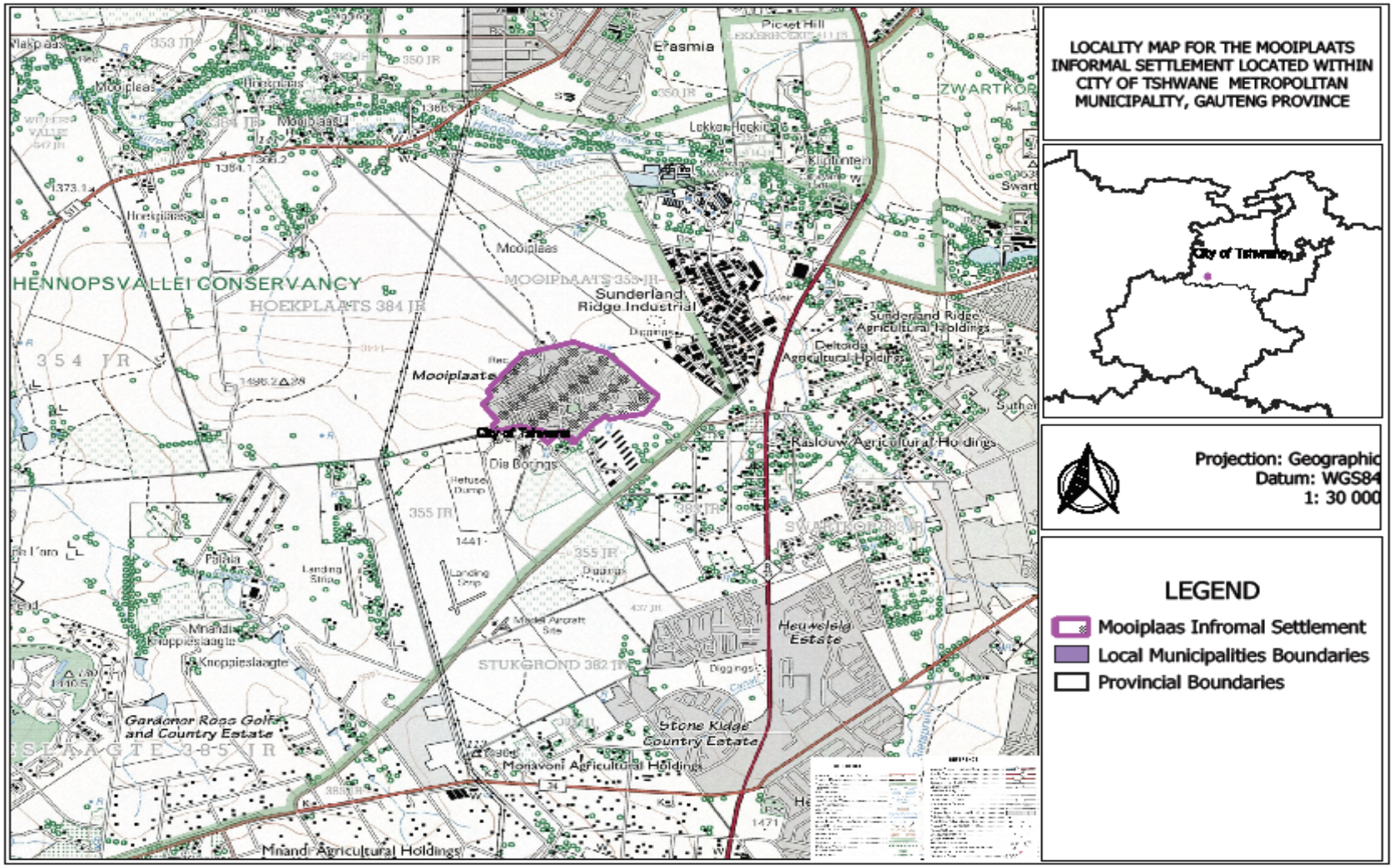

Figure 3.2: Locality Map for Mooiplaas informal settlements

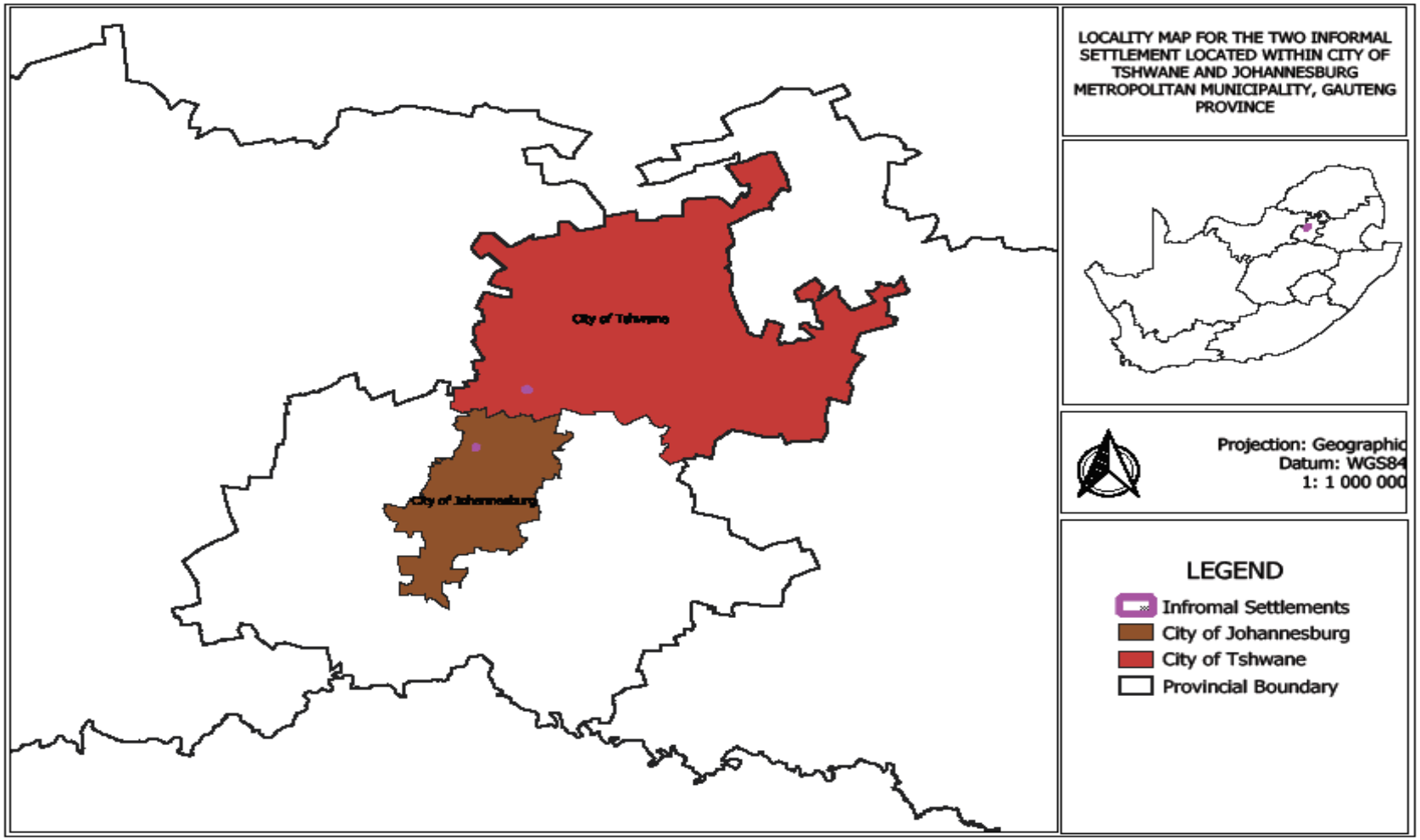

Figure 3.3: Overall map for Kya Sand and Mooiplaas Informal settlements (source, Author 2021)

Kya Sand is located at Randburg in ward 100 within the jurisdiction of the City of Johannesburg Metropolitan Municipality Region A of the Gauteng Province. It is an informal settlement, according to Huchzermeyer et al. (2014), which defines informal settlements as those that were not planned and do not have formal government authority to operate. Professional Mobile Mapping estimates that the community has a population of 16,238 people living in 5,325 homes, according to Weakly (2012). This is a relatively high population density for the area, with a population density of around 104 000 km^2 (1000/ha), close to that of Nairobi's Kibera Informal Settlement (Weakley, 2012).

Mooiplaas is an informal settlement in Centurion under Ward 48, which is administered by the City of Tshwane Metropolitan Municipality in the Gauteng province. It is home to about 16 000 people, the majority of whom are either stateless or undocumented. In both Kya Sand and Mooiplaas informal settlements, there are no resources such as schools, police stations, and electricity.

3.2 Research Design

Both qualitative and quantitative approaches were used to acquire the necessary data needed for this study (Figure 3.4).

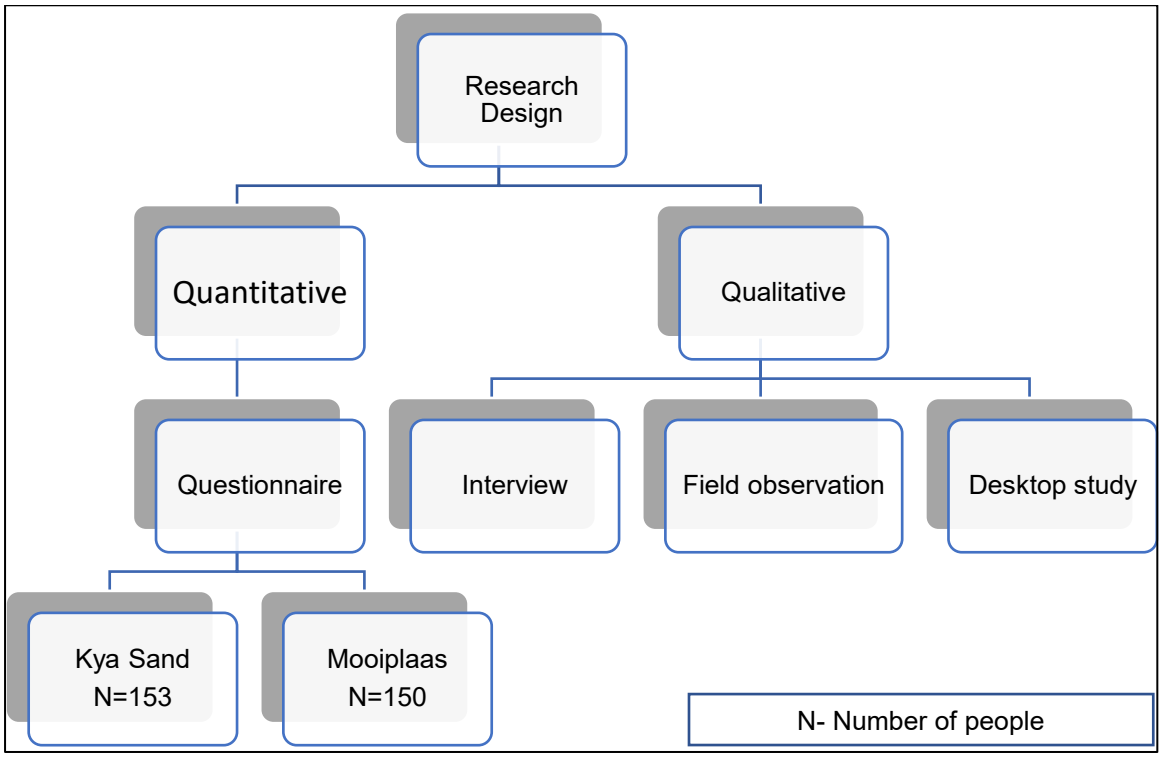

Figure 3.4: Research Design

3.3. Sample population and size for the study

The number of samples was solely influenced by solid waste collection trend and the variability. The population size sampled for the questionnaires was made up of 153 people (Kya Sand) and 150 people (Mooiplaas) derived based on the total population of residents living in both informal settlements. Interviews were conducted with four officials from CJMM (Deputy Director: Waste Management and Regulation and Pikitup Manager) and CTMM (Acting Director: Waste Removal and Policy and Acting Deputy director on Waste Operation Region 4) and two people per informal settlement from the award committee. Lastly, waste quantification and characterisation were conducted by collecting, segregating, and weighing waste from 20 households per informal settlement for a month, the exercise started in June-July 2021.

3.4. Field Observations

Observations of the environment on the research studies and taking pictures were performed to assess the existing waste disposal practices in the two informal settlements. The locations of the disposal sites were also crucial in terms of making comparisons based on their distance from the source of trash generation. Another goal of the observation was to observe garbage pickup and the frequency with which it took place. Personal field observations were conducted, by doing a site inspection at the two informal settlements to observe the physical aspects of the waste management, and a camera was used to capture the photos of disposing of solid waste. As a result, direct observation of their actions in relation to their responses was employed to check the accuracy of their responses and as a data gathering strategy. This dissertation contains several images taken during the investigation that illustrate much of the observation work.

3.5 Interview guide approach

The study used an interview approach which was more structured than the informal conversational interview. It included an interview protocol listing the closed and open-ended questions (Creswell, 2009). Individual thoughts and experiences on SWM were disclosed through in-depth interviews. The researcher read out the questions and interpreted them in a local language to make sure that the respondents understand every question to get accurate answers.

Purposive sampling was also utilized to choose study participants. Four representatives from the government were among the stakeholders from both municipalities. More so, two residents per informal settlements were also interviewed. Individuals were chosen for the study based on their prior knowledge of the topic and willingness to participate. During the interview sessions, the researcher was able to engage and communicate with the participants.

Interviews with municipal officials (under the waste management sections) and key stakeholders were conducted (civic members, ward committee) from the two settlements (See Appendix A for the interview set questions).

3.6 Questionnaires

The questionnaires were administered by the researcher using a set of 200 questionnaires per settlement with closed-ended and open-ended questions, they were distributed randomly at Kya Sand and Mooiplaas to analyse the solid waste management practices (Appendix B). To ensure that the study is as accurate as possible, the sample was selected from the entire geographical spread of the Kya Sand and Mooiplaas informal settlements. Observation and administration of questionnaires were employed to discover the extent of community participation in solid waste management. Questionnaires were used to establish the level of involvement of other stakeholders in SWM. A visit to the two informal settlements to administer the questionnaire and have a verbal discussion with the residents helped to identify the level of extent of participation of the community members in solid waste management. The questionnaires also helped to understand the social and demography of the two informal settlements. The SPSS software, Version 25, was used to analyse the data.

3.7 Waste Quantification and characterisation

The waste stream assessment exercise was used to evaluate comparative amounts of garbage generated by type. It entailed certain members of the household keeping solid garbage of their own. The researcher randomly selected 20 households to participate in sampling. Household waste was weighed and separated. This exercise was done every morning for 29 days in both settlements (June-Juy 2021) the waste was collected door to door and weighed every day because the respondents indicated that they won't afford to keep waste for more than a day since they did not have proper bins.

During sampling, hand-sorting was employed that is SW was sorted according to waste type, which included, food waste, cans/tins, paper, bottles/glass, plastic and disposable nappies The individual components were weighed and the weights were then expressed as the percent of original total waste generated. This type of method is also similar to what Owojori (2020) did when conducting her study. Two types of weighing scales (5 kg and 300 kg) (Figure 3.5) were used because sometimes the waste collected can be too little in such a way that it cannot be detected by the 300 kg scale and vice-versa.

Figure 3.5: Sorting and weighing waste (source Author 2021)

The ASTM (American Society for Testing and Materials) D5231-92 standard method was used to characterize the trash in this investigation (ASTM, 2008). The characterisation processes and sample methodology were taken from a standard test method for assessing the content of unprocessed municipal solid waste (ASTM D 5231-92).

The composition of garbage identified in the two informal settlements was determined, in order to establish whether any waste components may be recycled or reused.

The goal of the study was to find out what proportion of solid trash was generated in the designated activity areas. Using equations I and ii below, calculate the total amount of solid waste created from the selected activity areas and the total value of recyclable waste.

- Percentage recyclable = PC/PL X100……. (i)
- Per-capita waste = total waste generated/ no. of person X no. of days (ii)

3.8 Secondary Data

Literature was reviewed through desktop study from previous research articles, intending to acquire background information about the study areas and other solid waste management practices and also the relevant legislative framework, to ensure that the topic was not repeated in previous reports or papers in the same area, However, while most studies indicated that residents in slums be involved, just a few or none expressly focused on their role in the SWM system. On the other hand, the studies were found useful as they were used to enhance the understanding of the informal settlement's SWM problems. Furthermore, they enhanced the collected primary data triangulation, verification, and the researcher was able to ascertain the reliability of the data collected from the entire study.

3.9 Data Processing and Analysis

The prepared data was analysed through the SPSS software. A descriptive analysis was employed whereby cross tabulation and SWOT analysis were utilised to provide a general overview of the results, as it gives an idea of what is happening and was described statistically and presenting the concepts on which an investigation was focused. The frequency distribution results were presented in pie charts, graphs, and tables.

3.11 Ethical Consideration

The nature of this research involves developing a people-centred framework for solid waste management in an informal settlement within Tshwane (CTMM) and Johannesburg Metropolitan (CJMM). Ethical clearance was obtained from the University of Venda to formalise all activities in the field (SES/19/ERM/21/1202), see Appendix C. Permission was also obtained from the two municipalities hosting the two settlements. The identity of the researcher was revealed and accurately represented.

CHAPTER 4 : FINDINGS AND DISCUSSION

This chapter presents the findings and discussion of the study following the different research questions. The discussion of the chapter is formed from the data gathered from field observation, questionnaires, and interviews. This chapter also gives the socio-economic/demographic characteristics of respondents. The discussion of this chapter seeks to give answers to the research questions and to achieve the set objectives of the study.

4.1 Socio-Economic Characteristics

According to Njoku et al. (2019), social and demographic characteristics of the respondents need to be identified to understand the social and economic characteristics of residents living in a specific area. The socioeconomic statuses of both Mooiplaas and Kya Sands informal settlements were presented under the categories of gender, age group, language, educational level and employment status. Only 150 (75%) and 153 (76.5%) questionnaires were returned from the 200 distributed in both study areas, respectively, some respondents did not return the questionnaires because they felt like they were wasting their time in participating on the project since the government always gave empty promises.

Table 4.1 shows the social and demographic characteristics of the respondents. Results shows that there were more female than male participants in both communities due to the availability and readiness of the female respondents to participate in this study. At Mooiplaas informal Settlement women accounted for 70% of the respondents while in Kya Sand, they accounted for 58%. In most areas in South Africa, most households are headed by women (Tsheleza et al, 2019). Mattos et al. (2012) used the gender of the household's head as a proxy indicator for household involvement in waste management and found that female-headed households participate in waste management at a higher rate than male-headed households.

Table 4.1: Respondents categories by gender within the two informal settlements

Community	Variable	Frequency	Percent
Mooiplaas	Male	45	30.0
	Female	105	70.0
	Total	150	100.0
Kya Sand	Male	64	41.8
	Female	89	58.2
	Total	153	100.0

The study shows that the participants aged from 26 to 35 years were the most dominant in both settlements (Table 4.2). Tsheleza et al (2018), found that in high-density and informal communities, the leading age group was 31–45 years. These identified age groups are for mature and active people who have the capability of participating positively in SWM strategies.

Table 4.2: Age groups of the respondents

Community	Age	Frequency	Percent
Mooiplaas	18-25	13	8.7
	26-35	74	49.7
	36-45	53	35.6
	46-55	7	4.7
	56-65	2	1.3
	Total	149	99.3
	Undisclosed	1	0.7
	Total	150	100
Kya Sand	18-25	21	13.7
	26-35	89	58.2
	36-45	37	24.2
	46-55	3	2.0
	56-65	1	0.7
	66-75	2	1.3
	Total	153	100.0

The results showed that two informal settlements are occupied by black people (Table 4.3). The majority of the people in the Mooiplaas settlement speak Sepedi (21.3%) and IsiZulu (18.7%), other dominant tribes in Mooiplaas include people speaking Sesotho, IsiXhosa, Setswana, and other African Languages (Venda, Tsonga, IsiSwati, Ndebele, Nyasa, Shona). Similarly, in Kya Sand, the majority of the people speak IsiZulu (20.3%) and Sepedi (13.7%).

The educational levels were determined by looking into the respondents' greatest educational qualifications. These were divided into four categories, as shown in Table 4.3. According to the findings, only 8% of Mooiplaas respondents have completed post-secondary education, while 7.2% percent of the respondents were from Kya Sand. As a result, it can be assumed that the majority of residents in the area work in occupations that do not demand a high level of education, and so their earnings are likely to be low (Puling, 2004), however, there is a high percentage of the respondents who completed high school (secondary school) with 74.7% (Mooiplaas) and 77.1% (Kya Sand), respectively.

Table 4.3: Languages and educational status of the respondents at Mooiplaas and Kya Sand Informal settlement

Languages of the respondents			
Community	Variable	Frequency	Percentage
Mooiplaas	Sepedi	32	21.3
	Isizulu	28	18.7
	Sesotho	17	11.3
	Setswana	10	6.7
	IsiXhosa	21	14.0
	Others	42	28.0
	Total	150	100.0
	Sepedi	21	13.7
	Isizulu	31	20.3
	Sesotho	15	9.8
	Setswana	11	7.2
	IsiXhosa	20	13.1
	Others	55	35.9
	Total	153	100.0
Educational level			
Mooiplaas	No formal education	3	2.0
	Primary Education	21	14.0
	High school	112	74.7
	Tertiary Education	12	8.0
	Total	148	98.7
	Undisclosed	2	1.3
	Total	150	100.0
Kya Sand	No formal education	2	1.3
	Primary Education	21	13.7
	High school	118	77.1
	Tertiary Education	11	7.2
	Total	152	99.3
	Undisclosed	1	0.7
	Total	153	100.0

Rambuda (2020) also identified that majority of participants ended their education at the secondary level in informal settlements at Ivory Park in Gauteng province, South Africa. Matabese (2019) also argued that there is a link between respondents' educational levels and

their employment situation. This is due to the fact that the majority of people in Hlalani have matric or lower levels of education, which may have contributed to the high rate of unemployment. Households with lower levels of education are more likely to be unaware of the consequences of large amounts of garbage and their effects on the environment (Parfitt et al. 1994). Societies with greater levels of education, according to Etengeneng (2012), have more positive attitude toward refuse management. The implications of waste management and environmental concern, are that there is a probability of the residents not concerned about waste management but much concerned about getting employed to sustain their living. Missouri (2005) indicated that solid waste should be addressed at all levels of formal education to build enough understanding and acceptable behaviours addressing individual responsibility for solid waste management. According to Markowitz (2012), persons who are well educated and have a high occupational position are more involved and concerned about environmental issues and waste management. Meyer (2018) also supported that, where the results in his study have shown that people with a more advanced education level observe all environmental problems as threats to the natural environments than those with a lower education level. Rajapaksa et al (2018) pointed out that people living in Indian informal settlements and villages were less worried about the environmental issues.

Employment status

The age groups listed in the previous subsection represents the economically active segment of the population in terms of employment, however, most respondents indicated that they were not working with 70% at Mooiplaas and 12.4% at Kya Sand (Table 4.4) this shows that the unemployment rate at Kya Sand is low compared to most of the informal settlements. This is evident to a study conducted by Matabese (2019) which is slightly similar to the Mooiplaas Informal settlement unemployment rate, she pointed out that 80% of the respondents were unemployed implying that majority of individuals living in slums are socio-economically disadvantaged. Earning money allows consumers to buy things that come in recyclable packaging that they can easily dispose of. Only 2.7% of the respondents in Mooiplaas had full-time jobs whereas in Kya Sand 12.4% were full-time employed. During the interview survey, the respondents indicated that most of the residents are street vendors, waste pickers, house cleaners, and labourers on construction companies, all these mentioned occupations are low-paying jobs. This demonstrates that a large number of residents are unable to support themselves. According to Schioldborg (2014), waste is one of the several indicators pointing towards a fundamental problem of limited livelihood prospects, as seen by lack of utilities and services such as water, sanitation, and electricity.

Furthermore, factors such as unemployment are of great concern; worsening living conditions may indicate that environmental issues are not a major concern, but rather other social issues such as poverty and a lack of service delivery (Meyer, 2018). According to Puling (2004), about 56% of family heads in Lwandle who were potentially economically engaged did not have regular jobs. Therefore, it simply shows that most of the people who reside in informal settlements are not working or are working on low-income jobs which makes them choose to live in a low-cost shelter such as shacks. These people also cannot afford to pay more attention to waste because they are much worried about how they can earn a living.

Table 4.4: Employment status of the respondents

	Kya Sand		Mooiplaas	
Employment Status	Frequency	Percentage %	Frequency	Percentage %
Full-Time Employment	19	12.4	4	2,7
Part-Time Employed	35	22.9	13	8.7
Self -Employed	11	7.2	17	11.3
Student	4	2.6	2	1.3
Other	84	54.9	2	1.3
Unemployed	19	12.4	105	70.0
Total	153	100	143	95.3
Undisclosed			7	4.7
Total			150	100

Duration of stay by the respondents within the two informal settlements

Outcomes from Table 4.5 indicate that only 4.6% of respondents lived in Kya Sand for less than a year whereas 4.7% lived in Mooiplaas informal settlement. The results also have shown 40.5% of the households have been in Kya Sand whereas 49.3% have been in Mooiplaas for a period of one year to five years. About 46.4% the respondents have been staying at Kya Sand where as 38.7% of the respondents stayed in Mooiplaas for a period in the range of 5 to 10 years. 7.8% and 4.7% of the respondents from Kya Sand and Mooiplaas, have lived within the settlement for a period more than 10 years, respectively.

This predicament could be due to migration, with people not residing in the same place for long period of time. This type of situation has ramifications on how people interact with their surroundings when it comes to environmental issues. This is due to the fact that the bulk of the population may lack a sense of ownership, resulting in a lack of respect for the environment. Puling (2004) also supported that absentee property owners are difficult to deal with in Kenyan informal settlements. This further reveals that the majority of the landlords in

the informal settlements do not live there. According to Omollo (2019), residents of absent landlords do not participate in urban service delivery programs such as SWM.

The longer they stay in an area, the better equipped they are to understand their surroundings and whether or not service delivery has improved. That puts residents in a position to be able to spot changes in garbage disposal procedures and management in local areas.

Table 4.5: Duration of time living in the informal settlements

Duration	Kya Sand		Mooiplaas	
Variable	Frequency	Percent%	Frequency	Percent%
<1 years	7	4.6	7	4.7
1-5 years	62	40.5	74	49.3
5-10 years	71	46.4	58	38.7
10-40 years	12	7.8	4	2.7
>40 years	0	0	3	2.0
Total	152	99.3	146	97.3
Undisclosed	1	0.7	4	2.7
Total	153	100	150	100

Household Size

Twenty households were randomly selected to determine the household size of the two informal settlements (Table 4.6), the results show the average household size of the sampled participants to be 2.5. Most households consist of two people (35% of the participants) in Mooiplaas and in Kya Sand (30%). The highest number of people per household was 4 at both Mooiplaas and Kya Sand, respectively. As a result, in terms of household size, the conditions in Mooiplaas are comparable to those in Kya Sand. According to Omollo (2019) the situation at the two informal settlements is different from Langa's informal settlement where in the study conducted resulted in an average household size of four. The majority of the household in Kya Sand and Mooiplaas had 2 to 4 people and produces waste ranging from 0.5 kg to over 2 kg per day. According to Okalebo et al (2014) the waste generated by a household increases as the number of members increases.

Table 4.6: Number of people per household at the two informal settlements (Source, Author 2021)

	Kya Sand (no of people Per household)	Mooiplaas (no of people Per household)
1	1	1
2	3	3
3	4	4
4	4	4
5	1	1
6	4	3
7	1	1
8	1	1
9	2	2
10	2	2
11	3	4
12	2	2
13	3	3
14	3	3
15	2	2
16	4	4
17	2	2
18	1	2
19	3	3
20	2	2
Total	48	49
Average	2.4	2.5

Table 4.7: Number of people per household in percentage (Author 2021)

No. of people per household	Kya Sand		Mooiplaas	
Variable	Frequency	Percent%	Frequency	Percent%
1	5	25	4	20
2	6	30	7	35
3	5	25	5	25
4	4	20	4	20
Total	20	100	20	100

4.2 Waste characterisation and quantification at Mooiplaas and Kya Sands

The measurement of the quantity and composition of solid waste in a community is a critical prerequisite for establishing a long-term SWM systems through a settlement since it offers adequate and trusty worthy data on the generated waste, see Figure 4.1 below. Tables 4.8 & 4.9 illustrates the waste produced in Kya Sand and Mooiplaas settlements, a piece of detailed information about the daily waste generated in the two informal settlements is shown in Appendix E.

Table 4.8: Total weight of waste generated on two informal settlements in 4 weeks

Solid Waste generated at Kya Sand Informal settlement in Four Weeks/29 days						
	Food	Plastic	Cans/tins	Disposable Nappies	Glass	Paper
	4663	1590	500	14765	789	1
	11472	2690	930	12485	700	86
	9928	2723	395	16510	1370	53
	16231	825	195	29095	1699	1217
	3656	496	117	8015	899	345
	26256	4520	1341	12986	4255	261
	6663	1303	588	11082	1107	177
	3957	988	543	14990	277	214
	12089	1571	714		713	408
	7570	801	600		885	217
	24515	1115	869		845	156
	6861	1082	904		1154	200
	13765	495	595		708	219
	12980	480	670		1095	100
	9230	494	1512		899	196
	8070	386	375		555	356
	15500	590	405		626	210
	7559	429	553		662	252
	11332	539	543		758	40
	7880	471	553		717	
Sub Total	220177	23588	12902	119928	20713	4707
Total	402 kg					
Average	13.9 kg per household per month					
Std	46.2					

Table 4.9: Waste produced at Mooiplaas Informal Settlement in four Weeks in grams

Solid Waste generated at Mooiplaas Informal settlement in Four Weeks/29 days from 20 households						
	Food	Plastic	Cans/tins	Non-recoverable Waste	Glass	Paper
	4710	1350	1051	15805	734	205
	12890	1635	613	12425	1685	115
	10216	1523	543	16090	1117	69
	14931	1655	714	0	327	166
	3646	570	600	29095	713	78
	28466	3735	869	7915	875	767
	6903	1203	804	11536	845	301
	3969	988	395	0	1154	261
	12289	1191	670	11282	708	177
	7570	801	1492	14240	895	214
	24515	1005	375		2409	403
	6861	977	405		1170	217
	12865	495	588		460	136
	12680	430	526		895	200
	9230	494	557		899	228
	11690	386	620		555	100
	8070	590	345		626	196
	7649	434	405		701	356
	11322	544	195		743	155
	8230	501	100		737	224
Sub Total	218702	20507	11867	118388	18248	4568
Total	392 kg					
Average	13.5 kg per household per month					
Std	38.7					

Figure 4.1: Weighing and sorting of waste at the informal settlements (source, Author 2021)

From Tables 4.8 and 4.9, in Mooiplaas informal settlements, the average garbage generated per month was 13.5 kg per house hold and this could be due to the number of people per household, most of the households that had more than two people included babies and kids who were still using disposable nappies; therefore, the weight of waste was much influenced by wet nappies. This could be due to the number of people in the household, that is only 1 person was living in the shack. However, at Kya Sand, the highest average waste generated was 2 kg per day, whereas the least was also 0.2 kg. In both settlements, the waste generation per day per household is almost the same and this can be concluded that the lifestyle of people living informal settlements is similar.

According to the research conducted the average number of people per household was 2 at Mooiplaas and 2.5 people per at Kya Sand this is shown on table 4.6. This is comparable to Havelock informal settlement in Durban, where the average was 2 adults and 0.5 children (Parikh et al., 2020). The average per-capita waste generated in the Mooiplaas and Kya Sand Informal settlement was found to be the same (0.3 kg/capita/day) see Table 4.10. However, the generation rate is within the sub-Sahara Africa's per capita waste generation rate, which ranges from 0.09 to 3.0 kg/person/day (World Bank, 2012). This can be compared to UN-Habitat (2009) research in Africa, which found 0.5 kg/capita/day in Port Novo (Benin) 0.4 kg/capita/day in Accra (Ghana) 0.6 kg/capita/day in Kampala (Uganda), and 0.6 kg/capita/day in Nairobi (Kenya). This study's per capita waste generation was lower than prior studies, which could be attributable to population size.

Table 4.10: Per Capita Waste generated

Item No	Population	Waste Generated per Day	Per Capita/Per Day
Kya Sands	48	13.8	0.3
Mooiplaas	49	13.5	0.3

Food waste, plastic, paper, glass, bottles, cans, and diapers were among the waste types designated for these exercises. To allow for fast on-site weighing, the categories were streamlined. This can be further categorised as shown in Table 4.11.

In both settlements, the recyclable, compostable, and non-recoverable components of the trash created were identified. At Kya Sands, food waste (54.8%), Metal (can) (3.2%), Plastic (5.9%), glass (5.2%), Paper (1.1%) and non-recoverable (29.8 %) whereas in Mooiplaas food waste (55.8%), Metal (can) (3.0%), Plastic (5.2%), glass (4.7%), Paper (1.1%) and non-recoverable (30.2%) this has been illustrated in Figure 4.2. The waste characterization revealed a high potential for recycling and reuse in both settlements (70%), this may result in reduced volume of waste to be transported to landfills.

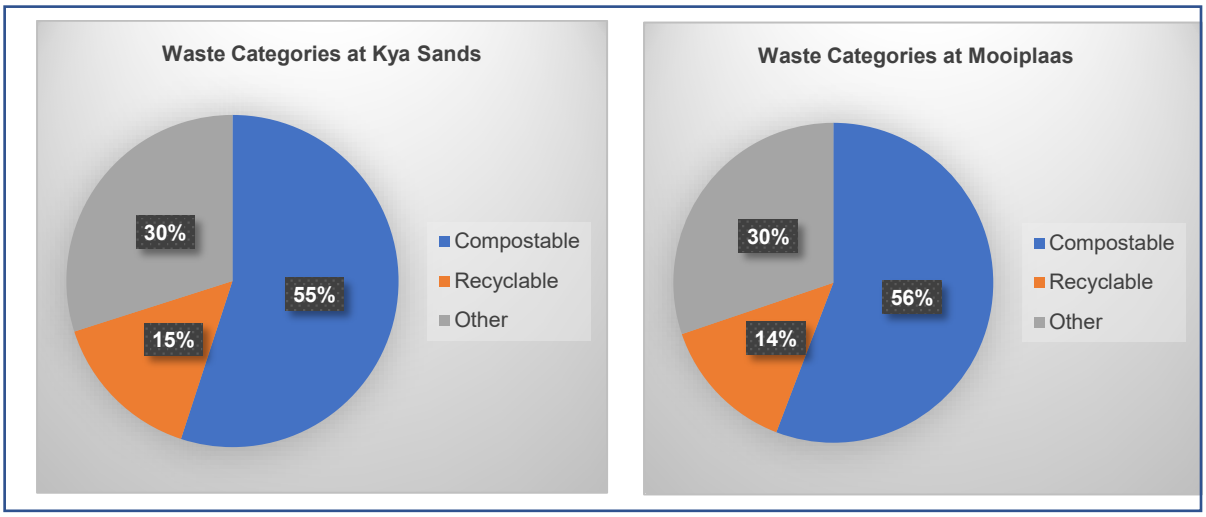

Figure 4.2: Waste composition at the two study areas (Source, Author 2021)

Table 4.11*:* Waste categories

Material	Category	Kya Sand (kg)	Percentage (%)	Mooiplaas(kg)	Percentage (%)
Compostable	Food	220.2	54.8	218.7.	55.8
Recyclables	Plastic	23.6	5.9	20.5	5.2
	Can/tins	12.9	3.2	11.9	3
	Paper	4.7	1.1	4.6	1.1
	Glass	20.7	5.2	18.2	4.7
Non-recoverable	Pampers and other	105kg	30%	118	30.2

A closer look at the material breakdown on Tables 4.11 reveals Kya Sand having food waste accounting for the highest kilograms (220.2 kg) followed by other waste which was highly composed of disposable nappies (105 kg) and the least was paper wastes (4.7 kg). More so, in Mooiplaas it's almost the same because food waste accounted for the highest component (218.7 kg) followed by other which was also highly composed of disposable nappies (118.4 kg) and the least was paper waste (4.6 kg). Food scrap accounts for the majority of garbage generated; the research revealed that most food wastes included pap which further concludes that most people in the informal settlements prefer to prepare their meals for themselves every day rather than buying. This is was also supported by Puling (2004) who stated that the most common type of waste in terms of mass-production is kitchen waste (almost 40%), followed by plastic and finally paper**.** Tsheleza et al. (2019) also recorded that food waste dominated the waste sampled in his study and in a study conducted by Ojeda-Benitez et al (2003), which relatively similar to the results from Kya Sand and Mooiplaas informal settlements. Tsheleza et al. (2019) also indicated that, concerning food waste, the results are similar to the study conducted by Ojeda-Benitez et al (2003).

Due to a high quantity of compostable waste, that waste can be of much use by transforming it into agricultural manure or used to generate biogas that can be used as energy. By recycling waste, the transport cost can be minimised; and create employment (Adogu et al. 2015). All other recyclables can be taken to the commercial recyclers and also formalize the illegal waste pickers who collect recyclables for a living. In both informal settlements, scrap yards were observed very close to the settlement therefore most of the recyclables were not found on the sampled waste because the illegal waste pickers and many other residents would quickly select the recyclables and rush to sell them to the nearby scrap yards. This signifies that there will be a remarkable reduction in waste sent to landfills if the potential to recycle these recyclables is optimized.

Composting could assist the towns investigated by reducing trash volumes sent to landfills. A high volume of organic waste, according to Ojeda-Benitez et al (2003), gives an opportunity for recycling through organic waste composting. If large amounts of biodegradable trash are left neglected, they can pollute the environment, causing odour and hygiene issues as well as negative environmental consequences (Omollo, 2020). Biodegradation of household solid waste results in the production of acidic and alkaline organic pollutants as well as various pathogens with the final product being leachate containing heavy metals, causing major surface and groundwater contamination (Rambuda. 2020). However, if appropriate treatment or conversion are implemented, the same waste categories present a significant economic opportunity, if recycling is an option. The socioeconomic status of the residents can be improved because there will be job creation and also a clean environment.

The per capita waste creation rate in the two informal settlements is estimated to be 0.3 kg/capita/day, which is within the South African solid waste generation per capita per day threshold range. The waste

quantification results were utilized to extrapolate the yearly waste generation rate, which yielded a figure of 1 777.6 tons per year (see equation C) as shown in Table 4.12 below. As indicated in Tables 4.12 and 4.13, this is also utilized to calculate the annual recyclable and compostable trash in the two informal settlements, which are 17.1 (recyclable) and 23.4 (compostable) tons, respectively.

Daily Waste generation **rate (tons)** $= \frac{\boldsymbol{per\ capita \times total\ population}}{\mathbf{1000}}$

Annual waste **generation (tons)** = Daily Waste generation rate (tons) × 365 days

Table 4.12: Annual recyclable and compostable waste in Kya sand

Activity area	Daily rate per person (kg)	Total population	Daily waste generation per tons per kg/person x total population/1000	Annual waste generation rate X 365 (tons)
Kya Sand	0.3	16 238	4.87	1 777.6
	Annual waste generation rate in ton		Percentage daily generation rate	Fraction recyclable per year
Compostable	977.68		55%	977.7
Recyclable	266.64		15%	266.6
Non-recoverable	533.28		30%	533.3

Table 4.13: Annual Recyclable and Compostable Waste in Mooiplaas

Activity area	Daily rate per person (kg)	Total population	Daily waste generation per tons per kg/person x total population/1000	Annual waste generation rate X 365 (tons)
Mooiplaas	0.3	16 000	4.8	1 752
	Annual waste generation rate in ton		Percentage daily generation rate	Fraction recyclable per year
Compostable	977.68		56%	977.7
Recyclable	266.64		14%	266.7
Non-recoverable	533.28		30%	533.3

4.3 Municipality's Major Approach towards Solid Waste Management in the two Informal Settlements

For the municipality, informal settlements provide a significant SWM challenge. The lack of effective garbage removal services has consequences for the environment and the community's health. It's worth noting that, despite the fact that informal settlements have long been a feature of the South African urban landscape, they receive little consideration in

municipal policies. Over time, service delivery issues have developed, posing significant waste management challenges in these settlements.

Results have shown that both Kya Sand and Mooiplaas lack basic infrastructure and services such as proper roads, sewerage systems, proper drainage systems, and SWM systems. The outcome of the interviews with the officials from the two municipalities indicated that, due to poor or no proper streets within the settlement, the municipality organised a solid waste collection service in an open space demarcated for solid waste to be disposed and there is a service provider that collects waste every day.

4.3.1 Interviews with Officials from the two hosting metropolitan municipalities

To gain the participants' perspectives, the researcher conducted interviews with the key stakeholders to obtain their views. Four representatives from the government were among the stakeholders from both municipalities. More so, two residents per informal settlements were also interviewed. The interview questions were based on waste collection, removal and community participation.

Firstly, the officials were asked, "*Are there any strategies for solid waste disposal in place for informal settlements, and are you following them*". The response from the officials from both municipalities indicated that they do have strategies and they follow them, from CTMM, it was indicated that there is a waste removal program, initially, they used to give residents four refuse bags per household per week, however, because it was observed that the residents did not use the plastic for waste but for storing their belongings then the municipality decided to stop giving out the plastic. However, they decide to demarcate a communal dumping site within the Mooiplaas settlement. At CJMM the officials also indicated that there is City Integrated Waste Management Policy and Plan (IWMP) that caters for all households in the City. Therefore both municipality has strategies in place but these results show that there is a need to review and monitor their implementation because there are some gaps within these policies towards waste management.

The officials were asked, "*How much solid waste is being generated and if there were any landfills for solid waste disposal for those settlements?"* Results from the interview with the officials from the two hosting Metropolitan Municipalities indicated that in both settlements, they don't know how much waste is generated nor collected because the waste is not weighed at the landfills, where the trucks dump waste have no weighbridges. The officials also indicated that it's very difficult to calculate the waste generated per year because even the population is very difficult to estimate due to the frequent migration of people residing there. They also

indicated that most people live in informal settlements in the first few months they arrive in Gauteng, once they get decent jobs they relocate to better locations where there are decent houses and basic services.

The officials also stated that there is a truck that collected waste every day, and most respondents confirmed that as shown in Figure 4.3, however, the researcher observed a lot of uncollected waste along streets in both settlements and in the nearby stream at Kya Sand, (Figure 4.4). Even though there was a truck collecting waste every day, the area was always full of garbage and the designated open space is located at the centre of the dwellings therefore it poses some health risks to the residents. Most respondents indicated that the area smells bad.

The officials from CTMM indicated that they have contracted a service provider to collect waste every day and also at CJMM they have given a contract to Pikitup to collect waste every day, at Kya Sand (Figure 4.3). These companies have been given the responsibility of waste management in designated communal dumps and illegal dumping sites. At CTMM, they indicated that they have an Illegal waste collection team, which is responsible for that.

The officials also indicated that there are actions in place to prevent illegal dumping of solid waste within the settlements, these included providing waste education and awareness and compliance enforcement, putting up signs indicating that illegal dumping is prohibited. The municipality By-laws also allow the officials to take legal action against those who are responsible for the illegal dumping.

Figure 4.3: Collection of waste at Mooiplaas Informal settlement from a designated dumping area (Source, Author 2020).

4.3.1.1`Challenges experienced when implementing the MSWM system in Kya Sands and Mooiplaas informal settlements

The officials raised the following issues as the encumbrances towards sustainable waste management:

- Illegal dumping and inaccessible roads for trucks.
- It is alleged that residents hide information because some industrial waste such as rubble has been identified from both settlements but the residents do not give information on who is responsible for the illegal dumping.
- The number of people per yard is too much, hence the area is overpopulated and the resources strained.
- Financial constraints as the budget is limited.
- People stay at these settlements temporarily hence they do not care about the environment, this can be due to a lack of ownership.
- People living in informal settlements do not pay municipal services, therefore it causes financial constraints to the government.
- Most people living there are undocumented foreign nationals, therefore it is difficult to register them.

The researcher also asked the officials if the residents from the study area are cooperative towards the management of solid waste generated. The response from CJMM indicated that

they cooperate however the official from CTMM indicated that they partially cooperated because when they are given resources they do not use them for waste, for example, they were given plastic bags for storing waste but use them for something else and even the skip bins were provided and dump waste around the skip bin.

The officials also indicated there is a strategy to evaluate the present MSWM system in the city of Johannesburg that is IWMP and is reviewed every 5 years. The researcher also asked whether the municipality ever suggested giving incentives to the community members to collect waste and the officials from CJMM indicated that they do not offer but the municipality work in partnership with the private sector and other public-based organization in waste management, however, the officials from CTMM indicated that they were still working on incentivising proper waste disposal. The response from the officials has shown that establishing waste recycling facilities, enforcement of City bylaws, education, awareness, and appointing more waste inspectors for the settlements will reduce dumping of waste in open areas or rivers.

Lastly, the researcher asked if there were any specific waste items that the municipalities were not able to collect when collecting waste or if they also pick waste from the illegal dumpsites. Officials from CJMM and CTMM indicated that they collect every waste and they clean up the illegal dumpsites.

According to the responses from the survey, 91.3% of the participants from Kya Sand indicated that the garbage was collected every day and a few indicated that the waste was not collected at all. This is because most of the residents were dumping waste at the designated site and a few respondents stay a bit far from the designated dumping site therefore they just dump wherever there is an open space or along the streets. During site visits, it was discovered that the majority of home garbage was packed and disposed of in little plastic shopping bags. When the bag was full, it was dumped in the nearest open area. This demonstrates that the municipality does not provide sufficient and easily accessible waste collection places because only one designated area is available for the entire informal settlement. However the residents also need to cooperate in order to manage waste in a sustainable manner, both municipality and community should work together towards ensuring clean environment around the settlements.

Most of the areas in informal settlements are inaccessible by municipal trucks. 89% of the respondents from Mooiplaas dumped waste on the designated open space. Few people burned their waste, and 2.1% of the respondents bury, dump along streets and dump in a river. According to the interview survey with the CTMM officials indicated that initially, they had

put some skip bins at Mooiplaas however, residents disposed their garbage around the skip bin instead of putting inside and there were complaints that robbers hide inside the skips to hijack people during late hours. Zandamela (2016) indicated that skips bins increased crime in her study areas. The skips were discovered to be being used to dump the bodies of murdered victims, and this was uncovered only after the skip was carried to the landfill hence they removed them from the site. Therefore, they realised that skips are unsuitable for waste collection in the area and were removed.

Most respondents (59.7%) have shown dissatisfaction with the cleanliness and the management of waste due to the area which was always dirty. However, 40.3% of the respondents showed that they were happy about the cleanliness of the area (Figure 4.4). However, According to the interview survey, the Pikitup truck collects waste every day at Kya Sand. The frequency of rubbish collection was determined to be excessive, but the area remains always dirty. This could be due to the fact the Pikitup trucks are unable to reach the entire town, residents who live far from garbage drop-off places are forced to dump in open spaces near their homes or in the stream. During site visits, it was discovered that people dump rubbish along and inside the river, as well as in rugged areas with no vehicular access (Figure 4.4). Illegal dumping is now the second largest trash stream, demonstrating that it is a severe problem in the area. According to CoJIWMP (2011), Waste Service Delivery should be provided to all citizens within the CJMM.

The Constitution of South Africa (Act 108 of 1996) and the Municipal Systems Act, 2000 (Act 32 of 2000), requires the local government to provide waste collection, disposal, and cleaning services to all South African residents. Pikitup (PTY) Ltd was established in 2001 as a waste management utility that is completely owned by the CJMM and is responsible for all operational waste collection and disposal (CoJIWMP) 2011).

The study found that most of the respondents stay away from the designated area, where waste is collected regularly by the Pikitup trucks for waste removal at the designated communal point/place. However some respondents who are residing closer to the main street indicated that they dump their waste and the place is accessible by the trucks. More so, a few people dump waste in the designated area but most of them dump in the nearby stream and nearby open spaces and most of those areas where people do illegal dumping are inaccessible by trucks. All of the respondents were dissatisfied because the municipality refused to extend its services further into the settlement to serve individuals who are living in inaccessible parts of the informal settlements.

Figure 4.4: Illegal dumping of waste at Kya Sand (Source. Author 2020)

4. 4. The Perceptions of the Public from the Two Communities concerning Solid Waste Management in the Study Area?

4.4.1 Interviews with key stakeholders from the two informal settlements

To gain a better understanding of the implications, valuable information regarding community practices and sustainability in solid waste management, interviews were held with key stakeholders from the two informal settlements, which included two ward committee members in each informal community. The information they provided provides a more comprehensive picture of the situation in the informal settlements as it relates to inhabitants' livelihoods. The stakeholders, their duties, and the type of data collected are all listed in Table 4.14.

Table 4.14: Acquired Interview Information

Institution	Roles and Responsibility Regarding SWM	Type of data required
Ward committee Member at Kya sand and Mooiplaas informal settlements	➢ Represent the communities and guide how to conduct a questionnaire survey within the area, considering different cultures. ➢ Interested and affected parties currently experiencing the effects of poor domestic SWM	➢ Demographic status of the study areas ➢ Types of waste generated ➢ Code of conduct for community engagement. ➢ Current Waste management practices ➢ Concerns regarding domestic solid waste management from the community

		➢ Required Intervention ➢ Opportunities of recycling ➢ Factors that contribute to improper management of waste. ➢ Adherence to Municipal By-laws. ➢ Community program aimed at achieving long-term domestic SWM ➢ Proposed improvements towards waste management ➢ Required intervention from the City of Johannesburg. ➢ Mitigation measures towards SWM

In terms of community involvement in trash management, the study found that there is no community involvement in waste management. This was due to a lack of understanding about recycling and related opportunities, employment obligations, a lack of enthusiasm, and the idea that trash management is only the duty of the municipality, despite the perceived necessity of this service. As a result, the prevailing opinion was that garbage management was just a delivery business with no input from the community.

Zandamela (2016) supported this sentiment by noting that the majority of respondents from his study agreed that that the cleanliness of their environment was a problem. They added that it was due to the municipality's failure to collect the garbage regularly and 40.3% of the respondents were satisfied. However, in Kya sand, 87% of the respondents indicated that they were not happy and 11% were satisfied. The reason for the dissatisfaction by some of the respondents was because the truck that collected waste was only collected from one spot and most residents did not dispose of their waste in the designated area. The people who are very close to the designated dumping area are the ones who dispose of their waste there. However, Parikh et al (2020) indicated most (82%) of the respondents from the study conducted at Havelock informal settlement, showed satisfaction with the municipal SWM systems within the area. Most respondents from the two informal settlements did not have indoor bins and disposed of rubbish every time their small plastic bags get full to the nearby open space or stream rather than disposing of in the designated area. However, some noted that the community lacks environmental knowledge and appropriate waste management practices.

The respondents were also asked why they were not happy about the cleanliness of the area, 37.3% (Mooiplaas) and 35.3% (Kya Sand) indicated that the area is always dirty, 12.7% and 22.2% respectively indicated that waste was disposed of everywhere; 1.3% and 2% respectively indicated that there was a bad smell from the unmanaged waste and some mentioned that people's health could be at risk due to unmanaged waste. Some participants from Mooiplaas (46%) and Kya Sand (17%) did not respond to the question (Figure 4.5 and 4.6). The residents at Kya Sand also dump waste in the nearby river (Figure 4.5). The study's findings are comparable to those of another study conducted at Ivory park, where the results have shown that the respondents have normalised illegal dumping because they alleged that the municipality has neglected them since it does not collect their waste (Rambuda 2020).

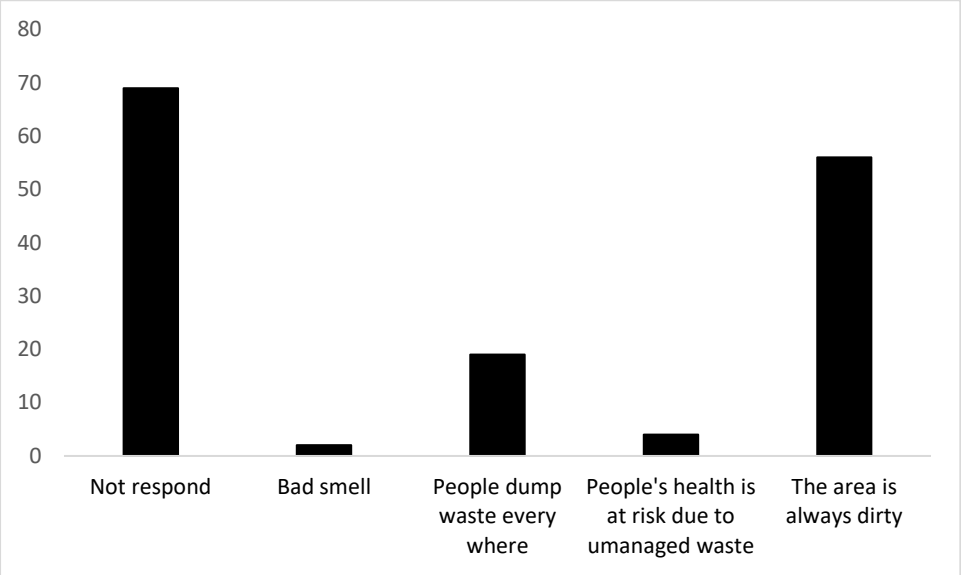

Figure 4.5: Why residents were not happy about the cleanliness at Mooiplaas (Source, Author 2020)

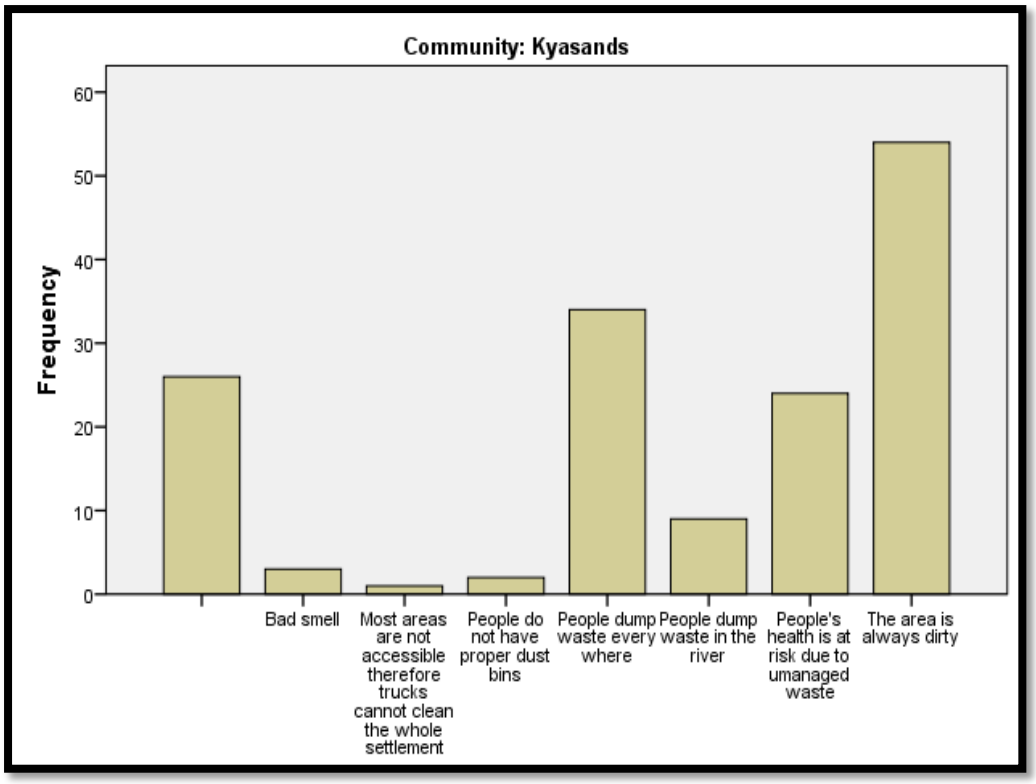

Figure 4.6: Why respondents were not happy about the cleanliness at Kya Sand (Source, Author 2020)

4.4.1 How to manage Solid Waste Sustainably at Mooiplaas and Kya Sand

The participants were further asked what could be done to have a cleaner and better environment around the settlement**.** Some respondents suggested that the municipality need to provide residents with proper bins and collect the waste at least weekly (Figures 4.7 and 4.8). Some of the respondents suggested the need for environmental management campaigns. Others opined that residents in the settlements should be hired to clean the environment on a full-time basis in both communities (11.3% and 22.2). This thought was also supported by Muriithi (2009) where youth groups affirm that the local community has been very supportive in solving the solid waste problem from the Kibera informal settlement in Nairobi.

Some respondents indicated the need for regular collection of wastes around Mooiplaas (3.3%) and Kya Sand (5.2%). At Kya Sand, some indicated that some legal actions of charging fine to those who dump waste illegally must be introduced (6%). This is also supported by Kubanza at al (2020), who indicated that the majority of the respondents in their survey thought waste should be removed more regularly because collection locations were overflowing. More so, in all settlements, the respondents suggested that the municipality need to put skip bins in the central places. Some respondents suggested that the government needs to develop the

area (25.3% and 39.2%) but this is a bit tricky because both informal settlements are located in a private owned land.

Most respondents (91%) from both settlements indicated that there were no environmental awareness programmes conducted within the settlements while only 1.3% and 4.6 respectively indicated that there are some environmental campaigns done. A study done in an informal settlement at Ekurhuleni Metropolitan Municipality yielded identical results to the current research, with 83.3% of the respondents from the informal areas, indicating that they were never given any environmental education (Fayez, 2012).

Most respondents in both informal settlements (90.7% and 86.3%) expressed keen interest to champion solid waste campaigns within their community. Zandamela (2016) indicated that community workshops involving SWM can encourage a sense of ownership on waste management practices. Further strengthened the thought by indicating that education, encourages appropriate garbage disposal practices and attitudes, as well as instilling individual responsibility for the environment.

Results of the study indicated that the respondents in Mooiplaas (88%) and Kya Sand (90.2%) know the consequences of living close to the unmanaged solid waste dumpsite and the health and environmental risks associated with it. The respondents listed several health problems, which included cholera, malaria, diarrhoea, TB, and flu. They also listed the environmental risks, which included land, water, and air pollution. These results indicate these people have intermediate knowledge and if environmental awareness campaigns can be introduced, they can participate without difficulties. Most respondents indicated that their children are more vulnerable to diseases and the danger of being hurt by broken bottles. Zandamela (2016) supports that though most women had concerns about their children's safety when playing outdoors they also indicated that children are particularly vulnerable to diseases other conditions caused by dirty environments.

Some other environmental and health problems that the respondents thought to emanate from unmanaged waste included bad smells, mosquitoes, rats, and flies; all these can spread diseases to human beings. Sinthumule & Mkumbuzi (2019) reported that environmental pollution is triggered by garbage being thrown and gathering in big heaps in the open, diseases from stray animals and insects living off the dumping sites have also developed into a significant public health concern in India

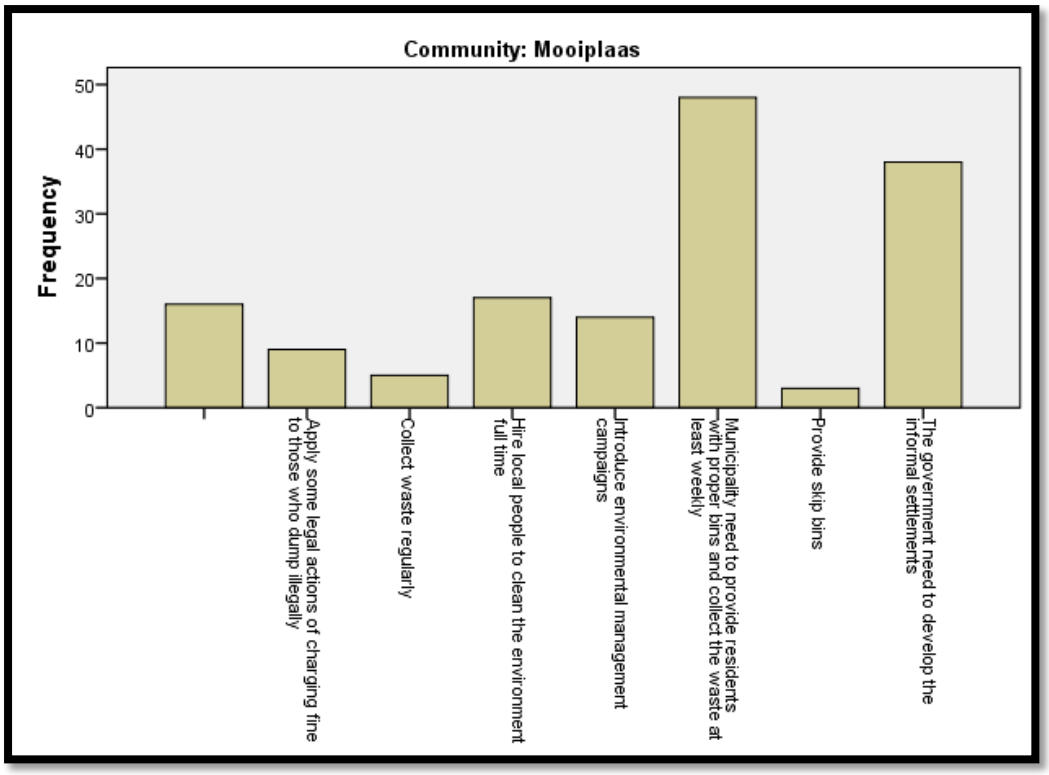

Figure 4.7: How to manage waste at Mooiplaas (Source, Author 2020)

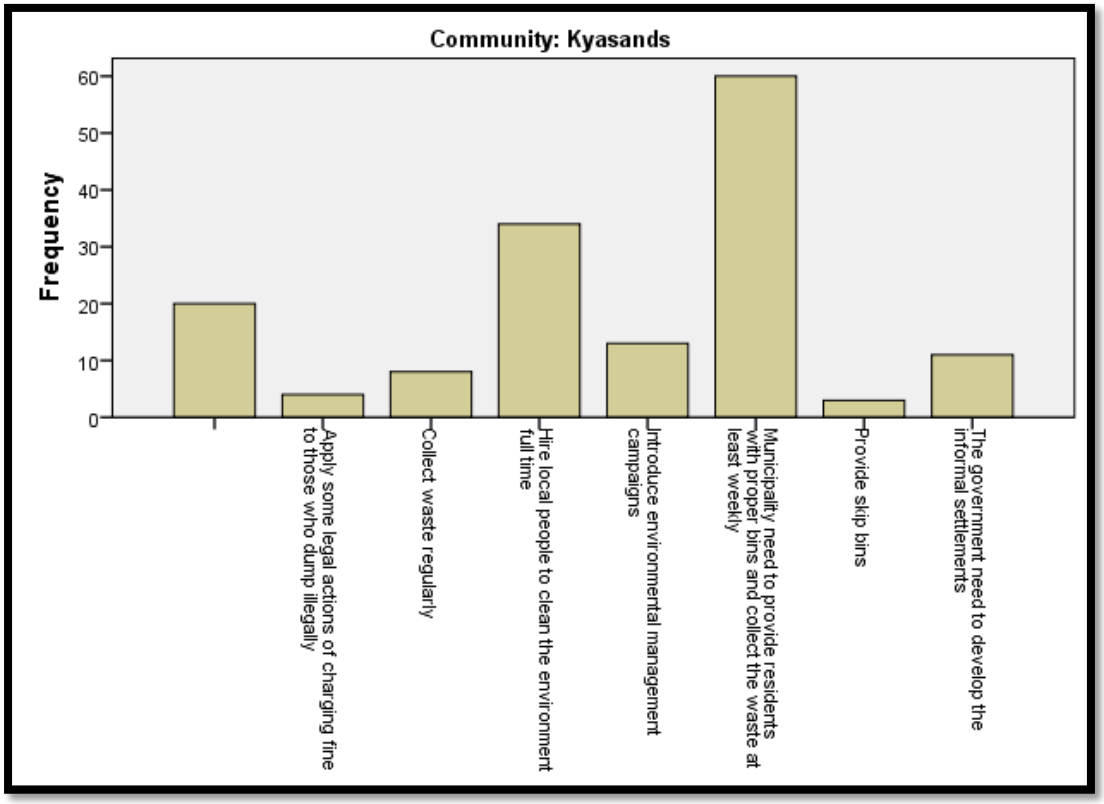

Figure 4.8: How to manage waste at Kya Sand (Source, Author 2020)

The research results indicated that the municipality is not doing enough and this is similar to a study conducted in India which found inadequate infrastructure, limited money and poor waste removal systems, such as lack of mass door-to-door collection services, therefore much of the garbage from households in Indian urban areas went uncollected (Abazeri 2014).

Finally, the close proximity of the shacks in both informal communities prevents rubbish from being placed outside each door. Residents must dispose of rubbish elsewhere in order to preserve their nearby surroundings healthy and clean, which leads in waste being discarded along roadsides and streams. Households must dispose rubbish whenever they generate it. Such actions, on the other hand, are in violation of the protocol for sustainable waste management. The Republic of South Africa's Constitution aims to protect the environment while also ensuring that all residents live in a clean environment that does not jeopardize their well-being or health. Many of the people who live in these squatter camps are destitute (De Jager & Maserumule 2021).

4.5 Community-based framework for solid waste management in the informal settlements

Mutumba (2014) argued that because humans generate solid waste, their engagement in waste management is essential. This can also reveal that the 3Rs can be applied because already the survey showed that most people reuse some of their waste, for example, peanut butter containers people can also use them to put in their spices and salt. More so, during the waste characterisation activity, a lot of plastic, paper, and glass were observed, these can be recycled. Food waste was the one that weighed the highest mass, therefore if there is proper environmental education conducted the food waste can be composted and used as organic fertiliser. Therefore programs, such as environmental education, and waste management awareness can be implemented since there are already informal waste pickers, who rely on selling recyclables for a living but do not have proper equipment and transportation.

The officials from the two hosting municipalities (CJMM and CTMM) indicated that they collect waste every day in these informal settlements. However, the areas remain dirty, therefore some suggestions were raised by the respondents which can be implemented and improve solid waste management within the two informal settlements. These included providing people with proper dustbins per yard and selecting a day in a week when people can take out their dustbins for waste collection. Even though in the meantime, the truck is collecting waste every day, the research revealed that it’s not effective enough due to inaccessibility to all parts of the settlements and most people do not dispose of waste in the designated areas. The municipality can hire local youth and community members to clean the environment and monitor all people who practice indiscriminate dumping within the area and charge fines. The

municipality must ensure waste management regulations are adhered to. Giving people dustbins will reduce the cost of travelling every day to collect waste, maybe the truck might collect twice a week. Municipalities must have weighbridges so that they can have a clear estimate on how much waste is collected, this could help the planners to decide how many days are needed per week for collection and how many bins they can distribute per stand.

Waste can be handled through reduction, reuse, recycling, or recovery, according to Singh and Sushil (2017), but all of these waste management strategies require new innovative technologies and processes. The development of innovative waste management techniques and technologies necessitates research and development initiatives. Waste management becomes better and more effective as a result of research and development. Sarder (2017) suggested that Strength, Weakness, Opportunity, and Threat (SWOT) analysis is an excellent tool for learning more about the changes and ways strategies start and efficiently administer a MSWM program.

The study found that the existing solid waste management techniques at the two informal settlements are inefficient and unsatisfactory due to lack of awareness and inappropriate collection, lack of segregation, absence of recycling storage facilities, and recovery of recoverable waste. The conclusions were drawn from an examination of waste generators, assessment of the solid waste management procedures, questionnaire and interview session with key stakeholders, field observations, and the comparison of existing legislative standards to current waste management practices. An integrated waste management method was used to create a sustainable waste management framework for informal settlements, since this will serve as a bridge from existing solid waste management practices to sustainability.

The SWOT analysis was used to examine both the negative and positive aspects of the MSWM in this study (Table 4.15). Some possible activities, such as environmental, social, economic, and strategic actions, were found after examining all of the SWOT components. The construction of particular plans, the establishment of new management strategies, the creation of policies for public knowledge and engagement, and the update of legislation and regulations are among the proposed lines of action.

Table 4.15: SWOT Analysis

STRENGTHS	WEAKNESSES
The management of solid waste in the country is governed by relevant laws.	Lack of waste segregation at the source makes recycling difficult.
Some people within the informal settlements are educated and can educate other community members on solid waste management	Municipalities have insufficient funds to purchase all the required resources for waste management
The informal settlements have a designated area where residents can dump waste before collection	Inadequate monitoring of the waste management process by relevant personnel.
The residents are willing to take part in awareness campaigns.	Residents' perception and attitude of towards waste management is wrong.
The majority of individuals are aware of the harmful consequences of inadequate waste management.	Most residents do not participate in waste management thinking that Waste management is the municipality 's responsibility
Community members are willing to participate in waste management	Unstable nature of the population size
	Poor road access
	Lack of ownership
	Absence of recycling and composting facilities in the settlements.
	Lack of knowledge on the nature and properties of garbage produced in settlements.
	Compliance is not monitored on the waste management regulations
	Lack of segregating facilities
	Lack of awareness and environmental programs to achieve sustainability.
OPPORTUNITIES	**THREATS**
The possibility of applying sustainable waste management, reduction, and diversion strategies.	High population rate poses more pressure on the available resources
Collaboration with private waste management sectors provides a public-private collaboration potential.	Air, water and land pollution
Employment opportunities through the recovery of waste resources and the transformation of waste into wealth.	Stigma to the residents (people tend to see people living in informal settlements to be untidy)
There is a potential for recycling	
There are informal waste pickers who collect recyclables for a living	

4.5.1 Sustainable solid waste management system

This study develops a waste management system to promote recycling and waste diversion from landfills, encouraging sustainability and adding value to waste resources, based on the waste characterization study and assessment of existing waste management techniques (see Table 4.16). The waste hierarchy is the foundation for this solid waste management strategy. The hierarchy prioritizes waste management via reducing, reusing, and recycling, as well as recovering and disposing of garbage.

Table 4.16: Sustainable Waste Management Strategy

Number	Strategy	Impacts/output
1.	Environmental Education\ Awareness	Awareness
2.	Teach the communities to recycle and reuse waste products and not to litter on land or water sources such as nearby streams the burning of waste	Reduced pollution
3.	Food waste can be composted to make manure for plants/crops	Waste reduction and improvement of soil nutrients
4.	Provide three colour-coded bins, for recyclable, compostable and trash at the informal settlements	Segregation makes it easier for recycling
5.	Hire local youth to clean the surrounding environment	Creation of jobs
6.	Implement some waste management legislations and also monitor compliance	Compliance
7.	Introduce some waste management campaigns	Knowledge and information
8.	Community participation	Residents feel honoured and respected by being allowed to voice
9.	The municipality should provide household bins for the residence	Reduce littering and land pollution
10.	There is an opportunity for community participation to address the challenges and uplifting socio-economic conditions of the urban poor such as those living in the informal settlement	Sustainable Livelihood Approach) as means to inform behaviour change of the public and community and improve their socio-economic conditions. Consider key livelihood strategies such as community waste collectors,

4.5.2 Development of a Framework on solid waste management

The informal activities of waste management systems in developing countries are expected to help fill the gap caused by local governments' inefficiency in this area (Gunsilius and Chaturvedi, 2011). According to Matumba (2014), human activities create solid waste, hence their engagement in waste management is essential. In this study, the SWOT analysis was utilised to design a sustainable waste management system that can be applied in the two informal settlements studied and others with same characteristics (Figure 4.9).

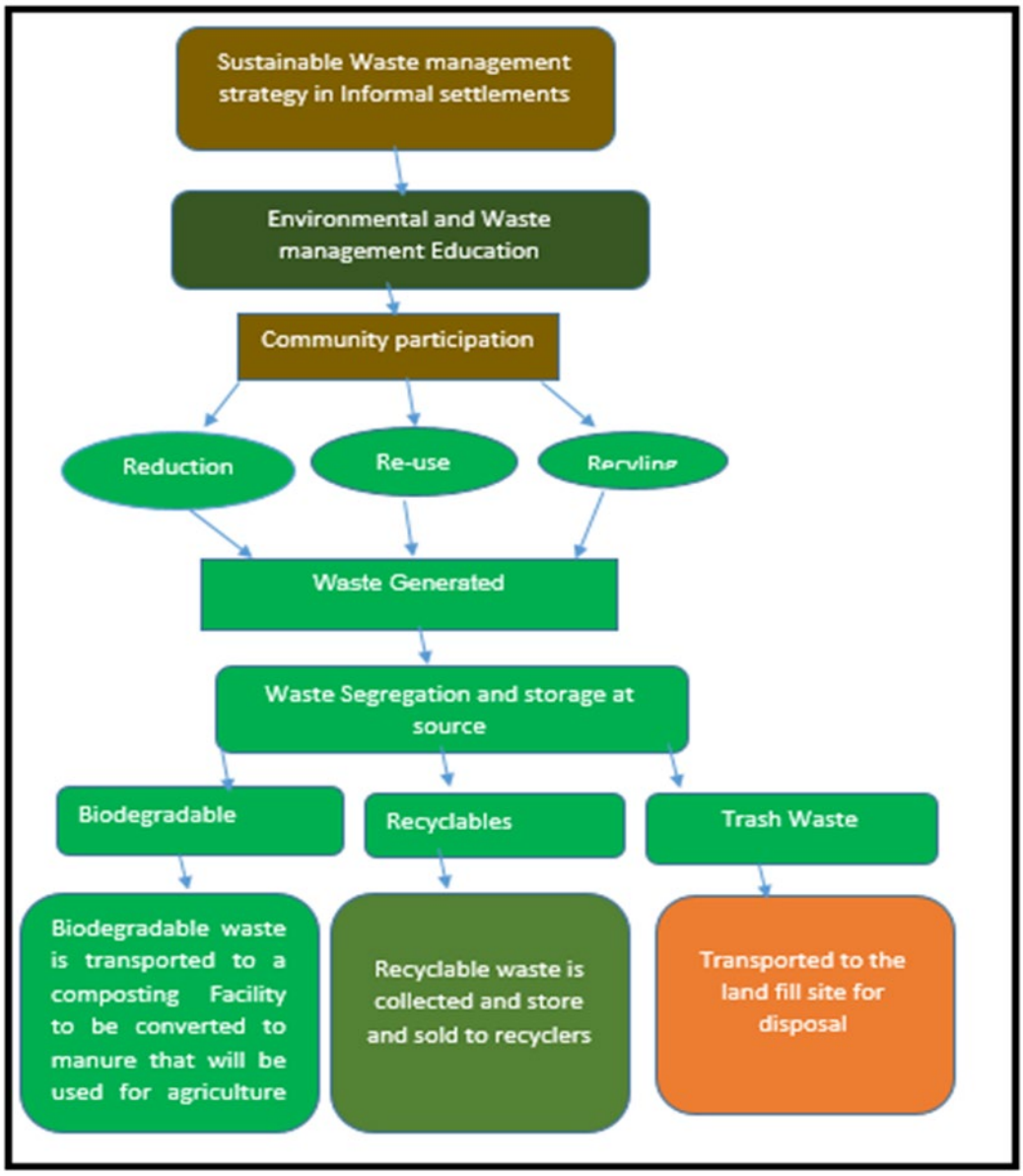

Figure 4.9: Proposed framework for sustainable livelihood in the informal settlements (Source, Author 2022)

The study's findings show that the current waste management system is inefficient and inadequate, implying that trash hierarchy must be improved by adopting sustainable and good waste management techniques. As the results show that there are informal waste pickers within the two informal settlements who depend on that for a living, therefore, the municipality can formalise that. The research also revealed that implementing recycling and reuse will result in a reduction of solid waste in informal settlements.

CHAPTER 5 : CONCLUSION AND RECOMMENDATIONS

To examine the quantity and types of solid waste generated in Kya Sand and Mooiplaas informal settlements.

Waste quantification and characterisation were performed, to estimate the garbage profile, generation rate, and amount of recoverable waste, thereby providing municipalities with baseline data. Several factors influence the composition of trash generated, including affluence, knowledge, and climate circumstances. In both settlements, the recyclable, compostable, and non-recoverable elements of the trash created were identified. At Kya Sands, food waste accounted for 54.8%, metals/cans (3.2%), plastic (5.9%), glass (5.2%), paper (1.1%) and non-recoverable (29.8%) whereas in Mooiplaas, food waste (55.8%), metals/cans (3.0%), plastic (5.2%), glass (4.7%), paper (1.1%) and non-recoverable (30.2%). The waste characterization revealed a high potential for recycling and reuse in both settlements (70%), reducing the amount of waste that must be transported to landfills.

To develop a community-based framework for the management of solid waste in informal settlements of metropolitan cities.

This research has successfully investigated SWM in Kya Sand and Mooiplaas informal settlements and proposed a more people-centred framework in informal settlements. The study's objectives were met by evaluating the current garbage collection, storage, and disposal practice. The existing practice's strengths and faults were compared to acceptable legal norms. This research study set out to investigate SWM in informal settlements (Mooiplaas and Kya Sand) and to find viable options that could improve the quality of life in these communities. According to the findings, sustainable waste reduction in the two informal communities has failed due to a lack of resident commitment. The municipality would be relieved of some of its responsibilities if accountability was shared.

To examine the municipality's approach to solid waste management in informal settlements

The findings of this study suggest that the municipality needs to provide dust bins and improve road access and investigate how many times they can collect waste per week and also hire the local community members and youth. Efforts currently being made in this area are not effectively improving the living conditions in informal settlement.

To compare and contrast the perceptions of Kya Sand and Mooiplaas informal settlement residents concerning solid waste management.

The analysis uncovered a major issues that have affected trash management. The absence of authorized storage facilities and black bin bags to temporarily store waste before it is taken to dump sites, as well as the significant walking distance to the main streets where waste is collected on a daily basis, are among these issues and the municipality's financial burden. Illegal, unregulated dumping and littering are a constant problem that will only become worse if the community and the municipality do not collaborate. The results from the interviews conducted have shown that open dumpsites poses land contamination risks, but also act as sources of diseases vectors and pathogenic agent.

5.2 Recommendations

- The municipality can contract community members to collect waste from all households within their area and transfer it to central collection points where the municipal waste collection vehicles can collect the waste for disposal.
- Unemployed residents could be employed to clean the dumpsites and take the rubbish to the waste collection points.
- Introduction of alternative waste collection systems, and the initiation of waste recovery programs.
- Community participation should be implemented.
- Further research need to be conducted outside the scope of this study for example examining the water quality of the stream which runs through the Kya Sand informal settlement.
- It is recommended that recycling and reuse of materials should be implemented.
- It is recommended that green waste management initiatives in informal settlements to encourage people to avoid, reuse, reduce waste generation, recover cost and provide financial incentives for waste producers to change their waste generation behaviour.

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APPENDIX A: SAMPLE INTERVIEW QUESTIONS

Key stakeholders within the Two Informal settlements

1. How many people live in this community?
2. What kind of solid waste is being generated in the community?
3. Is littering of solid waste a problem in this community?
4. Do municipality trucks come to collect your waste?
5. Do you have a landfill or designated place for waste disposal?
6. How often do they come?
7. Is the waste generated adequately managed?
8. If not, what do you suggest can be done to improve the solid waste collection in this settlement?
9. Are there things the people in the settlement should do differently towards ensuring the cleanliness of the environment?
10. If yes what are they?
11. Do people dispose waste in the rivers or open land?
12. What are the major jobs people do that live in the community?
13. What other social amenities do you lack in your community?
14. Do you reuse some of the materials or products that you buy?
15. Are there waste pickers or recyclers in the community?
16. Are you willing to pay for waste management?
17. If you have been paying for waste management, how much does it cost you?
18. What role do you or your community play in solid waste management?
19. Does your community have collective responsibility for waste management?
20. Do you know why it is important to manage solid waste?
21. What happens when the waste is left in the open for a long time?
22. What solid waste do you reuse?
23. What do you reuse them for?
24. What is the benefit of reusing the waste?
25. Are there any industrial waste disposed around your area?

Municipality Officials

1. Are there any strategies for solid waste disposal in place in the specific metropolitan municipalities for informal settlement?
2. How much solid waste is being generated in this settlement?
3. Are there landfills or designated places for solid waste disposal

4. What are the measures in place to prevent illegal dumping of solid waste within the settlement?
5. Is there any solid waste management strategic plan within the two municipalities?
6. If there is strategic plan, do you follow it?
7. Are there any challenges experienced in implementing the MSWM system in Kya Sand/Mooiplaas?
8. Are the people cooperative towards the management of solid waste generated?
9. Is there any plan in place to evaluate the current MSWM system? If yes, how often do you evaluate?
10. Do you support the management of waste by external service providers?
11. What are the population of the people living in the settlement?
12. Has the municipality ever suggested giving incentives to the community members to collect waste?
13. What strategies could be put in place to reduce dumping of waste in open areas or rivers?
14. Are there any specific waste items that you are not reliable to collect when collecting waste?
15. Do you also pick waste from the illegal dump sites?

APPENDIX B: SAMPLE QUESTIONNAIRE

University of Venda

Name: **Ethinah Sibanda**

Department of Environmental Science

Title: An investigation into solid waste management in informal settlements: A case study of Kya Sand and Mooiplaaas in Johannesburg and Tshwane Metropolitan Municipalities.

1. Sex: Male ☐ Female ☐
2. Age: ……..
3. Home language: Sepedi ☐ IsiZulu ☐ Sesotho ☐ Setswana ☐ IsiXhosa ☐ Others ☐
4. Educational attainment: No formal education ☐ Primary education ☐ High school ☐ Tertiary education ☐
5. Are you: Full-time employed ☐ Part-time employed ☐ Self-employed ☐ Unemployed ☐ Student ☐ Retired ☐ Other.....
6. How many people stay in your home? ……..
7. How long have you been living at this informal settlement?
   < 1 year ☐ 1-5 years ☐ 5-10 years ☐ 10 - 40 years ☐ > 40 years ☐
8. How much refuse do you produce per day?

0-0.5 Kg ☐
0.5 – 1 Kg ☐
1Kg – 2Kg ☐
Over 2kg ☐

9. How is solid waste handled in your house? (You can tick more than one)

Burned	Bury	Dumped in an open space	Composted	Place in a special container
Dumped in a nearby river	Dumped along streets	Other, specify		

10. Is the waste collected by town council staff? Yes ☐ No ☐
11. How often does the Municipal council come to clear waste from your area?

Every day ☐

Thrice a week ☐

Weekly ☐

2 Weeks ☐

Once in a month ☐

Not at all ☐

12. Do you reuse some of the materials or products that you buy? Yes ☐ No ☐
13. Are you satisfied with the way solid waste is being managed in your community Yes ☐ No ☐?
14. Are you satisfied with the cleanliness around the settlement Yes ☐ No ☐
15. If no why?.....
16. What can be done to have a cleaner and better environment around the settlement……
17. Are there any campaign about the proper disposal of waste Yes ☐ No ☐
18. Are you willing to be a waste champion to campaign against indiscriminate handling of solid waste Yes ☐ No ☐
19. When buying items from the shop do you request less packaging material? Yes ☐ No ☐
20. Do you know that a landfill releases harmful substances into the environment? Yes ☐ No ☐
21. Do you understand the health consequences of living close to dumped solid waste in an open space? Yes ☐ No ☐
22. Are you familiar with the health and environmental risks related to unmanaged solid waste? Yes ☐ No ☐
23. If yes what are the possible health and environmental risk?

24. What health and environmental challenges/concerns do you experience and think it's coming from the dumped waste near your houses or shacks?

25. What should the municipality do to reduce/prevent these health and environmental concerns?

APPENDIX C: ETHICAL CONSIDERATION AND CERTIFICATE

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:
Ms E Sibanda

STUDENT NO:
11584253

PROJECT TITLE: **Developing a people centred framework for solid waste management in an informal settlement within Tshwane and Johannesburg Metropolitan Municipality.**

ETHICAL CLEARENCE NO: SES/19/ERM/21/1202

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Prof JO Odiyo	University of Venda	Supervisor
Ms E Sibanda	University of Venda	Investigator – Student

Type: Masters Research
Risk: Minimal risk to humans, animals or environment
Approval Period: October 2021 – October 2023

The Animal, Environmental and Biosafety Research Ethics Committee (AEBREC) hereby approves your project as indicated above.

General Conditions:
While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The project leader (principal investigator) must report in the prescribed format to the REC:
  - Annually (or as otherwise requested) on the progress of the project, and upon completion of the project
  - Within 48hrs in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
  - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the REC. Would there be deviation from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the REC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the REC reserves the right to:
  - Request access to any information or data at any time during the course or after completion of the project.
  - To ask further questions; Seek additional information; Require further modification or monitor the conduct of your research or the informed consent process.
  - Withdraw or postpone approval if:
  - Any unethical principles or practices of the project are revealed or suspected.
  - It becomes apparent that any relevant information was withheld from the REC or that information has been false or misrepresented.
  - The required annual report and reporting of adverse events was not done timely and accurately.
  - New institutional rules, national legislation or international conventions deem it necessary

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE
Date Considered: February 2020

Name of the AEBREC Chairperson of the Committee: Prof Irene Barnhoorn

Signature: _____

UNIVERSITY OF VENDA
OFFICE OF THE DIRECTOR
RESEARCH AND INNOVATION
2021 -10- 19
Private Bag X5050
Thohoyandou 0950

APPENDIX D: CALCULATION ON PER-CAPITA WASTE GENERATION RATE KYA SAND AND MOOIPLAAS

Average waste generated per day for the three weeks / no of persons Kya Sand =13.5/ 49 =0.3/kg/day Mooiplaas 13.8/ 48 =0.3/kg/day
Calculation on annual waste generation Kya Sand and Mooiplaas in ton Per-capita rate/Total population/1000 =0.3*16 238/1000 =4.9 Calculation for annual waste generation rate Annual waste generation rate X average number days in a year (365) =4.9x 365 =1788.5 Per-capita rate/Total population/1000 =0.3*16 000/1000 =4.8 Mooiplaas Calculation for annual waste generation rate Annual waste generation rate X average number days in a year (365) =4.8x 365 =1752

APPENDIX E: RESULTS OF WASTE SAMPLED AT KYA SAND AND MOOIPLAAS INFORMAL SETTLEMENTS