

**An analysis of domestic solid waste management practices in
Ivory Park, City of Johannesburg Metropolitan Municipality,
Gauteng Province**



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University of the Witwatersrand, Johannesburg, in partial fulfilment
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Environmental Science

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DECLARATION

I, Konanani Rambuda, student No. 2117833; hereby confirm that this MSc research report titled **“An analysis of domestic solid waste management practices in Ivory Park, City of Johannesburg Metropolitan Municipality, Gauteng Province”** hereby submitted by me to the University of the Witwatersrand, Faculty of Science, has never been submitted before for any examination or degree at this or other university and that it is my possess work in execution, which all reference fabric contained therein has been recognized.

Signature  Date **14 October 2020**

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ABSTRACT

Poor domestic solid waste management poses several risks to communities, both directly and indirectly, related to human health and environmental impacts including injury, infection, visual pollution, degrade the land and pollute the ambient air and watercourses. Ivory Park is one of the overcrowded former townships within the City of Johannesburg, Gauteng Province, that are rapidly developing due to urbanization and immigration. Overcrowding within Ivory Park has resulted in more poorly managed waste which has attracted rodents, cockroaches and flies, and deterioration of the natural environment (land, air and watercourses). Despite measures such as awareness and recycling programs that have been undertaken to address the issue, poor domestic solid waste management continues to be a problem within this township as it is elsewhere.

Questionnaires, key informant interviews and field observations were conducted to investigate the drivers of poor domestic solid waste management and to determine measures to be implemented for sustainable domestic solid waste management within Ivory Park.

It is demonstrated in this research study that the main source of poor domestic solid waste management includes domestic overcrowding, insufficient capacity and resources for waste management service provision, and lack of participation of the public in awareness programs and their unwillingness to pay municipal rates. The study also demonstrates the impacts of poor domestic solid waste management within the area, which include environmental pollution, illness associated with waste and pests, and the inability of the area to attract business investment.

Several measures have been previously proposed to address the issue of domestic waste management in South Africa. Results from this study suggest the most important measures include the allocation of more funds towards waste management, amendment of existing waste management policy, conducting awareness programs, enforcement of municipal By-laws, timely collection of waste, increase the frequency of waste collection (i.e. twice a week), and placement of waste skips at open spaces that are prone to littering. This study highlights the different possible actions of addressing domestic solid waste management, and the need for collective efforts and participation of different stakeholders.

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ACRONYMS

CoJ	: City of Johannesburg Metropolitan Municipality
CSIR	: Council for Scientific and Industrial Research
DEA	: Department of Environmental Affairs
DEADP	: Department of Environmental Affairs and Development Planning
EIS	: Ecological Importance and Sensitivity
IDP	: Integrated Development Plan
IWMP	: Integrated Waste Management Plan
JMPD	: Johannesburg Metropolitan Police Department
NWMS	: National Waste Management Strategy
PES	: Present Ecological Status
RDP	: Reconstruction and Development Programme
RSA	: Republic of South Africa
SOC	: State Owned Company
SOER	: State of Environment Report
StatsSA	: Statistics South Africa
UNEP	: United Nations Environment Program

CHAPTER 1: INTRODUCTION

1.1 Background information

Domestic solid waste management is a major environmental problem globally because the production of solid waste is part of human society, since humans rely on material things that eventually end up as waste (UNEP, 2005; Lindell, 2012; Guerrero et al., 2013). Domestic solid waste may include any types of garbage and debris (e.g. bottles, cans, clothing, compost, magazines, newspapers, food scraps, yard trimmings and building debris) that emanate from households, and may also include hazardous substances such as medicines, solvents, paints, batteries and cleaning detergents. According to Imoh and Emmanuel (2011), the volume of waste generated nationally and regionally depends upon economic function and status and level of technological development. Household income levels determine the volume of household waste generated within local municipalities (Nahman et al., 2012; Rodseth et al., 2020).

Uncontrolled domestic solid waste disposal has detrimental impacts on the environment, as it leads to the deterioration of watercourses (surface and underground) and air quality (Bartone, 1991; Kwailane et al., 2016; Bundhoo, 2018). The nature of environmental impacts depends on the types of waste and the informal (unregulated) modes of waste disposal, which are usually in the areas surrounding the domestic residences where the waste is generated. Waste may be bagged and dumped, or just discarded as litter. Uncollected solid waste may block stormwater runoff, resulting in stagnant water formation which may act as breeding areas for mosquitoes and other insects (therefore vector diseases) as well as blocking waterways leading to localised flooding (Mathee et al., 2020). Burning of waste creates fire and burn hazards to residents, mostly young children, as well as increasing levels of ambient air pollution. Contaminated or waste-covered land tends to lose its fertility as a result of degradation from waste (Mohammed and Eyasu, 2017). Organic waste usually attracts insects, rats and other household pests if not properly managed (Tsheleza et al., 2019). Uncontrolled domestic solid waste can also result in health effects to residents through pollution, pests and diseases (Ziraba et al., 2016). Sustainable and appropriate solid waste management practices can promote good environmental quality by protecting both surface and ground watercourse, prevention of health hazards associated with waste, as well as ensuring socioeconomic growth. However, inappropriate or poorly coordinated management practices can result in increased total waste production, environmental deterioration and negative social and

health impacts in communities (Breukelman et al., 2019; Kubanza and Simatele, 2020). Thus, it is imperative to have waste management practices that provide positive outcomes to the social, economic and environmental challenges facing households (Lindell, 2012), especially in developing world cities and in economically disadvantaged communities. However, this requires individual effort and participation in order to achieve a positive impact on the environment (Kamara, 2006; Kubanza, 2020).

According to Lindell (2012) and Guerrero et al. (2013), waste management issues are more significant in developing countries as they experience challenges of rapid population growth and urbanization rate. Jonas et al. (2014) identify several variables that constrain the appropriate management of solid waste in developing countries. These include poor funding for the procurement of the required resources, poor institutional structures, inadequate technology, public ignorance and unwillingness of community members to contribute towards solid waste management services. In spite of the fact that segment 24 of the Republic of South Africa's Constitution (1996) states that "everyone has the right to an environment that is not harmful to their health or well-being; and have the environment protected, for the benefit of present and future generations", the management of solid household waste is still a huge problem in most part of the country. This is associated with poor institutional practice, shortage of waste management funding, unreliable collection frequency (due to strikes), and lack of public corporation (Fakoya, 2014; Machete, 2019; Kubanza and Simatele, 2020). There are also differences between service provision in rural versus urban areas of South Africa (Rodseth et al., 2020).

Section 5 (b) of the Constitution stipulates that local government is primarily mandated to manage domestic solid waste management, and Section 152 (1) (b) indicates that local municipalities must provide basic services to local communities (Republic of South Africa, 1996). The Council for Scientific and Industrial Research (CSIR) (2011) studied local municipal waste management service delivery and showed that there is overall poor performance in the provision of waste services. Lindell (2012) proposed that local municipalities must improve their waste management plans and strategies to effectively address and minimize the negative environmental effects of uncontrolled domestic solid waste, as well as to avoid conflicts in future land uses. This can also assist to improve public health, environment, the resource value of waste, and prevent negative impacts of climate change (Dlamini et al., 2019; Kubanza and Simatele, 2020).

In view of the above issues, this study seeks to identify and discuss factors contributing to poor domestic solid waste management within Ivory Park township, Johannesburg, in order to identify measures that can assist in more sustainable domestic solid waste management practices.

1.2 Research problem and motivation

The City of Johannesburg Metropolitan Municipality is located within Gauteng Province, which is regarded as the economic hub of South Africa. According to the City of Johannesburg (2011), the city is rapidly expanding with in-migration from all over the country and the continent due to the availability of employment opportunities. Subsequently, the municipality is facing challenges regarding the increase in the generation of domestic solid waste. The City of Johannesburg (2011) further states that the lifespan of landfill infrastructure within the region is diminishing due to increasing volumes of waste deposited at these sites and as a consequence of land-use conflicts. Several recent studies confirm these waste management issues affecting Johannesburg (Simatele et al., 2017; Dlamini et al., 2019; Kubanza and Simatele, 2020).

Ivory Park is one of the former townships in eastern Johannesburg that are experiencing overcrowding due to rapid in-migration, and this has triggered the erection of iron shacks and brick rooms in most backyards which also increases the quantity of domestic solid waste produced per stand (CoJ, 2010). Moreover, informal settlements have mushroomed in most of the open spaces and along the riverbanks (Kaalspruit River) within the township. This has further triggered the generation of poorly managed waste. Figure 1 shows evidence of illegal dumping and uncontrolled waste burning in Ivory Park.

The City of Johannesburg has appointed Pikitup Johannesburg (SOC) Ltd to provide waste management service to residents within the city, including Ivory Park. Moreover, several programs such as community educational awareness and cleaning campaigns have been undertaken including through the Community Work Programme (Masuku, 2015), but littering and illegal dumping still take place. There is limited research concerning domestic solid waste management in the area, and so this study seeks to investigate the causes of poor domestic solid waste management and to determine measures that can be implemented to address the issue.



Figure 1: Evidence of illegal dumping and uncontrolled waste burning in Ivory Park. (A) Ivory Park Ext 12, (B) Kaalspruit River, (C) Thembakhoza (informal settlement), (D) Ivory Park Ext 11. (Source: K. Rambuda, 2018).

1.3 Aim and objectives of the study

The main aim of this study is to investigate the management of domestic solid waste in Ivory Park, Johannesburg. Ultimately, the study seeks to determine measures that can be implemented to attain sustainable domestic solid waste management in Ivory Park.

The specific objectives of the study are:

- To determine and classify the types of domestic solid waste generated from individual households,
- To determine the quantity of domestic solid waste generated from households,
- To evaluate the effects (environmental, health and socioeconomic) of poor domestic solid waste management,
- To assess individual knowledge of householders on the impacts of poor domestic solid waste management, and
- To investigate the causes of poor domestic solid waste management in the area.

1.4 Research Questions

The research process is guided by the following questions:

- What types and quantities of waste are being generated by households?
- What are the effects (environmental, health and socioeconomic) of poor domestic solid waste management in Ivory Park?
- What is knowledge do individuals have on domestic solid waste handling?
- What are the perceptions and recommendations of individuals on how to address the issue of solid waste?

1.5 Research methods

The study uses a quantitative and qualitative approach in the form of field observations, questionnaire surveys and key informant interviews to study various aspects related to domestic solid waste management in Ivory Park. The field observations help assess the behaviour and habits of residents regarding domestic waste management as well as identify areas prone to waste pollution. The questionnaire survey assists in understanding the types and quantities of waste generated within randomly-selected households, the level of individual knowledge on solid waste handling and their perceptions with regards to the possible solutions to address the problem. Key informant interviews assist in understanding the views of municipal officials regarding domestic solid waste management in Ivory Park and more generally. A textual analysis approach was utilised to analyse the collected data.

1.6 Scope of the study

This research specifically focused on the management of domestic solid waste in Ivory Park and was looking at both formal and informal residential areas. Although the area contains many small business (e.g. spazza shops, hair salons, informal restaurants, panel beaters, etc.), this research focused only on domestic solid waste emanating from households, not businesses.

1.7 Definition of terms

The below defines some of the major terms used in this report:

- **Household** – refers to a group of people living, eating, and sharing resources and/or a single person lining alone (StatsSA, 2011);
- **Domestic solid waste** – includes garbage and debris (e.g. bottles, cans, clothing, compost, magazines, newspapers, food scraps, yard trimmings and building debris) that comes from

households, including hazardous substances such as used medicines, solvents, paints, batteries and cleaning detergents;

- **Township** – refers to the underdeveloped, usually (but not only) urban, residential area that during Apartheid government was reserved for black people including Indians and coloureds, who lived near and/or worked in areas that were designated for ‘whites only’ in terms of Section 33 of the Black Communities Development Act and Proclamation R293 of 1962, Proclamation R154 of 1983 and GN R1886 of 1990 in Trust Areas, National Home lands and Independent States;
- **Waste Management** – involves amongst others the generation, storage, the collection process, recycling and eventually, the disposal of the waste (Pichtel, 2014);
- **Pollution** – refers to any change in the environment resulting from different activities, including storage or treatment of waste that has adverse effects on health and wellbeing of people, composition and productivity of the ecosystems and can cause effects in the future (National Environmental Management Act, No. 107 of 1998);
- **Formal Settlement** – refers to a formalised area with appropriate zoning which receives all the municipal services (i.e. water supply, electricity, waste management services, access roads, etc.);
- **Informal Settlement** – as defined by Part 3 of the National Housing Code 2007, as an area occupying illegally (without permission of the landowner), situated at inappropriate locations (i.e. under electricity servitudes, floodlines, etc.), mostly with no municipal services (i.e. water, electricity, waste management, roads, etc.), and represents the highest concentrations of poverty in the country.

1.8 Research ethics considerations

Ethics clearance was applied for and approved by the School of Geography, Archaeology and Environmental Studies (GAES) ethics committee before the commencement of the project, and the ethical codes of standards as required by the Wits University and of the society were strictly adhered to (Ethics No. GAES-2019-07-02). As part of the project questionnaire survey, no participant was forced to take part in the survey or interview. Furthermore, there was no misrepresentation of data and/or information acquired from participants. For this study, the researcher followed the following principles:

1.8.1 Informed consent

For this study, only households with available adult individuals (18 years or above) were randomly selected to participate in the questionnaire survey and interviews. Participants declared on the consent form that they are willing and met the requirement (age) to partake in the study. The background and objectives of the study were provided on a participant information sheet and verbally explained before individuals gave their consent to participate in the research. Furthermore, it was clarified that no compensation will be paid for taking part in the study.

1.8.2 Protection and anonymity of participants

This study did not in any way pose any potential harm to the participants. The respondents were given assurance that they did not have to answer any question that makes them uncomfortable, and that they could withdraw at any time from the study. It was explained that their identity would be protected in that their real names would not be required on the questionnaires or the final research report. A number was assigned to each questionnaire to prevent the linking of a questionnaire to a participant. Confidentiality was maintained through the safekeeping of the completed questionnaires and making sure that they are only accessed by the researcher and the supervisor.

1.9 Chapter outline

Provided below is the summary of the remaining chapters in this research report:

- **Chapter 2** – literature review of waste management issues, including the causes and impacts of poor domestic waste management in developing countries, including the sustainable practices of solid waste management within South Africa and specifically within the City of Johannesburg.
- **Chapter 3** – description of the study area, its geography and the biophysical and socioeconomic aspects of the area.
- **Chapter 4** - outlining the methodology used to acquire data for this study, and the techniques used to analyse the collected data.
- **Chapter 5** – presenting and discussing the results obtained from field observations, questionnaire survey and key informant interviews. The results were interpreted in the context of the wider literature.

- **Chapter 6** – summarising the findings of Chapter 5 set in relation to the research objectives, and subsequently making recommendations for implementation of more sustainable domestic solid waste management practices.

CHAPTER 2: LITERATURE REVIEW

The Department of Environmental Affairs (DEA) (2012) in South Africa and Pichtel (2014) indicate that solid waste management encompasses the successive generation, storage, collection, sorting and recycling, and ultimately the disposal of waste. One of the objectives of solid waste management is to minimize and ultimately prevent detrimental environmental, health and socioeconomic effects caused by poorly managed domestic solid waste. However, there are a number of barriers that prevent the achievement of this objective (Breukelman et al., 2019; da Silva et al., 2019).

This chapter reviews issues related to solid waste management under the following themes: major trends and issues of waste management in developing countries; drivers of poor domestic solid waste management; methods of handling the generated waste; impacts of inadequate solid waste management on the natural environment and communities; challenges for solid waste management in South Africa and waste management practices in the City of Johannesburg; and the wider importance of sustainable waste management practices. These themes enable an understanding of the approaches used to manage domestic solid waste, and identify research gaps that need to be addressed to achieve sustainable domestic solid waste management outcomes.

2.1 Major issues of solid waste management in developing countries

Waste management problems are more significant in developing countries as a result of political context, poor infrastructure, technical, social, organizational capacity, and regulatory and legal challenges (UNEP, 2005; Nigatu et al., 2011; Guerrero et al., 2013; da Silva et al., 2019). According to Kasay (2014), it is difficult for human activities not to generate waste, since all transformed materials have some form of waste as by-products. Tsheleza et al. (2019) showed that the capacity of generated waste globally is increasing faster than the rate of urbanization, meaning that more waste is being produced per capita. This arises as a consequence of economic development. Solid waste management is considered the major environmental and socioeconomic concern in urban areas especially in developing countries (Guerrero et al., 2013; Sibanda et al., 2017; da Silva et al., 2019).

Kasay (2014) shows that between 30% and 50% of generated waste in most developing world cities remains uncollected and can be found accruing in streets and watercourses, thereby posing hazards for human health and the environment. Most domestic solid waste in many developing countries is disposed of without consideration of its negative impacts (Lilliana et al., 2013). Waste management has, therefore, become an important issue for local municipalities in South Africa, as in other developing countries (Matete and Trois, 2008; Sibanda et al., 2017; Breukelman et al., 2019; Machete, 2019).

2.1.1 Drivers of poor domestic solid waste management in developing countries

Several previous studies have determined the factors affecting domestic solid waste management in developing countries (e.g. Kasay, 2014; Kwailane et al., 2016; Cobbinah et al., 2017). Local governments that are mandated to provide domestic solid waste management services to local communities often face difficulties that are beyond their ability to address, including infrastructure, financial problems, technology, and personnel training (Sujauddin et al., 2008; Abuenyi, 2010). This may be worsened by public ignorance and unwillingness to pay for waste management services, especially amongst disadvantaged communities (Abuenyi, 2010; Ndau and Tilley, 2018; Almazán-Casali et al., 2019) who believe that the government should provide waste management services free of charge (Akunnaya and Adedapo, 2016).

A study conducted in Nigeria by Akunnaya and Adedapo (2016) highlighted some of the challenges that local governments face regarding solid waste management. These comprise a lack of adequate road systems for waste collection trucks, inadequate fleet, lack of institutional capacity, and financial resources. Sánchez (2013) showed that the level of education has an influence on an individual's attitude, behaviour and knowledge towards waste management, including the willingness to partake in recycling programs and/or initiates and adopt other positive mechanisms to deal with solid domestic waste. This is also confirmed in other studies undertaken in Africa (Momoh and Oladebeye, 2010; Ndau and Tilley, 2018). Kenya has strong legislation, policies, and associated regulations and by-laws that deal with domestic solid waste management, but the government lacks adequate personnel to implement and enforce the laws (Njoroge et al., 2014). Similarly, the Botswana government is also facing the challenge of being unable to enforce waste management legislation (Tumelo et al., 2016).

According to Makwara and Magudu (2013), waste collection in Zimbabwe has collapsed drastically since 1990 due to political and economic circumstances. Mapira (2007) observed that urbanization continues faster than the provision and expansion of infrastructure, as well as planned services including water, electricity and sanitation. As a result, urban areas are now more polluted than semi-urban areas. Musademba et al. (2011) indicated that inadequate solid waste management resulted in the cholera outbreak between 2008 and 2009 in Zimbabwe that killed approximately 3500 people.

2.1.2 Methods of handling domestic solid waste at the household level

Many studies in Africa highlight the problems with decision-making and waste strategies undertaken by householders (Bundhoo, 2018). Akunnaya and Adedapo (2016) considering households in Nigeria's Ayobo state revealed that the majority of household waste consists mainly of food waste, followed by other recyclable products such as glass and plastics. The study found that the majority of participants prefer to store waste and burn it, as they believed that this is better in order to avoid health hazards. In Zimbabwe, Musademba et al. (2011) showed that due to lack of local government services, participants have resorted to disposal by dumping in open pits, burying and burning of waste. Illegal dumping also takes place on street corners.

Similar management practices of domestic solid waste are also found in South Africa (Mbiba, 2014; Wernstedt et al., 2020), in particular through student projects examining case studies of domestic solid waste management within informal or township settlements (e.g. Rajpal, 2002; Nshimirimana, 2004; Kamara, 2006; Tahulela, 2017). These studies show the specific challenges faced by poor households in these settlement, and thus the role of socioeconomic conditions on both attitudes towards and practices of domestic waste management, and how municipal inefficiency compounds these challenges. Mabadahanye (2017) in Thulamela Local Municipality, South Africa, found that householders manage generated waste in any available ways because the community does not receive waste management services from the local municipality. As a result, individuals burn flammable waste in an open pit, and inflammable waste such as napkins, glass bottles, and tins are usually separated and disposed of in open illegal dumpsites (e.g. Rodseth et al., 2020).

Although the practice of domestic waste recycling is also considered, the attitudes of householders vary with significant limitations on the capacity of households to undertake recycling, including their lack of knowledge, lack of information from the municipality, and how waste segregation can be undertaken at home (Mbiba, 2014; Dlamini et al., 2017).

2.2 Effects of inadequate solid waste management

Inadequate domestic solid waste management has resulted in poor hygiene within the home and has also impacted on access to clean water in most developing countries (Olufemi, 2014). Highlighted below are other effects of inadequate domestic solid waste management on the environment and socioeconomic aspects of developing world communities.

2.2.1 Environmental effects

Poor domestic solid waste management has several detrimental impacts on the natural environment. Uncollected waste tends to contaminate the ground and leads to loss of productive land (Mohammed and Eyasu, 2017). This, in turn, becomes a disadvantage to communities who rely on agriculture for survival even in urban areas. Moreover, natural indigenous vegetation is unable to thrive in contaminated soil, making the area susceptible to soil erosion by wind and rain (Tsega and Reddy, 2013). Some domestic solid waste releases contaminated fluid (leachate) which can infiltrate underground and contaminate groundwater resources. Waste burning and uncontrolled disposal contribute significantly to increased air pollution with associated environmental and human health effects.

Domestic solid waste that is thrown and/or swept into rivers tends to change the chemical composition of the water, thereby causing water pollution (Nwaopani, 2015). This has negative impacts on aquatic species, as well as humans and animals that use such polluted water (Inanc et al., 2004). Many rivers in South Africa are subject to different types of pollution including waste pollution, which can cause water quality problems (Kleynhans, 1996). This tends to decrease the integrity of the river's Present Ecological State (PES), as well as reduce the Ecological Importance and Sensitivity (EIS) of the river, making it incapable of supporting certain ecosystems and maintaining biodiversity in the catchment (Table 1).

Table 1: Description of Ecological State categories (source: Kleynhans, 1996).

Category	Mean Score	Description
A	>4	Natural with no modification.
B	>3 to 4	Mostly natural with minimal modifications of natural aquatic habitats.
C	>2 to 3	Relatively changed, with minimal loss of natural aquatic environment.
D	1 to 2	Significant loss of ecosystem functions including the natural habitats.
E	>0	Extensive disruption of natural riverine ecosystem.
F	0	Completely disturbed with comprehensive loss of natural habitat.

Table 2 shows that the integrity of watercourses with a category rating of A and B is deemed high, category rating of C is considered to be medium, while category ratings D, E and F are deemed to be Low.

Table 2: Ecologically Important and Sensitive water quality categories (source: Kleynhans, 1996).

EIS Categories	Median Range	Category
Highly ecologically important watercourses with a major role in supporting the water quantity and quality of major rivers.	Very high 3 - 4	A
Moderately ecologically important watercourse with minimal support to major rivers.	High 2 - 3	B
Relatively ecologically important watercourse with little support to major rivers.	Moderate 1 - 2	C
Insignificant ecologically important watercourses with an insignificant role in supporting the water quantity and quality of major rivers.	Low 0 - 1	D

2.2.2 Human health effects

Inadequate domestic solid waste management results in poor domestic hygiene and can attract rodents, insects and other household pests, which can cause gastrointestinal parasites, worms, yellow fever and other conditions, and causing various other diseases (Mohammed and Eyasu, 2017). Waste collectors including scavengers and people residing close to such areas suffer the most in terms of their health impacts (Fakere et al., 2012). Burning of solid waste has potential risks of burning injuries to people, mostly children (Mathee et al., 2000), and fumes from burning waste result in respiratory infections (Musadamba et al., 2011).

Furthermore, waste dumps usually contain gas cans or old aerosol cans that can easily explode. The discarded chemicals from households can also produce toxic smoke into the atmosphere (CSIR, 2011).

2.2.3 Socioeconomic effects

Uncontrolled solid waste management decreases neighbourhood property values (DEA, 2012). A dirty and unhealthy area makes it difficult to attract formal businesses, investors and tourists. These areas as a result often have a poor standard of living and may lose out on job and business opportunities (Mathee et al., 2000). Poor domestic solid waste management also reduces the aesthetic quality of the area, making it unattractive to potential commercial and residential developers (Yadav, 2018). The results of inadequate solid waste management also put a strain on local governments as they must continually clean up illegal dumpsites (DEA, 2012).

2.3 Challenges of solid waste management in South Africa

South Africa, as the most economically developed country in Africa, has attracted immigration from nearby countries (Karani and Jewasikiewitz, 2007). The country has strong legislation, policies, and regulations for solid waste management. According to the DEA (2012), the management of solid waste is framed by the principles of the waste management hierarchy (avoidance, reduction, re-use, recycling, recovery, treatment, and legal disposal), as this strategy can reduce the amount of municipal waste collected by local municipalities as well as the ways in which the waste is managed (e.g. Mupara et al., 2018). DEA (2012) further indicates that municipal solid waste contributes only 40% of the total waste generated in South Africa. However, waste poses greater health and environmental risks and also requires more funding to manage. Such municipal waste consists mainly of non-recyclable (e.g. food waste), organic waste (garden waste), recyclable waste (bottles, papers, etc.) and building rubble (DEA, 2012). Table 3 shows the annual municipal waste composition within Gauteng Province.

Table 3: Gauteng Province municipal waste composition (source: DEA, 2012).

Type of waste	Contribution volume (%)
Non-recyclable	40%
Organic waste	15%
Recyclable waste	25%

Type of waste	Contribution volume (%)
Building rubble	20%

Table 3 shows that approximately 25% of waste produced within Gauteng Province can be recycled. This is similar to the proportion of recyclables in other parts of Africa (Kaseva et al., 2002; Bundhoo, 2018).

Recycling plays an important role in landfill space reduction (Ogola et al., 2014; Dlamini et al., 2019). There is however limited or no separation of different waste streams in some areas in South Africa due to the absence of recycling in municipal waste management strategies (Godfrey and Oelofse, 2017).

The informal sector (street waste pickers) has been successful in closing this gap despite the lack of necessary support (Schenck et al., 2016; Simatele et al., 2017; Hettiarachchi et al., 2018). Many local municipalities in South Africa are faced with domestic solid waste management service delivery difficulties (CSIR, 2011). Highlighted below are major challenges that most South African local municipalities are currently faced with.

2.3.1 Rapid population growth

The growing South African population is characterized by both urban growth and immigration to urban areas, and this is currently posing challenges to most cities to provide adequate waste services for their residents (DEA, 2018; Machete, 2019). Gauteng is the fast-growing province in South Africa (Figure 2) and this has increased demand for domestic solid waste management service provision (DEA, 2018). Gauteng mainly consists of both higher and middle-income class individuals, who tend to generate more waste as they can afford to purchase more products (Mupara et al., 2018).

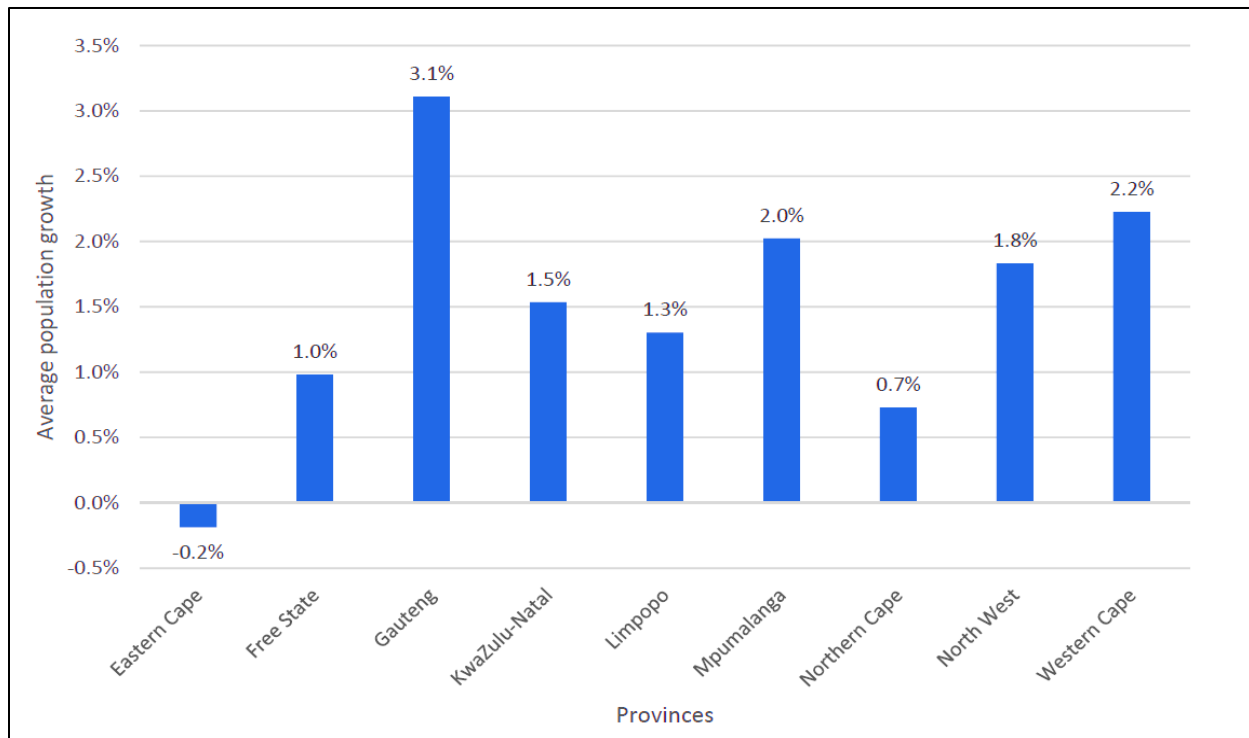


Figure 2: Average annual population growth per province (2013-2017) (source: DEA, 2018).

2.3.2 Inadequate organizational capacity

Most municipalities do not have enough capacity and resources to fully execute the implementation of solid waste management strategies. The waste removal service is not effective, mainly due to old trucks and equipment as well as staff shortages (CSIR, 2011). There is also a lack of trained personnel to monitor and enforce residence to comply with the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) including municipal By-laws (CSIR, 2011). In most cases, unqualified staff without relevant experience and skills are employed as managers instead of qualified individuals, which can lead to poor delivery of waste management services (Fakoya, 2014).

2.3.3 Illegal dumping and littering in open spaces and unmanaged parks

The Department of Environmental Affairs and Development Planning (2017) indicated that illegal dumping demonstrates poor waste collection services and limited community awareness of solid waste management practices, particularly issues pertaining to waste prevention, reduction, reuse, and recycling (e.g. Breukelman et al., 2019).

However, waste management awareness is being conducted in most areas of the country, especially urban areas where waste generation is high, but illegal dumping persists which might be due to lack of cooperation or ignorance by the public (Fakoya, 2014). Moreover, open spaces and unmanaged parks provide easy access for illegal dumping perpetrators, as no one is managing or monitoring their usage. Lack of accessibility to informal settlements also promotes illegal dumping as there are no adequate means of waste collection in such areas (CSIR, 2011).

2.3.5 Increased costs of solid waste management

Domestic solid waste management is categorized as a lower priority in budget allocation and funding of solid waste programmes by municipalities and other spheres of government (Ogawa, 2005). Lack of funds may restrict waste management operational costs such as fuel, salaries, maintenance, as well as lack of capital to replace old vehicles and equipment (Puopiel, 2010). Such issues are promoted by the lack of willingness of communities to contribute financially towards waste management services, thereby reducing municipal revenue. According to CSIR (2011), other drivers of poor domestic solid waste management in South Africa include:

- Poorly designed collection routes make it impossible to access most of the area effectively;
- Insufficient funds for waste collection (i.e. absence of cost recovery);
- Lack of waste reduction promotion amongst communities (re-use, re-purpose, recycling, etc.);
- Insufficient public awareness which results in unnecessary littering and burning of solid waste;
- The inefficiency of organizations in providing resources required for operation and staff training;
- Historical accumulation of waste in informal settlements; and
- Insufficient buyback centres in order to support waste pickers/scavengers.

2.4 Contextualizing municipal solid waste management in the City of Johannesburg

According to the City of Johannesburg (2011), the Johannesburg area has the highest share of South Africa's employment opportunities and GDP. This therefore attracts people looking for employment as well as career improvement. All these issues contribute to increased domestic solid waste generation resulting from population growth.

The City of Johannesburg has appointed Pikitup (Pty) Ltd as a waste management utility to ensure the provision of waste management services to communities under the jurisdiction of the city. The City of Johannesburg has an Integrated Waste Management Plan (IWMP), a requirement of the National Waste Management Strategy, which is also incorporated in the municipal Integrated Development Plan (IDP). The IWMP aims to advance the municipality's solid waste management services in order to minimize financial costs and improve the quality of life to all residents (CoJ, 2011). Although the City of Johannesburg has an IWMP, domestic solid waste management services are still inadequate in many areas (Kubanza and Simatele, 2020). Highlighted below are some of the most significant waste management issues within the City of Johannesburg.

2.4.1 Domestic solid waste collection

Pikitup currently provides the waste collection service in all formal and most of the informal residential as well as business areas (CoJ, 2011). Each household from the formal settlement is provided with one 85ℓ plastic bin, whereas some of the informal settlements are not provided with plastic bins, however, 11 m³ bulk containers are placed outside the informal settlements due to lack of accessibility to these areas by vehicles (CoJ, 2011). Moreover, the waste collection service by Pikitup is usually unreliable mostly during strikes, and this contributes to increased illegal dumping in open spaces in both formal and informal settlements, as well as localized burning of uncollected domestic solid waste.

2.4.2 Waste management community awareness

Different programmes have been undertaken within communities and in schools as part of the public participation process, and these include educational awareness; clean-up campaigns against illegal dumping and littering; and use of art and posters to communicate messages on waste management (CoJ, 2011; Kubanza, 2020). Although awareness campaigns are being conducted in most areas of the city, littering and illegal dumping still take place.

2.4.3 Compliance monitoring and enforcement of Waste Management By-laws

Enforcement and monitoring of municipal waste management by-laws is still a challenge. According to the City of Johannesburg (2011), the mandate of waste management compliance and enforcement lies with Johannesburg Metropolitan Police Department (JMPD).

However, the appointed officials do not have relevant knowledge to enforce these By-laws, as such the compliance and enforcement tasks are conducted by the City of Johannesburg Environmental Health Department (CoJ, 2011). Moreover, there is no formal linkage between JMPD enforcement section with the associated City of Johannesburg waste management sections (CoJ, 2011).

2.5 The importance of sustainable solid waste management practices

Sustainable solid waste management practices assist in advancing public health outcomes by decreasing the spread of disease which occurs due to unregulated dumping sites (Mathee et al., 2000). Appropriate solid waste management enhances the quality of the natural environment through the protection of water bodies, and the prevention of littering. Furthermore, well-planned solid waste management practices can also support economic activities as well as contribute directly towards poverty alleviation through job creation (Lindell, 2012; Simatele et al., 2017).

2.6 Summary

According to the literature reviewed, domestic solid waste management is still a challenge in many developing countries, despite all measures and initiatives undertaken to address this issue. Some of the contributing factors include population growth, lack of capacity within local government, and lack of funding to provide domestic solid waste services.

The City of Johannesburg has developed solid waste management strategies, regulations and By-laws to assist in the management of domestic solid waste management in the city, and different programmes such as community educational awareness and cleaning campaigns have been undertaken. However, domestic waste collection services are erratic and inconsistent, and littering and illegal dumping still takes place. Poor domestic solid waste management therefore results in a variety of negative environmental, social and economic impacts. As such, this study seeks out to investigate the cause of poor domestic solid waste management as well as to determine measures to be implemented to address this issue.

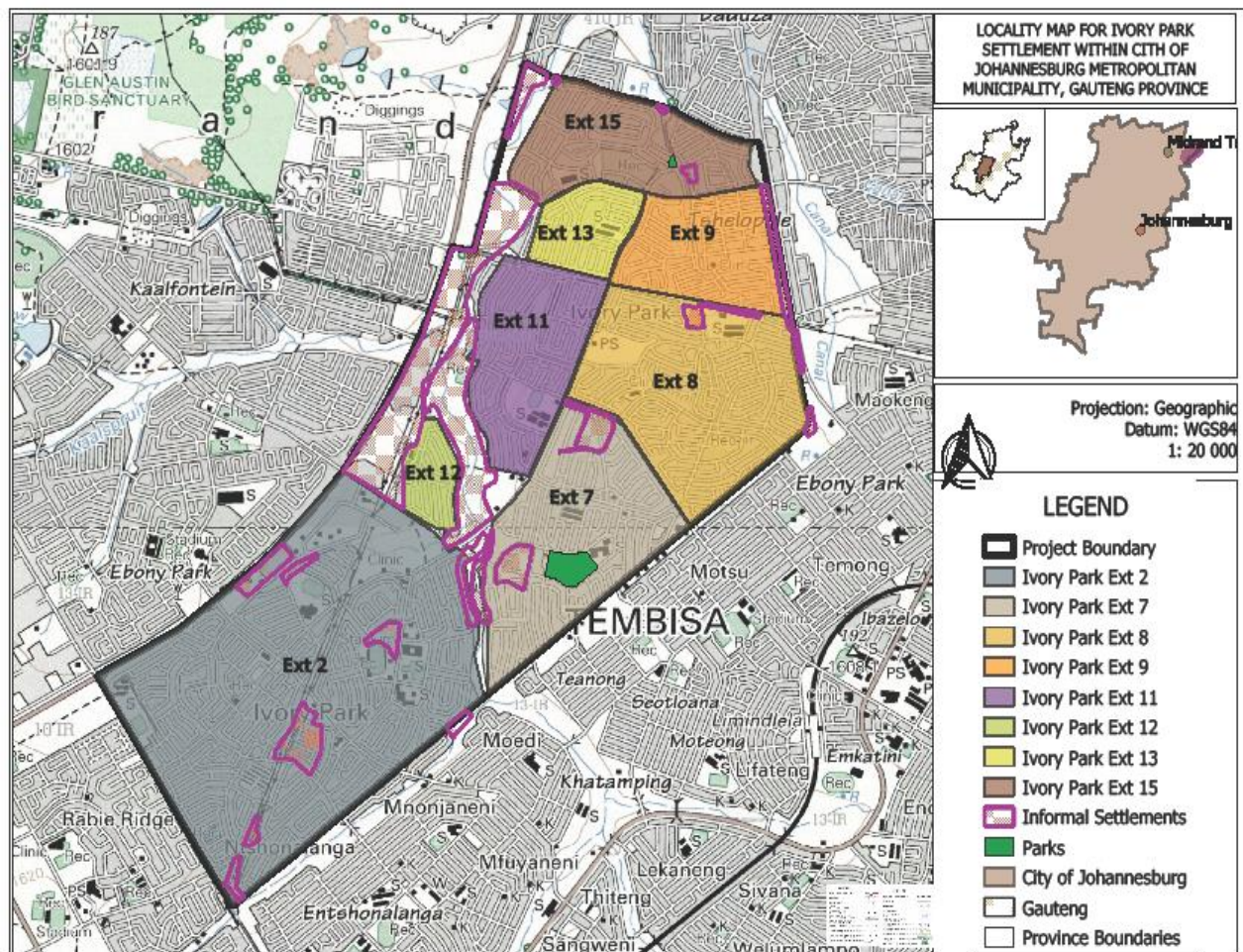


Figure 4: Subareas within Ivory Park (source: K. Rambuda, 2019).

3.2 Study area characteristics

Ivory Park is characterized by formal township development, consisting of a mixture of self-build houses, Reconstruction and Development Programme (RDP) houses, corrugated iron shacks, and other housing types, with most of the household's units containing backyard rooms. The area has two formal public green spaces (Figure 4), and the rest of the township's open spaces are left unattended and are in turn used as dumping sites and invaded by squatter camps. The township has litter almost everywhere on the streets with piles of solid wastes on most street corners. Ivory Park has been involved in the government-funded Community Work Programme, part of which involves employing and training residents on waste management.

3.3 Biophysical factors

3.3.1 Hydrology

There is one perennial river (Kaalspruit River) which passes through Ivory Park. The river is heavily populated from illegal dumping, sewage effluents and runoff from informal settlements and businesses. Figure 5 shows evidence of water pollution within the Kaalspruit River.



Figure 5: Water pollution in the Kaalspruit River within Ivory Park (source: K. Rambuda, 2018).

3.3.2 Infrastructure

Many households within the formalized area of Ivory Park have access to electricity, whereas most households of the informal settlement rely on gas, coal and paraffin stoves for cooking which has negative impacts on ambient air. The area has adequate main road infrastructure, which is easily damaged by overflowing sewage effluents and runoff water due to poor stormwater management. Most of the internal streets are not tarred. Other parts of the formalized area have access to sanitation and clean running water. However, residents of the informal settlements make use of pit toilets without ventilation and candles for lighting. The settlement has a clinic, police station, fire station, two libraries, two community hall, four schools, a soccer field, and two shopping complexes (Figure 6).

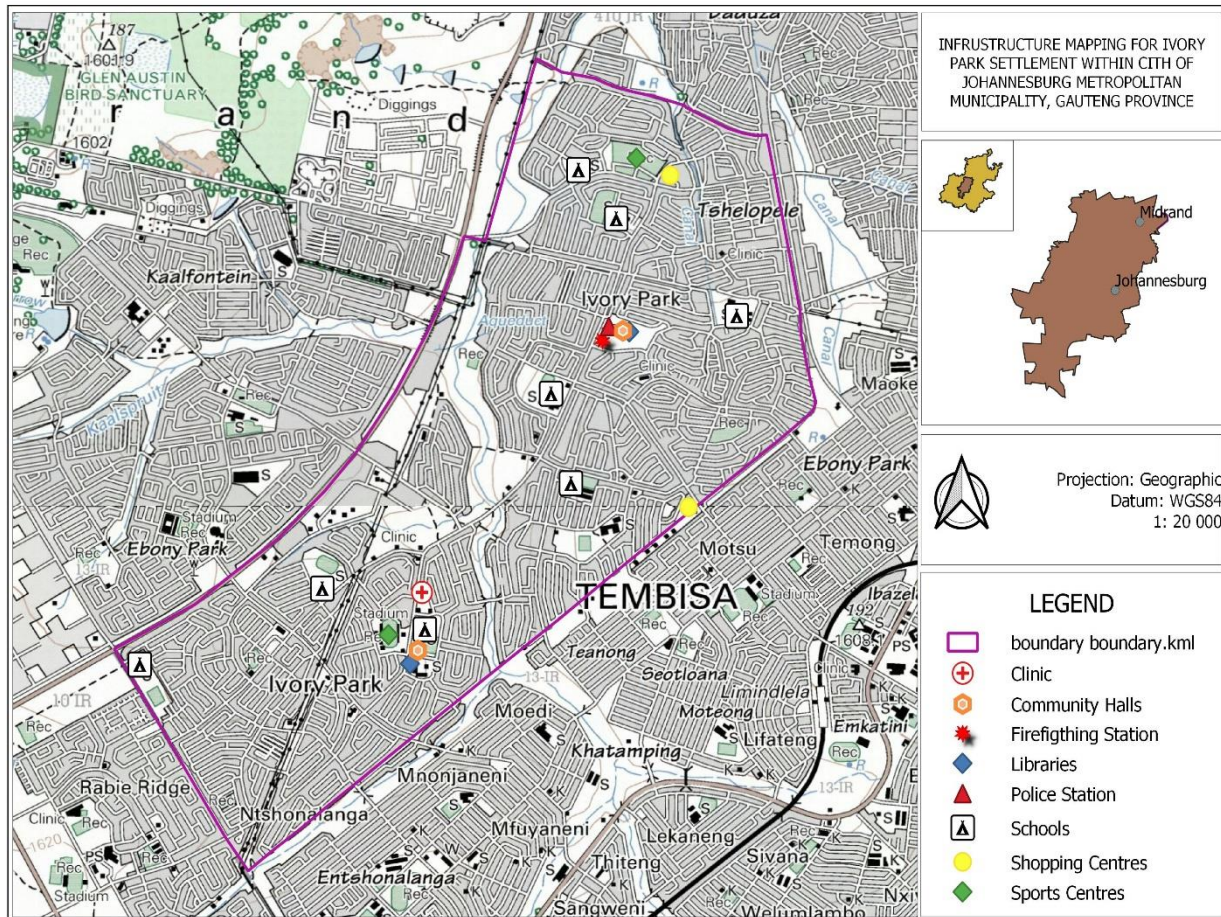


Figure 6: Public infrastructure within Ivory Park (source: K. Rambuda, 2020).

3.4 Socioeconomic characteristics

3.4.1 Population size

According to Statistics South Africa (Stats SA) (2016), Ivory Park consists of 68 299 households with a population size of 184 238, with Sepedi and IsiZulu being the dominant languages. The area is overcrowded due to urbanization and migration, which has resulted in houses overlapping on pavements and iron shacks erected in most backyards (CoJ, 2010). The majority of households have backyard rooms for renting purposes, which might also increase the quantity of domestic solid waste produced per stand.

3.4.2 Economic activities

Generally speaking, a country's economic status and the level of revenue per capita per month determines the quantity of waste generated (Imoh and Emmanuel, 2011; Rodseth et al., 2020). Ivory Park has many informal small businesses (spaza shops), which are mostly owned by immigrants (CoJ, 2010). According to DEA (2011), economic growth in most townships contributes to various waste management challenges, such as historical waste services backlog. Figure 7 shows that approximately 23.7% of the Ivory Park population receives a monthly income of R19 601–R38 200. About 22% of the population does not have any source of income.

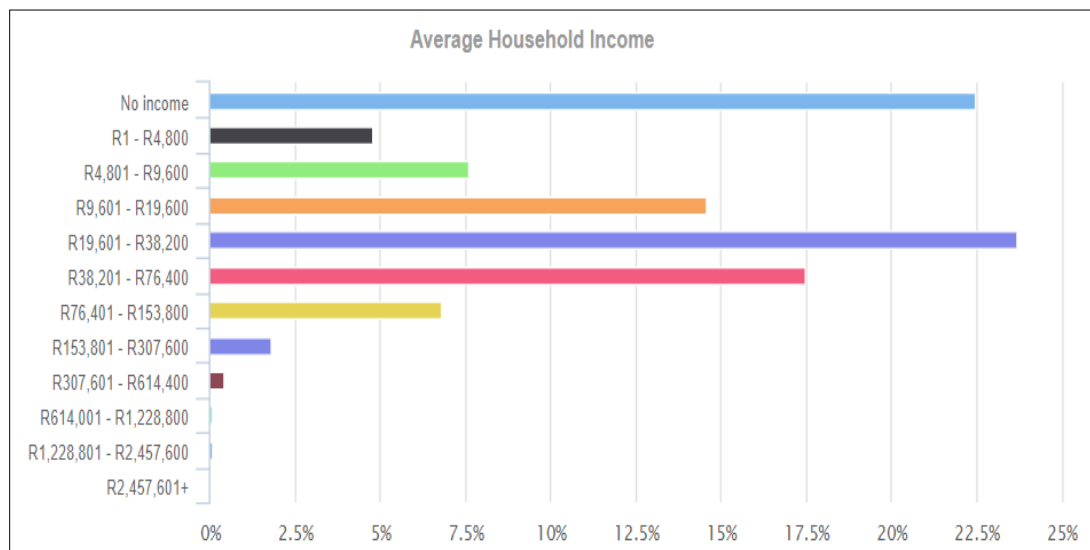


Figure 7: Income category per capita per month in Ivory Park (source: Stats SA, 2016).

3.4.3 Employment status

In terms of employment levels in Ivory Park, about 34% of residents are employed (mostly self-employed), whereas 18% of the residents are unemployed (Stats SA, 2016) (Figure 8). A study conducted by DEA (2011) reveals that affordability also contributes to the generation of more household's waste quantity.

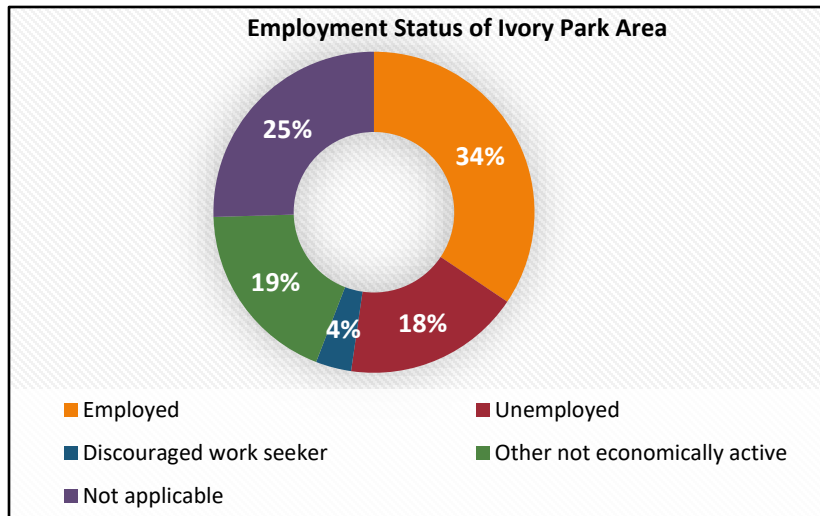


Figure 8: Employment status in Ivory Park (data source: Stats SA, 2016).

3.4.4 Educational level

Stats SA (2016) breaks down educational levels into each year of study, and for this study, educational levels are grouped into key schooling (primary and secondary) and higher educational categories. Most people in Ivory Park are still at the secondary level. Of note is that only 5% of residents have tertiary level education (Figure 9). According to Sánchez (2013), education level has a significant influence on individual attitudes, behaviours and understandings of household solid waste management.

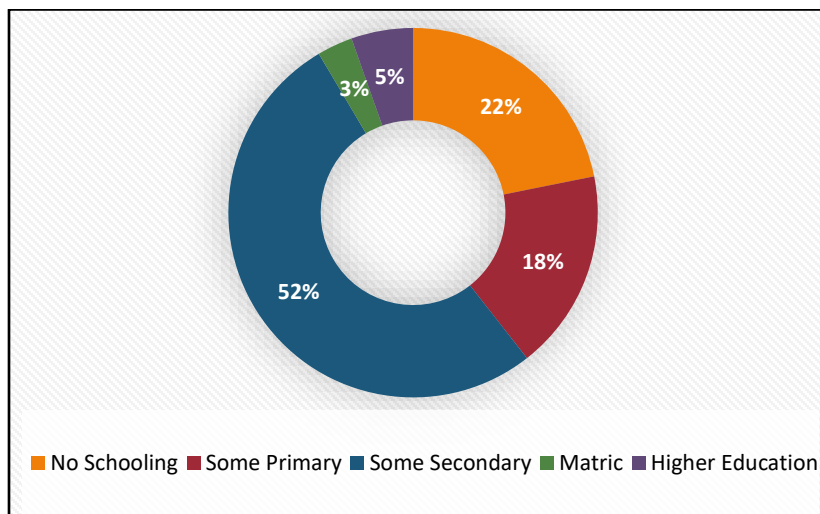


Figure 9: Educational level in Ivory Park (data source: Stats SA, 2016).

3.5 Domestic solid waste management within Ivory Park

Pikitup has the responsibility of ensuring that there is adequate domestic solid waste management within Ivory Park. Refuse collection takes place weekly as follows (Table 4):

Table 4: Pikitup collection schedule within Ivory Park (source: Pikitup Collection Schedule, 2019).

Section	Collection Schedule
Ivory Park 2	Tuesday
Ivory Park 7	Monday
Ivory Park 8	
Ivory Park 9	
Ivory Park 11	Thursday
Ivory Park 12	
Ivory Park 13	
Ivory Park 15	Friday

Considering the schedule, it can be said that there should be adequate domestic solid waste management within the area. However, littering and illegal dumping still take place.

3.6 Summary

This chapter provides a description of the study area and the overall setup of the area. It has also described the biophysical (hydrology and infrastructure) and socioeconomic (population, economic status, employment, and educational level) aspects of the area. The current waste management collection schedule is also discussed. The physical infrastructure of Ivory Park, including the geography of roads, municipal buildings, and residential/commercial areas have implications for the locations where solid waste will be generated, and the potential management structures and practices (refuse storage locations and vehicle accessibility) that can be used in the area.

CHAPTER 4: METHODOLOGY

This chapter outlines the methodology used to conduct this study. It also describes the research design and sampling methods used for data collection and analysis.

4.1 Research design

A quantitative and qualitative approach was adopted to investigate the drivers of domestic solid waste management practices as well as identify appropriate measures that can be implemented to develop more sustainable waste management practices in Ivory Park. The study collected data from both primary and secondary sources using different techniques. Primary data were collected through field observations of individual behaviour and habits regarding domestic solid waste management, questionnaire survey and key informant interviews with community individuals and government officials responsible for domestic solid waste management. Secondary data were obtained from a desktop study on the background of the study area, the reviewed literature, the City of Johannesburg Integrated Waste Management Plan including relevant municipal By-laws and Pikitup policies. This approach and the use of primary (interview/questionnaire) and secondary data has been used in previous studies on solid waste management in South Africa (e.g. Jatau, 2013; Dlamini et al., 2017; Almazán-Casali et al., 2019; Kubanza, 2020), and in detailed studies on solid waste management practices within informal or township settlements (e.g. Rajpal, 2002; Nshimirimana, 2004; Kamara, 2006; Tahulela, 2017).

4.2 Research sampling

Ivory Park consists of eight formal and several (approximately 10) informal settlements. Two formal and informal settlements were purposefully selected to participate in the **questionnaire survey** of the study. Themba Khoza was selected to represent the informal settlement, whereas Ivory Park Extension 11 and 13 were selected for the formal settlements. The settlements were selected based on the following:

4.2.1 Informal Settlement

Themba Khoza is the biggest and oldest informal settlement in Ivory Park and has been in existence for approximately 17 years. Based on this, it was believed that people residing within Themba Khoza can provide valuable information on waste management practices within the informal settlement.

4.2.2 Formal Settlement

Ivory Park Extension 11 and 13 are located in close proximity to Themba Khoza and the two settlements are separated by Kaalspruit River. As such, these two settlements can be more easily compared due to their proximity concerning service provision. The researcher is also a local and has specific knowledge of these areas.

The questionnaire sample comprised 40 households (20 households from the formal settlements and 20 households from the informal settlements) which were randomly selected following systematic sampling along certain streets within the Extensions. Selection of individual participants was based on the following:

4.2.3 Availability of adult individuals

For this study, only adult individuals (18 years and above) from the households were randomly selected to participate in the questionnaire survey. The researcher only engaged with households where there was an adult present who permitted the researcher to enter the household.

4.2.4 Consent to participate

The questionnaire survey was conducted after the individual gave consent (both verbally and written) to participate in the survey. From the selected 40 households, eight of the participants (four from each settlement) only gave verbal consent to participate and as such their questionnaire responses were excluded from the study. The number of households engaged (40) was guided by the saturation principle. According to Benjamin et al. (2018), saturation is when the collected data are sufficient for the intended analysis. Based on this, the sample of 40 households were deemed adequate to achieve the research objectives.

Ten individuals, five from the selected formal and five from the informal settlement, were selected for **key informant interviews**. The individuals were selected based on their interest to share more information regarding the research subject as compared to other individuals who participated in the survey. Eight municipal officials who are appointed to assist with solid waste management in Ivory Park were also invited for interview. This includes one official from Pikitup (Region A); two officials from City of Johannesburg Municipality (Waste Management, Environmental Health, and By-laws enforcement), one official from City Parks (Region A), and four ward councillors (in wards 77, 78, 79 and 111).

The officials were first contacted telephonically and via email in order to give the background of the study, as well to secure appointments for the interview. Consent was given by the individuals prior to the interview.

4.3 Primary data collection

The primary data were gathered through field observation, questionnaires and key informant interviews, which are described below.

4.3.1 Field observations

The field investigation involved observing the study area to assess individual behaviour and habits regarding domestic solid waste management. The following aspects were assessed during field observations:

- The days (during the week) where illegal dumping is more intense;
- The preferred areas for illegal dumping;
- Waste collection frequency by Pikitup; and
- The environmental impact caused by illegal dumping.

The field observations were conducted twice for each settlement. The first observation was done on the day of scheduled collection day to assess the collection consistency as per the Pikitup collection schedule. The second observation was done three days after collection day to assess the accumulation rate of generated domestic solid waste. Field notes on waste dumping patterns and characteristics were taken during field observation. Photos (with date stamps) were also taken as evidence of the observed activities and the locations of areas prone to illegal dumping. This assisted in mapping all areas where dumping is prevalent, and in identifying measures that can be undertaken to safeguard such areas.

4.3.2 Questionnaire survey

A questionnaire survey was used to acquire information from households that were randomly selected. The sampling comprised of 40 households made of 20 households from two formal settlement (10 households each) and 20 households from two informal settlements (10 households each). Guidance on the code and conduct regarding the engagement of individuals was required from community leaders.

The questionnaire was developed in English but the researcher explained all the questions in local languages (Sepedi and/or IsiZulu) to participants where required. Moreover, the majority of participants were able to complete the questionnaires without the assistance of the researcher. The questionnaire was structured to gather information regarding the following aspects:

- Number of households per stand;
- Number of occupants per household;
- Availability and size of the waste bins for domestic waste storage;
- Frequency and mode and of the domestic solid waste collection;
- Approaches of domestic waste disposal in case of waste bins overflow;
- Level of municipal service payment;
- Factors contributing to poor domestic solid waste management;
- Knowledge on environmental, health and socio-economic impact of poor domestic solid waste management;
- Knowledge of municipal Waste Management By-laws and level of compliance;
- Community initiative towards sustainable domestic solid waste management;
- Initiatives that can be undertaken to curb littering and illegal dumping;
- Proposed improvements to Pikitup; and
- Required intervention from the City of Johannesburg.

The questionnaires were deployed for each settlement (informal and informal). However, the formal settlement questionnaire differed slightly from the informal settlement, as it included questions on the number of individual households (backyard rooms) within a stand, and level of municipal service payment, which were not asked at the informal settlement. This was motivated by the fact that informal settlements do not/are not expected to pay municipal rates, and do not have space to accommodate backyard rooms.

The surveys were pre-tested at Ivory Park (study area) prior to the full questionnaire being conducted. This assisted to understand if the community felt comfortable in responding to the survey; to verify if the questionnaire is not too long, and to ascertain issues that should be omitted or included within the questionnaire.

4.3.3 Key informant interviews

Individual interviews were undertaken with key stakeholders working in the solid waste management sector pertaining to Ivory Park, as it is believed that they are likely to provide viable information pertaining to the research objectives from the management perspective. Moreover, ten individuals from both formal and informal settlements were also interviewed as they could provide valuable information regarding community practices based on their experience on poor domestic solid waste management within Ivory Park. For this research, interviews were recorded (with individual consent) and transcribed as this assisted the researcher to fully interact and engage in the conversation. Table 5 describes the key stakeholders, their responsibilities and the type of data that the study required from them.

Table 5: Interview data collection.

Institution	Roles and responsibility regarding solid waste management	Type of data required
City of Johannesburg (Waste Management, Environmental Health, and By-laws enforcement)	Source of waste management funds, develop and enforce policies and by-laws regarding solid waste management for the city including Ivory Park Township.	• Identified gaps in the Waste Management Policies and Regulations. • Costs necessary for waste management. • Challenges in implementing the Waste Management Policies and Regulations. • Challenges regarding By-laws. • Resource and capacity for waste management. • Required Intervention.
Pikitup (Region A)	Pikitup is mandated to provide skips, collection, and disposal of domestic solid waste.	• Sections receiving waste collection service • The number of dustbins provided. • Transportation of the collected domestic solid waste. • Encountered problems in managing waste. • Possible measures and required intervention.

Institution	Roles and responsibility regarding solid waste management	Type of data required
City Parks (Region A)	It is mandated to: • Manage parks and public open spaces, • Ensure the conservation of the natural environment through direct conservation action, education, research, and recreational activities.	• Current plans and challenges regarding open spaces management. • Community awareness on the management of open spaces. • Required intervention.
Ward councillors (ward 77, 78, 79 and 111).	Represent the communities and provide a bridge between the community and the council. Ward councillors will provide guidance on how to conduct a questionnaire survey within the area, considering different cultures.	• Code of conduct for community engagement. • Concerns regarding domestic solid waste management from the community. • Required Intervention.
Household individuals	They reside in Ivory Park and are currently experiencing the effects of poor domestic solid waste management.	• Factors contributing to poor domestic solid waste management. • Level of compliance with Municipal By-laws. • Community initiative towards sustainable domestic solid waste management. • Proposed improvements to Pikitup. • Required intervention from the City of Johannesburg.

4.4 Data analysis

Textual analysis was used to record, describe, interpret, measure and compare information acquired during data collection (field observation, questionnaires and key informant interviews).

According to Frey et al. (1999), it is vital to know and understand the appropriate types of texts to be analyzed, attaining suitable texts, as well as determine the best approach to employ in analyzing collected data.

For this study, the output of communication (responses from research participants) was used to understand the views of householders and responsible officials regarding domestic solid waste management in Ivory Park. Frey et al. (1999) further state that there are four major textual analysis approaches that can be used for data analysis, and these are content analysis, interaction analysis, rhetorical criticism and performance studies. For this study, a textual content analysis approach was used to identify, analyze and enumerate specific responses from individuals. The qualitative content analysis focused more on the deeper understanding and meanings of participants' responses, whereas quantitative content analysis focuses on enumerating and coding of the survey, observation and interview outcomes using tables and charts. This data analysis approach is most suitable for answering the aims and objectives of the study.

4.5 Summary

This chapter has described the methodology followed to acquire and analyse the required data for the study. Quantitative and qualitative approaches and different techniques were used to collect data from both primary and secondary sources. The research design, sampling (site selection, household sampling, design of field observations, questionnaire survey and key informant interviews) have been discussed in detail. The textual content analysis approach was used to analyse the collected data. The next chapter (Chapter 5) focuses on the presentation and discussion of the collected data.

CHAPTER 5: RESULTS, ANALYSIS AND DISCUSSION

This chapter presents the results of data collection through questionnaires and interviews, as well as visual evidence collected during field observation. The results are presented under the following themes: socioeconomic characteristics of the research participants; the types and quantities of waste generated by households; the level of community knowledge of handling of domestic waste; and proposed measures to address the poor domestic solid waste management issues in Ivory Park. The findings are further separated into subthemes and verbatim quotes from interviews are also incorporated.

5.1 Socioeconomic characteristics of the research participants

The socioeconomic statuses of both formal and informal research participants are presented under the categories of gender and employment status, age distribution, and educational level. It should be noted that from the 40 questionnaires, four from each settlement were not included as the consent forms were not signed.

5.1.1 Formal settlement

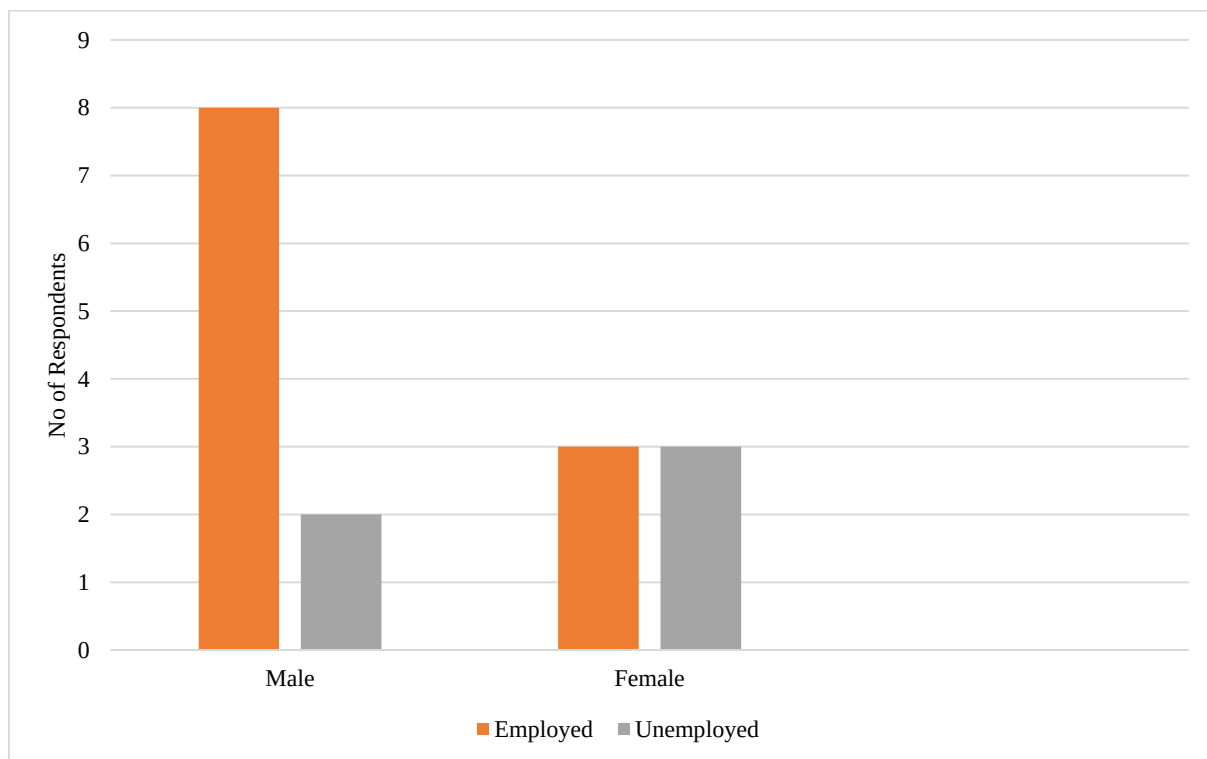


Figure 10: Gender and employment status of participant – formal settlement.

Figure 10 shows that 16 individuals participated in the formal settlement survey, of which 10 were males and 6 females. The majority of male participants were employed (8 of 10) compared to female participants (3 of 6). Half of all participants were between 18 and 30 (50%) as shown in Figure 11. Moreover, 56% of participants (9 of 16) finished education at the secondary level whereas 44% (7 of 16) of them have reached the tertiary level (Figure 12). This suggests a relatively good literacy within the formal settlement.

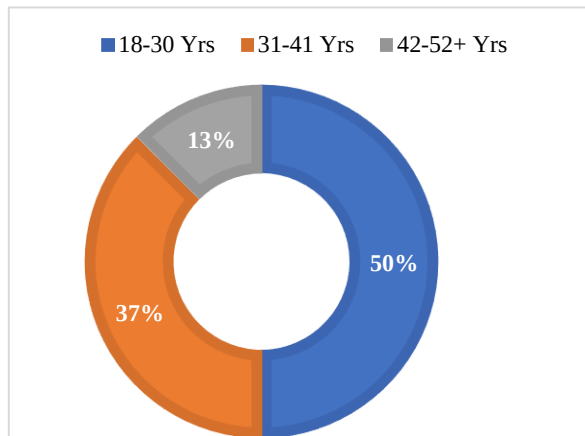


Figure 11: Age distribution – formal settlement.

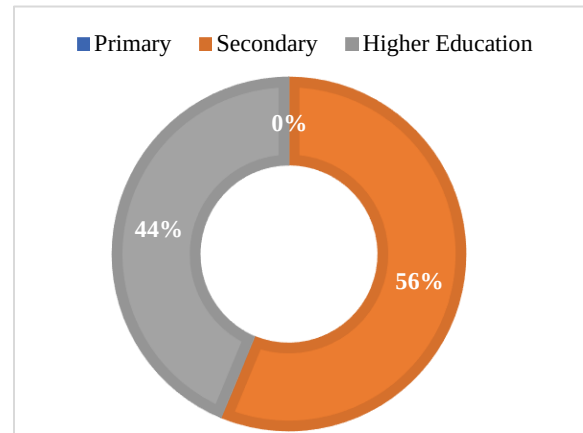


Figure 12: Education level – formal settlement.

5.1.2 Informal settlement

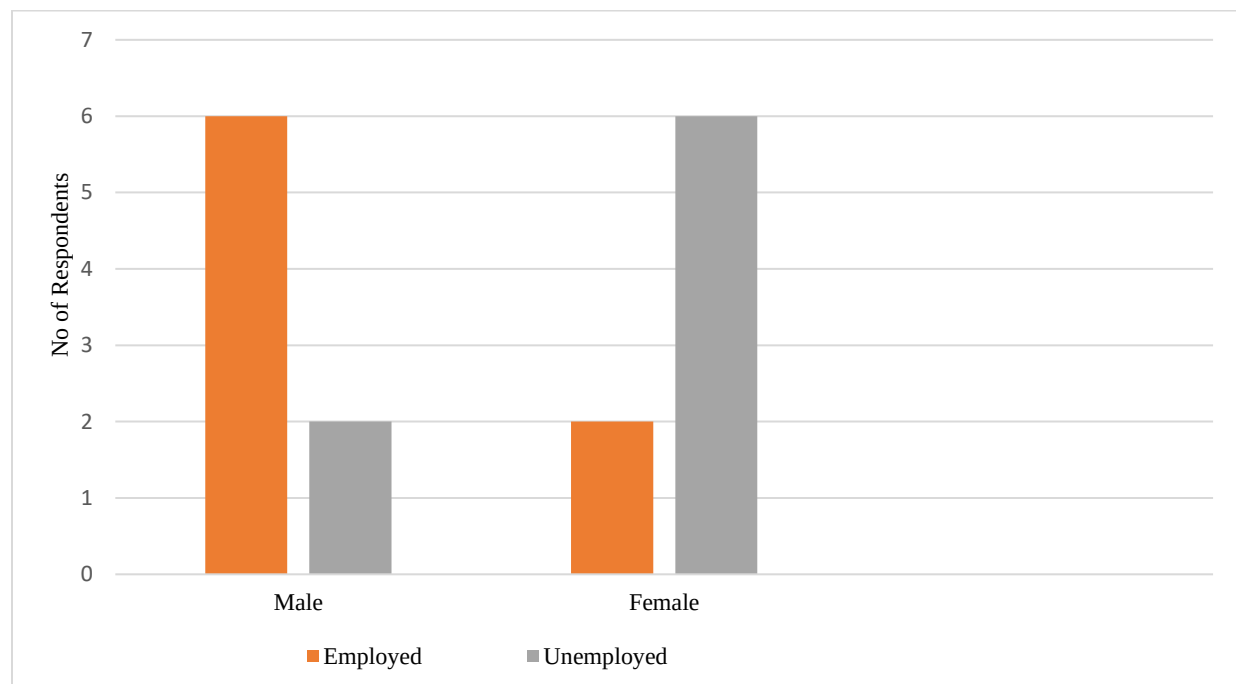


Figure 13: Gender and employment status – informal settlement.

Figure 13 shows that 16 individuals (8 males and 8 females) took part in the survey in the informal settlement. Half of the participants are 31-41 in age (Figure 14). The majority of participants (55%, 9 of 16) ended their education at the secondary level, whereas 38% (6 of 16) reached the tertiary level, which is lower than the formal settlement (Figure 15). The demographic characteristics of participants are therefore slightly different between the formal and informal settlements.

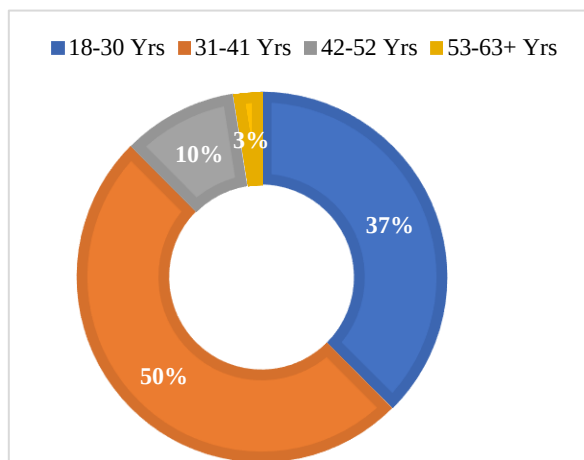


Figure 14: Age distribution – informal settlement.

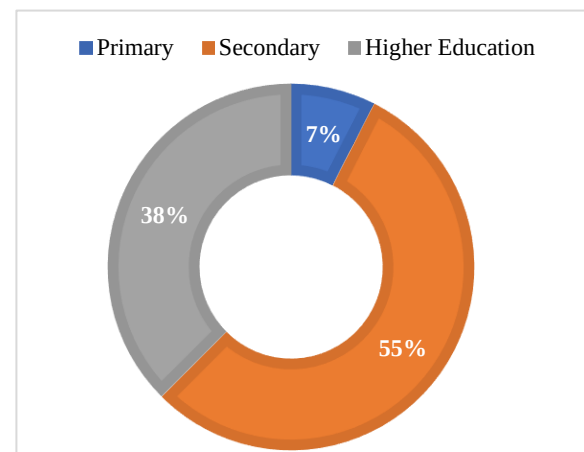


Figure 15: Education level – informal settlement.

5.2 The types and quantity of waste generated by households

To classify the types and to quantify of the volume of domestic solid waste generated from households, a general question was designed on the questionnaire (Appendix C) dealing with waste types (kitchen, recyclable, organic, toxic, building rubble, etc.) generated per week and the associated volume (ℓ) from domestic settings. The analysed responses are presented in Figures 16 and 17. Participants were also asked if they have backyards rooms and the number of such rooms in order to determine the relationship between the number of occupants and the volume of generated within households (Figures 18, 19).

5.2.1 Type of domestic solid waste generated from households

Kitchen and recyclable waste are the most common waste types within both formal and informal households (Figures 16, 17). These results are very consistent between settlement types. The results confirm the findings by DEA (2012) that the majority of municipal waste generated in Gauteng Province consists of non-recyclable waste (i.e. kitchen waste) with 40% followed by recyclable waste (25%).

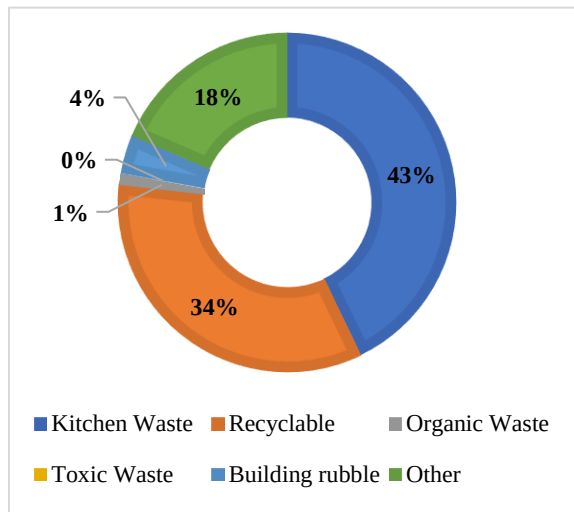


Figure 16: Type of waste produced – formal settlement.

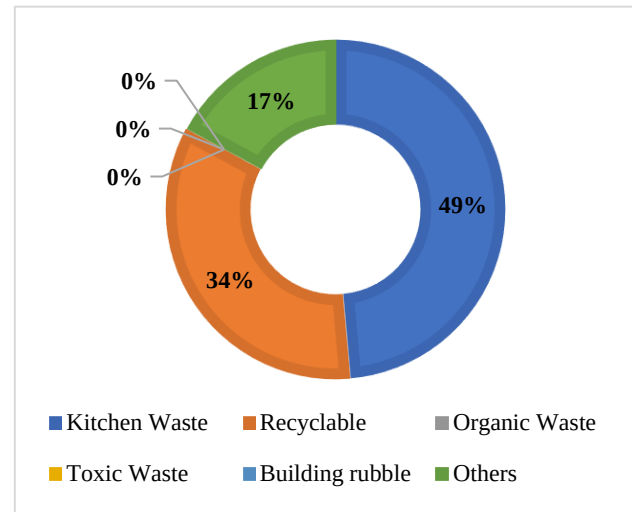


Figure 17: Type of waste produced – informal settlement.

The relatively high proportion of recyclable waste suggests there is an opportunity to reduce total waste volume produced by engaging in recycling (e.g. Kaseva et al., 2002; Mbiba, 2014; Mupara et al., 2018). This may also indicate opportunities through buyback centres, and more recycling awareness in the community (Nahman and Godfrey, 2010; Dlamini et al., 2019).

5.2.2 Quantity of domestic solid waste generated by households

From the formal settlement, it was noted that 14 of the participants have backyard rooms ranging from 2 to 9 backyard households. There were no backyard rooms in the informal settlement. This can be correlated with the volume of waste produced. Figures 18 and 19 show that the formal settlement generates more waste (average of 184ℓ per household per week) as compared to the informal settlement (average of 37ℓ of waste per household per week). Therefore the presence of backyard rooms at the formal settlement contributes to greater waste generation.

However, these results also indicate that the number of occupants within a household is not always proportional to the volume of waste produced. This was shown by the fact that some households with fewer occupants generated more waste than the expected average. For example, a household of 5 individuals is expected to generate on average 45ℓ of waste per week, instead of 30ℓ (Figure 18). This supports the findings by DEA (2018) that affordability contributes to the generation of more waste or more wasteful practices.

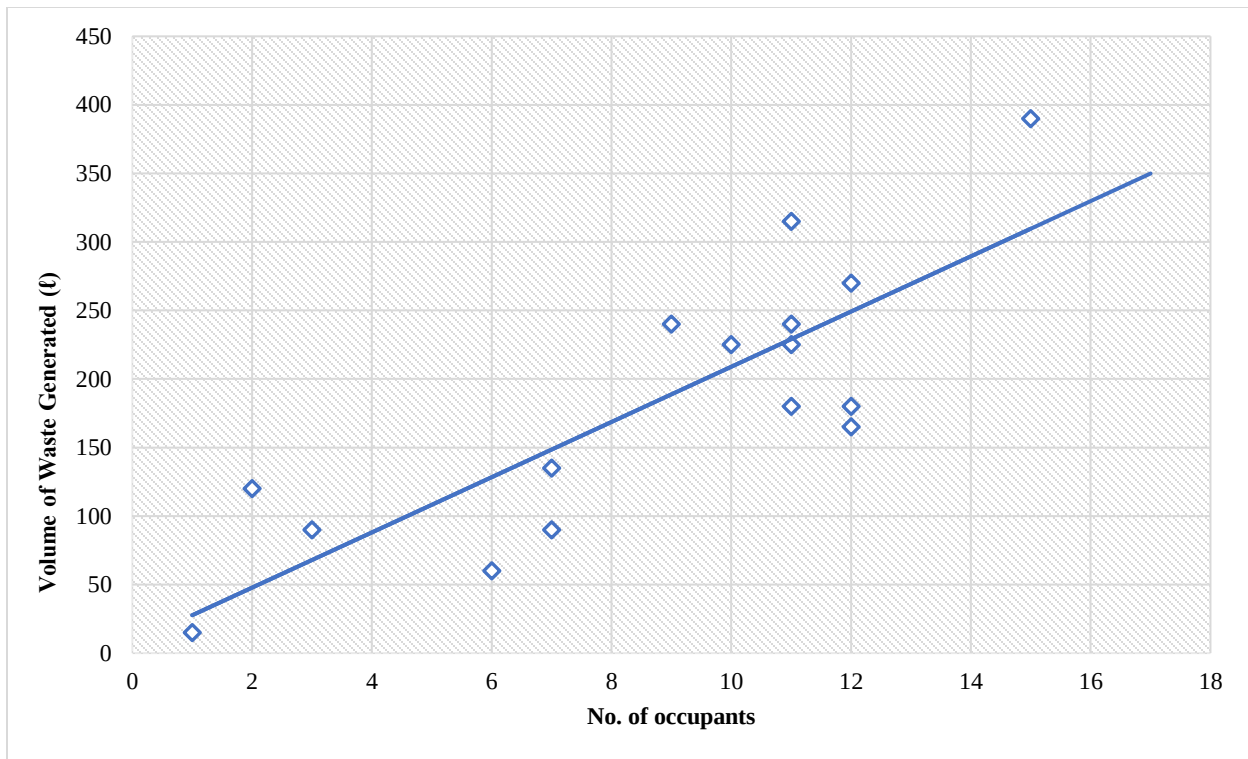


Figure 18: Quantity of waste generated by households – formal settlement.

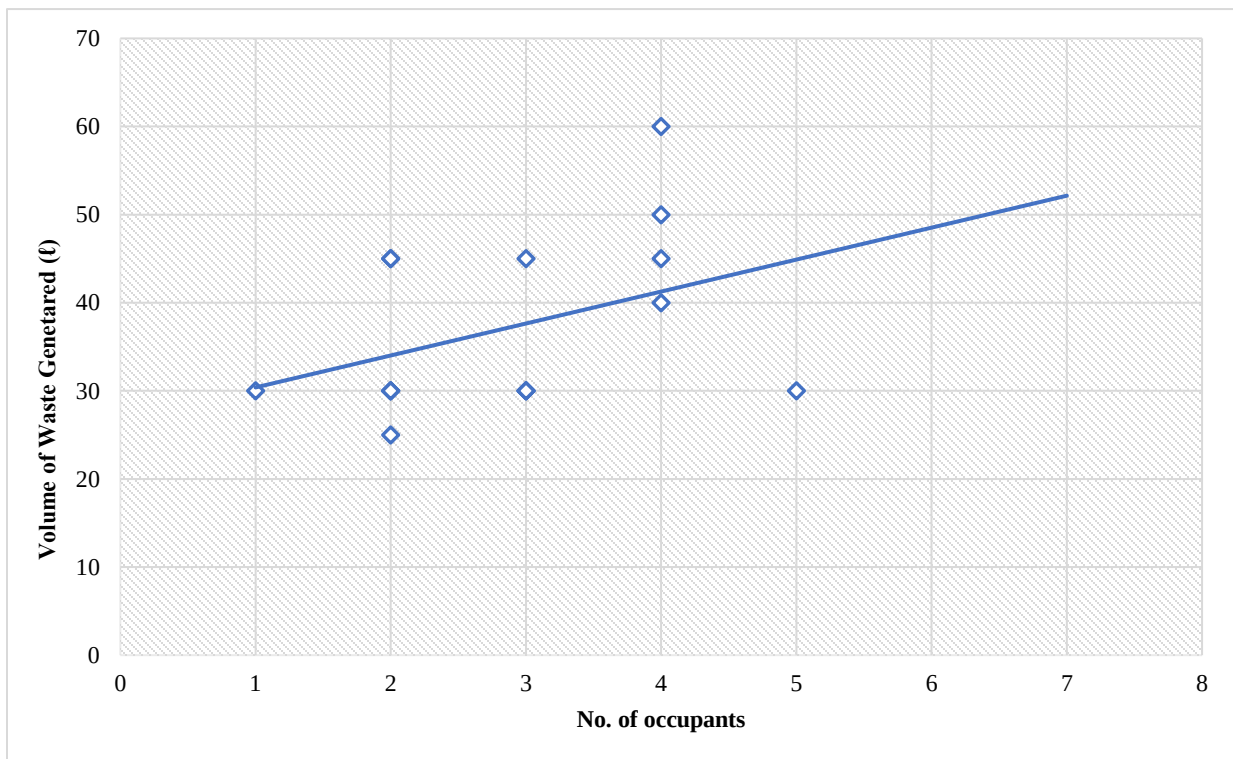


Figure 19: Quantity of waste generated by households – informal settlement.

5.3 The level of community knowledge on domestic waste handling

The level of community knowledge by individuals is presented in three subsections, focusing on their understanding of current municipal waste management practices, access to municipal waste management services, and perceptions of the effects of poor domestic solid waste management.

5.3.1 Understanding of current municipal waste management practices

According to the City of Johannesburg (2011), different waste management educational programmes have been undertaken by the municipality in Ivory Park. This then assumes that individuals in that the community should have adequate knowledge of waste management practices. Individual understanding of waste management was assessed based on knowledge regarding recycling, collection and disposal methods, and understanding of waste management by-laws. Results show that the majority of participants (60%) at both settlements are aware of recycling but that only 9% of them practice it (Figure 20). A significant minority (31%) do not have knowledge about recycling. These results are similar to previous studies that indicate that inadequate knowledge about recycling generally is compounded by a lack of information from local government on how and where to recycle (Ndau and Tilley, 2018; Almazán-Casali et al., 2019).

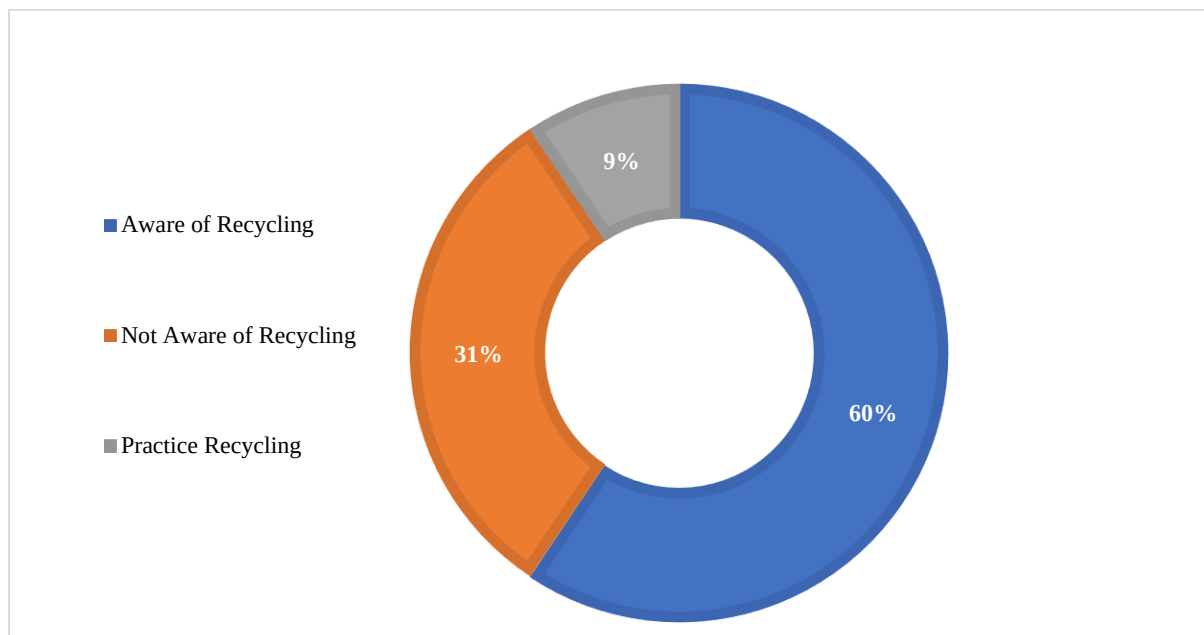


Figure 20: Knowledge and practice of recycling – formal and informal settlements.

Figure 21 shows that the majority of participants are not aware of or have participated in the awareness programme (84%) or are aware of municipal by-laws applicable to their area (88%). Thus, it can be deduced that the current waste management community awareness programmes are ineffective. A key informant interview with a City of Johannesburg official stated that *“We have conducted several environmental awareness together with the ward councillors. We have trained ward committees so that they also assist in spreading the word within their respective wards. However, there is usually ignorance from the community.”* Here the blame is ascribed to householders. There are thus multiple potential reasons for the cause of low, confusing or conflicting information on waste management. Kubanza (2020) states that there is a lack of communication between Pikitup, the municipality and community members. Abuenyi (2010) also finds that public ignorance and attitudes worsen poor domestic solid waste practices.

Moreover, the majority of participants (56%) within the formal settlement indicated that they pay their municipal rates and thus expect municipal services in return (Figure 21). Based on this, one can assume that the municipality should be generating revenue from the municipal rate. However, the City of Johannesburg official indicated that *“The existing waste management policies must be amended to cater for the rapidly expanding population and the backyard rooms, and all backyard rooms must pay municipal rates as they are currently not contributing towards the municipal service fee, but generate extra waste not catered for.”* It is clear therefore that each side blames the other in this situation. In the literature, willingness-to-pay models support the balance between community expectations and service delivery, but that this trade-off varies between different communities according to their needs and expectations (Momoh and Oladebeye, 2010; Nahman and Godfrey, 2010; Ndau and Tilley, 2018). In KwaZulu-Natal, Dlamini et al. (2017) showed that 97.3% of community participants are dissatisfied with municipal waste services, but that there is a clear gap between expectation and delivery.

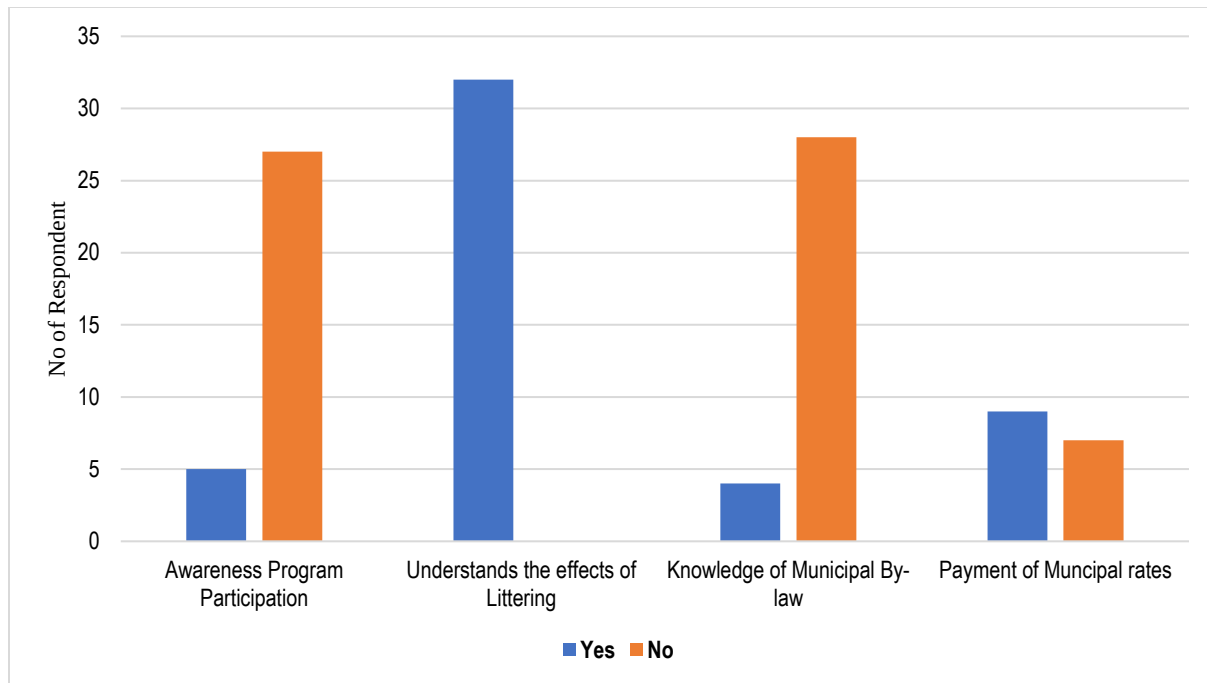


Figure 21: Knowledge of domestic solid waste management practices by householders in formal and informal settlements.

5.3.2 Access to municipal waste management services

Each main household within the formal settlement is provided with one waste bin (80ℓ), which is collected weekly by Pikitup (although the collection day is not consistent). However, according to an official from Pikitup *“The area is overcrowded, and this increases more waste generated and not catered for. This then puts more pressure on Pikitup to try and collect a large amount of waste which also damages the assigned truck within a short period.”* It was indicated that the provided bins within the formal settlement are usually not enough to cater for all occupants. As a result, householders resort to other methods of waste disposal including illegal dumping in open spaces, river and street corners, burning of waste, and storing in extra plastics (Figure 22).

According to householders from the informal settlement, they do not receive waste disposal services from the municipality and so they use their own methods to handle domestic waste (Figure 23). The statement was disputed by an official from Pikitup who said that *“Pikitup used to provide waste plastic bags to many informal settlements (including Themba Khoza), however, most people were using plastic bags for personal use instead of storing waste inside, as a result, they discontinued the provision of the services.”*

The results indicate that about 63% of uncollected waste within the formal settlement is handled through illegal dumping (Figure 22), whereas in the informal settlement only 48% of waste is dumped in this way (Figure 23). Of concern is that 22% of the waste in the informal settlement is thrown or washed into the river, thereby disturbing river flow and degrading water quality and ecosystems (e.g. Inanc et al., 2004). Musademba et al. (2011) found that many householders in informal settlements use methods such as illegal dumping as a result of a lack of domestic waste management services. However, other studies highlight that there are complex feedbacks between communities, service providers and infrastructure, and that decision-making at the household level is not straightforward (Breukelman et al., 2019; Wernstedt et al., 2020). The results found here indicate a need for the municipality to ensure the provision of adequate waste management services equitably in both settlements to prevent other improper methods of waste handling.

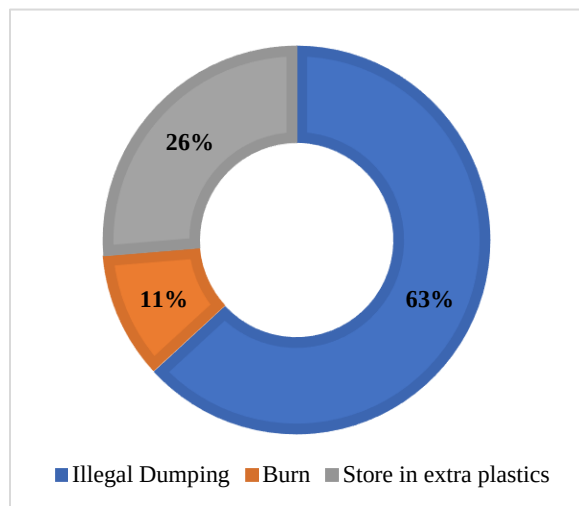


Figure 22: Management of uncollected waste – formal settlement.

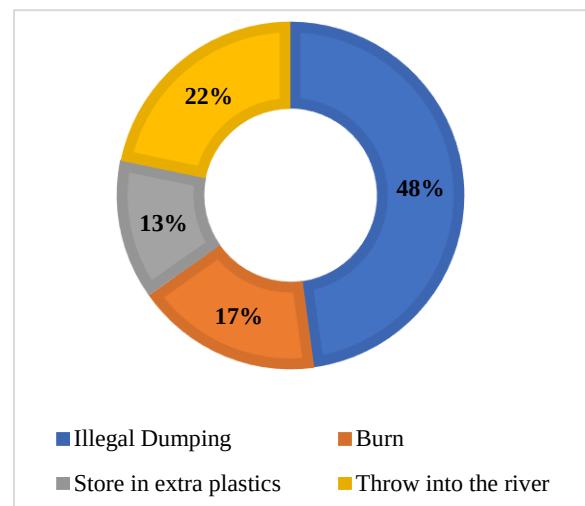


Figure 23: Management of waste – informal settlement.

The study also shows that other householders in both formal (11%) and informal settlements (17%) prefer to burn uncollected waste as it is believed that the method has a minimal negative impact on health and the natural environment. This is similar to findings by Akunnaya and Adedapo (2016) where residents prefer to burn waste to avoid health hazards.

5.3.3 Perceptions of the effects of poor domestic solid waste management

Questionnaire and interview results show the participants' perceptions of the effects of littering on the environment, health and socioeconomic aspects of the area (Table 6).

These areas of concern include pollution of water and land, negative impacts on community health, an increase in rats, cockroaches and flies, and reduced inability to attract business investment. From the identified effects, the majority of participants (50% of the formal settlement and municipal officials, and 63% from the informal settlement) are more concerned about human health and sicknesses effects that result from littering, followed by pollution of the environment (38% from the formal settlement, 44% from the informal settlement and 50% from the municipal officials).

Table 6: Participants' perceptions on the effects of littering.

Formal Settlement	No of Respondents (n=16)	(%) Percentage
No Business Attraction	1	6 %
Attract Flies, Rats, and Cockroaches	2	13%
Sickness	8	50%
Pollutes the area	6	38%
Informal Settlement	No of Respondents (n=16)	(%) Percentage
Attract Flies, Rats, and Cockroaches	1	6%
Sickness	10	63%
Make the area untidy	3	19%
Water Pollution	7	44%
Municipal Officials	No of Respondents (n=8)	(%) Percentage
Attract Flies, Rats, and Cockroaches	2	25%
Fire outbreak	1	13%
No Business Attraction	1	13%
Sickness	4	50%
Environmental Pollution	4	50%

Although sicknesses statistics were not acquired for this study, it is clear that most participants are more concerned about direct health and sicknesses effects. It was observed that children in the informal settlement usually play at polluted open spaces, which is believed by residents to threaten their health. Rodents were observed roaming around both formal and informal settlements in areas affected by litter. Littering attracts rodents and other insects as well as parasites which can transfer diseases to humans (Mohammed and Eyasu, 2017).

These findings show that the health and wellbeing of communities must be prioritized in waste management, not least because it is of significant community concern (Kubanza and Simatele, 2016).

It is notable that none of the respondents from either the formal or informal settlements mentioned the effects of the burning of waste on air quality and pollution (Table 6). It was also noted in field observations that waste burning takes place commonly than just illegally disposing of waste in open spaces (Figure 24). During the interview, a community participant stated that “*The community can burn uncollected waste as it has less impact on the river and land, and also prevent sicknesses resulting from exposed waste*”. This shows that more information about health effects arising from air pollution and toxic smoke is needed in community awareness programmes (e.g. Ziraba et al., 2016).

Based on the field observations, it was evident that littering is degrading the natural environment (river and land) (Figure 24). Kaalspruit River is heavily polluted as a range of domestic waste types is being dumped within the river, including raw sewage from the informal settlements and overflow from the formal areas, while other waste is swept into the river during heavy rain. This has created blockages in the river, leading to flooding, and bad smells. Based on these factors, the PES of the river (Kleynhans, 1996) can be categorized as critically modified (Category F), while the overall EIS of the stream is rated as a Category D (Low significance). It should be noted that no aquatic species (e.g. fish and frogs) were observed in the river during field investigation, which may demonstrate that the current state of the river might not be suitable for aquatic species.

It was also observed that the internal tracks within the informal settlement were tidy and generally free from litter compared to the internal streets within the formal settlement. Although illegal dumping at the formal settlement also takes place within and along the watercourse, the majority of such activities was observed along the streets and unattended open spaces. Yadav (2018) found that littering reduces the aesthetic quality of the area. This was also observed in Ivory Park as almost all streets, open spaces and riverbank is covered by litter (Figures 24, 25). Other research participants also state that littering makes the area unattractive for business.



Figure 24: Evidence of littering at Ivory Park. (A) Kaalspruit River, (B) polluted unnamed stream leading to Kaalspruit River, (C) street littering, (D) evidence of waste burning in an open space (source: K. Rambuda, 2019).

An official from City Parks stated that *“Most open spaces are not maintained accordingly, as such there is uncontrolled illegal dumping in such open spaces within the area. This tends to degrade open spaces that are supposed to be utilized for recreational activities.”* Figure 25 shows the areas that were prone to littering within both the formal and informal settlements, based on field observations.

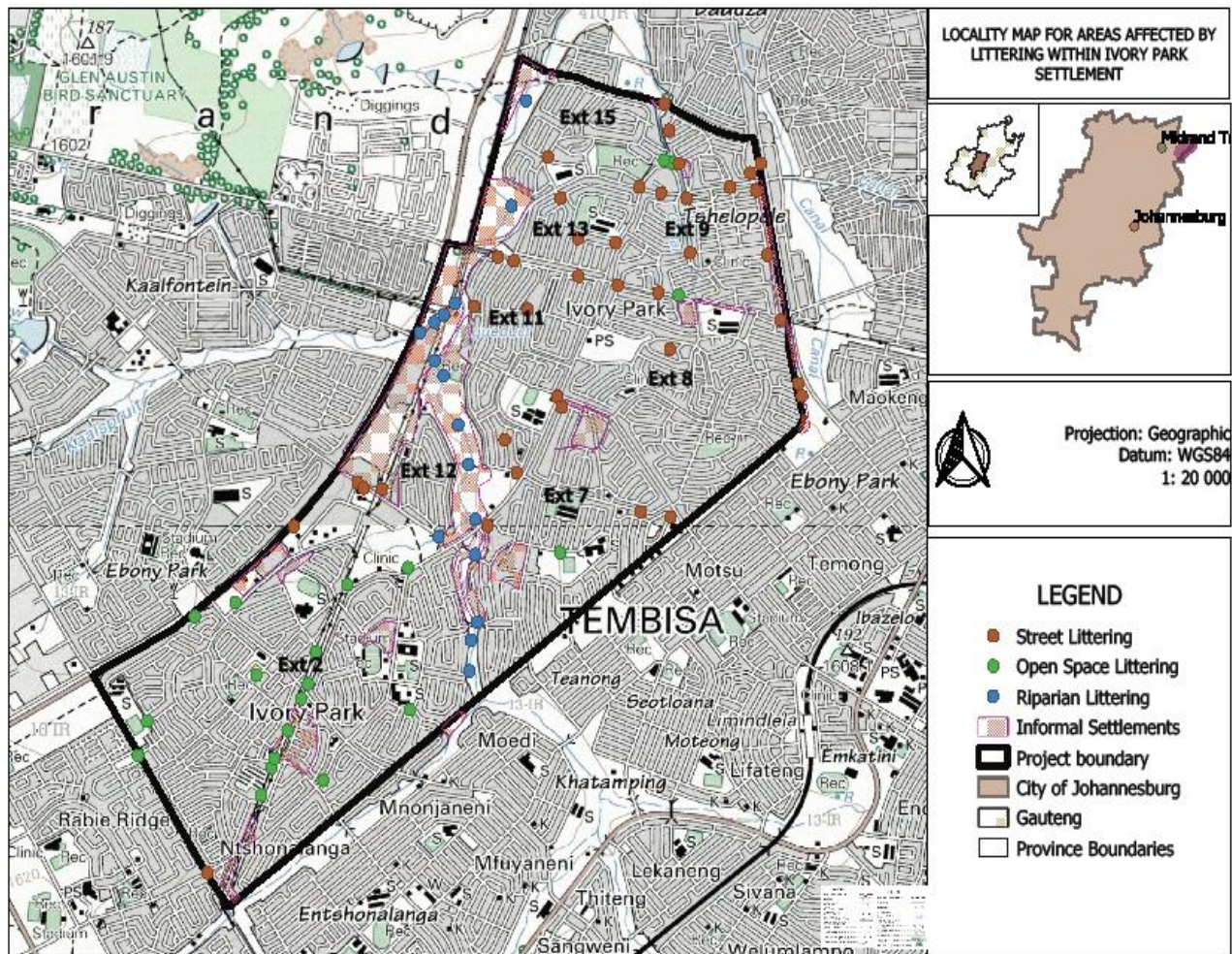


Figure 25: Areas prone to littering within Ivory Park (source: field observations by K. Rambuda, 2019).

5.4 Challenges in achieving sustainable domestic solid waste management

The different research participants pointed out several factors that contribute to poor domestic solid waste management in Ivory Park (Table 7). Results show that 69% of participants in the formal settlement and 100% of participants in the informal settlement believe that inconsistent or absent waste collection service by Pikitup is the main cause of littering. All municipal officials who participated in the study indicated that lack of funds is the reason behind littering. A City Parks official stated that *“Although the department has many plans to address the issue, we do not have funds to implement the plans. Funds are required to procure more resources as well as to provide enough capacity.”* Other causes of littering were also identified (Table 7) and are discussed below.

Table 7: Participants’ perceptions on the causes of littering.

Formal Settlement	No of Respondents (n=16)	(%) Percentage
No By-law enforcement	2	13%
Insufficient waste bins	5	31%
Overcrowding	3	19%
Public ignorance	4	25%
Inconsistence waste collection service	11	69%
Informal Settlement	No of Respondents (n=16)	(%) Percentage
Overcrowding	1	6%
Lack of knowledge	2	13%
Area not formalised	8	50%
No waste collection service	16	100%
Municipal Officials	No of Respondents (n=8)	(%) Percentage
Lack of funds	8	100%
Overcrowding	4	50%
Ignorance of people	4	50%
Uncontrolled squatter camps establishment	1	13%
Limited resources (staff and fleet)	1	13%
Lack of prioritization of waste by government	2	25%

5.4.1 Inconsistent waste collection service at the formal settlement

According to participants in the formal settlement, Pikitup does not collect the waste regularly and as a result, they are forced to use other methods of waste management (Figure 16). According to a Pikitup official *“Pikitup used to dump Ivory Park waste at FG landfill (located close to the area) before it was closed. The current distance to the dumping site is too long, which requires more unbudgeted logistic costs, and there are limited resources (staff and logistics) required to assist in providing waste management service.”* An official from the City of Johannesburg (Environmental Health section) identified limitations of the existing policy to the effectiveness of Pikitup: *“The existing waste management policies must be amended first for Pikitup to function well.”*

5.4.2 No waste collection service in the informal settlement

It was observed that illegal dumping has been institutionalized (normalized) within the informal settlement, as there is no provision of domestic solid waste management services by Pikitup in the area. Therefore it can be argued that this lack of service from the municipality forces the community to dump or burn waste. A householder respondent in an interview that: *“The municipality has neglected the area, as there is no improvement in solid waste collection. This is the reason why people dump anywhere during the day without any guilty conscious or showing*

any remorse.” However, a Pikitup official stated that “Many informal settlements are not accessible by Pikitup trucks; hence no collection is made. Pikitup has tried to place waste skips in open spaces, however, they usually get stolen. Moreover, we have also issued out plastics to many informal settlements but they were not being utilised accordingly as many people were using the plastics for personal use instead of storing waste inside.” This shows the need for the municipality to extend the waste collection services to the informal settlement and to find solutions to the identified problems. Moreover, the municipality could encourage the residents to place their waste at the periphery of the informal settlement for ease of collection by trucks.

5.4.3 Municipal By-law enforcement

The City of Johannesburg has a waste management By-law in place. However, according to participants (13%) from the informal settlement, there is no enforcement of this By-law (Table 7). An official from the City of Johannesburg (Environmental Health section) indicated that: *“We do not have enough enforcement officers to monitor and enforce the implementation of the By-laws. Although we are aware of the issue, we do not have enough funds to appoint the required enforcement officers to execute our mandate accordingly. The issue is also worsened by a lack of prioritization of waste management by top management as well as the attitude of the perpetrators towards the enforcement officers”*. Previous studies show that African countries have good legislation and the associated waste management policies in place, but that they lack personnel to implement, monitor and enforce the policies (Makwara and Magudu, 2013; Njoroge et al., 2014; Kwaitane et al., 2016). Based on this, it is clear that for enforcement to take place, enough resources (funds) are required to appoint more enforcement officers and that sufficient resources are invested in communities to ensure that illegal waste dumping does not take place, e.g. by providing waste bins. The lack of enforcement within municipal management systems has been identified by Machete (2019).

5.4.4 Insufficient waste bins

According to a participant from the formal settlement, *“the provided waste bins are not enough to cater for the generated waste per week”*. It was also observed during field observation that the majority of households, especially the stands with backyard rooms, normally fill their waste bins within 3 days after the collection date (Table 8). This indicates the need to consider a change of collection of waste to twice a week.

Table 8: Days on which illegal dumping is more intense in different Ivory Park sections (see Figure 24).

Item	Section	Day of waste collection	Days where illegal dumping is more intense
1	Ivory 2	Tuesday	Saturday
2	Ivory 7, 8 and 9	Monday	Friday
3	Ivory 11, 12 and 13	Thursday	Monday
4	Ivory 15	Friday	Tuesday

5.4.5 Overcrowding

According to the City of Johannesburg (2010), Ivory Park is one of the overcrowded townships in South Africa as a result of urbanization and migration. The City of Johannesburg (Environmental Health section) official stated that *“The majority of households within the formal settlement have backyard rooms thus increasing waste generated not catered for. The majority of these backyard rooms are not approved by the municipal planning, nor considered when doing budgeted inputs”*. This then shows the need to amend the existing policies in order to cater for backyard rooms and overcrowding.

5.4.6 Lack of knowledge on solid domestic waste management issues

According to the ward councillor *“We have tried to engage with the community in order to get their assistance, as the municipality cannot address the issue on its own.”* An official from the City of Johannesburg (Environmental Health section) also stated that *“We have conducted several environmental awareness together with the ward councillors, and we have trained ward committees so that they also assist in spreading the word within their respective wards.”* However, the majority of participants (84%) indicated that they have not participated in a waste awareness programme (Figure 21). The ward councillor further stated that *“We are unable to educate the whole community at once as the township receives new immigrants on a daily basis.”* Jatau (2013) argued that education on waste management may assist people to protect their property’s values and protect themselves from infections associated with waste. An official from the City of Johannesburg (Environmental Health section) stated that *“The community must take ownership of their area by ensuring that it is always clean. They can also assist by stopping and preventing illegal dumping in their area.”* There is clearly a lack of communication and unwillingness to accept responsibility and partnership on both sides (Kubanza and Simatele, 2020).

Based on levels of education (Figures 11, 14) and being a more affluent area, one can expect more efficient domestic solid waste management in the formal rather than the informal settlement. This has been found in several studies in Africa (e.g. Matete and Trois, 2008; Guerrero et al., 2013). However, both formal and informal settlements in Ivory Park are polluted, and education and wealth cannot be taken by themselves as sole indicators of environmental behaviour (e.g. Wernstedt et al., 2020). Illegal dumping at formal settlements may usually take place at night, as no illegal dumping activities were observed during the day, which may mean that perpetrators understand that it is wrong to do so. Abubeyi (2010) showed that public ignorance or deliberate negative behaviour usually worsens solid waste services. People may also dump waste where they see an opportunity to do so, i.e. in unmaintained open spaces (CSIR, 2011). It was noted that no littering was observed at the two parks currently being maintained by City Parks (Figure 4). The above findings show that the municipality (officials and ward councillors) also put the blame on the community's ignorance, and are satisfied that they have conducted adequate awareness campaigns in the area.

5.4.7 Areas not formalized and the uncontrolled development of informal settlements

The rapid development of informal settlements in any open spaces and along the riverbanks of the Kaalspruit River poses problems for environmental pollution and human health. The City of Johannesburg official stated *“The government must have proper town planning prior to establishment or formalization of any township.”* The Pikitup official also indicated that *“it is difficult for them to provide waste management service to many informal settlements, as these areas are not easily accessible”*.

5.4.8 Lack of prioritization of waste by government

Some (13%) of the municipal officials interviewed indicated that there is a lack of waste management prioritization by the government (Table 7). A City Parks official stated that *“there is lack of funds, and this is because the top management does not really understand the financial implications of poor domestic solid waste management.”* This is despite much literature showing that there are close links between all types of waste management, community and environmental health, hazards and risk, economic development and sustainability (Matete and Trois, 2008; Guerrero et al., 2013; Kubanza and Simatele, 2016; Bundhoo, 2018).

If political decision-makers can understand the implications of poor domestic waste management, more funds may be allocated. The City Parks official further stated that “*We are working closely with all relevant government departments to address the issue; however, lack of funds is a serious stumbling block to achieve all the objectives.*”

5.5 Proposed measures to address poor domestic solid waste management in Ivory Park

All participants were asked about their recommendations on domestic solid waste management. These ideas are now presented.

5.5.1 Proposed mitigation measures – community participants

Participants from both formal and informal settlements believe that some measures can be undertaken to address existing and control future domestic solid waste management (Table 9). The majority of participants in the formal settlements (63%) indicate that if Pikitup increases waste collection frequency to twice a week then poor domestic solid waste management issues can be addressed. In the informal settlement, most participants (56%) believe that formalized with proper streets will make it easier for Pikitup to provide waste management services. Other proposed measures are listed in Table 9.

Table 9: Proposed mitigation measures from community participants.

Formal Settlement	No of Respondents (n=16)	(%) Percentage
Law enforcement	3	19%
Collection waste in time and twice a week	10	63%
Provide more dust bins	3	19%
Pikitup to hire more staff and increase fleet	5	31%
More awareness programmes	3	19%
Place waste skips in open spaces	1	6%
Informal Settlement	No of Respondents (n=16)	(%) Percentage
Formalize the area	9	56%
Provide waste skips and dust bins	5	31%
Collect waste twice a week	5	31%
Awareness programmes	4	25%
Clean up the river and fine all polluters	3	19%

5.5.2 Proposed mitigation measures – municipal officials

The municipal officials who participated in the study also proposed mitigation measures that can assist them in executing their mandate, namely, domestic solid waste management services in Ivory Park. The proposed measures mentioned are:

- Increase the budget allocated for waste management as this will assist in procuring the required resource;
- More investigation must be undertaken in order to demonstrate to top management the financial implications of poor domestic solid waste management;
- Amendment of existing policies to cater for backyard rooms and fast-growing populations. It was proposed that all backyard rooms must pay municipal rates and taxes, as this will assist the municipality to generate more revenue;
- The government must have proper town planning prior to the establishment or formalization of any township;
- Placement of waste skips in all strategic areas prone to illegal dumping, however, monitoring is required as they get stolen easily;
- Increase staff capacity to ensure the enforcement of municipal By-laws;
- Appoint unemployed youth to clean up the area, as well as policing for illegal dumping;
- Establish buy-back centres in both formal and informal settlement as this will also assist in job creation, and the same time addressing the waste management issues by increasing participation in recycling;
- Cleaning or neighbourhood waste campaigns can assist to change the mind-set or attitude of residents towards domestic solid waste management.

5.6 Summary and critical analysis of the findings

This chapter presented and discussed the research data. The discussion focused on the socioeconomic characteristics of the research participants in Ivory Park (age, education and employment status), the type and quantity of waste generated by households, the level of community knowledge on domestic waste handling, community understanding of current municipal waste management practices, access to municipal waste management service, and perceptions of the effects of poor domestic solid waste management. Challenges that hinder sustainable domestic solid waste management were identified and measures to address these issues were proposed by both community participants and municipal officials.

This analysis shows that there are multiple failures on many levels and with each stakeholder blaming others for a lack of policy engagement or action on the ground.

The types of waste produced is relatively similar between different households (Figure 16, 17), but the volume of waste produced varies between formal and informal settlement types, and on number of individuals within the household (Figures 18, 19). Whilst this is similar to results from previous studies (e.g. Sujaudhin et al., 2008; Mbiba, 2014; Jonas et al., 2014), there are implications of these findings for domestic solid waste management practices. First, different households have different attitudes and practices to waste management, irrespective of the type/volume of waste they produce. Second, municipal policies towards waste management, and practices undertaken by Pikitup, are based on assumptions of the number of householders and individual within households. The presence of backyard rooms in formal settlements dramatically increases waste production within the household stand (Figure 18), hence may be a reason why illegal dumping is more prevalent (Figure 22). This highlights the need for accurate information on number of individuals within households, in order for appropriate waste management infrastructure to be put in place. There is also a mismatch between an understanding of the concept of recycling and active recycling behaviour within the household (Figure 20). The reasons for this mismatch are not clear. Respondents and the literature suggest this is due to a lack of information on how and where to recycle (Ndau and Tilley, 2018), but the role of informal waste pickers and recyclers (Schenck et al., 2016) has not been explored at household level, in influencing household behaviour (Momoh and Oladebeye, 2009; Mbiba, 2014; Simatele et al., 2017). This is an important future research priority.

The next chapter (Chapter 6) provides a summary of the analysed results discussed in Chapter 5, and associated implications thereof, followed by future recommendations.

CHAPTER 6: SUMMARY AND RECOMMENDATIONS

6.1 Summary of the research findings

This study aimed at investigating the management of domestic solid waste within Ivory Park, City of Johannesburg, with the objectives of identifying the causes of poor domestic solid waste management, determining the types and quantity of waste generated by households, assessing individual's knowledge regarding management of household solid waste, and evaluating the effects of poor domestic solid waste management on the environment, health and socioeconomic quality. A quantitative and qualitative approach was adopted to investigate the drivers of poor domestic solid waste management.

The study findings demonstrate that there is a significant problem with littering and other impacts of illegal dumping of domestic waste in Ivory Park, which is negatively impacting the environment, human health and wellbeing, and the area's economy. Participants indicated that the main causes of poor domestic solid waste management include overcrowding, insufficient capacity and resources of the municipality and Pikitup to provide appropriate and effective waste management services, and lack of knowledge of the public to participate in awareness programmes (Table 7).

According to the study findings, kitchen and recyclable waste constitute a high percentage of the generated waste within both formal and informal settlements in Ivory Park, as compared to other types of waste (Figures 16, 17). The study also found that the formal settlement generates more waste due to the presence of backyard rooms (average of 184ℓ per household per week), as compared to the informal settlement without backyard rooms (average of 37ℓ per household per week) (Figures 18, 19). The amount of waste generated is also related to the socioeconomic conditions, meaning that households can generate different volumes of waste even though they may have the same number of occupants.

Although the majority of community participants do not know about municipal waste management By-laws, they are aware of waste recycling and the negative effects of poor domestic solid waste management on the natural environment (e.g. water and air pollution, land degradation) (Figure 24). The study also noted that poor domestic solid waste management results in illnesses associated with waste and the area is not attractive to business investors (Table 6).

6.2 Recommendations of this study

Based on the study findings, the following recommendations are made, informed by community and key informants' comments:

- The municipal authority must increase budget allocation for waste management, as this will assist in implementing the proposed measures (i.e. the increase of capacity, procuring required resources such as the provision of more dust bins, waste skips, more fleet vehicles and organizing of cleaning and awareness campaigns, and the establishment of buy-back centres);
- The existing waste management strategy must be amended to cater for the backyard rooms and fast-growing population;
- The municipality must undertake an audit to identify all households with backyard rooms to determine the appropriate rates for waste management services. This will assist the municipality to generate more revenues for solid waste management;
- The management of domestic solid waste requires everyone's involvement, including community participation and cooperation to address the issue;
- A study must be conducted to determine the financial implications of poor domestic solid waste management. This will provide the city council with adequate information for decision making. The council, which is responsible for waste management budget allocation must identify waste management as a priority service within the City of Johannesburg.

6.3 Future research questions

From this study, a number of future research questions can be identified:

- What are the factors that influence householder decision-making regarding domestic waste use and disposal?
- What education tools are most effective for different community groups?
- How can communities work together to reduce better manage waste in their environment?
- How can stakeholders communicate better with local communities?
- What is the role of local community leaders and businesses in environmental remediation with respect to waste?
- How can waste management be integrated with other aspects of sustainable urban development, such as water use and water quality, food gardens, and air pollution?

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LIST OF APPENDICES

Appendix A: Participant information sheet

Appendix B: Consent form (English, Sepedi and isiZulu versions)

Appendix C: Questionnaire survey forms (formal and informal settlements)

Appendix D: Key informant interview questions (community individuals and municipal officials)

Appendix E: Field observations

Appendix A: Participant information sheets

University of the Witwatersrand

Private Bag 3

Wits, 2050

To whom it may concern

Dear Sir/Madam

My name is Konanani Rambuda, a master's student at the University of the Witwatersrand in Johannesburg. As part of my master's program, I am undertaking a study which focuses on the domestic solid waste practices at Ivory Park Township. The study aims to investigate the management of domestic solid waste within Ivory Park Township. It also seeks to determine measures that can be implemented in order to have sustainable domestic solid waste management within the area.

I am inviting you to participate in the **questionnaire survey**, which entails the completion of the developed questionnaire form and it will take approximately 30 minutes. You are selected because you are affected by the project issue (domestic solid waste management within Ivory Park township). Please note that your participation is anonymous as I will be using code names to represent your participation in the final research report. You will not be required to answer questions that make you uncomfortable and you are also welcome to withdraw at any time should you wish not to proceed with the study. Moreover, no compensation will be received as a result of participating in the study.

The result of the research will be used to write a master's thesis, and a copy of the research report will be made available online through the university's library website. A copy of the report's summary can also be made available to you upon request. Should you have inquiries, concerns or complaints regarding the ethical procedures, or require further information regarding the study, kindly contact the below:

Researcher:	Supervisor:	University Human Research Ethics Committee (Non-Medical)
Konanani Rambuda Cell: 076 893 5757 Email: 2117833@students.wits.ac.za	Prof. Jasper Knight Tel: 011 717 6508 Email: Jasper.Knight@wits.ac.za	Tel: 011 717 1408 Email: Shaun.Schoeman@wits.ac.za

University of the Witwatersrand
Private Bag 3
Wits, 2050

To whom it may concern

Dear Sir/Madam

My name is Konanani Rambuda, a master's student at the University of the Witwatersrand in Johannesburg. As part of my master's program, I am undertaking a study which focuses on the domestic solid waste practices at Ivory Park Township. The study aims to investigate the management of domestic solid waste within Ivory Park Township. It also seeks to determine measures that can be implemented to have sustainable domestic solid waste management within the area.

I am inviting you to participate in the **key informants' interview**, which entails answering the developed open-ended questions and it will take approximately 30 minutes. You are selected because you are affected by the project issue, and it is believed that you can provide valuable information based on your experience towards poor domestic solid waste management within Ivory Park. With your permission, I would like to record the interview using a cell phone, as this will assist me to fully interact and engage in our conversation.

Please note that your participation is anonymous as I will be using code names to represent your participation in the final research report. You will not be required to answer questions that make you uncomfortable and you are also welcome to withdraw at any time should you wish not to proceed with the study. Moreover, no compensation will be received as a result of participating in the study. The result of the research will be used to write a master's thesis, and a copy of the research report will be made available online through the university's library website. A copy of the report's summary can also be made available to you upon request. Should you have inquiries or require further information regarding the study, kindly contact the below:

Researcher:	Supervisor:	University Human Research Ethics Committee (Non-Medical)
Konanani Rambuda Cell: 076 893 5757 Email: 2117833@students.wits.ac.za	Prof. Jasper Knight Tel: 011 717 6508 Email: Jasper.Knight@wits.ac.za	Tel: 011 717 1408 Email: Shaun.Schoeman@wits.ac.za

City of Johannesburg Metropolitan Municipality

P.O Box 1049,
Johannesburg, 2000

Dear Sir/Madam

My name is Konanani Rambuda, a master's student at the University of the Witwatersrand in Johannesburg. As part of my master's program, I am undertaking a study which focuses on the domestic solid waste practices at Ivory Park Township. The study aims to investigate the management of domestic solid waste within Ivory Park Township. It also seeks to determine measures that can be implemented in order to have sustainable domestic solid waste management within the area.

I am inviting you to participate in the **key informants' interview**, which entails answering the developed open-ended questions and it will take approximately 30 minutes. You are selected because you are involved in the management of domestic solid waste within Region A (including Ivory Park), and it is believed that you can provide valuable information from the management perspective. With your permission, I would like to record the interview using a cell phone, as this will assist me to fully interact and engage in our conversation.

Please note that your participation is anonymous, as I will be using code names to represent your participation in the final research report. You will not be required to answer questions that make you uncomfortable and you are also welcome to withdraw at any time should you wish not to proceed with the study. Moreover, no compensation will be received as a result of participating in the study.

The result of the research will be used to write a master's thesis, and a copy of the research report will be made available online through the university's library website. A copy of the report's summary can also be made available to you upon request.

Should you have inquiries or require further information regarding the study, kindly contact the below:

Researcher: Konanani Rambuda Cell: 076 893 5757 Email: 2117833@students.wits.ac.za	Supervisor: Prof. Jasper Knight Tel: 011 717 6508 Email: Jasper.Knight@wits.ac.za	University Human Research Ethics Committee (Non-Medical) Tel: 011 717 1408 Email: Shaun.Schoeman@wits.ac.za
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Appendix B: Consent forms (English, Sepedi and isiZulu versions)

Consent Form for Participating in the Questionnaire Survey - The analysis of domestic solid waste management practices at Ivory Park Township, situated within the City of Johannesburg Metropolitan Municipality, Gauteng Province.

I have read and understood the aims of the project in the participant information sheet, provided by Konanani Rambuda who is conducting this research as part of a master's degree at the University of Witwatersrand supervised by Prof. Jasper Knight.

I have been clarified and understand that:

- My participation is entirely voluntary.
- I am free to withdraw from the project at any time.
- I will remain anonymous and information is confidential.
- I am free to request further information at any stage.
- I am aware that my personal information will not be shared or included in the final document.
- I will not receive any compensation for participating in the study.
- There won't be negative implications on me should I decide to participate in the study.

I am willing to participate in this research project: Yes ☐ No ☐

I meet the requirement to participate in the study (18 and above years): Yes ☐ No ☐

Signature

.....
Date

For any inquiries about the research, I can contact the researcher Konanani Rambuda (2117833@students.wits.ac.za, 0768935757) or supervisor Prof. Jasper Knight (Jasper.Knight@wits.ac.za, 011 717 6508).

Consent Form for Participating in the Key informants Interview - The analysis of domestic solid waste management practices at Ivory Park Township, situated within the City of Johannesburg Metropolitan Municipality, Gauteng Province.

I have read and understood the aims of the project in the participant information sheet, provided by Konanani Rambuda who is conducting this research as part of a master's degree at the University of Witwatersrand supervised by Prof. Jasper Knight.

I have been clarified and understand that:

- My participation is entirely voluntary.
- I am free to withdraw from the project at any time.
- I will remain anonymous and information is confidential.
- I am free to request further information at any stage.
- I am aware that my personal information will not be shared or included in the final document.
- I will not receive any compensation for participating in the study.
- There won't be negative implications on me should I decide to participate in the study.

I am willing to participate in this research project: Yes ☐ No ☐

I meet the requirement to participate in the study (18 and above years): Yes ☐ No ☐

I agree to be audio recorded Yes ☐ No ☐

Signature

.....
Date

For any inquiries about the research, I can contact the researcher Konanani Rambuda (2117833@students.wits.ac.za, 0768935757) or supervisor Prof. Jasper Knight (Jasper.Knight@wits.ac.za, 011 717 6508).

Foromo ea tumello ea ho nka karolo Thutong ea lipotso - Tlhatlhobo ea litloaelo tsa taolo ea litšila tsa lapeng ka hara toropo ea Ivory Park, e fumanehang kahare ho Masepala oa Metropolitan oa Motse Kapa.

Ke balile mme ke utloisise sepheo sa morero ho leqephe la tlhaiso-leseling le nkang karolo, le fanoeng ke Konanani Rambuda ea etsang lipatlisiso tsena e le karolo ea lengolo la master ho Yunivesithi ea Witwatersrand e hlokometsoeng ke Prof. Jasper Knight.

Ke hlalositsoe 'me ke utloisisa hore:

- Ho nka karolo ke boithatelo ho hang.
- Ke na le bolokolohi ba ho itokolla mosebetsing ka nako efe kapa efe.
- Ke tla lula ke sa tsejoe mme tlhahisoleseling ke lekunutu.
- Ke na le bolokolohi ba ho kopa tlhahisoleseling e ngoe mothating ofe kapa ofe.
- Kea tseba hore tlhahisoleseling ea ka e ke ea arolelanoa kapa ea kenyetsetsoa tokomaneng ea ho qetela.
- Ha ke fumane matšeliso bakeng sa ho nka karolo ho ithuteng.
- Ha ho na ho ba le litlamorao tse mpe ho nna haeba nka qeto ea ho nka karolo ho ithuteng.

Ke ikemiselitse ho nka karolo morerong ona oa ho etsa lipatlisiso: E ☐ Che ☐

Ke fihlela tlhokeho ea ho nka karolo thutong (lilemo tse 18 le tse kaholimo): E ☐ Che ☐

Saena

Letsatsi

Bakeng sa lipotso leha e le life mabapi le lipatlisiso, nka ikopanya le mofuputsi Konanani Rambuda (2117833@students.wits.ac.za, 0768935757) kapa mookameli oa Prof. Jasper Knight (Jasper.KNight@wits.ac.za, 011 717 6508).

Foromo ea tumellano ea ho nka karolo Sehlopheng sa Sefahleho sa ho Talima Pejana - Tlhatlhobo ea litloaelo tsa taolo ea litšila tsa lapeng ka hara toropo ea Ivory Park, e fumanehang kahare ho Masepala oa Metropolitan oa Motse Kapa.

Ke balile mme ke utloisise sepheo sa morero ho leqephe la tlhaiso-leseling le nkang karolo, le fanoeng ke Konanani Rambuda ea etsang lipatlisiso tsena e le karolo ea lengolo la master ho Yunivesithi ea Witwatersrand e hlokometsoeng ke Prof. Jasper Knight.

Ke hlalositsoe 'me ke utloisisa hore:

- Ho nka karolo ke boithatelo ho hang.
- Ke na le bolokolohi ba ho itokolla mosebetsing ka nako efe kapa efe.
- Ke tla lula ke sa tsejoe mme tlhahisoleseling ke lekunutu.
- Ke na le bolokolohi ba ho kopa tlhahisoleseling e ngoe mothating ofe kapa ofe.
- Kea tseba hore tlhahisoleseling ea ka e ke ea arolelanoa kapa ea kenyelletsoa tokomaneng ea ho qetela.
- Ha ke fumane matšeliso bakeng sa ho nka karolo ho ithuteng.
- Ha ho na ho ba le litlamorao tse mpe ho nna haeba nka qeto ea ho nka karolo ho ithuteng.

Ke ikemiselitse ho nka karolo morerong ona oa ho etsa lipatlisiso: E ☐ Che ☐

Ke fihlela tlhokeho ea ho nka karolo thutong (lilemo tse 18 le tse kaholimo): E ☐ Che ☐

Ke lumela ho rekota audio: E ☐ Che ☐

Saena

Letsatsi

Bakeng sa lipotso leha e le life mabapi le lipatlisiso, nka ikopanya le mofuputsi Konanani Rambuda (2117833@students.wits.ac.za, 0768935757) kapa mookameli oa Prof. Jasper Knight (Jasper.K.Night@wits.ac.za, 011 717 6508).

Ifomu lesivumelwano sokubamba iqhaza ocwaningweni lwemibuzo - Ukuhlaziywa kwezindlela zokuphathwa kwemfucuza eqinile e-Ivory Park Township, etholakala kuMasipala waseDolobheni laseGoli esifundazweni saseGauteng.

Ngifunde futhi ngaqonda izinhloso zephrojekthi ekhasini lababambiqhaza elibambe iqhaza, elinikezwe uKonanani Rambuda owenza lolu cwaningo njengengxenywe yeziqo ze-master's University of Witwatersrand egadwe nguProf. Jasper Knight.

Ngicacisiwe futhi ngiyaqonda ukuthi:

- Ukubamba iqhaza kwami kungokuzithandela ngokuphelele.
- Ngikhululekile ukuhoxa kuphrojekthi nganoma yisiphi isikhathi.
- Ngizohlala ngingaziwa futhi imininingwane iyimfihlo.
- Ngikhululekile ukucela eminye imininingwane nganoma yisiphi isigaba.
- Ngiyazi ukuthi imininingwane yami ngeke yabelwe noma ifakwe kudokhumenti yokugcina.
- Ngeke ngithole isinxephezelo ngokubamba iqhaza ocwaningweni.
- Kuzoba nemiphumela engemihle kimi uma ngabe ngithatha isinqumo sokuhlanganyela ocwaningweni.

Ngizimisele ukubamba iqhaza kulo msebenzi wokucwaninga, Yebo ☐ cha ☐

Ngihlangabezana nesidingo sokubamba iqhaza ocwaningweni (iminyaka eyi-18 nangaphezulu), Yebo ☐ cha ☐

Isiginesha

Usuku

Ngeminye imibuzo mayelana nalolu cwaningo, ngingaxhumana nomcwaningi uKonanani Rambuda (2117833@students.wits.ac.za, 076 893 5757) noma umphathi uProf. Jasper Knight (Jasper.Knight@wits.ac.za, 011 717 6508).

**Ifomu lesivumelwano Sokubamba iqhaza Ebuhlotsheni Bokubhekana Nobuso -
Ukuhlaziywa kwezindlela zokulawulwa kwemfucuza eqinile e-Ivory Park Township,
etholakala kuMasipala waseDolobheni laseGoli esifundazweni saseGauteng.**

Ngifunde futhi ngaqonda izinhloso zephrojekthi ekhasini lababambiqhaza elibambe iqhaza, elinikezwe uKonanani Rambuda owenza lolu cwaningo njengengxenywe yeziqo ze-master's University of Witwatersrand egadwe nguProf. Jasper Knight.

Ngicacisiwe futhi ngiyaqonda ukuthi:

- Ukubamba iqhaza kwami kungokuzithandela ngokuphelele.
- Ngikhululekile ukuhoxa kuphrojekthi nganoma yisiphi isikhathi.
- Ngizohlala ngingaziwa futhi imininingwane iyimfihlo.
- Ngikhululekile ukucela eminye imininingwane nganoma yisiphi isigaba.
- Ngiyazi ukuthi imininingwane yami ngeke yabelwe noma ifakwe kudokhumenti yokugcina.
- Ngeke ngithole isinxephezelo ngokubamba iqhaza ocwaningweni.
- Kuzoba nemiphumela engemihle kimi uma ngabe ngithatha isinqumo sokuhlanganyela ocwaningweni.

Ngizimisele ukubamba iqhaza kulo msebenzi wokucwaninga, Yebo ☐ cha ☐

Ngihlangabezana nesidingo sokubamba iqhaza ocwaningweni (iminyaka eyi-18 nangaphezulu),
Yebo ☐ cha ☐

Ngiyavuma ukutholwa kabusha ngomsindo, Yebo ☐ cha ☐

Isiginesha

Usuku

Ngeminye imibuzo mayelana nalolu cwaningo, ngingaxhumana nomcwaningi uKonanani Rambuda (2117833@students.wits.ac.za, 076 893 5757) noma umphathi uProf. Jasper Knight (Jasper.Knight@wits.ac.za, 011 717 6508).

Appendix C: Questionnaire survey forms (formal and informal settlements)

Questionnaire Survey: Formal Settlements

N.B: This information will only be used for this study purpose, and it will not reveal any personal names of the participants.

- Do not write your name on this questionnaire.
- It is completely voluntary.
- Kindly answer all the questions.

General Information

Date: _____ Consent form signed? Yes ☐ No ☐

Settlement: _____ Street Name: _____

Title: Mr ☐ Mrs. ☐ Ms. ☐ Dr ☐ Others _____ Age: _____

Are you working? Yes ☐ No ☐ If yes, What do you do? _____

Level of Education:

☐ No schooling

☐ Primary

☐ Secondary

☐ Higher Education

Any back yard rooms? Yes ☐ No ☐ If yes, How many backyard rooms _____

How many occupants are residing within the stand? _____

Number of adults _____

Number of children below 18 years _____

Details on Domestic Solid waste storage

Type of waste produced per week	Volume (i.e 15ℓ shoprite plastic bag)
Kitchen waste (i.e. food scrap)	
Recyclable (papers, plastics, and glass)	
Organic waste (i.e. yard trimmings)	
Toxic Waste (i.e. chemicals, medicines)	
Building rubble	
Others	
Total volume (ℓ) of domestic waste produced	

No. of provided waste bins _____, Is it enough? Yes ☐ No ☐ If No, Please explain_____

How often is waste collected? Weekly ☐ Monthly ☐, On what day?_____

Details on domestic waste handling

Does the produced waste fit in the provided waste bins in a week? Yes ☐ No ☐, If No,

How do you manage the remaining waste?

☐ Disposal

☐ Burn

☐ Store in extra plastics

☐ Other, Please Explain _____

Do you know about Recycling? Yes ☐ No ☐ If Yes, Do you recycle? Yes ☐ No ☐

If Yes, how do you recycle? _____

Do you know the environmental, health and economic effects of littering on the streets?

Yes ☐ No ☐, If yes, please explain _____

Have you seen or participated in any waste management awareness in your community?

Yes ☐ No ☐ If yes, please explain _____

Do you pay municipal rates? Yes ☐ No ☐

Are you aware of the municipal waste By-law? Yes ☐ No ☐

What do you think is the main cause of street littering in your area?

What measures do you think should be undertaken to curb street littering within Ivory Park Township? _____

Any further information you would like to share?

We appreciate your time and participation in the study. Thank you!

Questionnaire Survey: Informal Settlements

N.B: This information will only be used for this study purpose, and it will not reveal any personal names of the participants.

- Do not write your name on this questionnaire.
- It is completely voluntary.
- Kindly answer all the questions.

General Information

Date: _____ Consent form signed? Yes ☐ No ☐

Settlement: _____ Title: Mr ☐ Mrs ☐ Ms ☐ Dr ☐ Others _____

Age: _____ Are you working? Yes ☐ No ☐ If yes, What do you do?

Level of Education:

☐ No schooling

☐ Primary

☐ Secondary

☐ Higher Education

How many occupants are residing within the household? _____

Number of adults _____

Number of children below 18 years _____

Details on Domestic Solid waste storage and handling

Type of waste produced per week	Volume (i.e 15ℓ shoprite plastic bag)
Kitchen waste (i.e. food scrap)	
Recyclable (papers, plastics, and glass)	
Organic waste (i.e. yard trimmings)	
Toxic Waste (i.e. chemicals, medicines)	
Building rubble	
Others	
Total volume (ℓ) of domestic waste produced	

Are you provided with waste bins? Yes ☐ No ☐ If No, How do you manage the waste?

☐ Disposal

☐ Burn

☐ Store in extra plastics

☐ Other, Please Explain _____

If yes, how often is waste collected? Weekly ☐ Monthly ☐ , On what day? _____

Do you know about Recycling? Yes ☐ No ☐ If Yes, Do you recycle? Yes ☐ No ☐

If Yes, how do you recycle? _____

Do you know the environmental, health and economic effects of littering on the streets?

Yes ☐ No ☐ , If yes, please explain _____

Have you seen or participated in any waste management awareness in your community?

Yes ☐ No ☐ If yes, please explain _____

Are you aware of the municipal waste By-law? Yes ☐ No ☐

What do you think is the main cause of street littering in your area?

What measures do you think should be undertaken to curb street littering within Ivory Park Township? _____

Any further information you would like to share?

We appreciate your time and participation in the study. Thank you

Appendix D: Key informants interview questions (community individuals and municipal officials)

Key informants Interview Questions: municipal officials involved in domestic solid waste management

General Information

Date: _____ Consent form signed? Yes ☐ No ☐

Do you give consent to be audio recorded? Yes ☐ No ☐

Employer: _____ Department _____

Highest Qualification: _____

Years of experience in the environmental field _____ Job description (role in domestic solid waste management): _____

Information related to domestic solid waste management

1. Are you aware of poor domestic solid waste management within the Ivory Park township?
Please explain.
2. What are the main concerns regarding the issue i.e. pollution, health impacts, etc?
3. How has or is your department addressing the issue of poor solid waste management?
4. Any challenges encountered in addressing the issues, i.e. insufficient capacity, lack of funds, etc?
5. Are there any gaps in the municipal waste management policies? If yes, please explain.
6. What do you think is the main contributor to poor domestic solid waste management?
7. Do you think that there should be an improvement from Pikitup as the appointment entity to manage domestic solid waste? If so, please explain
8. What role can other government departments (i.e. Department of home affairs) play in the control of domestic solid waste management within the municipality as a whole?
9. What role do you the community can play to address the issue?
10. What do you think the national government can assist in solid waste management issues within the municipality as a whole?

11. Possible measures and required intervention to address the issue.
12. Any further information you would like to share?

We appreciate your time and participation in the study. Thank you!

Key Informants Interview Questions: Community Individuals

Date: _____ Consent form signed? Yes ☐ No ☐

Do you give consent to be audio recorded? Yes ☐ No ☐

Settlement: _____ Age: _____ Are you working: Yes ☐ No ☐

If yes, what do you do? _____

Level of Education:

☐ No schooling

☐ Primary

☐ Secondary

☐ Higher Education

Information related to domestic solid waste management

1. Are you aware of poor domestic solid waste management within Ivory Park township? Please explain
2. What are the main concerns regarding the issue i.e. pollution, health impacts, etc?
3. What are your feelings toward poor domestic solid waste management?
4. Which negative impact has poor solid waste management contributed to your area?
5. How does this affect your daily living?
6. What do you think are the main contributors to poor domestic solid waste management?
7. Do you think that there should be an improvement from Pikitup as the appointment entity to manage domestic solid waste? If so, please explain
8. What role can other government departments (i.e. Department of home affairs) play in the control of domestic solid waste management within the municipality as a whole?
9. What role is the community currently playing to address the issue?
10. What measures do you think should be undertaken to curb poor domestic solid waste management within Ivory Park Township?
11. Any further information you would like to share?

We appreciate your time and participation in the study. Thank you!

Appendix E: Field Observation Collection Results

Field Observation Results				
Item No	Section	Day of waste collection	Days where illegal dumping is more intense	Location (GPS Coordinates)
1	Ivory 2	Tuesday	Saturday	26° 1'7.85"S 28°10'43.55"E 26° 0'44.94"S 28°10'28.55"E 26° 0'38.20"S 28°10'30.52"E 26° 0'52.73"S 28°10'55.17"E 26° 0'49.84"S 28°11'8.50"E 26° 0'45.49"S 28°10'58.02"E 26° 0'47.31"S 28°10'57.42"E 26° 0'39.98"S 28°11'0.78"E 26° 0'29.21"S 28°10'54.07"E 26° 0'33.82"S 28°11'3.86"E 26° 0'30.94"S 28°11'5.21"E 26° 0'15.03"S 28°10'49.55"E 26° 0'17.72"S 28°10'40.77"E 26° 0'36.01"S 28°11'27.22"E 26° 0'11.56"S 28°11'13.67"E 26° 0'0.13"S 28°11'2.19"E 26° 0'8.16"S 28°11'26.79"E 26° 0'28.40"S 28°11'40.05"E
2	Ivory 7	Monday	Friday	26° 0'22.33"S 28°11'40.36"E 26° 0'18.92"S 28°11'41.83"E 26° 0'5.57"S 28°11'41.28"E 26° 0'36.01"S 28°11'27.22"E 26° 0'28.40"S 28°11'40.05"E
3	Ivory 8	Monday	Friday	25°59'58.23"S 28°12'23.58"E 25°59'57.29"S 28°12'17.08"E 25°59'36.78"S 28°12'0.02"E
4	Ivory 9	Monday	Friday	25°59'34.63"S 28°12'51.93"E 25°59'32.22"S 28°12'51.13"E 25°59'19.82"S 28°12'47.32"E 25°59'7.05"S 28°12'44.44"E 25°59'25.50"S 28°12'23.40"E 25°59'14.95"S 28°12'25.29"E 25°59'14.44"S 28°12'20.95"E 25°59'12.99"S 28°12'12.14"E 25°59'6.66"S 28°12'27.79"E 25°58'54.51"S 28°12'42.03"E 25°58'53.82"S 28°12'36.44"E 25°58'55.99"S 25°58'55.99"S

Field Observation Results				
Item No	Section	Day of waste collection	Days where illegal dumping is more intense	Location (GPS Coordinates)
5	Ivory 11	Thursday	Monday	26° 0'0.04"S 28°11'43.93"E 25°59'58.70"S 28°11'41.37"E 28°11'41.37"E 28°11'39.88"E 25°59'40.27"S 28°11'37.67"E 25°59'30.71"S 28°11'34.51"E 25°59'27.77"S 28°11'32.60"E
6	Ivory 12	Thursday	Monday	25°59'51.54"S 28°11'15.96"E 25°59'52.64"S 28°11'17.33"E 25°59'52.77"S 28°11'21.24"E
7	Ivory 13	Thursday	Monday	25°58'55.94"S 28°11'59.79"E 25°59'3.81"S 28°12'3.47"E 25°59'4.74"S 28°12'11.72"E 25°59'11.22"S 28°12'3.64"E 25°59'8.26"S 28°11'49.62"E 25°59'7.41"S 28°11'46.14"E 25°59'17.69"S 28°11'52.73"E 25°59'17.11"S 28°11'41.16"E 25°59'16.44"S 28°11'36.99"E 25°59'18.82"S 28°11'34.56"E 25°59'20.19"S 28°11'32.51"E 25°59'22.22"S 28°11'29.45"E
9	Ivory 15	Friday	Tuesday	25°58'49.17"S 28°12'43.04"E 25°58'51.02"S 28°12'40.73"E 25°58'49.14"S 28°12'25.31"E 25°58'49.04"S 28°12'23.80"E 25°58'48.55"S 28°12'22.07"E 25°58'54.93"S 28°12'21.50"E 25°58'53.80"S 28°12'16.81"E 25°58'42.64"S 28°12'23.27"E 25°58'37.51"S 28°12'22.26"E 25°58'36.93"S 28°11'52.32"E 25°58'47.86"S 28°11'57.03"E 25°58'57.43"S 28°11'49.19"E