Sustainable solid waste management in South Africa: A study of the people's perceptions on the impact of solid waste management on human health and the environment in the informal settlement of Diepsloot, Johannesburg, South Africa.

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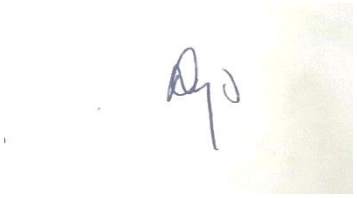
DECLARATION

I, Ngonidzashe Mangoro, declare that this research report is my own unaided work. It is being submitted to the Degree of Master of Science in Geography and Environmental Studies at the University of the Witwatersrand, Johannesburg, South Africa. It has not been submitted before for any degree or examination at any other University.



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Abstract

Solid Waste Management (SWM) has become a monumental human health and environmental risk world over, particularly in the **Developing countries.** Governments, led by environmentalists are frantically trying to mitigate this global catastrophe but the battle promises to surge due to increasing production of goods and booming populations, particularly in **Developing countries**. As such, governments are adopting expensive state of the art technologies to minimise waste on landfills. **Communities in localities where waste is poorly managed can be a credible source of information with regards to the actual situation on the ground.** However, when governments adopt the aforementioned technologies, they tend to overlook the valuable insights that can be derived through studying the communities that produce the solid waste.

It is for this reason that this research studied community perceptions regarding the impact of SWM on human health and the environment in Diepsloot, **Johannesburg**, South Africa. The rationale behind the choice of Diepsloot is justified by the observations that Diepsloot is characterised by scattered illegal dumps on street corners while water courses frequently get targeted for illegal dumping of household waste and construction rubble. The research was further guided by two important interrogations; first, a focus on what could be the associated consequences of solid waste mismanagement in Diepsloot, Johannesburg, South Africa. Second, a focus on how can the impact of solid waste mismanagement on human health and the environment in Diepsloot be mitigated.

Using qualitative and quantitative research methods, data for this research were collected from thirty-five (35) purposively selected participants in two localities of Diepsloot i.e. Diepsloot West Reception Area (DWRA) and Diepsloot West Extension 1 (DWE1). An additional three participants were recruited from three organisations i.e. Greater Kyalami Conservancy (Gecko), "Roots and Shoots" and Pikitup, **a branch of the municipality responsible for waste management.** The results of the study revealed that participants from the Diepsloot community had limited knowledge of the impact of SWM on human health and the environment. However, some were able to point out land and air pollution as well as respiratory complications as the possible impacts. Greater insights were harvested from NGO officials. According to these officials, the impacts on the environment were as follows; water course pollution, habitat destruction, depletion of bullfrog population, etc. The insights were, however, limited with regards to the impacts on human health because they lacked expertise in environmental health and epidemiology. For these officials, this was compounded by the lack of epidemiological

information from the responsible authorities such as the Departments of Health and of Water and Sanitation which fail to make the information public. However, the perceived direct impacts on humans were as follows; seasonal drowning of minors, air pollution due to decomposing waste, proliferation of rodents (rats) as well as rat bites at night.

Poor service delivery by Pikitup was at the centre of the poor plight of SWM in Diepsloot. This was realised through poor service delivery; poor distribution of containers for waste storage, Inadequate distribution of communal dumping areas and poor environmental programmes. In **my** view, these inadequacies explain the widespread environmental unawareness by the residents of Diepsloot. In the greater scheme of knowledge, the results of this study indicate the persisting threats on human health and the environment due to poor SWM. This is centred on poor urban governance in Developing countries where SWM is not considered a priority. To alleviate these issues, we proposed for both short term and long term solutions. Among other means, the proposed short term measures were excavation of drains to redirect sewerage effluent, establishment of new buy back centres and intensification of existing ones. The long term measures were the widening of streets to accommodate waste trucks, establishment of a co-management system and buffering water courses, among other ways.

Key words: Environment, human health, perception, solid waste management, Johannesburg and South Africa

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For a Social Scientist with a strong Archaeological background, it is hard to maintain one's religious faith. However, I believe that the universe was created by a higher intelligence and not a series of complicated random processes. With this deeply entrenched into my flesh and soul, I would like to thank our Lord Jesus Christ and the Father in heaven for making this study a success.

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This study is dedicated to my grandmother, Regina, for raising me up to be a responsible man and to my uncle, Gilbert, for believing in me.

ABBREVIATIONS AND ACRONYMS

DWE1 – Diepsloot West Extension 1

DWRA – Diepsloot West Reception Area

GEKCO – Greater Kyalami Conservancy

IDP – Integrated Development Plan

JHB - Johannesburg

MSW – Municipal Solid Waste

NGO – Non Governmental Organisation

SSA – Sub Saharan Africa

SWM – Solid Waste Management

Contents

Chapter 1: General introduction to the study

1.1. Background to the study

The world is faced with multiple human health and environmental problems caused by negligent or ignorant anthropogenic activities. Individuals and commercial enterprises have been responsible for the unlawful and unsustainable disposal of **municipal solid waste (msw)** in undesignated and environmentally unsustainable locations (European Parliament, 2018: 11). In addition, some governments in developing countries are guilty of encouraging environmentally unfriendly behaviour **with regards to waste disposal**. This is typically done through among other things, the failure to take action against unscrupulous solid waste **disposal**, poor or ineffective **legislation** or **political interference** or delays on issues of solid waste management (swm) (e.g. Kubanza and Simatele, 2019). **There is a tendency of political interference on swm issues in South Africa whereby politicians fight over waste management issues (see Chapter 2**). The population in **the developing countries** is **increasing rapidly**. This is explained by a variety of reasons. Among them are rapid urbanisation, growing economies and high fertility rates (Medina, 2010; UNEP, 2018). The rate of migration from smaller economies to larger economies and from rural to urban areas is on the rise. This **increases** the populations **in the areas involved**. These factors unite to cause the production of unprecedented quantities of solid waste and immediately **create** grounds for environmental and human health concerns.

In developing economies, **municipal solid waste (msw)** collection is generally a task for municipalities (Zohoori and Ghani, 2017: 39). Typically, municipalities embark on **door-to-door** collection of **msw** in garbage bins and dispose of the waste in landfills. Collection frequency is typically higher in formal settlements where navigation routes are clearly defined and where citizens pay their municipal rates (Puling, 2004: 9). This is a longstanding method of solid waste management in developing countries and may have shaped the perception of citizens in these economies on issues of msw management. **For a variety of reasons, municipalities in developing countries face a daunting tasks in the**ir attempts to deliver their constitutional mandate of ensuring clean and habitable environment for all **citizens and residents**. **The waste collection in informal areas is either erratic or non-existent, for example in the informal parts of Alexandra**. Among other reasons, **in my view**, municipalities struggle with solid waste management in informal areas because:

- The lack proper navigation routes which makes accessibility difficult or impossible

- Informal settlements typically fall out municipal jurisdiction (e.g., Fitchett, 2017)
- Political interference which causes delays or outright stoppage of service delivery

The general failure by municipalities in developing countries to effectively and reliably manage **municipal solid waste** in informal settlements influences sanitation issues in these areas. Informal settlements in developing countries are typified by indiscriminately dumped MSW on the streets, in drains, **on** wetlands, **on** rivers among other areas. South Africa is no exception from these realities. **Although clean up campaigns do not necessarily lead to behavioural transformation, it has the capacity to inspire unconscious environmental citizenship. It appears that this is not the case among Diepsloot residents**.

1.2. Statement of the problem

The recent history of the informal settlement of Diepsloot is replete with cases of illegal **disposal of msw in various areas by different actors** (e.g. Carutthers, 2008; Himlin *et al*, 2014; Fitchett, 2017). These actors appear to be Diepsloot residents and some unscrupulous construction companies operating in the more affluent suburbs of Johannesburg in the north that dump construction rubble in the area (**pers com, Kristin Kallesen**). Geographically speaking, the landscape constituting Diepsloot features important freshwater ecosystems e.g. wetlands and rivers with various biodiversity, among them the near threatened "Giant bullfrog" (*Pyxicephalus adspersus*) (Martin and Otto, 2013). One long-time resident of Diepsloot revealed that they used to witness frogs and fish on catchment areas **in** Diepsloot. However, with the onset of indiscriminate disposal of msw and burst sewer pipes, these aquatic species appear to have vanished[1]. Indeed, raw sewerage is reported to have contaminated wetlands in Diepsloot (Himlin *et al*, 2014: 5), causing the water colour to turn blight green and emit unpalatable odours[2]. Freshwater aquatic species cannot thrive in such environments. Along with this predicament, waste water from households is discharged into informal pathways which falls out of the municipal jurisdiction (Fitchett, 2017: 310), thus there is waste everywhere. The polluted water courses e.g. wetlands and rivers, form part of a long stretching drainage system that cuts across Gauteng and beyond. Therefore, these are shared resources.

[1] https://www.iol.co.za/saturday-star/news/watch

[2] www.groundup.org.za/article/rubbish-piles-diepsloot-extension-2/ (22/10/2019)

Contamination in Diepsloot thus presents health risks to aquatic species and communities living downstream.

The population in Diepsloot continues on an upward trend without municipal regulation of housing. It is currently estimated to be within the limits of 300 000[i] and 500 000[ii] over such a small expanse of land replete with catchment areas (Pfigu, 2014). The population crowding Diepsloot is so vast that it requires another area the size of Diepsloot to adequately accommodate the population (Himlin *et al*, 2014: 5). The increase in population entails more production of solid waste. Yet with the deteriorating quality of life in South Africa, the population in the area will probably continue to increase in search for cheaper accommodation**. It is organic that when the economy deteriorates, informal settlements mushroom or the existing ones attract more people**. As it stands, Diepsloot is characterised by back yarding[iii] whereby formal house owners erect numerous shacks around their homes for subletting in order to harvest extra income. **The construction of shacks in Diepsloot causes informality where sanitation measures cannot be easily put into effect**. The ultimate effect is the creation of constricted spaces that can attract illegal disposal of waste while further creating conducive environments for insect breeding

The back yarding phenomenon in Diepsloot is exacerbated by its attractive economic geographical location. With the onset of **democracy** in 1994, various upmarket places have been constructed or upgraded around Diepsloot e.g. Sandton, Fourways, Dainfern and Midrand. In addition, Diepsloot is now accessible easily through the Mogale/ Tshwane highway (N14), William Nicole Drive (R511) (Benit - Gbaffou *et al*, 2013: 87; Himlin *et al*, 2014: 2). This has attracted some industrial development in Diepsloot while also building potential for population boost in the area. This increases the prospect for more waste production.

Throughout the years, the scourge of indiscriminate disposal of solid waste in Diepsloot attracted several actors and projects with the goal to alleviate the crisis. Some of them are the "Diepsloot Sanitation project" in 2014, School Wetland Clean Up campaign, 2020" while one resident formed a waste management company to curb illegal disposal[iv]. Regardless of these initiatives, the illegal disposal of waste recurs and appears to be increasing. This has brought about several potential problems on human health and the environment in Diepsloot. **For example,** residents complain about malodorous odours arising from decomposing organic

waste dumped indiscriminately[v]. Burst sewer pipes also contribute to this problem (Carutthers, 2008). Yet the residents are partly responsible for illegal dumping.

The illegal and unsustainable disposal of solid waste discussed above had additional effects. At one point Diepsloot experienced a rat outbreak due to indiscriminate waste disposal[vi]. Rats are scientifically known to be vectors. They carry diseases e.g. the "Rat bite fever" (Elliot, 2007: 13), and spread them through bites and food contamination. In addition, they can spread diseases by contaminating water with their pathogen **infested** urine or by simple inhalation of their excrements (Meerburg *et al*, 2009:222). With burst sewer pipes typifying the streets of Diepsloot (Himlin *et al*, 2014: 5), the phenomenon attracts a plague of flies in the hot weather9 thus increasing the chances of **poor hygiene related diseases** like diarrhoea, cholera, typhoid among others (see Khamesipour *et al.* 2018: 1). The problem of sewerage flooding the streets may be attributed to the **outdated sewer reticulating system** that is now unable to withstand pressure from the densely populated Diepsloot informal settlement.

The Diepsloot streets are **replete** with informal businesses e.g. **Pakistanis and South African businesses.** By 2014, there were no bylaws to regulate informal traders (Himlin *et al*, 2014: 7) so that order and **sanitation** were scarce or non-existent. Currently, the streets of Diepsloot are still characterised by such traders and with devastating environmental effects due to illegal solid waste dumping. **However, it should be emphasized that these businesses only constitute part of the problem. They are not the only ones contributing to the problem**. **When all the problems are considered**, the character of Diepsloot is that of a dirty, foul smelling and neglected human settlement that is risky to human health and the environment. With the situation in Diepsloot described fully, the research seeks to understand people's perceptions on the subject especially when Diepsloot residents participate prominently in the illegal disposal of waste. In light of the above this research seeks to answer the following questions:

I. What can be the actual and perceived consequences of poor solid waste management on human health and the environment in Diepsloot?

II. How can the impact of solid waste management on human health and the environment in Diepsloot be mitigated?

III. What are the implications of the findings of this study in a wider context, particularly in sub-Saharan Africa?

1.3. Research aims and objectives

The aims of this study are to explore the **community members'** perceptions on the impact of solid waste management on human health and the environment in Diepsloot, Johannesburg, South Africa and to contribute to the existing literature on solid waste management in South Africa. The objectives of this research are to:

I. Identify the problems affecting solid waste management in Diepsloot, JHB, SA
II. Examine the impact of solid waste management on human and environmental wellbeing in Diepsloot, JHB, SA.
III. Propose feasible alternative solutions to mitigate the impact of solid waste management on human and environmental wellbeing in Diepsloot, JHB, SA

1.4. Dissertation outline

This dissertation comprises six chapters organised as follows: **Chapter One** introduces the study and gives a concise background of the study. In addition, it critically outlines the significance of the study while also articulating **the research questions, aims and objectives**. **Chapter Two** presents a comprehensive review of literature on the impact of solid waste management on human health and the environment. The literature **is** specifically confined to; developing countries in general, Sub Saharan Africa and South Africa. **In articulating this literature**, focus is also given on the causes of poor solid waste management practices in these areas. This is done in line with the topic, aim and objectives of the study. In **Chapter Three**, the focus is on the methodology that underpins data collection for this study. However, the chapter commences with a comprehensive outline of the study area (Diepsloot). This includes a brief settlement history and land use practices, current human and physical geographies. The chapter is concluded by an outline of methods to be used for data analysis. **Chapter four** focuses on data presentation and analysis in order to derive conclusions. **Chapter five** discusses the results of the study taking cognisance of the research questions and aims of the study and give conclusions. **Chapter six** presents a conclusion of the study as well as recommendations for future studies.

Chapter 2: Literature review

2.1. Introduction

This chapter reviews the literature on solid waste management issues, including community perceptions on the impact of **solid waste management** on human health and the environment **in developing countries** (with a focus on developing countries). In doing so, the literature review is done on a three tier basis; developing states, Sub-Saharan Africa (SSA) and South Africa contexts. These categories allow the researcher to make analytical comparisons and conclusions on **solid waste management impacts on human health and the environment** cutting across developing countries world over. A critical discussion of the literature then follows, while the chapter is concluded with justification and relevance of the study.

2.2. Solid Waste Management problems in developing states

Developing countries face an increased rate of solid waste generation, particularly in the cities (Boadi and Kuitunen, 2005). The drivers of this modern waste phenomenon are generally as **follows: increasing** populations, expanding economies, rapid urbanisation, and steadily improving living conditions that have caused more access to packaged goods (Minghua *et al*, 2009; Guerrero *et al*, 2013: 220; Dhokhikah and Trihadiningrum, 2012: 329; Zohoori and Ghani, 2017; 39; UNEP, 2018; Tomita *et al*, 2020: 223). These factors unite to cause the production of vast quantities of **municipal solid waste (msw).**

The crisis appears to be much greater in some areas than in others**. South Asia seems to have the biggest crisis**. The region consists of countries: Bangladesh, India and Pakistan as major producers of MSW because they have exceedingly high populations. Together, these states have a combined population of 1, 68 billion people (Kaza *et al*, 2018: 69). Meanwhile, other countries in this region are: Afghanistan, Nepal and Sri Lanka home to an approximate population of 85 million people while Bhutan and the Maldives have a combined population of 1, 2 million people (Kaza *et al*, 2018: 69). These vast population numbers led to the production of approximately 334 million tonnes of solid waste in South Asia in 2018. This was achieved by an approximate 0.52 kg of waste per capita per day (Kaza *et al*, 2018). **An inspection of the population figures along with the general state of economies in South Asia would reveal possible imbalances between available resources and the population.** Municipalities in these countries fail to keep up with the increasing waste.

Some cities have far greater SWM management problems than others. For instance, 7000 tonnes of MSW were generated per day in Delhi (India) in 2007 (Talyan et al, 2008). Based on some drivers noted above, these numbers were projected to increase over time. 17 000 to 25 000 tonnes of waste would be produced per day (Talyan et al, 2008). However, no study was done to corroborate the projections from this study in 2011. In Pakistan, approximately 50 000 tonnes of MSW were produced by 2010 (Ejaz *et al*, 2010). In Cambodia, over 361 000 tonnes of MSW were generated and disposed illegally in Phnom Pehn (Cambodia) in 2008. These figures represent underlying complications of SWM in these jurisdictions and the extent to which some cities faces more SWM challenges than others.

Economies in nations in this category are improving as reflected by the **increasing** waste generation. The concomitant perception would be that municipalities in these nations are well resourced. Divergent to this, SWM in these countries has been **shambolic**. Firstly, municipalities are constitutionally tasked with the responsibility **for** SWM (Zohoori and Ghani, 2017: 39), yet they face a myriad of challenges. There is a perennial **problem** of underfunding **(Ejaz *et al*, 2010; World Bank, 2014; Zohoori and Ghani, 2017).** This chronic underfunding contributes to the global waste funding shortfall of US$40 billion per year (World Bank, 2014), and this figure is likely to have increased to date. Generally, there is lack of planning on issues of SWM and this is coupled with outdated management systems and equipment (Ejaz *et al*, 2010). Other challenges as summarised by Diaz (2011) are:

- **The poor laws and policies that can facilitate feasible long term planning**
- Use of unsuitable technology and related equipment
- Inadequate knowledge of simple waste management issues
- Increased rural-urban migration and the concomitant evolvement of settlements without planning
- Communities generally fail to pay their contributions to municipalities

These challenges work to the detriment of effective SWM and impose severe strain on municipalities that ultimately fail to keep up with high waste production. It leads to the indiscriminate and unsustainable disposal of **waste by the affected communities** and with negative consequences on human health and the environment.

2.2.1. The Impact of Solid Waste Management on human health and the environment in Developing countries

Poor SWM management practices results in degradation of human health and the environment. Improving economies, booming population and higher goods consumption leads to high waste generation. As such, SWM authorities in Pakistan, for instance, cannot cope with pace at which waste is produced. The country produced approximately 50 000 tonnes of waste every day by 2010. Of this, only 60% is disposed of in a proper manner while the rest goes to undesignated locations (Ejaz *et al*, 2010). In Bahawalpur, indiscriminate dumping flourishes (Mohsin and Chinyama, 2016: 74). This resulted in: deterioration of land, depletion of flora and fauna and depreciation of the aesthetic values of the environment (Mohsin and Chinyama, 2016: 74). The indiscriminate disposal of waste in Bahawalpur results in **the proliferation of illegal dumpsites**. From these, diarrheal illnesses caused by pathogens arise. For instance, Malaria and the typhoid fever cases are common in the city as a result of dirt and pools formed all over the city (Mohsin and Chinyama, 2016). Poor SWM is said to claim between 400 000 and 1 000 000 lives annually in the developing world (Sinha *et al*, 2020: 2).

Indiscriminate dumping also flourished in Dhaka, Bangladesh. Here, the once phenomenal Buriganga River has been severely depleted on account of indiscriminate dumping of household waste, sewerage, medical waste and plastics by households and organisations (Chakraborty *et al*, 2013: 245; Kibria *et al*, 2015: 323). This behaviour does not affect the viscosity and functionality of the river alone, but also the life in it. It leads to the degradation of the riverine habitat. **Furthermore, poor SWM in Dhaka has led to the contamination of groundwater in the western parts of the city**. In addition, aquatic organisms may ingest pieces of plastics with poisons. These can be dissolved and assimilated into different parts of the body and cause a variety of side effects (Hammer *et al*, 2012). This affects other organisms higher on the food chain e.g. sea birds, whales and sea lions (e.g. Ferronato and Torretta, 2019: 7), ultimately the **humans (Harris and Mitchell, 2018**).

In developing countries, the MSW that finds its way to landfills is still a threat to the environment and the people. This is usually exacerbated by poor land use planning. It is typical of developing countries to situate landfills close to human settlements. As the landfill waste decompose, it releases poisonous leachates such as organic carbons, ammonia and heavy metals among other poisons (Torretta *et al*, 2017). The impact of these is apparent in Kolkata, India. Leachates from MSW at Mathkal landfill in this city is said to have severely degraded water quality around the location through contamination of groundwater. This affected the

quality of life of the people living nearby (Biswas *et al*, 2010). Similar problems have also been reported at the Nonthaburi landfill in Thailand, where heavy metal concentrations that exceed the world health organisation (WHO) acceptable levels were detected in bole hole and runoff water (Prechthai *et al*, 2008).

The lack of funds for SWM initiatives persuades communities in developing nations to resort to casual burning. Burning in any given case, i.e. with precaution or otherwise, emits contaminants that are hazardous to humans and the environment. For example, burning affects soils with toxins that are released as a result. Some tests were done on soils in India, Philippines, Cambodia and Vietnam and some toxins were discovered. Some toxins that came as a result of incineration are; Polychlorinated dibenzo-p-dioxins (PCDDs), Polychlorinated dibenzofurans (PCDFs) among others (Minh *et al*, 2003). These have an effect of causing skin lesions and immune disorders among other things

Elsewhere, due to various factors affecting SWM in Huejutla Municipality, households burnt 24% of the total MSW they produced. This generates black carbon (BC) pollutes the environment and contribute to climate change in the country of Mexico (Reyna-Bensusan *et al*, 2018). It is apparent therefore that unsustainable SWM has catastrophic consequences on human health and the environment.

2.2.3. A review of Community perceptions on the impact of SWM in developing countries

The effects of poor swm on human health and the environment from a scientific perspective have been discussed. But what are the perceptions of communities on the impact of waste on human health and the environment? **It is important to understand community perceptions on human health and the environment because it can inform studies on how to improve sanitation in a given case study**. The community in Pulau, Langkawi in Malaysia appeared to understand the impacts. While the majority of the participants generally acknowledged that solid waste can be harmful to human health, some were more specific. In this study, 54, 5% of the participants (18 participants) linked poor SWM management with dermatological diseases. Others (36. 4% or 12 people) linked poor SWM with cancer (Abdullah *et al*, 2014). While these participants appear to be knowledgeable, they did not specify which cancers or dermatological disorders are results of poor SWM.

In another locality, undergraduate students at unnamed private universities in the Western Province in Colombo (Sri Lanka) also appeared to have generic knowledge on the impact of

SWM on human health and the environment. 80% of participants in this study noted that poor SWM can diminish the environment which in turn affects people's quality of life. The participants added that waste produced foul smells and led to rat and fly infestation in the area (Wanodya and Perera, 2018). The perceptions gathered in this study were not commensurate with the educational background of the participants which demonstrates a general lack of environmental education. The perception on odour above was shared by participants in Moratuwa (Sri Lanka). They highlighted that air pollution caused by waste trucks as they transport waste to landfills as well as malodorous odours from the nearby landfill (Bandara and Hettiarachchi, 2003). This community perceived more on poor SWM. According to the participants, the nearby landfill was a breeding spot for mosquitoes and flies while it also resulted in flooding in the wet season. This is not all they perceived of poor SWM. In addition, they noted the rise in smoke and toxic gases which was understood to cause safety problems. In addition, they stated that children suffered from skin diseases (Bandara and Hettiarachchi, 2003).

The perceptions of the above community in **Moratuwa** on the subject appear to be comprehensive **compared to the community in Colombo in Sri Lanka**. Their academic backgrounds were not highlighted by Bandara and Hettiarachchi (2003). Therefore, there is a possibility that the community was once subjected to environmental health education sometime before the study. Meanwhile, communities in Westbank (Palestine) contrasted sharply with those in Moratuwa (Sri Lanka). Their perception on effects of poor SWM were shallow as they only pointed out poor SWM results in unhygienic conditions (Al Khatib *et al*, 2015). This may have been influenced by lack of environmental education since Khatib *et al* (2015) recommended it at the end of their study.

Waste pickers' perceptions on the impact of SWM have also been studied. In Jequie, Sao Paulo (Brazil), waste pickers appeared to understand the impacts but the need for income preceded the perceived impacts. The 10 participants pointed out the impacts to be: cuts from sharp materials concealed in waste, respiratory problems, ringworms, pneumonia, cuts etc. (Cardozo and Moreira, 2015). Their understanding of the topic under review appears to be influenced by their frequent visits to doctors for health checks rather than education which they seemed not to have (see Cardozo and Moreira, 2015: 372, 373). In a separate study, other waste pickers in Bahian City (Brazil) did not care much about the hazards linked to lack of protective gear when picking waste in landfills (Moreira *et al*, 2019). **To them it was not a necessity to wear protective gear in order to scavenge the landfills**.

Meanwhile, participants (waste pickers) on the same topic in Bogota, Colombia appeared to care much about the environment. They opined the wisdom in reducing the amount of waste in sanitary landfills so as to increase the useful life of landfills (Bermudez *et al*, 2019).

2.3. SWM problems in Sub-Saharan Africa (SSA)

Sub-Saharan Africa (SSA) constitutes part of the developing countries in the world (Bello *et al*, 2016; Aryampa *et al*, 2019: 2). The region is characterised mostly by economies with low Gross Domestic Products (GDP) for a variety of reasons (see Manners and Behar, 2007), but there has been a steady transformation since 2007. **However, the** impression is still that of a large community with limited access to goods, to an uncritical mind, which would organically translate to low waste production. **This appearance of a region with limited access to** goods is misleading because the region produces high Solid Waste quantities. In 2016, the region generated 176 million tonnes of waste (Kaza *et al*, 2018: 76). S**ome** urban areas in Africa produced 123, 7 million tonnes of waste in the same year while it has been projected that 367, 7 million tonnes of waste would be produced in the same region by 2040 (UNEP, 2018: 153).

SSA municipalities face challenges managing solid waste in the region. There are many factors that can explain this. The region is characterised by booming populations (Mutunga *et al*, 2012). It has the highest fertility rate in the world with an average of 4.7 children per woman, particularly in the Middle and West African areas (UNDESAPD, 2017). In 2007, there were 807 million people in the region (ECOWAS, 2007: 3), while there was a significant surge to 1, 08 billion people in 2016[vii]. Related to this, there is high internal migration which is fuelled by several drivers. The major drivers are war, climate, economic problems (Abel *et al*, 2019), **as well as the construction of secondary cities (Zimmer *et al*, 2020).** The effect of the phenomenal migration trends is that millions of people cluster in chosen countries while those who migrate for economic reasons sends tonnes of goods back home – hence the production of waste and its mobility from one state to another.

While solid waste production surges in the region, municipalities face budget deficits for **swm** initiatives (Hoornweg and Bhada-Tata, 2012; Mombo and Bigirwa, 2017: 1; UNEP, 2018). However, the lack of funding is not the only factor fuelling SWM challenges. Generally, SSA municipalities are plagued with administrative inadequacies, unregulated land use leading to creation of slums, lack of planning or outdated management systems and equipment (Medina, 2010: 1; Ejaz *et al*, 2010: 380; Eugene and Busch, 2011: 1; Sankoh *et al*, 2013: 665). In addition, governments give low priorities on SWM issues (Kaza *et al*, 2018), while political

interference and regulatory capture exacerbates the problems (Kwarteng, 2011: 29; Kaza *et al*, 2018; Schenck *et al*, 2019: 1). These factors hinder possible municipal partnerships with private sector organisations.

Governmental involvement in waste management has seen governments assuming the traditional municipal responsibilities thus acting in detriment to the international trend of decentralisation. With high governmental interference emerges a large gap in waste management data collection which ultimately contributes to waste crises (Kaza *et al*, 2018: 77). In other cases, some politicians engage in fights on issues of waste management and oftentimes even landfills are put under an administration (Schenck *et al*, 2019: 9).

2.3.1. The impact of SWM on human health and the environment in SSA

The challenges facing municipalities highlighted above coalesce to cause solid waste management problems in SSA. One of the most common scenarios is open dumping which usually goes with incineration of the waste (Hoornweg and Bhada – Tata, 2012). It is common a scenario that less affluent communities are located close to dumpsites. Such communities face immense health risks due to improper waste disposal. This can contaminate water, food sources and vegetation (Kimani, 2012). In Gambia, in the City of Banjul, a densely populated human settlement was located close to a poorly managed landfill (Sanneh *et al*, 2011). The impacts at the time were; **terrible** visual impact, smoke from incinerated wastes envelops the skies around some sections of the residential areas while malodorous odours from decomposing waste plague the settlement (Sanneh *et al*, 2011). In a similar case, a medical evaluation was done on children living close to the Dandora landfill (Kenya) and it revealed some diseases like; respiratory, gastrointestinal and dermatological problems, asthma, fungal infections among other (Kimani, 2012). In Abuja (Nigeria), four of its largest landfills were closed off on account intensive bad odours (Aderoju *et al*, 2019). In addition, 43 informal waste pickers are reported to have been injured or taken to hospital from scavenging the illegal dumpsites in Tanzania. They mostly suffered from airborne diseases, animal bites, cuts or fungal infections due to lack of protective clothing (Palfreman, 20 15: 539). Across SSA, waste picking is fast emerging as a source of income and many people are resorting to this for income. This represents a growing risk of exposure to illness causing environments in SSA.

Toxicological analyses of sewage contaminated water have revealed the likelihood of gastrointestinal and respiratory problems (Giusti, 2009: 2235). Similarly, research on landfill emissions reveals that they have deleterious effects on human health and the environment.

These emissions comprise multiple toxic **gases such as** Sulphur Dioxide, Nitrogen Dioxide, and Hydrogen Chloride, chemical oxygen, ammonium nitrogen, organic carbons, ammonia, chloride, host of heavy metals etc. These upset air quality and may cause the following human health problems: coughs, chest tightness, breathlessness and bronchoconstriction. Other gases include methane and carbon dioxide that may cause cardio-respiratory failure, headaches etc. (Macklin *et al*, 2011: 11, 13; Torretta *et al*, 2017; Karak *et al*, 2013). A study of air pollution has revealed that in 2013, 712 000 people died in Africa due to contaminants in the air from burning waste (Organisation for Economic Co-operation and Development OECD in Niekerk and Weghmann, 2019: 5). **In Ghana, West Africa, a study showed that most communities living close to landfills were prone to Cholera outbreaks, (Osei and Duker, 2008).** In a similar case, residents in Nakuru (Kenya) experienced diarrhoea outbreaks linked to polluted water used to irrigate a vegetable farm. **This pollution was a direct outcome of leaching from the landfill**. Elsewhere in Kenya, unprocessed sewage often flows into catchment areas where communities source water for washing (van Niekerk and Weghmann, 2019).

Solid waste problems worsen during the wet season. In this period, toxic leachates from degenerating solid wastes are washed into water bodies while also polluting ground and surface water regimes (Ferronato and Torretta, 2019: 4). These pollutants enter the human bodies through contaminated crops, meat, food products, or water (Medina, 2002). This often results in the following; emergence and spread of infectious diseases, blockage of drains, environmental pollution and the depletion of fauna (Ejaz *et al*, 2010: 379; Sankoh *et al*, 2013). In Accra, Ghana, plastic waste piled up in water ways and clogged the drains. This resulted in extensive flooding that eventually killed 150 people (Hinshaw, 2017). Mosquitoes are attracted to such places for breeding. Malaria, Zika Virus and Dengue fever in SSA emerge from such scenarios and spread as the mosquitoes disperse for feeding (van Niekerk and Weghmann, 2019: 5).

2.3.2. A review of community perceptions on the impact of SWM on human health and the environment in Sub-Saharan Africa (SSA)

Communities comprising any region have varying perceptions on SWM issues, particularly with regards to the impact of SWM on human health and the environment. For some community members in Harare (Zimbabwe), the major impacts of poor SWM were the visual nuisance and general hygienic concerns. Apart from this, the participants had no knowhow of other impacts on the environment (Zvikaramba, 2008).

The above contrasts with research participants in the Morogoro municipality in Tanzania (see Chengula *et al*, 2015). Participants in this questionnaire survey categorically stated that the following diseases: malaria, diarrhoea, cholera, dysentery, typhoid and worm illnesses were a direct outcome of poor SWM (Chengula *et al*, 2015). In the same study, participants residing near disposal sites lamented bad odours emanating from landfills as well the associated unpleasant views (Chengula *et al*, 2015: 59). The ability to match the named diseases to waste may be linked to the higher levels of education by participants. Over 30 participants had high school education while 10 had college qualification and 5 had a university qualification (Chengula *et al*, 2015).

In addition to the above, participants in a study conducted in Conakry, Guinea were also rather too knowledgeable on the impact of waste on human health. Diseases named by participants in Morogoro, Tanzania above were also named but with an addition of "injuries" and "respiratory infections" (Mamady, 2016). While the above is commendable, methodological flaws in this study thwarts the validity of participants' perceptions. **The author posed leading questions such as "Are the following diseases caused by poor swm: cholera, typhoid, dysentery, diarrhoea etc. (Mamady, 2016: 4). This methodological flaw my limit clear inferences around education and environmental awareness.**

Elsewhere in Jalingo Metropolis, Nigeria – (specifically in political wards (Barade, Majidadi, Sintali A, Turaki A and Turaki B), 44.1% of the participants pointed out the impact of poor SWM to be unpalatable odours while 18.6% described solid waste to be a perfect breeding spot for insects. Yet other participants offered more. Poor SWM was linked with the loss of the natural view of the environment (8.8%) while 5.9% argued that poor SWM caused blockage of drains (Oruonye *et al*, 2018).

Participants in the Brong Ahafo region in Berekum Municipality (Ghana) were of the view that solid waste was a terrible environmental problem to them (Suleman *et al*, 2015). However, this study did not yield a wide range of perceptions. Research participants from Yeka Sub City in Addis Ababa demonstrated knowledge of the issue under review. Two separate groups both emphasised that solid waste infesting the streets caused an eyesore while generating unpalatable odours with the potential to spread unnamed illnesses. In addition, the following problems were also identified as direct outcomes of poor SWM:

- Clogged waterways which ultimately causes overflow during rains
- Traffic congestion

- Illnesses like diarrhoea, cholera, cough, skin rash (Woldetensae, 2018: 31)

Meanwhile, in Aba City (Nigeria), 40% (160) of the participants (waste pickers) highlighted that they had experienced major injuries due to waste picking. While waste pickers in this study acknowledged the hazards related to their job, the way they conceive of the hazards was rather unique. According to Nzeadibe *et al* (2012: 364), 18, 5% of the participants believed that the hazards they face were a direct outcome of supernatural issues e.g. witchcraft. This conception of occupational hazards has the potential to undermine the usefulness of protective clothing in this line of work. In addition, it also has the potential to actually reduce the number of waste pickers for the fear of supernatural attacks.

It is clear therefore that communities in SSA may have some knowledge on issues of SWM. However, this knowledge appears to be generic as it lacks depth. This appears to be the trend in all regions discussed above and it may be attributed to the general lack of environmental awareness.

2.4. SWM problems in South Africa

South Africa is at present immersed in a SWM crisis (Tomita *et al*, 2020: e223). Although the country has a significantly higher Gross Domestic Product (GDP) compared to the majority of Sub-Saharan African (SSA) countries suggesting higher economic activity[3] and therefore more funds on SWM issues, it faces Solid Waste Management challenges. Ultimately, these challenges lead to threats on human health and the environment. The South African National Environmental Management: Waste Act (59 of 2008) is sound in theory. For example, it provides for the National Waste Management Strategy (NWMS) which is aimed at addressing all SWM problems in SA (NWMS, 2011: 5). The NWMS correctly highlighted problem areas in SWM which if there was genuine commitment; SA would be free from the scourge of the waste crisis by now. In practice however, and through personal observation, these constitutional/legal provisions are weak due to erratic, non-existent or selective enforcement. This appears to be one of the pillars of a wide range of SWM problems facing the country.

In addition to the above, other SWM challenges affecting South Africa are: inadequate funding of SWM initiatives (Makgae, 2011: 71), and corruption in municipalities (Godfrey *et al*, 2013).

[3] It would be expected that with its higher GDP, South Africa should have adequate funds to tackle Solid Waste Management problems.

With regards to the funding challenges, the NWMS mandates the polluter to pay for their pollution in what is dubbed the "Polluter Pays Principle" or PPP. In essence, this mandates households and commercial enterprises to pay rates for waste management (Makgae, 2011: 71). In theory this would quell waste management financing issues. In practice this is untenable. To explain this, South Africa is faced with the plague of deep seated economic inequalities in which the less economically privileged resort to squatter camps or informal settlements. Such social groups will not take part in the PPP. Regarding corruption, officials in municipalities were reported to receive salaries 60 – 80% higher than in the private sector. In their attempts to justify this, municipalities feebly claim that the exorbitant salaries were a motivation to retain staff (Godfrey *et al*, 2013: 299). On closer inspection, this claim is underwhelming because South African municipalities are contaminated with unqualified staff (Godfrey and Nahman, 2007).

Related to the scandalous salaries above is the chronic financial incompetence infesting municipalities. For example, they oftentimes spend large amounts of funds on new fleets of vehicles that are used ineffectively for short periods of time **(Talyan *et al*, 2008).** This paints a picture of organisational inadequacies and corruption which can be traced back to the inadequacies of the unqualified personnel **across** the municipal organisations. Corruption oftentimes causes officials to waste funds on unsuitable machinery (Talyan *et al*, 2008). Although Talyan *et al* (2008) did not explain how corruption leads to this, it is the researcher's opinion that such unsavoury procurements are meant to mask the looting of vast amounts of funds. **In 2020, the government of South Africa announced an economic rescue package of about R500 billion. A few months after the announcement, there were numerous stories of looting of these funds by political officials across the government. It is clear therefore that looting is rife in South African national institutions**. It can also be argued that these problems might all be explained by the large disproportionate link between job specifications and officials' actual qualifications.

The organisational incompetence is further revealed through deep seated lack of effective SWM policies or strategies for the varying South African urban environments. Municipalities imprudently, perhaps conveniently (to cut costs) follow the "One size fits all" approach to waste collection (see Korfmacher, 1997: 477). The situation is still the same over two decades since Korfmacher's publication. This approach is soiled with faults with regards to informal settlements where among other problems, navigation remains a monumental problem. **The approach to waste management by the municipality is such that waste is collected door**

to door by collection trucks. With navigation problems in informal settlements, this approach is not possible. Such policy inadequacies encourage environmentally unfriendly behaviour which results in SWM crisis in many informal settlements across South Africa.

The National Treasury of South Africa has a constitutional mandate to inject some funds into qualifying municipalities. However, the municipalities typically receive the paltry cash subsidies late which lead to the lack of strategic resources for SWM (Godfrey *et al*, 2011; Godfrey *et al*, 2013: 295). With prolonged red tape involved in disbursement of funds, municipalities are often faced with legal actions from non-paid accounts so that funds are usually diverted to mitigate these problems rather than servicing the originally intended purpose of SWM (Godfrey *et al*, 2013: 298). All things said, the cases of corruption and organisational incompetence we discussed so far lead to the SWM crisis in which South Africa is immersed at the moment. How so? These cases of corruption lead to inadequate funding of SWM initiatives across the country, particularly in the informal settlements where residents do not pay municipal rates.

Some problems tend to be area specific. In Enkanini informal settlement in Stellenbosch, the municipality installed seven concrete waste bays (an equivalent of waste skips) to service community members with legitimate dumping areas (von der Heyde, 2014). On the surface, this was a noble idea but with closer inspection, this was done without prudence which can be linked to organisational incompetence. The seven waste bays were not located conveniently to some community members (von der Heyde, 2014). The result is that some community members have to walk long distances to dispose waste. This has an effect of encouraging illegal dumping.

Other problems fall in the ambit of social and environmental injustices perpetuated by the municipality. In the Zwide Township which falls under the Nelson Mandela Municipality jurisdiction, service delivery appears to vary with location. Gcobani (2013) argues that previously disadvantaged communities in this area are prone to erratic waste collection services. Gconani (2013: 3) authoritatively argued that the municipality is "…accustomed to a situation whereby it removes the waste on an ad hoc basis." It is further argued that the municipality is ignorant of the growing population in some townships of lower income and the effects tend to be environmental in nature.

There are other problems affecting SWM which are non-institutional. South Africa is an intermediate economy where per-capita earnings are much higher than other countries in the

SSA region. This results in higher solid waste production. In addition, being an intermediate economy surrounded by low GDP economies in SSA and Africa as whole, South Africa is faced with excessive illegal immigration (Segatti and Landau, 2011: 4). High illegal immigration contributes to the already large South African population thus more solid waste production and unsanitary habits. With the housing backlog stifling South Africa's constitutional commitments for citizens, the problem is worsened by poor illegal immigrants. For political reasons they are denied access to health care and clean habitable environments (Segatti and Landau, 2011: 122). Concomitantly, they are forced by poverty to join slams or informal settlements where "housing" is "affordable". Informal settlements are notorious for their lack of sanitation partly due to constricted spaces and illegal dumping. These problems all unite to cause SWM problems for municipalities and with risks on human health and the environment.

There is a widespread character of dependence on central authorities among South African communities. As Jean's (2014) research reveals, communities believe that the government is liable for sanitation services. Attached to this is the perception that illegal dumping and littering by communities cannot have negative effects on the environment (Jean, 2014). In fact, as Jean argues, there is a belief that correct disposal of bulky waste id unpleasant and inconvenient. This becomes a challenge to effective swm management in South Africa in the sense that sanitation becomes difficult to achieve.

2.4.1. The impact of SWM on human health and the environment in South Africa

Land use planning in South African urban centres is **poor** in many areas (Kubanza and Simatele, 2020). The country is faced with dangerous proximity of human settlements to both regulated and unregulated landfills. By definition, unregulated landfills are unlicensed on land waste disposal points that are not designed or built in a regulated framework (Machete and Shale, 2015: 447). Many settlements in South Africa have widespread spotting of illegal landfills due to a variety of issues discussed earlier in the Chapter. Therefore, the exposure of communities to landfills, whether regulated or otherwise should be treated as an emergency. The location of settlements close to landfills is a direct outcome of environmental racism where non-white communities during the era of the Apartheid State were segregated from White communities (Tomita *et al*, 2020: e225). The human health and environmental repercussions of this are still being felt today.

To give context to the above, some of these settlements are Badplaas, Carolina and Elukwatini under the Chief Albert Luthuli Municipality's jurisdiction (Machete, 2017: 1). Landfills in these settlements are located on average about 237 metres from residential areas and 400 metres from water sources (Machete, 2017: 5). Solid waste like asbestos, medical waste and electronic waste feature predominantly in these landfills that are often seen on fire (Machete, 2017). Fires generate toxic gases that are in turn released into the atmosphere. The toxic smokes permeate the human body through inhalation, skin absorption, or orally (Selin, 2013; Caravanos *et al*, 2013). In their study, Machete, (2017) concludes that there are high chances of exposure of the people in this area to heavy metals such as arsenic, mercury, lead and cadmium. Worse still, the landfills have no access control, storm water or leachate control mechanisms. This provides perfect grounds for exposure (Machete, 2017: 5).

In South Africa, municipalities and other waste stakeholders rely mostly on landfills for municipal waste disposal. Various types of waste are disposed of here and on decomposition, gases and compounds are emitted (DEA, 2018). 38 million tonnes of hazardous waste were produced in South Africa in 2017. From this, a measly 7% was reused or recycled while the rest of it was landfilled (DEA, 2018: 19). Among the waste was the following; batteries, inorganic waste, waste oils, asbestos containing waste, etc. (DEA, 2018). Some gases that are emitted from landfills are; methane, carbon dioxide, nitrogen and some volatile organic compounds (Pichtel, 2005; DEA, 2016).

Following the above, an estimated 43 million cubic meters of methane gas are estimated to be emitted from South African landfills annually (DME, 2004 in SEA, 2017: 186). However, with the increase in industrial production in South Africa since 2004, these figures might be rendered obsolete. The amount of methane gases emitted might have increased drastically over the years hence more threat on human health and the environment through contributing to climate change and respiratory illnesses to people. According to the DEA (2018: 38), landfill sites are one of the highest contributors of global Greenhouse Gas emissions. Complementary to this, Bogner *et al.,* (2007) notes that close to 5% of the Greenhouse gas emissions world over are contributed by the waste sector.

Compounds and odours are also released from waste water treatment in South Africa such as hydrogen sulphide, mercaptans, ammonia and many fatty acids (DEA, 2016). These have a direct negative impact on human health. They can cause; nausea, vomiting, loss of appetite, sleeplessness and hypersensitive reactions (DEA, 2016). The DEA fails to give case studies

where citizens and the environment were affected thus rendering the study generic. However, with the knowledge that waste production is escalating, the exposure of humans to hazardous waste also increases, thus, higher risks of diseases (e.g. Tomita *et al*, 2020: e224). As is the case in other countries, wastes are also generated at household level. It is common in South Africa, particularly in the Metropolitans, for residents to discard MSW in undesignated locations for various reasons. This practice is common in the informal settlements that locate mostly on the peripheries of Metropolitans. E.g. in Alexandra (Johannesburg) where satisfactory refuse collection was accessible only to approximately 37% of the populations and just 54% in Buffalo City (Richards *et al*, 2006: 379).

Erratic waste collection shapes the perceptions of people towards waste management and sanitation. Communities indiscriminately dispose of the uncollected waste in environmentally unsustainable locations**. Following the broken window analogy by Wilson and Kelling (1982), the prevalence of erratic waste collection has an effect of encouraging further dumping because communities would view this is a norm**. Such actions are a threat to the environment. Deteriorating organic waste releases leachates that seep into the earth and with negative ramifications. These contaminate water thus posing threat to human health and the environment (Blight, 2011). It goes further. Illegally disposed MSW can be carried by surface run off into rivers and oceans causing risks to fresh water quality and marine life (DEA 2018: 39, 41). Adding onto the above, indiscriminate dumping of waste by citizens makes the environment unsightly. It degrades the aesthetic value of any given place and this is typical of many places in South Africa. It can be seen therefore that South Africa is undergoing severe environmental and human health problems due to unsustainable anthropogenic activities.

2.4.2. A review of community perceptions on the impact of SWM on human health and the environment in South Africa

Erratic collection of waste has the potential to shape the perception of people towards swm. Related to this, the prevalence of poor land use planning in South Africa has led to many less affluent communities living close to landfills. Communities in this predicament face a lot of hazards due to their close proximity to these landfills. It is imperative to seek an understanding of community perceptions on the impact of solid waste on human health and the environment. Communities living close to the Thohoyandou Landfill in the Limpopo Province cited the following diseases as a direct outcome of their close proximity to the landfill:

respiratory complications, cancers, colds, eye problems, general body weakness, auditory difficulties, skin problems, among other complications (Njoku *et al*, 2019). On close analysis of the research statistics in this study, one would observe that the total number of participants naming these complications was generally under 50% of the total number of participants. The perceived relationship between the landfill and the illnesses reported can be challenged on the grounds that the illnesses can also be caused by other factors. Njoku *et al*, (2019: 14) also alludes to this. Studies seeking this kind of knowledge are not so many. We know that the chemical and microbiological processes transpiring in a landfill can be dangerous to the environment and communities that live close by (Njoku *et al*, 2019: 1).

Some occupational perceptions have also been studied in South African landfills. Waste pickers at nine unnamed landfills in South Africa were chosen for research on occupational risks (see Schenck *et al*, 2019). In this study, waste pickers named the following as the impact of scavenging on their health: cuts from sharp objects concealed in waste, tuberculosis, sicknesses from eating landfill food waste, bad odours, (Schenck *et al*, 2019: 13, 14). A rather unique kind of impact on human health was observed at one of the landfills. Some waste pickers claimed they were often traumatised at the sight of dead babies unearthed during scavenging (Schenck *et al*, 2019: 16). Meanwhile, on one of the landfills, waste pickers were offered protective gear e.g. gloves, masks and reflectors. However, they preferred working without these for unnamed reasons (Schenck *et al*, 2019: 10). Through deductive reasoning, this suggests that the waste pickers did not perceive of protective clothing as useful or that it was seen as a barrier to their work. Perhaps the weakness of this study is that the researchers did not provide statistics for the number of waste pickers with such perceptions. It is therefore impossible to assess the general perception held by the participants on the issues under investigation.

At Onderstepoort landfill in Tshwane, people complained of the following complications allegedly as a result of solid waste: bad odours, back pain, headache, diarrhoea, respiratory problems, and cuts sustained from sharp objects in the course of scavenging (Nyathi *et al*, 2018). Generally, waste pickers operating at this landfill did not wear protective clothing, particularly the men (Nyathi *et al*, 2018: 2). Statistically speaking, 40.7% of the female waste pickers revealed that they had been injured during work. Others claimed otherwise. On the other hand, 38.6% of male waste pickers admitted injuries during work while 61.5% claimed they had never been injured (Nyathi *et al*, 2018: 2). On scrutinising these statistics, it is suspicious how the number of waste pickers claimed never to have been injured. It may have been an attempt to justify their occupation as safe. Such responses seem to be consistent with

those from waste pickers in Pretoria in a separate study (see Schenck and Blaauw, 2011). In this study, the major concern for waste pickers was the fear of being overrun by trucks traversing the landfills (Schenck and Blaauw, 2011: 12).

Meanwhile, communities in Mamelodi East Township claimed to understand the impacts of waste on the environment (see Nkosi, 2014: 33). As such, they underscored the need to devise measures of curbing illegal dumping because of the perceived negative impacts on human health and the environment. Some of the stated consequences are: unpalatable smells, flies, rodents and respiratory disorders due to smoke from the landfills. They also lamented to sights of human foetuses dumped in illegal dumpsites (Nkosi *et al*, 2014: 34).

In EThekwini Municipality, all participants claimed to be aware that illegal waste disposal affects everyone through bad smells and the influx of rodents, mosquitoes and even snakes (Abel, 2014: 35). Furthermore, the participants reported that waste accumulates to form a large heap and eventually collapse downhill to clog flood systems and contaminate water bodies and negatively impact on wildlife and aquatic species (Abel, 2014: 41). However, two participants claimed that the illegally disposed waste had no impact on the environment (Abel, 2014). At UMkhanyakude and Zululand district municipalities, 256 (83%) respondents appeared to have in-depth knowledge on service delivery systems in their respective areas. They criticised the systems and perceived that environmental problems arise as a result of municipal solid waste decomposing near their houses and open spaces (Dlamini *et al*, 2017: 11). However, the participants did not spell out the environmental problems emanating from poor SWM.

2.5. Concluding remarks

This chapter attempted to review literature on the problems, impact and community perceptions on the impact of SWM on human health and the environment. In doing this, a particular **pattern** was observed in all the categories of developing countries discussed. It seems that the genesis of the problems lies in the **lack of political will** and underperforming municipal institutions. Municipalities are constrained with multiple impediments that make effective service delivery difficult. With so much waste being produced by communities that particularly lack robust environmental and human health awareness, the situation further deteriorates. It results in indiscriminate dumping of waste which in turn affects human health and the environment. This literature review has revealed a hierarchy of underperforming actors with regards to SWM i.e. governments» municipal institutions> communities.

Communities appeared to have a tendency of relying on central authorities for SWM. Yet the central authorities are typically plagued with institutional inadequacies and financial challenges. Until this tendency is eradicated, the dependence on authorities for general sanitation or waste collection will continue to prevail. The reviewed literature demonstrated the prevalence of generic knowledge on human health and environmental issues. Although some participants were able to name illnesses that may result from poor SWM, at times it was a result of poor methodologies employed by the researchers. Some researchers asked leading questions.

2.6. Knowledge gap and relevance of the study

Solid waste management studies in South Africa are quite widespread. However, most studies in this field of **geography appear to be more technical and fit only for academic consumption**. Most researchers have investigated the impact of solid waste on human health and the environment, particularly **in metropoles**. **Unfortunately, these studies are not very accessible to the public and are not also of interest to the public**. The general public neither reads nor understand the technical scientific terms used by environmentalists and environmental toxicologists. This stance makes these studies fit only for academic consumption.

In this era of global sustainability problems**, a participatory approach to the impact of swm on human health and the environment is required.** This research investigates people's perceptions regarding this subject. This is to be done in the informal settlement of Diepsloot in Johannesburg, South Africa. The informal settlement of Diepsloot is typified by indiscriminately disposed municipal solid waste. This is usually on the streets, in wetlands and in drains. Oftentimes, the residents of Diepsloot complain about the unsightly streets and bad odours emanating from the **solid waste that has the capacity to cause human health and environmental degradation**. Research has been done previously in Diepsloot. However, the researchers have focused mostly on devising ways to improve sanitation in the area (e.g. Fitchett, 2017). This research goes a step further. It seeks to understand the perceptions of the people of Diepsloot where waste problems have recurred for over a decade. **This study contributes to the literature on swm in South Africa especially when there are global efforts to** save the planet earth from various deleterious anthropogenic activities.

In addition to the above, the existing literature on solid waste management in the informal settlements in South Africa is negligible. Much of this literature is predominantly from

commercial enterprises. These are normally in form of Environmental Impact Assessments (EIA) and online reports by journalists and action groups. In Diepsloot, some notable investigations have been done by; Himlin *et al* (2014), Fitchett (2017) and Bopape (2017). These investigations did not focus primarily on MSW management but peripherally mentioned the issue. Expanding on this, none of these investigations focused on people's perceptions. Instead, focus was on improving; water quality and sanitation (refurbishing toilets). No study has been done in Diepsloot to under**stand the people's perceptions on the impact of waste on human health and the environment.**

Adding to the above, the South **African Department of Environmental Affairs, Forestry and Fisheries does not draw from the online reports by private firms, NGOS and journalists. Although** these reports touch peripherally on waste management crisis in Diepsloot, they often point out important information that would be necessary to planning by the DEA. In compiling annual reports, the DEA takes a scientific stance and points out the dangers of waste mismanagement in South Africa but none of these reports include the perceptions of **South African citizens** to whom these reports are targeted.

With the increasing economic hardships in SA, it is only imminent that more informal settlements will be formed while the existing ones will attract more people. This eventually results in more MSW management problems. Studies on people's perceptions on waste management are therefore increasingly becoming important. This study will assist in creating new and well informed literature which will also be useful in achieving sustainability goals, and the value of this study is immediately apparent

Chapter 3: Research Methodology

3.1. Introduction

This Chapter is divided into two main sections; "Study Area" and the "Research Methodology". The "Study Area" section unpacks the history, location and topography of the area of study. It also delineates the current social dynamics in the settlement so as to provide insights into the choice of study area. **The chapter also** delineates the methodological techniques that underpinned data collection for this research. This research methodology was designed to gather data to answer the following questions:

I. What can be the associated consequences of solid waste mismanagement in Diepsloot, Johannesburg, South Africa?

II. How can the impact of solid waste management on human health and the environment in Diepsloot be mitigated?

The research assumed a mixed methods approach. Following this standpoint, qualitative research methods were adopted for data collection and presentation while quantitative techniques were also adopted for data presentation (Chapter 4). The techniques for data collection utilised were: semi structured questionnaires with selected Diepsloot community members, photography, telephone interviews with officials from two Non-Governmental Organisations (NGOs) and Pikitup. The specifics of the data collection process are laid out in greater detail in the "Research Methodology" section in the body of the chapter, below. The data were collected over a period of two days beginning on the 22nd of June 2020, ending on the 23rd of June, 2020. The Chapter is concluded by a discussion of the data analysis methods and a concluding note that paves way for **Chapter 4**.

3.2. History and description of Diepsloot

Diepsloot is located approximately 30km north east of the Johannesburg Central Business District (CBD). It occupies an estimated area of 5km² (Johannesburg Development Agency, 2012). For many, Diepsloot is regarded as an informal settlement. In reality, this is a travesty because of the multivariate nature of the housing assemblage in the different sections of the settlement. The location of the settlement and its original housing in the "Diepsloot Reception Area" (DRA) were purposefully planned by the **Apartheid authorities** in the early 1990s

(Benit- Gbaffou, 2002: 47). It was intended to physically segregate White and Black communities while keeping the Black community close enough in order to provide labour to the White community and the Colonial State (Benit-Gbaffou *et al*, 2013: 87; Philip, 2014: 3). Black communities that illegally occupied land in places such as Honeydew and Zevenfontein were moved to Diepsloot. In addition, more Blacks in Alexandra and Strijdom Park were also resettled in Diepsloot at a different time (Benit-Gbaffou, 2002: 47, 50; Benit-Gbaffou *et al*, 2013: 87; Pfigu, 2014; Himlin *et al*, 2014). **Originally, the settlement was intended to be the "North Western Township – Norweto" in the same fashion as the "South Western Township – Soweto" (Benit- Gbaffou, 2002: 47). The discussed factors thus far, not only sum up the history of the settlement, but also serve to disqualify the settlement as out-rightly informal.**

The onset of democracy in 1994 reconfigured the settlement. Informal dwellings burgeoned because of the huge housing backlogs and the increased population. The burgeoning of informal settlements in Diepsloot after 1994 marked the beginning of; human health and environmental issues, social and environmental injustices that characterise the entire settlement today. It marked the commencement of a kind of class distinction between the formal and informal areas where service delivery is erratic in informal areas and more frequent in formal areas.

The political and economic situation in South Africa, and the surrounding countries led to massive migration of people into Diepsloot. Foreign nationals significantly increased the population in Diepsloot**. In 2011 the population stood at 138 329 people (Stats SA, 2011[viii]). In 2002, the population stood between 18 000 and 30 000 (Benit-Gbaffou, 2002: 48).** The Johannesburg Development Agency (2012: 2) estimated the population to have been 160 000 in 2012. This population was housed in approximately 24 737 shacks and about 5000 formal houses. **Others reported** the population to have been 300 000 in 2014 (Pfigu, 2014). In 2018, the population had surged to 350 000[ix] yet others put in well over 500 000[x]. With the increase in population and economic strife, the settlement expanded to include the following areas: Diepsloot West Extensions 2, 3, 5, 6, 7 and 9, Mayibuye Housing project, Extension 5, Tanganani ex 7 and Diepsloot West Extension 12 (Himlin *et al*, 2014: 4).

The expansion of the settlement was unfortunately not coupled with improvement of infrastructure e.g. sewer systems, construction of formal streets, storm water systems, roads and legitimate dumping areas to service the increased population. Perhaps the lack of

commensurate infrastructural development by the municipality was founded on the fear of appearing to legitimise the illegal occupations. It would be a dilemma for the Municipality. On one hand, the City has a constitutional mandate to ensure a clean and habitable environment for all citizens (SA Constitution, Act 108 of 1996[4]). Yet on the other hand, the city has no mandate to deliver services to the illegal foreign nationals who constitute the majority of occupants in the area. Whether this is an accurate analogy or not does not negate the current **poo**r plight of SWM in Diepsloot. Unfortunately, new shacks are constructed frequently as new people arrive. The lack of regulation in the expansion of the settlement has led to the construction of shacks into the Diepsloot Nature Reserve whose fencing was not secure.

The impacts of these factors are manifold. By way of analogical reasoning, the increase in population means that the existing sewer system is overwhelmed. This likely explains the perennial waste water flow along dusty streets of the informal areas and the subsequent deposition in water bodies such as wetlands and rivers. In further complication, muddy pools in the formal areas are likely a result of the perennial waste water flow. The increase in population is a precursor to several other threats to human health and the environment in Diepsloot. Firstly, the increase in shacks means an increase in **either** poorly constructed and unregulated structures that can easily catch fire. This is a threat to human life and an easy spread of communicable diseases in the event of an epidemic or pandemic. Secondly, it also means more production of solid waste by businesses and residents. The muddy areas noted earlier may have a psychological effect by attracting illegal and unsustainable dumping. It can be tentatively argued at this point that these may be responsible for the proliferation of illegal dump sites throughout the informal areas. The lack of accessibility of many parts of the informal areas due to narrow dusty streets and "cul-de-sacs" may also be responsible for the numerous illegal dumpsites in the area because waste collection trucks cannot navigate such places. These analogies will be tested in the following chapters.

3.3.1. Landscape and ecology

The character of Diepsloot and the problems typifying the settlement as described above have adverse impacts on the topography of the area. Diepsloot is located in a catchment formed by the Jukskei River and its tributaries (Figure 3.1). Running from the north east to the south west is the Diepsloot River. It bisects the western section of Diepsloot into two (Figure 3.1). The north easternmost part of Diepsloot is marked by a wetland that feeds current into the Diepsloot

[4] Section 24 of the South African Constitution of 1996 enshrines the rights of citizens to a clean and habitable environment

River. Running from the east is a stream that splits the settlement into two in this section. This stream deposits its current into an extensive wetland that eventually runs into the Jukskei River (Figure 3.1). There is another wetland located adjacent to Diepsloot extension 7 (figure 3.1). The wetlands in Diepsloot constitute habitat for the near threatened giant bullfrog (*Pyxicephalus adspersus*) species, and which was under threat from settlement expansion (Yetman & Ferguson, 2011; Envirolution Consulting, 2018). In addition, the riparian zones form habitat to the "Grass Owl" species (Envirolution Consulting, 2018: 58). However, the study of Grass Owls in Diepsloot has not been extensive.

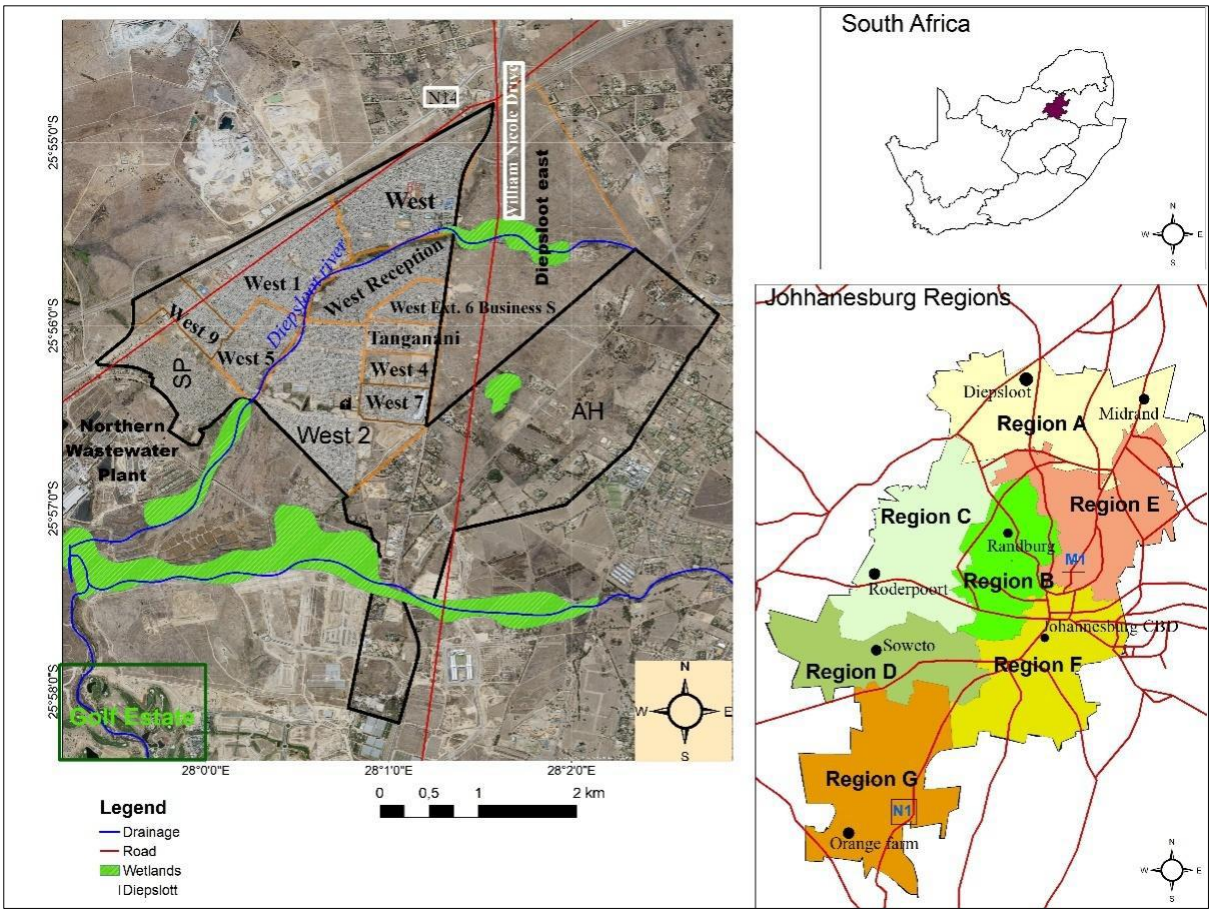

Figure 3.1: Study Area showing residential sections and various catchment areas.

Naturally, Diepsloot falls within the Egoli Granite Grassland of the Savana Biome. It is characterised by moderately sloping terrain and some low hills. In these is usually found tall *Hyparrhenia hirta* dominated grasslands and other attributes (see Mucina *et al*, 2006: 398). The average altitude in this area ranges between 1 280 – 1 660m above sea level (Mucina *et al*, 2006: 398).

The areas surrounded by the rivers, streams and wetlands are **replete** with informal settlements that lack drainage systems (sewerage and storm water) as discussed above. The lack of drainage systems in these areas would have a direct impact on the landscape and ecology of Diepsloot (see Chapter 5). Streams formed by leaking sewer systems feed contaminated water into wetlands and rivers where the associated biodiversity and communities downstream are under threat (Chapter 5). Communities close to the water bodies have formed artificial hills of solid waste by river and wetland sites.

The decision to choose Diepsloot as the case study was motivated by its topography and how humans are **interfering with authenticity of the environment**. Firstly, Diepsloot is a catchment area which by environmental standards should not have been chosen for residential purposes. Secondly, it is mostly an informal settlement. Informal settlements are generally associated with service delivery and poor SWM issues. In addition, the settlement is characterised by a high population density so that the convergence of these three factors points to severe destruction of the landscape and associated ecology. The manner in which the environment is utilised by Diepsloot residents provides a unique opportunity to assess community perceptions on issues of SWM. The residents produce waste and discard it into catchment areas around them. This is environmental pollution which endangers aquatic life due to water and soil poisoning.

3.3.2. Climate and waste

The area falls under the summer rainfall coupled with extremely dry winters. The average rainfall within this region is 680 mm annually (Mucina *et al*, 2006). The current plight of SWM in Diepsloot may have a long term effect on this **climate (aggregate condition of weather over a specified period of time**). Sewerage leaks in Diepsloot are longstanding and there have been very little attempts by the municipality to address this problem. In addition, there have been no attempts to measure the amount of sewerage water being deposited into water bodies cutting across the settlement so as to measure the extent of environmental damage. The flowing effluent has excavated deep furrows on the dusty streets of Diepsloot Extension 1 while residents have further aided this process by stacking bags of sand in some areas to barricade the flow of affluent into their shacks. These actions direct all the effluent into the water bodies close by. In addition to this environmental catastrophe, solid waste is also dumped close to and within water bodies in Diepsloot and therefore release a cocktail of toxins into the water and the atmosphere. The result is most likely the formation of poisonous rains emanating from the evaporation of water with toxic elements from the illegally disposed solid waste.

The settlement is often hit with floods with its poor or non-existent drainage systems and proximity to water courses (Fitchett, 2017). Various types of waste are deposited into water courses every year as noted above. Poor SWM has often resulted in the blockage of water courses resulting in floods in many parts of Diepsloot (Chapter 4 and 6). However, it is not known whether these floods can only be attributed to blockage of water courses or partly through the changes in climate due to poor SWM.

3.4. Research design

A research design is a set of strategies adopted for a research study. It details data collection and analytical techniques utilised in a research study (Creswell, 2009: 22). However, this conception of a research design was slightly appended in this research to further include justification of the research methods and data analytical tools adopted. By a greater measure, the research was qualitative. It sought to study community perceptions through semi structured questions. The intent of a qualitative research approach is to gather non-numerical data such as participant judgements or feelings (Walliman, 2011: 86). The research questions designed for this study sought to gather the thoughts of participants on the impact of SWM on human health and the environment in Diepsloot.

The philosophical positionality underlying this research is Pragmatism. This worldview represents the conception of the world through prior experiences and the concomitant beliefs emerging from these encounters (Kaushik *et al*, 2019: 3). The application of the pragmatist philosophy in the current study is evident in the organisation and nature of questions on the questionnaires administered to participants (see appendix). More importantly, "Section A" of each questionnaire, that is to say, the socio-demographic section, clearly sought to unravel the background of the participants and was utilised to analyse the responses they provided for the research questions – hence pragmatism. This positionality was also utilised in the discussion of results section in order to delineate each perception in line with the objectives of the study. However, when doing the data analysis, the researcher also collated the data numerically so as to quantify the general position of community members on issues of solid waste management in the settlement. This is a quantitative positionality. Therefore, the current research adopted a mixed method approach (Triangulation). The adoption of a mixed method approach is actually a facet of the pragmatic worldview (Creswell and Clarke, 2011). This quality sets the pragmatist approach apart from the traditional structuralist worldviews such as positivism, Interpretivism and constructivism.

3.4.1. The Case Study method

The research utilised the "case study" approach to investigate community perceptions on the impact of Solid Waste Management (SWM) on human health and the environment. As a research approach, a case study enables exploration and in-depth comprehension of complex problems (Zainal, 2007), particularly if it is a community related issue. In summary, the case study approach is defined as an empirical investigation of a current problem in its actual context (Yin, 1984: 23). The approach has been criticised for the so called "lack of robustness" as a research method (Zainal, 2007**). For instance, it is said that it requires a small sample to bring out an effective amount of data to be examined**[xi].Such a conception of the method does not hold any significant merits because researchers continue to utilise the method and with telling results (e.g. Teegavarapu *et al*, 2007: 4**). In addition, it is not correct do argue that only a sample is required. Some case study researches have recruited over a thousand participants.** In this research, the method was especially regarded as robust because of the potential of the listed questions to interrogate participants for in-depth responses (see appendix). It was my opinion that to better understand the perceptions about a given problem, it is best to approach a community that is directly affected – thus justifying the case Study method.

3.4.2. Ethical consideration

The research followed ethical guidelines. The process of data collection was preceded by the issuance of the following materials to the selected participants:

I. Participant information sheet: it detailed the purpose of the research project and the nature of participation of each selected participant – they had the right to end their participation at any time they wished.
II. Verbal Consent: After issuance of the participant information sheets, participants verbally agreed to participate in the study.

Permission letters were sought from officials selected from selected organisations. Meanwhile, the entire research was possible due to the issuance of a Certificate of Ethics from the Ethics Committee at University of the Witwatersrand (see Appendix). The collected data were in twofold: textual data on completed questionnaires and audio data (later transcribed) from telephonic interviews. To ensure the security of the data, audio data were uploaded onto a password protected cloud (accessible only to the researcher and the supervisor). In addition,

the questionnaires were stored in a lockable cabinet at the University of the Witwatersrand Masters Students Laboratories.

3.4.3. Qualitative data collection

The qualitative data for this research project was collected mostly through semi structured questionnaires. This data collection method was chosen because of its potential to confer credibility to the study by yielding data with high integrity. To elucidate, questionnaires **reduce** the influence of the researcher on the participant. In addition, with questionnaires, all questions irrespective of nature can still get responses (Walliman, 2011: 112). In our view, a questionnaire allows participants to think with focus and arrange their thoughts logically as long as the researcher keeps their distance. These perceived benefits necessitated the adoption of questionnaires for data collection in this research.

Questionnaires were administered to participants with the assistance of one field assistant. This was a third year Psychology student at the University of Johannesburg (therefore theoretically well versed with social science research methods). Preventive measures against the Corona Virus Disease of 2019 (Covid19) were adopted to safeguard both the health of the researchers and that of the community members of Diepsloot. These measures were: use of high risk latex gloves, N95 face masks and medical face shields, frequent use of 70% alcohol based hand sanitizers on both the researchers and the selected participants while a recommended social distance of 2 metres was always observed. There was no other way possible to collect data from the Diepsloot community because of the digital divide and the lack of a central repository of telephone numbers for the community of Diepsloot.

Data was collected over a period of 2 days in two purposively selected sections of Diepsloot i.e. Diepsloot West (Reception Area) a formal settlement and Diepsloot Extension 1 (a dense informal settlement). These two sections were deemed to adequately represent the entire settlement of Diepsloot composed of formal and informal areas. Participants were selected from properties on 18 dirty streets (solid waste scattered either on the streets or piled up in drains) in both the Reception Area and Diepsloot Extension 1. The rationale in this decision was that residents from such streets would be aware of **swm** issues.

A combined total of 35 residents from these two areas were issued with semi structured questionnaires. **The total of 35 was encouraged by the need to avoid much exposure to the possible contraction of the corona virus disease**. Of these, 21 were from Diepsloot Extension 1, a dense informal settlement, while 14 were from the Reception Area (Diepsloot West). Out

of the 21 participants from Diepsloot Extension 1, 12 were males while 9 were females. Of the 14 participants from the reception area, 6 were males while 8 were females. **Representativeness** was therefore a prioritised issue in this research. All participants were Black and over 18 years of age.

The study also enlisted **1 participant from 3 organisations** namely: Greater Kyalami Conservancy (Gekco) and Roots and Shoots (Environmental NGOs) operating in Diepsloot and Pikitup. **These organisations were chosen because of their longstanding history of environmental work in Diepsloot**. From these organisations, all the three officials were telephonically interviewed. The decision to interview these officials telephonically was premised on the idea of minimising face to face contact in the era of the Corona Virus Disease of 2019 (COVID19). In order to **collect informed and reliable data**, these participants were electronically presented with the questionnaire in order for them to prepare before the interview. Questionnaires were all in English. In addition, the telephonic interview with officials from selected organisations was also done in English. These participants were selected through the following sampling methods:

3.4.4. Study population and sampling procedure

The solid waste management crisis is spread throughout Diepsloot as evidenced by the widespread **littering** observed during fieldwork (Chapter 4). This was a critical observation. It suggested homogeneity in behaviour towards **littering** by the residents. Based on this assumption, it would have been beneficial to involve all residents over 18 to participate in the research for the best informed data. In reality, this approach would have been untenable for three major reasons: exposure to the Corona virus, limited time and budget. Therefore, judgement or purposive sampling, a non-probability sampling method was employed in order to select research participants as they are noted above. Judgement or Purposive sampling is defined as a purposeful or deliberate selection of research participants on account of the qualities they have (Etikan *et al*, 2016: 2). Non-probability sampling methods were particularly useful for this study because they are usually associated with case study and qualitative research studies (Taherdoost, 2016: 22).

Some scholars conceive of purposive sampling as inefficient. These scholars advance the argument that with purposive sampling lays the uncertainty of the representativeness of the selected participants of a given population (Etikan *et al*, 2016). The researcher does not subscribe to this position because it is narrow in scope. When viewed carefully, purposive

sampling is not just a random or haphazard process. It is rather an informed process where attributes of participants are listed prior to the fieldwork. **Etikan *et al* (2016: 1) do not believe that purposive sampling is a random process.** They present an argument that non-probabilistic sampling is replete with advantages particularly for studies that involve large populations; limited resources, time and workforce. The efficacy of this sampling technique is therefore immediately exposed.

Following Walliman's (2011) guidance, a survey to determine a "sampling frame" was done. A sampling frame is a number of groups in a given area that may be of interest to one's research (Walliman, 2011: 109). In Diepsloot, some residents live in shacks while others in formal housing. Of these, some live in dirty streets and some in cleaner streets far or close to illegal dumpsites, wetlands, rivers while there is an additional group of unemployed people who sat on the streets. These groups formed the research's sampling frame. A critical selection from this sampling frame was done in order to get samples that would truly represent the population and one that would provide rich responses. With this in mind, the following samples were chosen:

- People who lived in formal houses in Diepsloot West (Reception Area) and those in shacks in Diepsloot Extension 1 (all residing along dirty streets).

3.4.5. Other research instruments

The methods noted above are not exhaustive of the methods used to collect data. In the process of field data collection in Diepsloot, visual observations were made and noted down in a field notebook while photographs were taken to complement this where possible (see Chapter four). In addition, visual data were also gathered from the participating organisations e.g. pictures and maps dating back to 2014.

3.4.6. Challenges faced during data collection

The process of collecting data was characterised by several challenges but only in Diepsloot and not during telephone interviews with participants from selected organisations. Data collection in the formal area was relatively easy compared to the dense informal settlement due to navigational issues. The informal area lacked proper roads and the existing ones were soaked with sewerage water and misplaced Municipal Solid Waste making the entire data collection process complicated. We were faced with a unique problem of the discomfort of wearing

personal protective clothing in the era of the Corona Virus Disease of 2019 (Covid19). Apart from this, some residents were scared of us. They assumed that we were sick of Covid19 due to the protective clothing. Thus, potential participants often declined to participate. Other problems tended to be ethical. Participants, particularly those in the informal settlement were not willing to read the Participant Information Sheets (PIS). Their concern was that they did not want to spend too much time with us and that they were willing to feel like they were in school all over again.

3.5. Data Analysis

3.5.1. Questionnaires & telephone interviews

The Thematic Analysis method was adopted for the analysis of qualitative data. This method is used to systematically sort out data into codes and themes. In its practicality, it does this by identifying the similarities in the data (Aronson, 1994; Braun and Clarke, 2012: 57). The adoption of this method was founded on the basis that the method works with multiple types of research questions and data such as experiences or perceptions on a **given phenomenon** (Braun and Clarke, 2012; Clarke and Braun, 2013). Below is an overview of the steps in Thematic Analysis according to Braun and Clarke (2006; 2012a):

I. Data familiarisation: a researcher is required to take some time to familiarise with the data. This is important in establishing codes.
II. Coding: this entails designing codes reflecting the main idea in each data set. These must speak to the research questions. Questionnaires yield a vast amount of data that cannot be worked with in its original form. Coding is a data reduction technique which also serves as an analytical method. It allows for the "semantic and conceptual reading of data". This stage was concluded by collating all codes
III. Theme search: themes were developed from the codes above. A theme is defined as a "…coherent and meaningful pattern in the data…" It must speak to the tune of the research questions. The researcher was responsible, as recommended, for crafting themes from the data sets.
IV. Theme Review: at this stage, all the themes above were revisited to check whether they spoke to the research questions. Methodologically speaking, each theme must summarise the contents and meaning of the data it represents. Themes that appeared to be similar were merged or even split further.

i. Defining and naming themes: this stage is somewhat similar as above. Each identified theme was revisited and then a write up was done to tell the story in each theme and it blended with the story of the data it represented.

The above stages were executed on an excel spreadsheet with relevant headings and classifications. These were: question number, participant number, code in response, derived themes, source of influence – this sought for the events that could have influenced particular responses and these were derived from the **demographic sections** of the questionnaires as well as field observations and lastly the percentage similarity of themes per question. Below was the last stage of the thematic analysis process:

i. Writing up: at this stage, the data were woven together to produce an analytical narrative from the above stages – **particularly contextualising it to the existing literature**.

The multi method nature of the research led to the quantification of the results of the study. As a result, various data presentation tools were used in this study. These were: bar graphs, pie charts, frequency distribution graphs.

3.5. Concluding remarks

In my opinion, the character of Diepsloot owes much **to its origins in apartheid government** and the politics in nations surrounding South Africa. Although the **apartheid authorities** did not originally **intend** for Diepsloot to be an informal settlement, it sowed the seeds for overcrowding and service delivery failures over time. The location of the settlement by the colonial state did not consider the topography of the area which is replete with environmental sensitivities such as wetlands, rivers and the associated biodiversity. These factors converged to persuade the researcher to choose Diepsloot as a **case study.** The efficacy of the methodology adopted for this study will be proven in the next two chapters.

Chapter 4: Presentation of findings and Analysis

4. Introduction

The purpose of this chapter is to present and analyse key results of the study. Data analysis is done to break down data into an "intelligible and interpretable" state in order to address research questions (Kerlinger, 1978: 134). Before delving into the analysis, we present a reminder of the goal of the study in order to keep the analysis in full perspective. The study aims to explore community perceptions regarding the impact of Solid Waste Management (SWM) on human health and the environment in Diepsloot and to contribute to the existing literature on SWM in South Africa. The objectives of the study were to:

I. Examine SWM problems in Diepsloot and their impacts on human health and the environmental wellbeing in Diepsloot, JHB, SA;
II. To propose appropriate measures against the identified the impact of SWM on human health and the environment in Diepsloot, JHB, SA.

The method employed to analyse the data was "qualitative research method based on thematic analysis". The functionality of this analytic method was described fully in Chapter 3. The research questionnaires were divided into two important sections:

I. A focus on the socio-demographic characteristics of the participants and;
II. A focus on participants "perceptions" on the impact of SWM on human health and environmental wellbeing in Diepsloot.

The data from the first section was presented using quantitative techniques of graphical presentation. Graphs were made using Microsoft Office suite tools (Word and Excel). The full analysis of the data is presented below:

4.1. Socio-demographic characteristics of the participants

The study involved 35 participants from two localities in Diepsloot. These were Diepsloot West Reception Area (DWRA), a more formal area and Diepsloot West Extension 1 (DWE1), a dense informal settlement. From the 35 participants issued with questionnaires in Diepsloot, a total number of 48, 6% of the participants were females while 51.4% were males. Therefore, in this study, the males dominated the females by a small margin. This represents a balance in gender which would in turn ensure **representativeness** of the collected data. Below is a bar graph detailing the distribution of participants by gender from the two selected localities of Diepsloot.

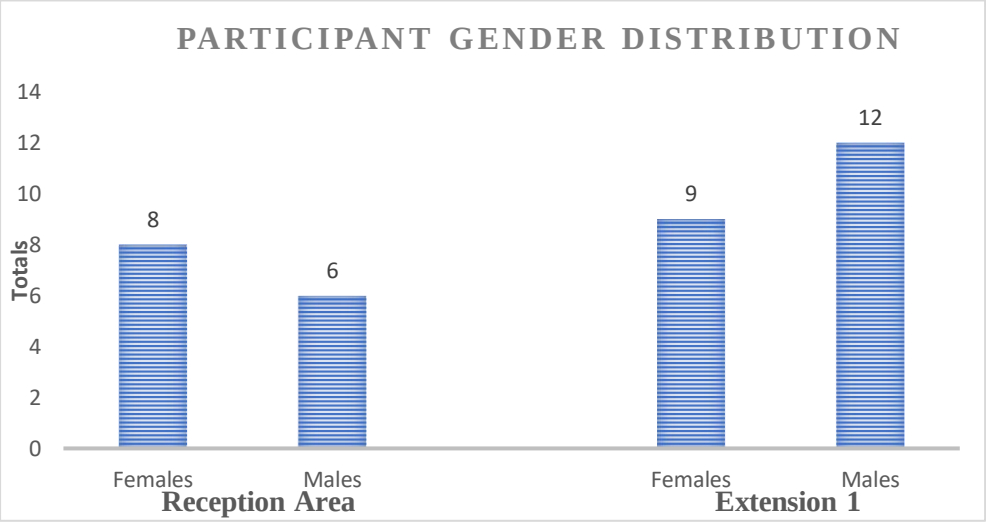

Figure 4.1: Gender of participants by location

The age of the participants was recorded as part of the demographic profiling for the study. The histograms below (Figure 4.2 & 4.3) show the distribution of age range of the participants by location. However, participants were not asked to state their exact age. Rather, participants had to choose from given age ranges.

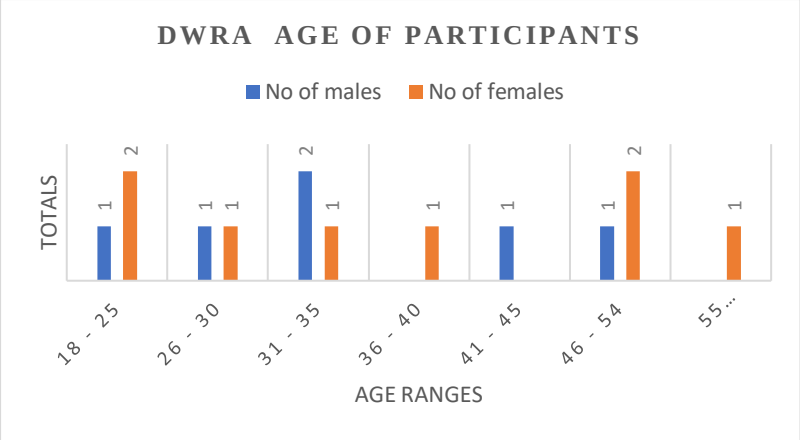

Figure 4.2: DWRA Age of participants

Figure 4.2 above present participant age range in Diepsloot West Reception Area (DWRA). There were seven age ranges beginning from 18 years ending at 55 years and above.

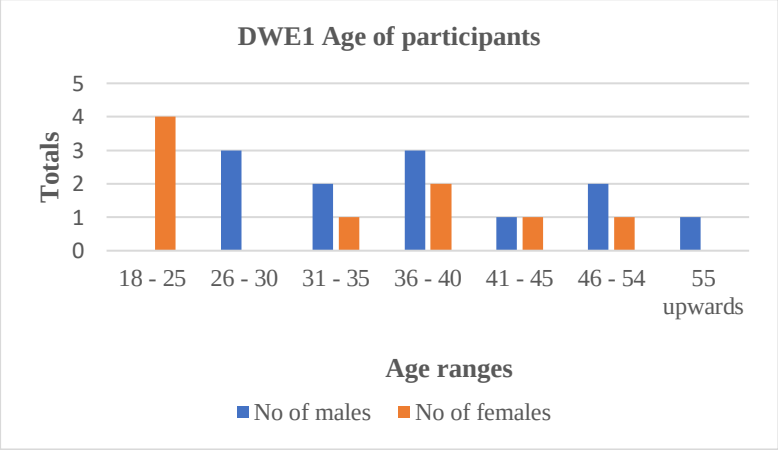

Figure 4.3: DWE1 Age of participants

Figure 4.3 above shows participant age range in Diepsloot West Extension 1 (DWE1), a dense informal settlement. There were seven age ranges as was the case in DWRA beginning from 18 years ending at 55 years and above. In figures 4.2 and 4.3, it can be seen that most participants were in the range of 18 – 25 years of age. This age group represented 22.9% of the total participants. This was followed by age range**s:** 31-35, 36-40 and 46-50 which each represented 17.1% of the total number of the participants. 14.3% of the total number of participants was from the age range of 26-30 while 8.6% were of the range between 41-45 years of age while 5.7% were from the age range of 55 and above. These figures represent a youthful population with high unemployment. Therefore, the selected participants formed a good sample for the study because they spend most of their time at home or on the streets.

From this background, it can be judged that the selected participants had more time to witness SWM issues in their localities.

The participants were asked to state how long they had lived in Diepsloot. This was done in order to assess the reliability of responses provided by participants. The associated logic was that the longer the participants had lived in Diepsloot, the richer their perceptions on issues of SWM in the area of study would be.

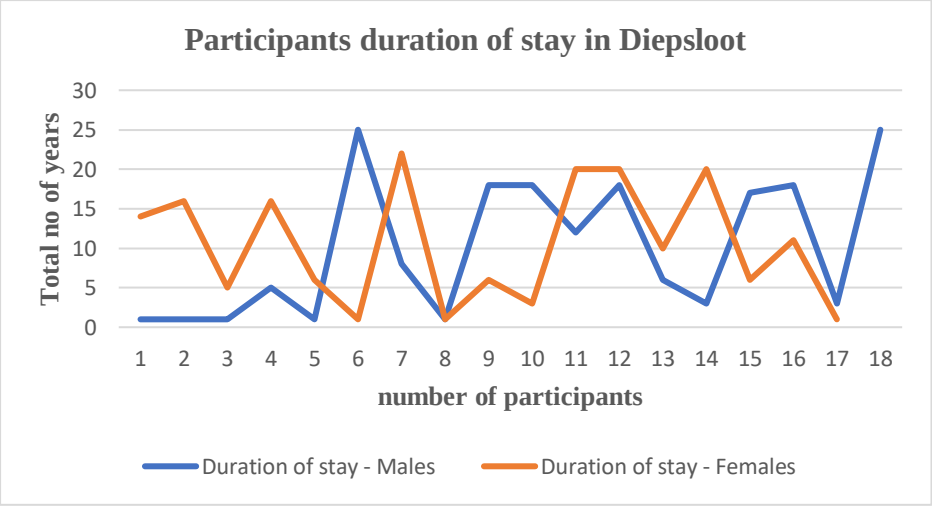

Figure 4.4: DWRA & DWE1 participant duration of stay in Diepsloot

The graph (Figures 4.4) above summarises the duration of stay in Diepsloot of participants in DWE1 and DWRA. **The graph was combined in order to make it easier to visualise and observe participants' durations of stay**. The combined statistics for both Diepsloot localities are as follows: 22.9% of the participants had lived in Diepsloot for 1 year, 5.7% each lived in Diepsloot for 3,5, 10, 16 and 25 years respectively, while 2.9% each lived in Diepsloot for 8,11, 12,14, 17 and 22 years each respectively. In addition, 11.4% of participants lived for 6 and 18 years each respectively while 8.6% each lived in Diepsloot for 20 years. It can be seen that all participants had lived in Diepsloot for not less than a year. This was critical for the study. It means that participants had had sufficient time of exposure to the SWM crisis in Diepsloot and can therefore be regarded as a good sample for the study. In addition, these statistics expose the fluidity of the population in Diepsloot as marked by the dominance of participants who had lived in Diepsloot for one year (22.9%). It may therefore be an early indicator for potential service delivery issues in the **area of study although this may also be explained by other reasons.**

Participants were asked to state their highest level of education. Figure 4.5 presents participant levels of education for both DWRA and DWE1.

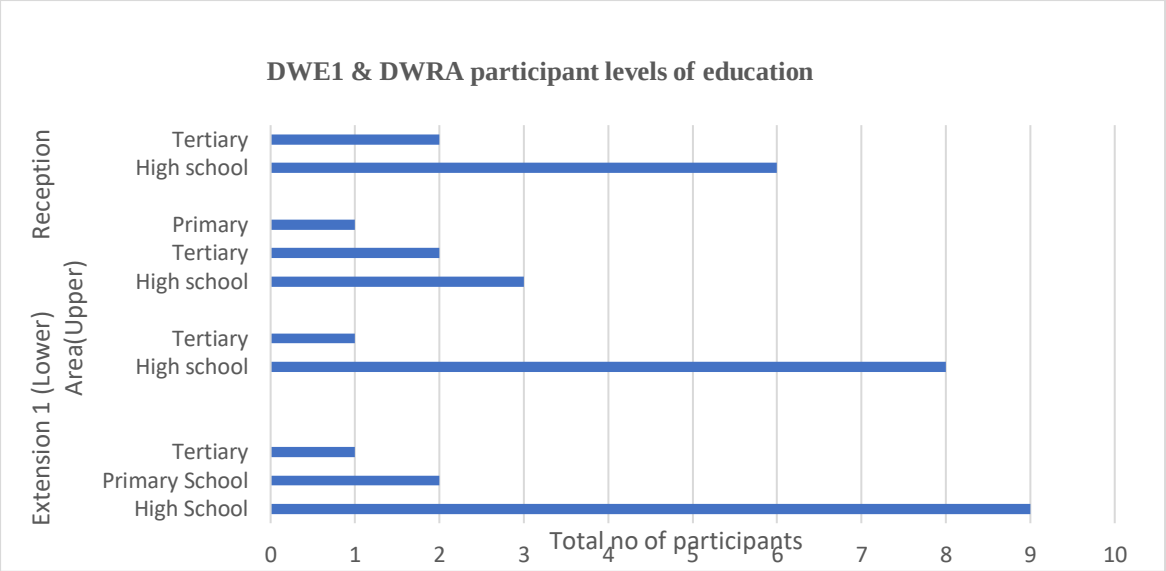

Figure 4.5: Participant level of education

It can be seen from Figure 4.5 above that 74.3% of the participants went as far as high school. On the surface, it can be assumed that these participants had the ability to read and understand English as well as to provide well informed responses to the questions posed on the questionnaires. As highlighted in Chapter 2, education is key to understanding environmental concerns. **Where participants have high school education, an understanding of teachings on the environment and human health issues is relatively easier to achieve. However, where the highest level of education is only primary school, the same results cannot be expected.** In context, 8.6% of the participants only made it to primary school. Participants in this category particularly failed to state what is meant by the term SWM on the questionnaire. On the other hand, 17.1% made it to various tertiary institutions such as Universities and colleges. This sample **(participants who went to tertiary institutions)** was crucial for the study because of their undoubted ability to respond to questions with depth and clear articulation. Figure 4.5 summarised this information.

Participants were asked if they were members to any community organisations that specialised in community health. These could be community waste initiatives, clinics, non-governmental organisations, etc.

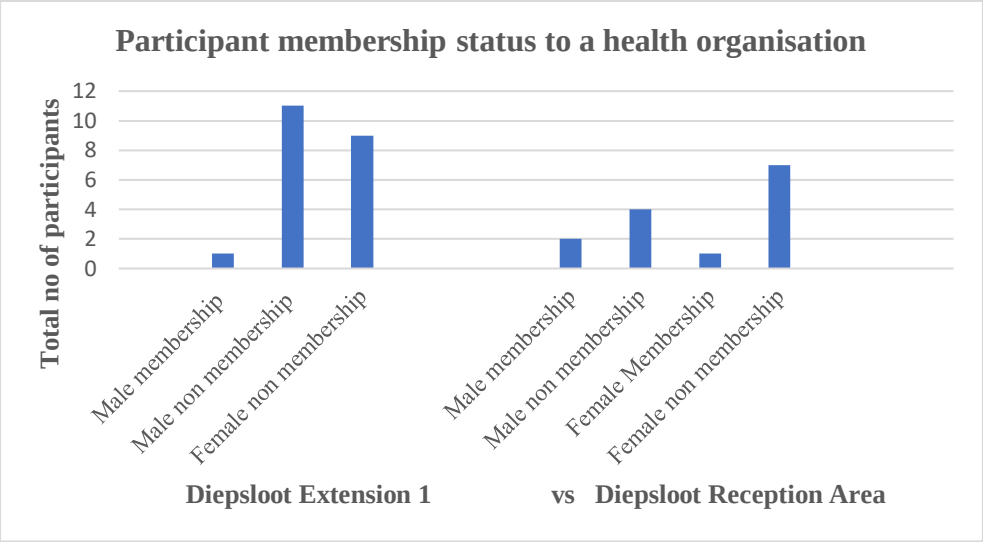

Figure 4.6: Participant membership status to community health organisations

Out of the 35 participants, 88, 6% did not hold any membership to such organisations (Figure 4.6.). This statistic spoke volumes about the participants' ability to adequately respond to questions on issues of SWM on human health and the environment. Conversely, 11, 4% claimed to be members of a community health organisation. On paper, therefore, these participants had the ability to provide in-depth and well informed responses to the **pose** questions. Figure 4.6 presents the membership status to community health organisations by location. In conclusion of the socio-demographic characteristics section of the questionnaire, participants were asked to state their employment status. These statistics were necessary in order to determine whether participants had maximum time to witness SWM issues in their localities. Figure 4.7 below presents employment status of the participants.

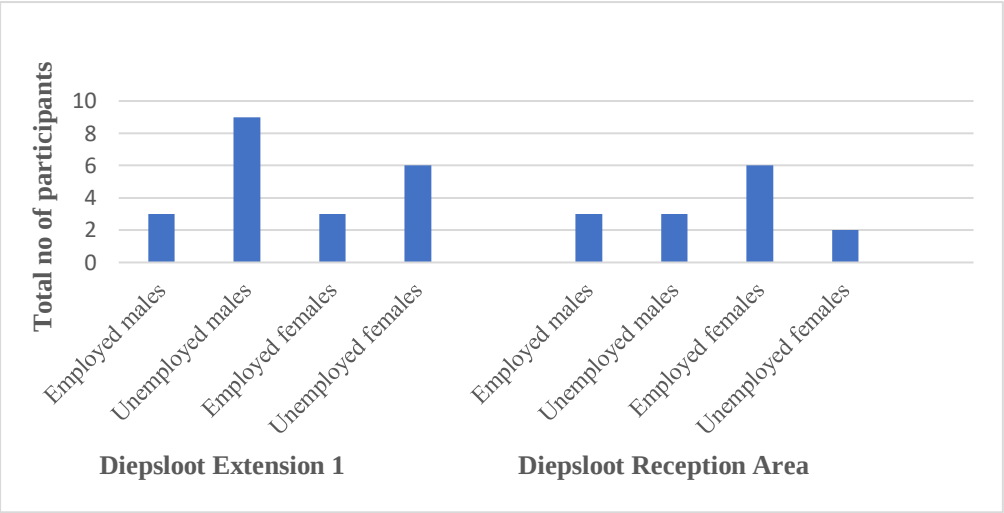

Figure 4.7: Participants' employment status

Figure 4.7 presents the employment status of the selected participants from both localities in Diepsloot. The total number of unemployed participants from both localities was of 57.1%. This figure can be taken to represent a sample that spend most of its time at home or in their localities so that they had sufficient opportunity to observe SWM issues in Diepsloot. On the other hand, the remaining total of 42.9% of the participants from both areas was employed. This does not negate their usefulness in this research. Most employed residents of Diepsloot are migrant workers. This means that when they are at work, they get exposed to environments much different from theirs in Diepsloot. For instance, many males are employed by wealthier people living in areas like Dainfern and Fourways, less than an hour from Diepsloot. This would assumedly alert them to SWM **issues in the area**.

4.2. Participants "perceptions" on the impact of SWM on the environment in Diepsloot

We begin this section by presenting the perceptions of participants on the impacts of SWM on the environment in Diepsloot. The ultimate goal of the study was to determine the impacts of SWM on human health and the environment in Diepsloot and to assess community perceptions on this. However, this was not an epidemiological study or an environmental impact assessment. The impacts mentioned here were observed through eye observations during fieldwork and through participants' opinions.

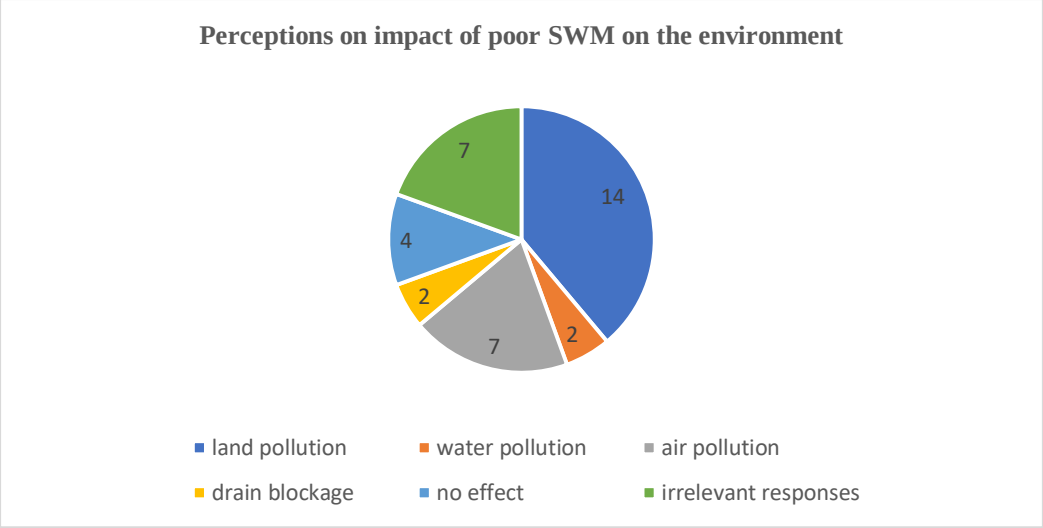

Figure 4.8: Perceptions on impact of waste on the environment

Figure 4.8 shows that 11.4 % of the participants (4) were of the view that poor SWM had no effect on the environment. These participants simply stated "No" without elaboration. 20% (7) of the participants stated irrelevant responses suggesting that they may not have understood the question correctly. In contrast, 68.6 % (24 participants) stated that poor SWM management had negative effects on the environment. This was broken down further into more specific details. In the pie chart above, 14 participants stated that poor SWM causes land pollution, 7 mentioned air pollution, 2 mentioned water pollution, and 2 others mentioned drain blockage. In analysing this information, two overlaps were discovered. This means that 2 participants stated both land and water pollution as the impacts of waste on the environment. Although most participants stated a single impact, 2 participants mixed both air and land pollution resulting overlaps. These results on the impacts of SWM on the environment are further illustrated by poor municipal solid waste management dumped on street as shown in **Figure 4.9** below.

Figure 4.9: Municipal solid waste dumped by the street side in DWE1

Photo credit: Researcher (2020)

Figure 4.9 is an illustration of the impacts of poor SWM on the land in Diepsloot. It corroborates the perceptions by 68.6% of participants. In this picture, municipal solid waste comprising plastics, cloth and paper can be seen immersed in sewerage effluent by the roadside in Diepsloot West Extension 1. This results in land, air and water pollution whilst also blocking drains thus matching the perceptions of participants. This area appears to be a designated dumping site as suggested by the communal bin in the picture. It can be seen that the bin is not full and yet it is surrounded by scattered solid waste. **This suggests ignorance on the part of the residents. However, it is also possible that children contributed to this because they cannot dispose of waste properly all the time**.

Figure 4.10: Wetland contaminated with construction rubble and household waste.

Photo credit: Researcher (2020)

In Figure 4.10., it can be seen that indiscriminate dumping resulted in land pollution. It can further be observed that at the convergence of land and the water course (wetland), solid waste ended up consuming parts of the wetland and with potential negative repercussions on the associated biodiversity. Participants from the two NGOs had finer perceptions on this issue. A participant from one NGO stated:

> Wetlands are contaminated and bullfrogs are in danger. High levels of sewerage pollution are affecting their breeding patterns…

Below we present the **proof** of the existence of the Giant Bullfrogs in the wetlands spanning across Diepsloot, particularly those in Diepsloot East.

Figure 4.11: Giant Bullfrogs in a wetland in Diepsloot

Photo Credit: Anton van Nierkerk (2019)

In **Figure 4.11** Giant Bull frogs can be seen in a wetland in Diepsloot. According to an official from an NGO, the pollution of wetlands has affected the breeding patterns of the near endangered frog species. The illegally disposed waste affects the measure of acidity or alkalinity (ph.) in the wetland. But how does this happen? On decomposition, the waste leaches toxic substances into the ground, and ultimately into the wetland. This intoxicates freshwater where the Bull frog thrives. However, this is not all that affected Bull frogs according to the participants.

Figure 4.12: A wetland contaminated with sewerage and solid waste

Photo credit: Anton van Nierkerk (2014)

Figure 4.12 demonstrates the devastating effects of poor SWM on the wetland. Municipal solid waste i.e. tyres, plastic bottles and sewerage effluent contaminated the wetland water

Figure 4.13: Land and wetland pollution in Diepsloot due to poor SWM

Photo credit: Anton van Nierkerk (2017)

In Figure 4.13 shacks can be seen constructed very close to a wetland. This affected the **integrity** of the wetland and further affects the associated biodiversity. **The construction of new structures in the settlement along the riverine environment has negative impacts**. An NGO official stated that:

> …bullfrogs can hibernate for up to a year underground and people are building their shacks on top which leads to the depletion of the bullfrog population…

In addition to the threat of shacks, Diepsloot is plagued by the importation of construction rubble from the Northern affluent suburbs of Johannesburg such as Dainfern and Fourways. An official from an NGO stated:

> …with regards to the rubble dumped by trucks from the northern suburbs, the rubble is dumped in vacant properties which are often wetlands or river courses…

The illegal importation of construction rubble from the northern suburbs of Johannesburg, and the subsequent dumping in Diepsloot water courses reveals underlying **problems** in SWM practices in both areas. Firstly, it reveals the lack of local institutions or the **problems associated with** of organisations that oversee the management of solid waste or the environment in Diepsloot in general. It also reveals the weaknesses of Pikitup, and national institutions such as the Department of Environmental Affairs and the Department of Water and sanitation.

4.3. Participants' "perceptions" on the impact of SWM on human health in Diepsloot

This study also aimed to understand perceptions on the impact of poor SWM on human health in Diepsloot. To this effect, the 35 purposively selected participants were asked if they thought **solid** waste affected human health. The outcomes are presented in the pie chart below:

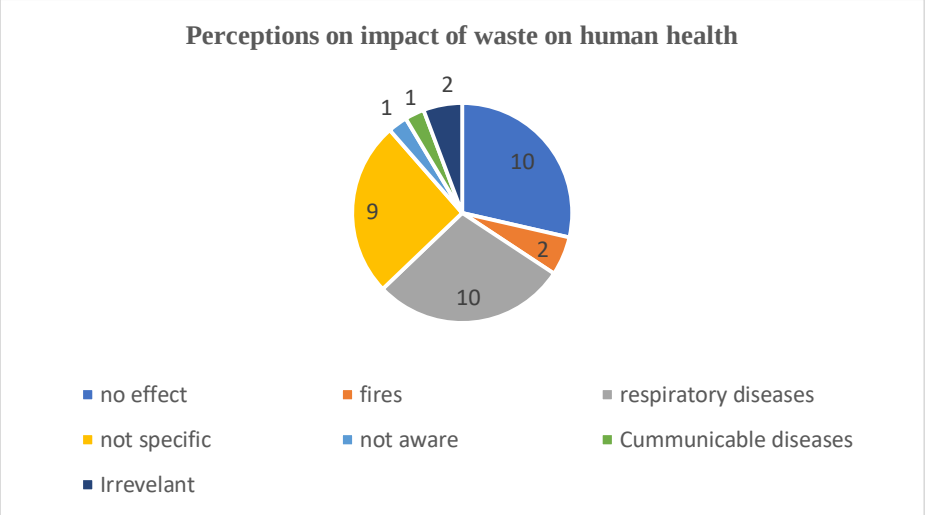

Figure 4.14: Perceptions on impact of waste on human health

In **Figure 4.14**, 28.6% of the participants i.e. 10 participants, claimed that poor SWM had no impact on human health. These participants simply stated "No" as their response suggesting some ignorance. Some participants in this class said "no, because I thw the waste away from me", or "no because I put on the streets". These responses reflect their lack of **environmental and human health knowledge** and also explain the existence and also explain the existence of **indiscriminate dumping and littering** in Diepsloot. All the 35 participants were asked if any of their **relatives in Diepsloot** had visited a clinic or a hospital as result of the effects of poor SWM in Diepsloot. 100% of the participants claimed that no one had done so. This might have partly influenced the perceptions of the participants who claimed that poor swm did not pose any risk to human health. Other participants i.e. 2.9% (1%) stated that they were totally not aware of the impacts on waste on human health. Furthermore, 2 more participants (5.7%) stated irrelevant responses.

To the contrary, 62.6 % of the participants i.e. 22 people, held the opinion that poor swm posed threats to human health. We break down this combined figure into 4 **parts**. These are respiratory diseases: not specific, fires and communicable diseases. 10 participants claimed that poor SWM caused respiratory complications such as coughs, breathing problems and sinusitis. In particular, one participant stated the following words:

Yes, it (Poor SWM) causes flu, sinuses and struggling to breathe.

The perceptions of these participants suggest several possibilities. **It could be that that at some point the participants suffered from these illnesses. It could also be that they knew of someone who did. Lastly, it may just be some hearsay.** This is in contrast with the claim by 100% of the participants that they knew of no one who ever visited the clinic due to poor SWM. **Other participants i.e. 9, stated that poor** SWM posed risks to human health; however, these participants were not specific regarding which diseases could result from poor SWM. One (1) participant claimed that poor SWM could result in diarrhoea. In addition, 2 participants stated that poor SWM could result in fires that could harm people. This particular perception suggests that residents resorted to the burning of waste in Diepsloot. It is possible that this might have influenced the awareness that waste causes air pollution. In general, the participants were not detailed in their responses which suggest the lack of in-depth knowledge on this issue. This suggests the lack of community health education on the impact of poor SWM on human health.

Figure 4.15 Sewerage leakage mixed with solid waste

Photo credit: Anton van Nierkerk

Figure 4.15 shows the overwhelmed sewer system leaking sewerage effluent onto the street. The effluent is mixed with illegally disposed solid waste (predominantly plastics). This picture appears to corroborate the occurrence of the diseases stated by participants above such as sneezing and sinuses as a result of unpalatable odours emanating from the waste

The true extent of the effect on human health of poor SWM in Diepsloot is not widely known by the participants for various reasons. From the perspective of NGOs, this information is never made public. **In my opinion, this suggests two possibilities** i.e. the total absence of disease surveillance by the responsible authorities such as the Department of Environmental Affairs and the Department of Water and Sanitation. The second possibility is that there may be deliberate censure of information by responsible authorities in order to evade the costs associated with cleaning up the informal settlement. It is apparent that the illegal dumping of the construction rubble in water courses result in floods (due to constriction of water courses), particularly in the rain season due to precipitation. This is summarised in the words below from one NGO official:

> *With human health…this causes flooding and quite often people drown in flood plains.*

This was reiterated by another official from a separate NGO who stated:

> Every year people drown. In Extension 7 children get washed away almost annually. Rubble dumped into wetlands causes flooding and at one point a child was drowned due to the floods.

It is evident from the quote that construction rubble poses serious threats to human life. Children get swept away on their way to or from school. The revelation that this happens almost every year suggests that authorities are not doing enough to address the plight of SWM in Diepsloot. Below we present evidence of the damage caused by illegal disposal of rubble and other waste into wetlands:

Figure 4.16: Solid waste heap constricting a water course

Photo credit: Anton van Nierkerk

Figure 4.16 above corroborates the statements from the NGO officials. It can be observed in the picture a significant portion of the water course is covered in a heap of illegally disposed waste by a foot bridge connecting the formal and the informal area. In the event of heavy rains, this is likely to result in the rise in water levels which may sweep away people as stated earlier. The participants from NGOs had more to say regarding the impact of waste on human health. People living in shacks, particularly in **Extension 1,** were oftentimes forced to sleep wearing shoes. This was meant to deter rats at night as they sleep.

Figure 4.17: sewerage effluent flowing down street and accumulating near shacks and a wetland in the foreground

The environment pictured in **Figure 4.17** corroborates what was said by the NGO official. Rats thrive in dirty environments. In this particular case, illegally disposed waste is located just behind shacks. The likelihood that rats infest the pictured shacks in search of food and shelter is high. Thus people adapt by wearing shoes when they sleep. In addition, the decomposing waste produces unpalatable smells which can cause such diseases as respiratory diseases or complications. The people living in the pictured shacks will be the most affected and therefore there is more likelihood to suffer from the respiratory complications stated earlier. However, as stated earlier, the data is not made public. One NGO official said the following words:

> I have no idea (of the impact of poor SWM on human health) because the information is never published but there has to be a problem because children play on the streets …

The above quote suggests that a lot needs to be done to make information accessible to the relevant stakeholders.

4.2.1 The perceptions of community members on SWM issues and associated outcomes

In this section we present "themes" derived from the data collected from the research participants. As highlighted at the beginning of this chapter, the purpose of the study was partly to investigate community perceptions on the impact of SWM on human health and the environment in Diepsloot. The perceptions of the participants on the impacts of SWM on both human health and the environment in Diepsloot have already been presented above. However, the study also sought to understand community perceptions on other SWM issues. In doing thematic analysis of the data, three main themes were made out of the data. These are; Poor

service delivery, collective community ignorance and "the main environmental pollutants are recyclable materials".

4.2.1.2 Community ignorance and negligence on SWM issues

The SWM issues on human health and the environment in Diepsloot were presented in the section above. The awareness of participants to those issues highlighted above ranged from very low to non-existent. 68.5% of the participants from the two localities of Diepsloot had no understanding of what SWM is. These participants had no comprehension of the term "Solid Waste Management". This was indicated by leaving the question unanswered or providing a totally wrong answer. To eliminate the possibility that the questions asked were too difficult, participants were each asked why they preferred to leave some questions unanswered. The frequent response was that participants did not know what SWM was and not that they did not understand the question. By conversing with participants, it was further observed that the term "management" was only associated with work done in the offices. Armed with this information, we concluded that even the impacts of poor SWM on human health and the environment could not be well comprehended by the participants. This can be linked to the low levels of education as stated in the second section of this chapter.

On the other hand, only 31.5% of the participants generally understood the concept of SWM. Notably, one participant defined SWM as "Cleaning and taking care of our community and its people". However, on further inspection of other responses falling under this category, it was observed that there was a general lack of detail in the responses. The lack of detail may be understood as a reflection of further ignorance on SWM issues. The non-existent or low levels of SWM awareness presented above might partly explain the widespread SWM crisis in Diepsloot.

Participants were questioned to explain the widespread littering of solid waste in Diepsloot. A total of 35% of the participants claimed that it was due to collective community ignorance on the significance of sanitation. In particular, one participant stated:

> *"People do not understand what the effects of littering are, so they litter everywhere".*

In line with this response, other participants simply stated "carelessness", "ignorance" or "laziness" as the reasons to explain widespread littering in Diepsloot. There was no way of measuring the accuracy of these responses because they generally lacked detail. However, through **observation and analysis**, it is possible that these responses were accurate.

Conversely, the remaining participants i.e. 65% blamed institutional failure for the widespread littering (this will be presented under a separate theme).

Given the above information, a question arises why there is widespread ignorance on environmental sustainability and public sanitation. Are there any awareness programs in the area? Why are they not effective? Firstly, participants were asked if they were members of any organisation that dealt with community health and sanitation. A total of 100% of the participants affirmed that they were not. In distinction to this, three officials from Non-Governmental Organisations (NGOs) and Pikitup confirmed the multiplicity of sanitation and awareness programs cutting across Diepsloot. These are the words of a Pikitup official:

> *"Pikitup has a program where they go to dumpsites to clean up. Also there is a program where they teach people about SWM and the consequences of dumping. They are taught to reduce waste because the landfills are running out of space. These programs are in both in formal and informal settlements. We (Pikitup) go to schools because children can take the knowledge home. Even the community has their own programs".*

While Pikitup asserts that they have community programs as shown in the quote above, 100% of the participants had no knowledge of such programs. Participants were also not aware of any community programs on environmental management. This raises questions whether the programs are done in all areas as claimed by the Pikitup official? It also raises questions on the keenness of community members to engage. One NGO officials said:

> *"We have an ongoing environmental education program. The clean ups are not sustainable – we would clean up this week and the next it's all back again. We have an incentivised programme with this group and it is successful (with youths) but the funding is bad. In 2019 we composted 1,3 tonnes of waste. We make eco bricks with single use plastics to make benches etc. People keep dumping because they know no value of single use plastics".*

It is apparent therefore that Diepsloot does not have a shortage of awareness programs. Even with incentivised initiatives in place, indiscriminate dumping continues possibly because of a natural negative attitude towards waste**. It is characteristic of people to view waste as useless and must just be discarded, particularly in urban areas where there is dependence on the municipality for general urban sanitation**. **Although the pollution in Diepsloot can be**

explained by several factors, the continued environmental pollution can therefore be attributed to the community members as asserted by a Pikitup official.

"Some are ignorant while some are negligent"

In addition to the above, the official added that:

"They say Pikitup must have a job to do"

The authenticity of this statement cannot be verified. The participants were asked if the solid waste they produce at household level posed any risk to human health. The objective of this question was to measure participants' comprehension of the consequences of solid waste on human health as stated above in line with the research questions. 40% stated that waste does not pose any risk to human health which further reinforces the theme of community ignorance.

A participant from Diepsloot Extension 1, stated that household waste does not pose risk to human health because they discarded the waste on the street far from their own homes. Another participant denied the existence of any risks from the discarded household waste because they discard on the streets. **This indicates that human health is viewed as centred on the self or household and that the issue is not viewed in relation to the community**. This indicated poor understanding of the potential impact poor swm on human health and the environment. **This line of thought might be reinforced by the following statistic**. 100% of the participants from Diepsloot stated that no family member had ever gotten ill because of poor SWM in Diepsloot. The absence of serious illnesses due to poor SWM might encourage indiscriminate dumping in Diepsloot. It also exposes the lack of effectiveness of the programs spearheaded by Pikitup and the NGOs in Diepsloot.

4.2.1.3 Poor service delivery

PIKITUP is a private company subcontracted by the City of Johannesburg to deliver SWM services in Johannesburg. One of the objectives of this study was to determine the problems of SWM in Diepsloot. From the collected data, the biggest problems to SWM in Diepsloot were poor service delivery and inadequate understanding of SWM issues. Participants were asked if there was a SWM crisis in Diepsloot. 82.9% confirmed the presence of a crisis and that it was because poor service delivery had been horrendous for a long time. Poor service delivery was said to have existed for more than a decade. In particular, a participant from Diepsloot Extension 1, a dense informal settlement said the following words:

Yes, it's been a while since the first year I came here in 2010"

The above quote referred to the commencement of poor service delivery in Diepsloot. In addition to the quote, another participant said that in areas like Extension 1, sewerage effluent flows all year round. Participants tended to vary on how long the problem had existed. Some figures pointed out were 1, 8, 18, 25 years among others. Even though these figures cannot be accepted at face value, they demonstrate that poor service delivery has plagued Diepsloot for a long time now. Earlier, we pointed out that 35% of participants said littering was widespread due to widespread community ignorance (see Community ignorance theme above). The remainder of those participants i.e. 65%, claimed that littering was widespread in Diepsloot because poor service delivery. One participant said that there were no big bins to dispose waste for residents while the available community disposal sites are far off. Another participant stated that Pikitup takes long to collect bins. However, is there evidence to suggest that poor service delivery is widespread? If so, what are the causes?

From an NGO perspective, the SWM crisis in Diepsloot emanates from the lack of formality in the informal areas. In particular, NGO officials emphasised that the lack of navigable streets makes it impossible for Pikitup trucks to navigate the settlement street by street to collect waste. This view was shared by a Pikitup official. Both the participating NGO officials reiterated that the lack of town planning presents major challenges to Pikitup in its efforts to deliver the municipality's constitutional mandate.

> *"Yes, there is a crisis. Lack of formality in Diepsloot causes the SWM crisis. There are informal structures _ in between them are narrow roads that waste collection trucks cannot navigate".*

In order to mitigate the navigation issues, Pikitup created communal waste disposal areas where residents are mandated to dispose of their waste once their plastic bags are full. In theory, this sounds strategic, but in practice, the organisational inadequacies are further exposed. The designated disposal sites are far off to some community members. A long distance to disposal sites discourages willing residents and encourages littering and dumping in undesignated places.

Furthermore, the NGO officials laid blame on Pikitup because they do not issue plastic bags to all residents but only to those who occupy formal houses and yet the majority of community members live in shacks (see chapter 2 for the statistics about shacks). This encourages indiscriminate dumping of waste. A question arises as to who is responsible for town planning so as to avert such crises. However, this would be beyond the scope of this study.

There is a consensus between the NGOs and Pikitup with regard to the issue of overpopulation in Diepsloot. NGO officials asserted that planning for informal settlements is complicated because of their fluid nature. For example, when national censuses are conducted, many residents living in shacks will be out to work thus giving a wrong figure to the government (**revealed by an NGO official**). A Pikitup official commented that overpopulation affects PikiTup programs. They are always expanding so it affects budgets. Although there appears to be a consensus between Pikitup and the participating NGOs regarding population, the ultimate position of the NGO officials was that overpopulation only exacerbates existing organisational inadequacies. Poor service delivery also manifests in the form of infrequent waste collection services.

> *"There is infrequency of waste collection which also contributes to the waste crisis. In Extension 1 – the more informal area with high population density, collection is done once daily…collection should be done multiple times a day. However, it is done once that is why people end up dumping rubbish on street corners…"*

An official from Pikitup claimed that:

> *"Frequency of waste collection depends on the area. Formal areas once a week, others 3 times a week (township), others daily especially in the informal settlement because they do not have bins but plastics".*

There is an apparent contradiction between what Diepsloot residents say and what Pikitup believes. As stated above, residents complained that Pikitup take long to collect bins. Questions then arise: Is it organisational incompetence or there are other hidden politics at play? Whatever the dynamics are, the end result is poor solid waste management delivery as emphasized throughout this chapter.

4.2.1.4. Key pollutants are Organic waste and recyclable materials

One of the objectives of this study was to locate ways to mitigate the impact of SWM crisis in Diepsloot. In order to achieve this, it was deemed necessary to locate the most dominant form of waste generated by Diepsloot residents. The purpose of this theme was to assist in determining the appropriate methods to mitigate the SWM crisis in Diepsloot as dictated by one of the research questions governing this study.

Figure 4.19: Municipal solid waste consisting mostly of plastics

Photo credit: Anton van Nierkerk (2019)

The participants were questioned to state the type of waste they generated the most at household level. All the participants (100%) pointed out food waste and plastics to be the waste they generated the most. This is corroborated by **Figure 4.18** above in which the bulk of the solid waste dumped by the wetland is made up of plastics. The widespread consequence of the abundance of plastics was environmental contamination as seen in most pictures in this research. River courses and wetlands were seen heavily contaminated with food waste and plastics. It is apparent from the data that the immediate consequence of poor SWM was environmental degradation.

With regards to the effect of solid waste on the environment, 71.4% of the participants understood the risks posed by waste on the environment. The responses provided by the participants lacked detailed but they generally conform to the impacts described earlier in the Chapter. Participants generally pointed out land, air and river pollution as the effects of waste mismanagement on the environment. However, the concept of environmental pollution was not well understood as evidenced by the responses that lacked elaboration.

4.3. Conclusion

This chapter presented the data collected during fieldwork. It is apparent from the data that most participants from Diepsloot lacked in-depth comprehension of SWM issues in their area

of residence. This can be attributed to a wide range of factors which will be discussed in **Chapter 5**. However, participants from the NGOs and Pikitup had in-depth knowledge which assisted in understanding the issues and processes associated with SWM in Diepsloot. The data revealed dichotomies on issues of service delivery between Pikitup and Diepsloot residents. **Chapter 5** presents a discussion of these and other issues raised in this chapter.

Chapter 5: Discussions and ways for improvement

5.1. Introduction

The purpose of this study was to explore community perceptions on the impact of SWM on human health and the environment in Diepsloot, Johannesburg, SA. In this chapter, i present a discussion of the data presented in **Chapter 4** which was meant to understand community perceptions on the impact of SWM on human health and the environment. To achieve this, we commence with the discussion on the socio-demographic characteristics of this study in order to justify the choice of the participants and to explain the quality of the data presented in **Chapter 4**. This will be followed by a discussion on the participants' perceptions on the impacts of SWM on both human health and the environment. The chapter further presents a discussion of the themes presented in **Chapter 4** so as to provide an understanding of the associated implications. The chapter also proposes the appropriate alternative solutions that can be applied to mitigate the SWM crisis in Diepsloot and lessen the impacts on human health and the environment.

Two localities forming part of Diepsloot i.e. Diepsloot West Reception Area (DWRA), a more formal area, and Diepsloot West Extension 1 (DWE1), a dense informal settlement, were purposively selected for the study because we perceived that the associated residents possessed characteristics beneficial for the study. The two selected areas formed a perfect mirror image of the entire settlement of Diepsloot which is marked by formal and informal areas. As such, the selected participants from both localities were assumed to have considerable knowledge of SWM practices in their respective areas of residence, which would mirror practices in all the Diepsloot localities noted in **Chapter 3**. We argue that the participants from these localities provided quality data required for the study. In hindsight, we argue that the study could have benefitted more from the recruitment of participants from more localities.

As presented in **Chapter 4**, the study had more males than females i.e. 17 females and 18 males **overall**. Males were more willing to participate because they were free of work to do. This can possibly be explained by the prevailing high unemployment rate in Diepsloot. Secondly, this may also be explained by the national corona virus disease of 2019 (Covid19) lockdown imposed in South Africa. Following this logic, no one was allowed to travel far so as to contain the spread of the disease, hence the availability of males. Conversely, females appeared to be occupied with domestic duties and could therefore not avail themselves for participation. This near perfect balance between male and female participants did not occur organically, we

worked to achieve it. The study could have had more males than females by far, on account of the reasons discussed above. However, for the purposes of gender balance, we sought for female participants far and wide throughout the two localities. Gender balance was considered critical for the study. The mechanics of this position were that females are more involved in the production of municipal solid waste at household level than males. In defence of this assertion, I argue that with the widespread **gender related** approach to daily duties in most African societies, the women could be assumed to generate more solid waste through kitchen work, shopping **(and therefore waste)** and so forth. In light of this, the perceptions of females on SWM issues were regarded quintessential.

Participant recruitment for any study must be age sensitive. In this study we recruited participants that were 18 years or older (**Chapter 4**). The default justification was that participants had to have reached the legal age of consent in South Africa and that the study was bound by ethical principles of research. However, there was more. Older participants were considered to have more access to income, and therefore were considered to generate more solid waste after every purchase. With this analogy, participants were supposed to be 18 years or older.

A crucial demographic characteristic of the recruited participants was that they had to have lived for over a year in Diepsloot. The rationale accompanying this position was that of the need to gather quality and well informed data. In this perspective, the longer the participants had lived in Diepsloot, the more their knowledge on issues of SWM in their locality. Membership of the Diepsloot community is fluid. There is a constant pattern of people arriving and others leaving. Following this trend, the study could not have benefitted from recruiting new members because of the possibility of having shallow knowledge on the subject matter under review.

Regarding the educational background of the participant, the suffered from the prevalence of high school dropouts in Diepsloot. In the developed countries where education standards are high, this argument would crumble. In justification of the initial position, we argue that the quality of basic education in South Africa is low (e.g. Spaull, 2013). From our position, we therefore argue that the participants had knowledge deficiency on issues of SWM as a result of poor basic education in South Africa. This might explain the ignorance and lack of depth in most of the responses provided by the participants.

5.2.2. Discussion of solid waste mismanagement and its associated impacts on the area of study

This study was the first of its kind in Diepsloot. Several studies done in Diepsloot have focused on other issues and peripherally focused on the issue of the waste crisis in Diepsloot. None of these studies involved the investigation of community perceptions on the impact of poor SWM on the environment and on human health (Chapter 2). Therefore, the contribution of this study to the existing literature is **immediately revealed**. Unlike existing studies in the area, this study offers a unique opportunity to explore the impacts of poor SWM on the environment from the people's perspective. It also offers an opportunity to understand the reasons behind the poor plight of SWM in the study area which facilitates for informed decision making on ways to resolve the crisis.

The concept of SWM and its associated processes were not well understood by the participants. We argue that the ability to briefly state the impact of waste on the environment without further explanations of the mechanics of such processes is equal to ignorance. For instance, 68.6% of the participants correctly linked poor SWM with land, river, air pollution as well as the blockage of drains. It was expected that participants would supply further information as dictated by the question. For instance; how does this pollution take place? Who or what is affected? Does it go beyond Diepsloot? We argue that this is general knowledge that participants should have fully engaged in to show comprehensive understanding. The rest of the participants virtually lacked knowledge on the impacts of poor SWM on the environment. To explain this apparent lack of knowledge on SWM issues, we borrow from the demographic information presented in **Chapter 4**. Most participants went only as far as high school**. This is possibly one of the weaknesses of the study**. Participants were not required to state their highest stage in high school. In our defence, we argue that regardless of the level reached, the quality of basic education in South Africa is very low so that it would therefore have been none consequential. Our position on the general lack of knowledge is corroborated by the widespread scattering of illegal dumping sites on street corners, drains and water courses.

The actual extent of the impacts of poor SWM on the environment from the perspective of NGOs and our own observations was seen in the destruction of aquatic life e.g. bullfrogs, destruction of aquatic habitats such as wetlands through contamination by solid waste, construction rubble and sewerage effluent. Explaining further, the deposition of sewerage water and solid waste into aquatic habitats has an effect of changing the required pH required for

species to thrive. Another consequence of water course pollution is the causation of unnatural flooding in the wet season due to the constriction of water courses by solid waste, particularly construction rubble. These unnatural floods would have further side effects of eroding the surrounding areas which would cause more pollution and depletion of the integrity of these water sources (**the unnatural floods erode the illegally disposed waste dumped on the peripheries of watercourses**). Participants and the entire community of Diepsloot, particularly those living close to the water courses witness these impacts and events but with limited knowledge of SWM issues it doesn't appear as a risk to them. These environmental impacts overlap with effects of poor SWM on human health as seen in Chapter 4 through the annual drowning of people, particularly children. The repeated cases of drowning in Diepsloot demonstrate the repeated ignorance on the importance of proper SWM in the area.

On land, the indiscriminate dumping of municipal solid waste has other potential impacts. Firstly, the decomposing waste causes air pollution and release of greenhouse gases that causes climate change. The entire study area, particularly the informal area has poor air quality. It is filled with unpalatable odours emanating from illegal dumpsites. Fitting this in existing literature, a study showed that the waste sector alone contributes 5% of the annual world greenhouse gas emissions (Sinha *et al*, 2020: 2). With the prevalence of poor SWM in the numerous informal settlements in South Africa, let alone the developing world, it can be seen that a significant portion of the global greenhouse gases emanate from areas alike Diepsloot. **Setting the argument above aside**, the prevalence of food waste and plastics (see Chapter 4) means toxic leachates are deposited into the ground with further effects such as soil, ground and surface water contamination. Equating this to the situation in Diepsloot reveals major problems for the population in the future. The informal area has limited access to piped water. Thus there is a likelihood of dependence on the natural water courses that are polluted with multiple agents.

Plastics have an additional effect_ prolonged periods of decomposition, which means more soil contamination. At a macro scale, the discussed impacts of the poor plight of SWM in Diepsloot actually traverse the borders of this place. The contaminated rivers and wetlands transport the contamination throughout the entire river system to the Indian Ocean while the greenhouse gases are also carried away to other places where climate change is therefore realised.

Regarding the impacts of poor SWM on human health, poor SWM has several potential impacts on the community of Diepsloot. These are respiratory illnesses due to poor air quality arising

from decomposing illegally dumped waste. **A total of 62. 6%** of the participants managed to point this out which suggests on paper that the community was aware of the **effects of poor swm on human health**. The prevalence of illegal dumpsites attracts rats and flies which carries pathogens. There is an interaction between people and these disease careers although it is not intentional and this is how diseases may be spread. For instance, children play on the streets running sewage swamped dusty roads while there is a culture among children to scavenge illegal disposal sites for valuables such as toys or discarded electronics. For the adults, waste pickers also scavenge waste heaps for recycling material whereas rats seek shelter and more food in their shacks resulting in rat bites. Rat bites at night causes the spread of these pathogens.

A critical look at the continued illegal disposal of waste suggests a dependency syndrome on organisations such as Pikitup and NGOs. **It was explained by the Pikitup official that the community of Diepsloot deliberately litters it dump waste illegally because they assumed it was the role of Pikitup to clean up after them**. This dependence encourages environmentally unfriendly behaviour so that illegal disposal is seen as a normal activity to engage in because there are organisations that clean up after them. Such frame of thinking is not expected to be found in an area where residents do not pay municipal rates to finance Pikitup operations.

These collection issues by PikiTup might be informed by the lack of rate payment by the residents and yet they have to do it in respect of the South African constitution which mandates municipalities to ensure clean and habitable environments for all citizens.

5.2.3. Discussion of community ignorance and negligence on SWM issues

This theme exposes the root causes of the problems of SWM in Diepsloot. For instance, the majority of participants i.e. 68.5%, had no comprehension of the term SWM. Only 31.5% of the participants attempted with limited success to define this term. In addition, 35% of the total participants linked the waste crisis in Diepsloot to community ignorance. This begs the question as to what caused the ignorance and negligence.

Participants lacked environmental education which would have been useful with regards to informing the community about SWM. As seen in **Chapter 4**, NGOs and Pikitup asserted that they ran environmental awareness campaigns in Diepsloot. Although there is evidence that NGOs actually run campaign programs in Diepsloot, we counter argue that these programme lacked extensiveness. Participants for the study were recruited over a wide area covering

DWRA and DWE1. This suggests that the programs did not reach these particular localities of Diepsloot, but others. This could be due to financial constraints.

The approach to environmental education through visitation to schools by Pikitup is marred by weaknesses. With close attention, it may be observed that this approach was meant to dodge higher expenditure and navigation issues required to achieve the intended goal. A closer look at the home environment would reveal further weaknesses of the approach by Pikitup. The production of municipal solid waste in the home environment may be more associated with adults and not children. Parents or guardians in Diepsloot mostly work in the informal sector as unemployment in the formal sector is rife. **As a result, adults buy food for the night in fast food packages. The following day the waste is discarded by adults when the children have left for school.** It can be observed therefore that the process of waste production is more linked to adults rather than school children. In addition, expecting learners to teach adults about the environment may not be an easy task because the demographics of Diepsloot appear to have more youths rather than younger people.

The waste crisis is exacerbated by the importation of construction rubble from well to do areas (Chapter 4). This investigation revealed that this was made possible by the prevalence of corruption by local political leaders which is reminiscent to **the** problem at national level in South Africa as discussed in **Chapter 2**. In the case of Diepsloot, these illicit dealings are made possible by the absence of checks and balances mechanisms. For instance, there are no existing committees **comprising** the relevant stakeholders (to be discussed further below) in waste management and environmental issues in Diepsloot. The presence of these could have an effect of galvanising SWM processes and curb waste management related corruption at community level. The lack of environmental education is further revealed in this regard in the sense that community members were made to believe that the dumping of construction rubble had something to do with construction of schools (Chapter 4). An environmentally aware resident would be capable of discerning reality from deception. The end product of the failure by responsible authorities to provide the much relevant environmental education breeds community ignorance on issues of SWM.

In the greater scheme of literature on SWM in South Africa, this theme finds place. Community ignorance is widespread in South Africa, particularly in informal settlements. As reported in **Chapter 2**, communities in EThekwini municipality illegally disposed waste which ended up clogging flood water systems and contaminating water courses just as was the case in

Diepsloot. This behaviour was encouraged by the lack of knowledge of how waste should be handled at household level.

5.2.4. Discussion of poor service delivery in Diepsloot

Poor service delivery is at the centre of the SWM crisis in Diepsloot (Chapter 4) and is therefore one of the **factors leading to** the SWM crisis in Diepsloot. While community ignorance discussed above contributes greatly to this crisis, it does not stand alone. Pikitup's service delivery was seen to be erratic and lacked strategic planning. In a locality where the population is frequently rising, Pikitup sticks to collection of bins once a day. In addition, they have few communal dumping areas which can therefore not service everyone or they are far from other households thus encouraging dumping in a community that is not environmentally aware. More explicitly, these service delivery problems which are more felt in the informal areas lead to environmental catastrophes and human health risks in Chapter 4. This particular problem is surrounded by multiple legal dilemmas that will be discussed later under this topic.

As noted in the previous chapter, a Pikitup official claimed that service delivery was more active in informal areas than in any formal areas of Johannesburg. This claim may not be accurate in light of the data we found. It therefore demonstrated the organisational weaknesses with regards to the manner in which operations run in the company. It reveals the lack of checks and balances within the organisation whereby information on operations is reported but with no effort to ground truth through fieldworks. Our position is therefore that Pikitup is characterised by system problems.

Although municipalities are required by the Constitution to provide waste management services for every locality in South Africa so as ensure a clean and habitable environment for all citizens (SA Constitution, 1996), they are met with complicated legal and financial dilemmas. Informal settlements are self-imposed i.e. communities unlawfully invade vast expanses of land without the authority of the City Council, let alone the government. This puts the informal areas of Diepsloot outside the jurisdiction of the municipality and therefore, the municipality may feel that they are not obligated to provide their services. Therefore, there is a clash with the constitutional liberties of **all people in the country** who should be provided with clean and habitable environments. There is a further twist. The informal areas of Diepsloot have a high population of illegal foreign nationals. **The municipality may not have positive sentiments towards the delivery service to foreign nationals despite the Constitutional obligation to do so**.

5.2.5. Discussion of food wastes and plastics as key environmental pollutants in Diepsloot

The key environmental pollutants in Diepsloot appear to be of domestic origin. These are food wastes and plastics. This observation dictates that salvage measures must target the households rather than schools. This theme also supports the theme of ignorance discussed above. When the adult runs out of space to store waste at household level, the immediate solution is to visit to nearby illegal dumpsite and the same goes for all the likeminded Diepsloot residents hence, the crisis. But then, how does this come about? In our view, this emanates from poor service delivery. For an uneducated resident, waste management is the role of the municipality to play. When this fails to materialise, they would feel they have no choice but to illegally dispose of waste. Ultimately, poor service delivery has ripple effects:

I. The residents are cornered and therefore left with no choice but to illegally dispose of the waste.

II. The environment i.e. water courses and street corners is at the receiving end. Air quality problems set in, habitat for flies and rats is created

III. Human health problems e.g. respiratory illnesses become a possibility while for the environment, aquatic habitats for bullfrogs are destroyed etc. (see Chapter 4).

This chain of events is reminiscent of the situation in other informal settlements not just in Johannesburg, but also the country at large. Looking back to the research questions, we ask, "What are the problems of SWM in Diepsloot?" In response, we argue that the problems in Diepsloot appear to start with organisational failures on the part of the municipality which gives birth to other problems which may be levied upon residents as discussed above. While NGOs have a role to play, they do not have a constitutional mandate to ensure clean and habitable environment for all citizens. Thus, the problems of SWM in Diepsloot emanate from a faulty system on the part of the municipality.

5.3. Some ways for improving the SWM systems and its impact on human health and the environment in Diepsloot

The SWM crisis in Diepsloot cannot be eradicated over a short period as would be environmentally preferable. Rather, the approach to tackling the crisis should be viewed from two perspectives i.e. short term and long term. This categorisation is in view of the economic status of the Republic of South Africa. As stated in Chapter 2, South Africa is a developing country whose annual national budgets often struggle to meet the needs of the swelling

population. This is further complicated by the Covid-19 pandemic that has affected the national budget to facilitate for the health sector. Meanwhile, literature on SWM world over tends to recommend for high technologies that are very expensive as solutions to mitigate SWM crises. In the South African context, advocating for such technologies would be untenable because of the plight of the South African economy. The recommendations we make in this study are guided by this background information.

5.3.1. Infrastructural construction and rehabilitation

As a short term measure, the construction of drains using readily available and cheaper materials is advisable. For instance, simple tools such as picks to excavate drains and paving using pebbles or stones. The purpose of these drains would be to redirect the perennial streams of sewerage effluent that run along the dusty streets of Diepsloot, particularly in the informal areas. From an environmental perspective, this would protect water courses and the associated biodiversity such as the near endangered Giant Bullfrogs by redirecting the sewerage effluent. From a human health perspective, the likelihood of the occurrence of diseases mentioned in **Chapter 4** is reduced or eliminated. The construction of drains has the potential to eliminate the chances of exposure to the sewerage effluence, particularly for the children.

I. Under this section, Rehabilitation of the dusty streets by tarring and widening falls under the long term measures. Pikitup waste collection vehicles faces navigational constraints in Diepsloot. To eliminate this problem, a long term measure would be to increase formality of navigation routes by rehabilitating the streets to accommodate waste collection vehicles. There is challenge that since there is inadequate space in the settlement, this might not be possible. This would therefore require demolition of structures.

From an environmental perspective, this would limit or out rightly eliminate indiscriminate dumping of waste in undesignated areas. This is not all it would do. The pollution of water courses would also be reduced or eliminated. From a human health perspective, the rehabilitation of streets would reduce or eliminate exposure to toxic odours that may cause illnesses such as respiratory diseases. In addition, it would also eliminate breeding hotspots for flies and mosquitoes whilst ensuring that rats have nowhere to feed and multiply.

In addition to rehabilitating the roads, the rehabilitation or renewal of the sewer systems would eliminate the perennial sewerage effluent streams spread across

Diepsloot. The population of Diepsloot is not known for sure. However, estimates put the population within the region of 300 000 and 500 000 for a space of just 5km² (**Chapter 3**). Over the years, this has imposed a severe strain on the sewer infrastructure originally intended for a significantly smaller population. Therefore, the rehabilitation of the obsolete sewer system to suit the current population would eliminate sewerage spills into freshwater courses as well as to eliminate exposure disease causing liquids and solids.

5.3.2. Community engagement and participation

The success of the mitigating measures against the SWM crisis in Diepsloot depends largely on community engagement and participation by the responsible authorities such as the local government through Pikitup and Non-Governmental Organisations operating in Diepsloot. However, this would be a long term measure because educating the ordinary folk about Green Citizenship would require radical transformation in everyday behaviour (see MacGregor, 2007). These **complication of transforming folk behaviour** is crystallised by the nature of Green Citizenship which is immersed in democracy and voluntarism on the part of candidates (e.g. Bell, 2004; MacGregor 2007). The end product of this is that the candidate Green Citizen would be at liberty to prolong the process of transition, consciously or otherwise, and could even eventually out-rightly reject to be a Green Citizen.

The community engagement would be in the following ways:

I. Diepsloot requires more environmental education. Throughout the thesis, we demonstrated the presence of a SWM crisis in Diepsloot which negatively affects the environment and risks a human health crisis. We have also seen that a bigger fraction of the environmental pollutants is household waste. With the crisis being pivoted by the lack of environmental education in the households, a targeted approach is more advisable. In this approach, we propose that the educational programs must target the adults at home rather than learners at school. None of the participants were aware of environmental programs that run in Diepsloot suggesting weaknesses in the approaches used. In order to mitigate this, Pikitup and the NGOs operating in Diepsloot must expand their campaigns to all areas of Diepsloot and with increased frequency.

5.3.3. Improvement of service delivery

The results of this study suggests that although Pikitup claims on paper that they work with the community in Diepsloot to alleviate the crisis of SWM, in practice this is not really the case. In our view, this problem is a result of the existing "Top Down" management style which culminates in arbitrary and uninformed decisions – as compared to an effective co-management style which we propose. The stance currently taken by the local government with regards to Diepsloot is in contravention of the provisions of the White Paper on Local Government which calls for the Integrated Development Plans (IDPs) (see Ministry, 1998). Through IDPs, there should be partnership between the local government and the citizenry with regards to local affairs of governance. The local government has a mandate to inform citizens of their right to participate (Ministry, 1998: Section 29). The results of this study have shown that this is not the case in Diepsloot because there is little or no public participation at all. In my view, this non inclusive Top Down management style results in poor service delivery by Pikitup. The adoption of a co-management approach dictated by the IDPs of the White Paper on Local Government (Ministry, 1998), would be a long term measure aimed at mitigating the impacts of poor SWM in Diepsloot. In view of this measure, we propose:

I. Establishment of a committee comprising Diepsloot community leaders (councillors and selected residents), police, Pikitup officials and representatives of Non-Governmental Organisations operating in Diepsloot such as the Greater Kyalami Conservancy (Gekco) and the "Roots and Shoots". We already know that corruption by local politicians makes it possible for unscrupulous construction companies from well to do areas to export rubble to Diepsloot. Here are the words of the NGO official:

The crisis is also due to politics specifically with regards to the rubble dumped by trucks from the northern suburbs…This is politically motivated in the sense that there are people in the community who benefit from rubble being dumped there. Community members are too scared to speak about it because the people who are involved are politicians (the politicians were named but will not be mentioned in this study).

In my view, the establishment of a committee comprising the proposed stakeholders would eliminate this problem by galvanising the chain of communication and increasing the checks and balances. It follows that, the voice of environmental NGOs backed by environmentally aware residents would not permit further rubble disposal in water courses in Diepsloot. The

proposed initiative coupled with environmental education would therefore work hand in glove with this co-management initiative.

II. In the immediate measures category, Pikitup must improve service delivery. The study has revealed discrepancies in the information supplied by a Pikitup official and community participants regarding service delivery in Diepsloot. For example, according to the Pikitup official, collection of bins was done every day in all the localities of Diepsloot. On the ground, interviewed participants from NGOs and residents lamented that Pikitup took long to collect their bins. It follows that even when they do; it would be once a day. In addition, the designated points of disposal were located far from some residents while disposal bags were issued only to people living in formal houses. This encouraged dumping. We therefore propose for an increased waste collection frequency to three times a day due to the ever growing population. In addition, Pikitup must establish more dumping areas to avoid long distances to the existing designated dumping sites. Plastic bags must be issued every week to all residents, including those in shacks.

The process of service delivery improvement can be reinforced through the establishment of a registry for all shacks in Diepsloot. This requires physical counting or estimations of the total number of shacks and the associated people. The benefit of this measure is that it informs the process of resource allocation at the beginning of every financial year. Service delivery can be further improved through the establishment of a landfill in the north. Currently, Pikitup faces astronomical costs transporting waste from Diepsloot to the nearest landfill which lies 30km away. Perhaps the poor service delivery is influenced by the transportation costs along with the fact that residents in the informal areas do not pay municipal rates.

5.4. Law enforcement

This is a short term measure that can be employed immediately, specifically with regards to the importation of construction rubble from the northern suburbs. Construction companies involved in this illegal activity must be held to account by paying hefty fines and cleaning up after the rubble they dispose of in Diepsloot. The funds generated through the legal process can be used in the rehabilitation of the water courses rather than be absorbed into the national treasury.

An additional long term measure would be to legally enforce waste minimisation at household level. It is reported that the City of Johannesburg has plans to make it a legal requirement for all residents to adopt a waste minimisation stance. This approach is said to be immersed in the waste management hierarchy which dictates for waste reduction, re-use and recycling (see Rasmeni and Madyira, 2019: 1029). With regards to Diepsloot, this approach would only be tenable if Pikitup issued waste bags to all residents rather than the current selective distribution. Reduced waste production means that Pikitup is not overwhelmed by waste production. This means less illegal waste disposal sites which would be a relief to the environment. Recycling would assist in further reducing the production of waste but this would be possible only if more buy back centres are established in Diepsloot and for all manner of plastics, including the single use type. Separation at source, which is a facet of the waste management hierarchy, would especially be beneficial in Diepsloot. As discussed in Chapter 4, food waste was one of the main types of waste produced in Diepsloot. Separation at source would assist in the formation of communal composts as one of the sustainability measures to mitigate the SWM crisis.

This approach goes against the basic principles of liberal green citizenship which emphasizes personal choice. However, there is a twist to the way liberal green citizenship can be viewed. It has been argued that liberal green or environmental citizenship like any other citizenship comes with rights and responsibilities. In their view, the term "responsibility" does not suggest something voluntary on the part of candidate environmental citizens (Bell, 2004).

5.5. Buffering of water courses

This would be a long term measure against disposal of waste into water courses. The community of Diepsloot illegally and unsustainably dispose of solid waste in water courses e.g. wetlands and rivers. These water courses form habitat to various biodiversity (Chapter 4) and yet communities continue to construct their dwellings on the banks of these environmental features. In order to eliminate this, we propose that NGOs partnering with the relevant government departments build buffer zones around water courses, particularly wetlands. We further propose for the construction of these buffers using concrete blocks as opposed to steel bars. This is done to deter potential theft of the steel bars for use for other purposes.

5.6. Establishment of buy back centres and intensification of existing ones

I. This is partly a short term and a long term measure. There is one buy back centre in Diepsloot extension 7 where waste pickers sell their waste plastic for recycling. There is need to expand their operations in order to accommodate single use plastics which are said to be of low value. As discussed earlier, plastics form the largest source of pollution in Diepsloot. Therefore, the purchase of single use plastics by the existing buy back centre would result in less pollution in Diepsloot.

II. As a long term measure, we propose for establishment of multiple buy back centres in Diepsloot. The current buy back centre may be far from other localities in Diepsloot. The effect of this is to discourage environmentally friendly behaviour which results in the current situation in Diepsloot. We propose for a buy back centre in every extension in Diepsloot because the production of waste is very high due to the high population.

5.7. Conclusion

This study has revealed that poor SWM practices by the community in Diepsloot have dire consequences on the environment and on human health. The study also revealed that although Diepsloot residents are responsible for the poor plight of SWM in their locality, there are factors that encourage this behaviour and that also contribute to the poor plight of SWM in the area. Through understanding these other factors, we have proposed short and long term measures required for mitigating this crisis. All things said, this study was not epidemiological as it sought to understand community awareness of the potential impacts of their SWM practices on human health. This forms one of the limitations of this study and could therefore have been more informed if it was an epidemiological and if water and air quality tests were conducted. These were not possible due to the shortage of funds and the skills required doing so. The following chapter discusses the recommendations for future studies.

Chapter 6: General conclusion and recommendations

The purpose of this study was to examine community perceptions on the impacts of Solid Waste Management (SWM) on human health and the environment as well as to propose ways to mitigate the crisis. This was done with focus on Diepsloot, an informal settlement as a case study. To achieve the goal of this study, a mixed methods approach based on semi structured questionnaires and telephone interviews to collect qualitative and quantitative data was deployed. Using these tools, community members and representatives from selected organisations were requested to answer various questions regarding the causes and impacts of poor SWM in the area. The benefit of this methodology and the associated results is that they enable the relevant authorities to understand the causes of the poor plight of SWM in Diepsloot. This is crucial in minimising or totally eliminating the SWM problems. Why is this important? In order to avoid the human health and environmental crisis in Diepsloot, there is need for behaviour change due to widespread ignorance on SWM issues. To arrive at this conclusion, it was important to understand community perceptions on SWM issues in their locality.

In conducting the study, several problems which can be classified into two groups were identified. These are institutional and societal problems because some problems were a result of the limitations of organisations while others were due to the errors made by the community of Diepsloot. Under the category of institutional problems, the results of the study showed that Pikitup, the municipal wing responsible for solid waste management in Johannesburg had service delivery limitations ranging from infrequent collection, poor educational programs, organising few communal disposal sites to the failure to provide residents with storage bags. The inefficiency of Pikitup reveals the failure of the local government to deliver its mandate as dictated by the South African Constitution of 1996 (Act 108). The Constitution mandates the Municipality to ensure clean and habitable environments for all citizens. Under the same category (institutional), corruption by politicians finds a place. The importation of construction rubble from the leafy suburbs of Johannesburg in the north was made possible through illicit business between construction companies and political leaders in Diepsloot.

It can be argued that the above limitations fuelled the problems that we categorise under societal problems. Under this category, there is one umbrella problem i.e. community ignorance on SWM issues. The community disposed of solid waste in undesignated locations such as street corners and water courses such as rivers and wetlands. To address the main research question which required to the study to expose the impacts of poor SWM on human health and the environment, it can be argued that the above problems culminated in the

following impacts on human health and the environment in Diepsloot; Land pollution though illegal dumps, contamination of water courses such as rivers and wetlands, the depletion of giant bullfrog population due to wetland contamination, aquatic habitat destruction through unsustainable disposal of solid waste such as construction rubble into rivers and wetlands as well as air pollution and greenhouse gases. Regarding the impact on human health, respiratory illnesses such as coughs and sinuses, proliferation of breeding spots for flies and rodents e.g., rats that bite people while they sleep and spread diseases and lastly seasonal floods that drowned children.

Despite this SWM crisis visible to every eye, the residents of Diepsloot had little comprehension of the concept of SWM. These results when situated in the existing knowledge, it was found that there are basic similarities in the community perceptions on the impacts of SWM on human health and the environment in other localities in South Africa where participants demonstrated similar low levels of understanding. Drawing from Chapter 2, for instance, less than 50% of the participants in the community of Thohoyandou in Limpopo, were able to tell the effects of poor SWM on human health even when they lived close to the landfill. This demonstrates the need to introduce or intensify environmental education programs in South Africa as recommended in Chapter 5.

The contribution of this study to the existing literature on SWM in South Africa lies in several ways which are not novel to the existing knowledge. The results of the study reinforce the widespread SWM problems in South Africa discussed in Chapter 2. For instance, the organisational problems whereby for instance, high ranking municipal officials fought regarding SWM issues resulting in poor service delivery or corruption, though of a different form whereby looting and exorbitant salaries were present. Congruencies can be drawn in Diepsloot where politicians were responsible for allowing unscrupulous construction companies to dump construction rubble into wetlands and rivers. Regarding literature on the sub Saharan African perspective, let alone the developing community world over, this study echoes the limitations with which governments in the developing world are not doing enough to meet global climate change goals.

6.1. Recommendations for future studies

This study revealed the impacts of poor SWM on human health and the environment in Diepsloot through the perceptions of the community and selected officials from three organisations. While it was important to understand such perceptions for the purposes of

formulating mitigating measures such as those in Chapter 5, this study alone was not enough to facilitate for the much needed transformation in Diepsloot. We therefore recommend the following future studies:

i. Future studies must be more practical. This can be done through Environmental Toxicology investigations such as wetland water quality testing and air quality tests. These studies are important in order to assess the potential impacts of the contamination on human health and aquatic species as well as to determine the intervention measures required. These tests can be accompanied with the delineation of wetlands. Drawing from the results of the study, the continued disposal of municipal solid waste into the water courses has diminished the area covered by the water courses. Therefore, we recommend for future studies to delineate the wetlands for purposes buffering and rehabilitation as recommended in Chapter 5.

1. The SWM crisis in Diepsloot was mainly fuelled by the problem of poor service delivery by the Municipality through Pikitup which beget other problems. Pikitup is characterised by problems in communication within the organisation whereby there are no systems of checks and balances. However, this study was not rigorous on this issue. We therefore recommend for future studies to take a Systems Approach in order to fully reveal the problem areas in management at organisational level and formulate ways in which to eliminate the system's weaknesses. The significance of this approach is that it facilitates for better service delivery.
2. From a human health perspective, we recommend for epidemiological studies to be conducted across the settlement. As highlighted in the study, both NGOs and participants involved in the study had little or no information regarding the actual diseases or deaths as a result of the SWM crisis in Diepsloot. We know at large that SWM is responsible for the deaths of many people across the world, particularly in the Developing countries (Chapter 2). To be better informed epidemiological studies in the area such as diseases surveillance and tracking should be done. These studies must be accompanied with the publication of the results for stakeholders to see.

3. We also recommend for demographic studies in Diepsloot. Firstly, as emphasised in Chapter 3, the actual population of Diepsloot is not known. It follows that the distribution of gender, age or race is also unknown to the municipality, let alone the

government16. One may argue that the government of South Africa performs occasional censuses nationwide so that our recommendation is rendered unnecessary. However, in defence of our position, we borrow from the words of an NGO official that participated in this study. Diepsloot is characterised by migrant labour where the employed residents travel to many places for employment so that when censuses are conducted, many will not be home. In addition, we argue that with back-yarding rife in Diepsloot, some places are not easily accessible to an outsider, including the census enumerators. The study that we propose will assist the national government and the Johannesburg municipality with information required for planning. But how does this relate to SWM? We argue that having this information handy will assist with planning information for waste management initiatives. It is impossible to plan for a population that is unknown.

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APPENDICES

Appendix 1: Questionnaire for the residents of Diepsloot

SOCIO DEMOGRAPHIC DATA

1. Indicate your gender (x):

Male	
Female	
Other	

2. Select your age group (x)

No	Age Range	Indicate
1	18-25	
2	26-30	
3	31-35	
4	36-40	
5	41-45	

6	46-54	
7	55 and above	

3. How long have you been a resident of Diepsloot?

……

4. How many people do you stay with and what is your relationship with them?

…….

5. What is your highest level of education?

Primary	
High School	
Tertiary (specify e.g. University)	
Vocational training	
Other?	

6. What is your occupation?

.....

7. Are you a member of any social organisation in Diepsloot or elsewhere and that deals with community health?

.....

SECTION B

PERCEPTIONS ON SOLID WASTE MANAGEMENT

Date of issue	D	D	M	M	Y	Y	Starting time	Finishing time

1. What do you understand by the term "solid waste management?"

.....

2. Where do you dispose of the household waste you produce?

.....

3. Are there any water bodies in Diepsloot? If so, name them.

……

4. Is there a problem of waste management in Diepsloot? (YES/NO). If yes, how long has this been happening (state the number of months or years)

……

5. Diepsloot is known for the presence of litter in many undesignated locations. In your opinion, what is the cause of this?

……

6. Which rubbish do you generate the most in your household and why?

……

7. Does the solid waste you produce at household level pose any risk to human health? If so explain how.

……

8. Does the solid waste you produce at household level pose any risk to the environment? If so explain how.

……

9. Have you or your relative ever visited a clinic on account of poor waste management related diseases? If so state, the illness

.....

Appendix 2: Questionnaire for Pikitup

SOCIO DEMOGRAPHIC DATA

1. Indicate your gender (x):

Male	
Female	
Other	

2. Select your age group (x)

No	Age Range	Indicate
1	18-25	
2	26-30	
3	31-35	
4	36-40	
5	41-45	

6	46-54	
7	55 and above	

3. How long have you worked for Pikitup and where is your residence?

…….....

4. As a PikiTup official, have you visited any informal settlement in Johannesburg?

.....

5. What is your highest level of education?

Primary	
High School	
Tertiary (specify e.g. University)	
Vocational training	
Other?	

7. What are your professional responsibilities at Pikitup?

.....

SECTION B

PERCEPTIONS ON SOLID WASTE MANAGEMENT

Date of issue	D	D	M	M	Y	Y	Starting time	Finishing time

1. Which central authority is responsible for collecting waste in Diepsloot?

.....

2. How often is waste collected in Diepsloot? Please state any challenges if there are any?

.....

3. Would you consider Diepsloot to be a clean and habitable place? Explain your answer.

.....

4. Have there been any disease outbreaks in Diepsloot? What do you think were the causes?

.....

5. Do you think residents in Diepsloot are using the environment safely? Why do you say so?

.....

.

6. Apart from door to door waste collection, what other waste management programs does Pikitup run in Diepsloot?

.....

7. Diepsloot is known to be overpopulated. Does this affect your organisation's waste management initiatives?

.....

8. Why are there inequalities in waste collection services between well up suburbs and informal settlements in Johannesburg?

.....

Appendix 3: Questionnaire for NGOs

1. Indicate your gender (x):

Male	
Female	
Other	

2. Select your age group (x)

No	Age Range	Indicate
1	18-25	
2	26-30	
3	31-35	
4	36-40	
5	41-45	

6	46-54	
7	55 and above	

3. How long have you worked for your organisation and what does your organisation specialise in?

…….....

4. How long has your organisation been involved in Diepsloot?

…….....

5. Do you know what solid waste management is? If so, how do you characterise it?

.....

6. How would you characterise your relationship with the residents of Diepsloot relating to the environmental and human health work you do?

.....

SECTION B

PERCEPTIONS ON SOLID WASTE MANAGEMENT

Date of issue	D	D	M	M	Y	Y	Starting time	Finishing time

1. Is there solid waste management crisis in Diepsloot? If so explain the causes.

.....

2. Who is responsible for waste management in Diepsloot and to what extent?

.....

3. Are the residents of Diepsloot supplied with bags to store solid waste? If so, does this include community members living in shacks?

.....
.

4. What community or environmental programs have you done in Diepsloot in the past and have they been successful?

.....

5. Throughout the duration of your work in Diepsloot, what has been the impact of waste mismanagement on human health?

.....

6. Throughout the duration of your community work in Diepsloot, what has been the impact of waste mismanagement on the environment?

.....

7. What can be done to curb the solid waste management problem in Diepsloot?

.....

8. Diepsloot is known to be overpopulated. Do you think the problem of waste management in Diepsloot is population related? If so please explain how.

.....

Appendix 4: Consent Form NGOs& Pikitup

Consent Form in order to participate in a telephone interview with NGO officials

Title of research project: Sustainable solid waste management in South Africa: A study of the people's perceptions on the impact of solid waste management on human health and the environment in the informal settlement of Diepsloot, Johannesburg.

I consent to take part in this research project. The research project has been fully explained to me and I have fully grasped what my involvement entails.

My participation will strictly be anonymous YES NO (tick)

The researcher may use some quotes anonymously in his dissertation YES NO

The researcher is granted permission to audio record the interview YES NO

Date……..

Appendix 5: Participant Information Sheet NGOs & Pikitup

PROJECT TITLE

Sustainable solid waste management in South Africa: A study of the people's perceptions on the impact of solid waste management on human health and the environment in the informal settlement of Diepsloot, Johannesburg.

Good day

My name is Ngonidzashe Mangoro. I am a Masters student in Geography at the University of the Witwatersrand in Johannesburg. As part of the requirements for the degree of Master of Geography, I am required to undertake a research project. In this case, I am investigating people's perceptions on the impact of solid waste management on human health and the environment. I have chosen the informal settlement of Diepsloot to be my case study area.

In order to acquire the data required for this research project, I would like to invite you to be a participant in a "telephone interview" regarding solid waste management in Diepsloot**.** In line with the objectives of this research, I would like to ask you about solid waste management processes at informal settlements in Johannesburg, particularly Diepsloot. The interview will be conducted in English and the process will take approximately 30 minutes. I would like to verbally request for your permission participate as well as to audio record this interview. Your participation in the telephone interview will strictly be anonymous. Your name or any other details that can be used to identify you will not be requested for and will therefore not be mentioned in my research. The Human Resources Department or the Reception has referred me to you by way of call forwarding and your name was not requested for. This is meant to guarantee your anonymity. The recorded voice call file will be kept in a password protected cell phone while a copy will be stored in a password protected cloud. This is for purposes of confidentiality. Should you have any questions regarding this research project you are welcome to enquire.

Participation in this research will not result in any material gain and the information you provide will be used only for the purposes of academic research. If you become uncomfortable participating in the research somewhere along the process, you can decline to answer any question without any repercussions. The responses you provide are going to be used to write up a Masters dissertation which will be published online.

Research participants are encouraged to contact the Wits University Human Research Ethics Committee (non-medical) should they have any concerns regarding ethical procedures of research done under the auspices of the University. The Committee can be contacted on the following telephone number: + 27(0)11 717 1408 or email, Shaun.Schoeman@wits.ac.za.

Yours sincerely,

Ngonidzashe Mangoro

Email: mangoro77@gmail.com Cell number +2783 398 3594

Supervisor:

Dr. Nzalalemba Serge, Kubanza email: serge.kubanza@wits.ac.za

Appendix 6: Participant Information Sheet Diepsloot Residents

PROJECT TITLE

Sustainable solid waste management in South Africa: A study of the people's perceptions on the impact of solid waste management on human health and the environment in the informal settlement of Diepsloot, Johannesburg.

Good day

My name is Ngonidzashe Mangoro. I am a Masters student in Geography at the University of the Witwatersrand in Johannesburg. As part of the requirements for the degree of Master of Geography, I am required to undertake a research project. In this case, I am investigating people's perceptions on the impact of solid waste management on human health and the environment. I have chosen the informal settlement of Diepsloot to be my case study area.

In order to acquire the data required for this research project, I would like to invite you to be a participant to complete the attached research questionnaire. It regards the impact of solid waste on human health and the environment in Diepsloot. For our own safety during the Covid19 pandemic, we shall both be wearing latex gloves which i shall provide. This is done to protect us from possible contraction of the Covid19 disease. These should be disposed of immediately after completing the questionnaire. The researcher will also provide you with a pen/ pencil to be used. This will be disinfected with a 70% alcohol based hand sanitizer in your presence. This is done to protect us from possible contraction of the Covid19 disease. While you are in the process of completing the questionnaire, the researcher will socially distance himself 2 meters away from you to avoid possible transmission of the corona virus.

In line with the objectives of this research, I would like to ask you about your experiences and perceptions on the effect of solid waste on human health and the environment in Diepsloot. The process of filling up the questionnaire takes approximately 15 minutes and the questions should be answered in English. If you are not comfortable with English, a questionnaire in IsiZulu will be provided for you. Should you have any questions regarding this research project you are welcome to enquire.

Participation in this research will not result in any material gain and the information you provide will be used only for the purposes of academic research. If you become uncomfortable participating in the research somewhere along the process, you can decline to answer any question without any repercussions. The responses you provide are going to be used to write up a Masters dissertation which will be published online.

Research participants are encouraged to contact the Wits University Human Research Ethics Committee (non-medical) should they have any concerns regarding ethical procedures of research done under the auspices of the University. The Committee can be contacted on the following telephone number: + 27(0)11 717 1408 or email, Shaun.Schoeman@wits.ac.za.

Yours sincerely,

Ngonidzashe Mangoro

Email: mangoro77@gmail.com Cell number +2783 398 3594

Supervisor:

Dr. Nzalalemba Serge, Kubanza email: serge.kubanza@wits.ac.za

Appendix 7: Ethics Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Mangoro

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H20/05/19**
PROJECT TITLE	Sustainable solid waste management in South Africa: A study of the people's perceptions on the impact of solid waste management on human health and the environment in the informal settlement of Diepsloot, Johannesburg
INVESTIGATOR(S)	Mr N Mangoro
SCHOOL/DEPARTMENT	Geography, Archaeology and Environmental Sciences/
DATE CONSIDERED	22 May 2020
DECISION OF THE COMMITTEE	Approved Risk level: Low
EXPIRY DATE	16 June 2023

DATE 17 June 2020 **CHAIRPERSON** _____
(Professor J Knight)

cc: Supervisor : Dr N Serge Kubanza

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

_____ _____/_____/_____
Signature **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES