AN ASSESSMENT OF THE POSSIBLE INTRODUCTION OF RAIN WATER HARVESTING TO BUILD RESILIENCE IN MARIKANA INFORMAL SETTLEMENT IN EKURHULENI MUNICIPALITY, SOUTH AFRICA

By

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DECLARATION

I, **Beauty Moyo**, declare that the thesis that I herewith submit for the master degree; **Master of Disaster Management** at the University of the Free State is my independent work, and that except for references cited, which have been duly acknowledged, this thesis is the result of my own research. It has never been presented anywhere either in part or whole for the award of any qualification at another institution of higher education.

…… 28/06/2019

Beauty Moyo Date

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DEDICATION

I dedicate this achievement to my late mother, Peggy Moyo, who laid the first foundation stone for my education and my late sister Rhoda Seleke, who would have been very proud of my achievement.

My late nephew, George will always be remembered.

May their precious souls rest in eternal peace in the Lord's Heavenly Kingdom!

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ABSTRACT

Academics have predicted that by 2030 South Africa, a sub-Saharan developing country will be impacted by severe water shortages which will be fuelled by increasing effects of climate change, exploding population growth and growing economic sectors. In order to avert this crisis, South Africa needs to stand together with all relevant stakeholders to find suitable and sustainable water management practices, such as rainwater harvesting to cushion the effects of hydrological hazards while building resilience within the local community livelihoods. Domestic rainwater harvesting has not been embraced in urban informal settlements as compared to the rural areas where in certain instances it acts as the primary source of water. This research study was conducted to establish the possibility of introducing rain water harvesting and whether it is feasible in urban informal settlements, particularly in Marikana informal settlement in the City of Ekurhuleni Metropolitan Municipality. This study highlighted the link between ecosystems, human well-being and rainwater harvesting taking into cognisance the possible challenges and benefits that could accompany its adoption.

Keywords: rainwater harvesting, domestic, informal settlement, resilience, livelihood, climate change

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LIST OF ABBREVIATIONS AND ACRONYMS

ANC: African National Congress
CC: Climate Change
CERT: Community Emergency Response Team
CoE: City of Ekurhuleni
COGTA: Cooperative Governance and Traditional Affairs
DFID: Department for International Development
DiMTEC: Department of Disaster Management Training and Education Centre for Africa
DRR: Disaster Risk Reduction
DRWH: Domestic Rain Water Harvesting
EbA: Ecosystem based Adaptation
EFF: Economic Freedom Fighters
EIA: Environmental Impact Assessment
EMM: Ekurhuleni Metropolitan Municipality
FAO: Food and Agriculture Organisation
GDP: Gross Domestic Product
HDI: Human Development Indexes
HFA: Hyogo Framework for Action 2005-2015
IUCN: International Union for the Conservation of Nature
KPA: Key Performance Area
MDGs: Millennium Development Goals
NDMF: The South African National Disaster Management Framework
RDP: Reconstruction Development Program
RWH: Rain Water Harvesting
SLF: Sustainable Livelihood Framework
SPSS: Statistical Package for the Social Sciences
UFS: University of the Free State
UN: United Nations
UNDP: United Nations Development Programme
UNEP: United Nations Environmental Programme
UNISDR: United Nations International Strategy for Disaster Reduction

DEFINITION OF TERMS

Climate Change

The Disaster Management Act as amended (RSA, 2002:8) defines Climate Change as a change in the state of the climate that can be identified by changes in the variability of its properties and that persists for an extended period, typically decades or longer.

Disaster

The Disaster Management Act (RSA, 2002:5) defines a disaster as;

A progressive or sudden, widespread or localised, natural or human-caused occurrence which-

(a) causes or threatens to cause-
    (i) death, injury or disease;
    (ii) damage to property, infrastructure or the environment; or
    (iii) disruption of the life of a community; and
(b) is of a magnitude that exceeds the ability of those affected by the disaster to cope with its effects using only their own resources;

Disaster Management

The Disaster Management Act (RSA, 2002:5) defines a disaster management as

…a continuous and integrated multi-sectoral, multi-disciplinary process of planning and implementation of measures aimed at-

(a) preventing or reducing the risk of disasters;
(b) mitigating the severity of consequences of disasters;
(c) emergency preparedness;
(d) a rapid and effective response to disasters; and
(e) post-disaster recovery and rehabilitation.

Hazard

A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR, 2004).

Informal settlement

Residential areas where a group of housing units has been constructed on land to which the occupants have no legal claim, or which they occupy illegally; unplanned settlements and areas where housing is not in compliance with current planning and building regulations (UN-HABITAT, 2015).

Livelihood

The means for securing the necessities of life so that individuals, households and communities can sustain a living over time, using a combination of social, economic, cultural and environmental resources (UNDP, 2007).

Rainwater harvesting

Rainwater harvesting is a technique consisting of a wide range of technologies used to collect, store and provide water with the particular aim of meeting demand for water by humans and /or human activities (UNEP, 2009).

Resilience

The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organising itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures (UNISDR, 2004).

Chapter 1: OVERVIEW OF THE STUDY

1.1 Introduction

Water is a precious natural resource and access to water is one of the minimum standards required in humanitarian terms to support life (Sphere Project, 2011). The primary source of water in both rural and urban areas is rainfall. The amount of water available is therefore, directly proportional to the amount of rainfall received within a particular period of time (Dobson, 2017). The world is currently facing severe water shortages due to issues which include those of growing population and climate change. While African cities are known for their innovation and opportunities, pressures of climate change, economic crises, disease and epidemics, shortages of resources and political instabilities are mounting up, and besetting residents of these geographical areas (UN-HABITAT, 2013). All the above elements may have severe consequences on people and the environment. The Republic of South Africa is not exempted from such effects which have caused serious concern with regard to water issues. The issue of climate change has brought about effects and challenges which include sea level rise, increase in temperatures and the major one being the changes in rainfall patterns, with short periods of good rainfall in the rainy season and severe droughts in the dry season (UNEP, 2009).

The changes in precipitation patterns result in either excessive or insufficient rainfall amounts; both of which can be catastrophic to human beings and the ecosystem (UN-HABITAT, 2013). Decreasing rainfall amounts have caused severe shortages of the water resource so much so that some countries are prepared to go to war because of the shortage of water. Despite the water challenges caused by natural effects such as those of climate change, the problem of water scarcity is further compounded by socio-economic factors which are forever increasing the demand for water. Zheng, Gao, Xie, Jin & Zhang (2018) list some of the socio-economic contributors as; population explosion, irrigation demands and changing patterns of water use. According to Handia, Tembo & Mwiindwa (2003) other factors that lead to the lack of safe water supply to the majority of city dwellers include - lack of financial resources to increase the water supply system, rural to urban migration and lack of government's service delivery to communities. Despite the dying need for the water resource, during rainy season, most of the rainy water is lost through the surface runoff more especially in urban areas where there is development (UNEP, 2009). It is due to the reasons stated above, that alternative sources of water supply such as

rainwater harvesting are needed to intervene towards the issues of climate change and socio-economic factors. The varying amounts of rainfall and changes in the rainfall patterns have brought about challenges to both human beings and the environment in which they live. The effects of such issues are well known for derailing the efforts of poverty reduction, food security and water security (Hammill, Leclerc, Hirvonen & Salinas, 2005). The adoption of sustainable strategies such as rainwater harvesting technologies can overcome water shortages. Such strategies have the potential to create synergy between good ecosystems management and human well-being.

Rainwater harvesting involves the collection and management of rainwater run-offs to supplement water availability for purposes of agricultural and domestic use as well as the ecosystem maintenance (Zheng, Gao, Xie, Jin & Zhang, 2018). Some of the benefits that can be brought about by harvesting rainwater include, reduced disaster risks and promotion of adaption to the impacts of climate change. Rainwater harvesting could be used as a Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) tool to build resilience and to sustain livelihoods of informal settlements including that of Marikana community. This study explores the possibilities of rainwater harvesting to build resilience to the residents of Marikana informal settlement, in the City of Ekurhuleni.

The back ground of the study area will be discussed next.

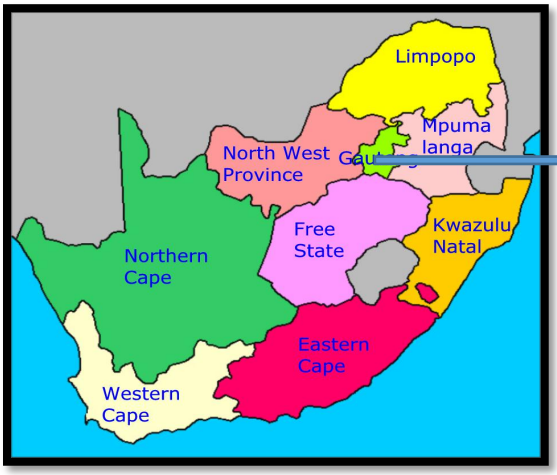
1.2 Background of the study area

The study area is described under different relevant subheadings below:

1.2.1 Location

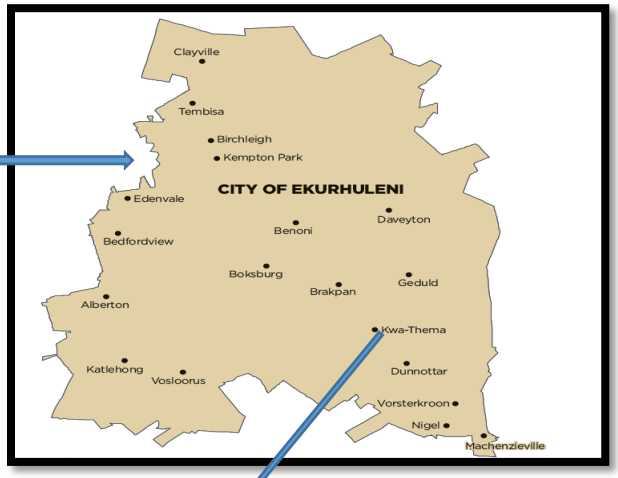
The study was conducted in Gauteng Province which is divided into three metropolitan municipalities, the City of Ekurhuleni (CoE), City of Johannesburg and City of Tshwane. Ekurhuleni is a Tsonga word which means a place of peace and prosperity (Ekurhuleni voice, 2013). The City of Ekurhuleni (CoE) covers an area of about 1 975km² stretching from Germiston which is its administrative capital to Springs and Nigel in the east. Its towns include Alberton, Bedfordview, Benoni, Boksburg, Brakpan, Edenvale, Germiston, Kempton Park, Nigel and Springs. All these towns contain townships and informal settlements; under Springs town, there is a township called Kwathema (Coordinates: 26°17´51"S 28°24´9"E) where Marikana informal settlement is found; this place is the focus area of this study. Marikana informal settlement was established in an area which was formally a cemetery (Nombeni, 2013). In 1993, the local

government of Ekurhuleni formally known as "*Greater Springs*" closed down the cemetery stating that the area was a wetland, hence, the graves including those with tombstones were being flooding with water and sinking. It was after the closure of the cemetery that the community members without consulting with the government decided to build shacks in this area. The local government and the Department of Housing called for help from the "red ants" to forcefully remove the community members who had unlawfully built their shacks in this unsafe area, but the community members retaliated and fought back; from then onwards, this area has been called 'Marikana' (Ekurhuleni Environmental Organisation, 2013). The name Marikana is associated with a town in North West Province where approximately 34 miners protesting over salary increments died in an encounter with the South African police (Aljazeera news, 2013).



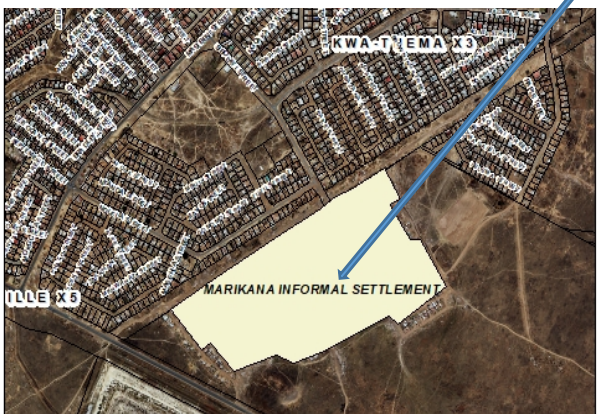
Source: **www.googlemaps**.com

Figure 1.1: Map of South African provinces



Source: Ekurhuleni Voice (2013)

Figure 1.2: Map of Ekurhuleni and its towns



Source: Ekurhuleni Voice (2013)

Figure 1.3: Aerial map of Marikana in Ekurhuleni

1.2.2 Climate and general weather conditions

South Africa has a predominantly subtropical climate with high-pressure systems. She experiences extreme variability in weather and climate which tend to pose challenges for weather predictions and seasonal forecasting (Gauteng-info, 2016). Gauteng climate offers one of the best climates where summer days are warm and windy and winter days are crisp and clear. Rainfall generally occurs during summer months from November to March, with hail being common during the summer thunderstorms and with an average annual precipitation of 703 millimeters (mm) (Gauteng-info, 2016). Gauteng's average temperatures is approximately 17°C (Gauteng-info, 2016).

1.2.3 Economy

The economy in Ekurhuleni is well established and diverse and accounts for almost a quarter of Gauteng's economy which contributes over a third of the national Gross Domestic Product (GDP). The good network of roads, airports, rail lines, telephone systems and electricity grids has enabled Ekurhuleni to rival with cities in Europe and America. Many of Gauteng's factories for production of goods and other commodities are located in CoE, often referred to as "Africa's Workshop". The City of Ekurhuleni is also home to Africa's biggest and busiest airport, OR Tambo International Airport (Gauteng-info, 2016).

1.2.4 Social and political setup

This area is home to people of different tribes, different cultures and some foreign nationals; most of these people are either migrants or immigrants who came to the City Of Ekurhuleni in search of jobs and better ways of living (Ekurhuleni voice, 2013). The majority of the population being migrants in the area, means that they lack strong family support systems so they greatly depend on social groups known as 'societies' for a sense of belonging. The Marikana, settlement is considered low class and mainly associated with poverty. The area is dominated by members affiliated to the ruling party, the African National Congress (ANC), seconded by the opposition party, Economic Freedom Fighters (EFF).

1.3 Problem statement

Leedy & Ormrod (2015) state that the research problem or question is the axis around which the whole research effort evolves and that it clarifies the goals of the research project. However, in this chapter, the researcher separates the research problem from the research questions for simplification and easy understanding for both the researcher and the reader. The City of Ekurhuleni is one of the most densely-populated areas in Gauteng Province, which results in competition for limited resources such as water and land (Ekurhuleni

voice, 2013). Gleick (1994) indicates that conflicts among nations are caused by many factors such as religious differences, ideological disputes, arguments over borders, economic competition and conflicts for natural resources such as fresh water; all of these play an increasing role in international as well as local disputes. Water has become the main reason for strategic rivalry among communities and countries due to its scarcity. The former United Nations Secretary General Kofi Annan was quoted as saying "*The next war in our region will be over the waters of the Nile, not politics.*"

Marikana informal settlement has no fresh water systems, residents walk for long distances to get their water from the neighbouring Reconstruction Development Programme (RDP) houses where there are communal taps. Nombeni (2013) indicates that the communal taps in the surrounding areas of Marikana are very few and are usually congested with people who fetch water from them. Marikana informal settlement is situated in a wetland area so it is prone to flooding which can have negative consequences on the livelihood of the community. There are no drainage and sewerage systems in this community. Members of this community use mobile communal bucket toilets to relieve themselves while young children relieve themselves within the yards and using 'flying toilets'. It is for these reasons that serve as motivation of this study, which aims to investigate how rainwater harvesting can lessen the water burden, build resilience and help sustain the livelihoods of the people of Marikana community (Nombeni, 2013).

1.4 Research questions

Research is an intensive activity that is based partially on the work of others and which generates new ideas to pursue and questions to answer (Salkind, 2014). Research questions are usually designed to address the identified problems in the study area. The following are the research questions directing this study:

- Do the residents of Marikana know about rainwater harvesting?
- Do they have the necessary resources to practice rainwater harvesting?
- How will rainwater harvesting benefit the Marikana community?

The answers to the above research questions will guide the possibility of adopting the technique of harvesting rainwater within the study area.

1.5 Research aim and objectives

The aim of the study was to explore the possibility of introducing rainwater harvesting in Marikana community in order to build resilience and to cushion the harsh effects of hydrological hazards on the local people and the environment.

A research objectives describe what one expects to achieve in a research project and therefore, they can be referred to as the 'building blocks' of the study (Wanjohi, 2014). According to Wanjohi (2014) the importance of research objectives lies in the fact that they determine: the kind of questions to be asked in a study, the data collection and analysis procedure to be used and the design of the investigation. The research objectives of this study are divided into primary and secondary objectives.

1.5.1 Primary objective

The primary objective of this study is to assess the possible introduction of rainwater harvesting in Marikana informal settlement in Ekurhuleni to build residents' resilience.

1.5.2 Secondary objectives

- To explore the concept of rainwater harvesting in Marikana urban informal settlement
- To investigate the benefits of rainwater harvesting in order to build resilience in the community of Marikana
- To identify the challenges that may be faced by rainwater harvesting in Marikana informal settlement.

1.6 Rational of the study

There is no previous documented research relating to rainwater harvesting that has been conducted in the study area. There is also a lack of awareness with regard to rainwater harvesting within the local community, therefore, the researcher was motivated to conduct this study. This study will be the first of its kind in this area. It is believed that this assessment if successful, will help the community to have access to readily available water which can be used to perform household chores and to help remedy the scarce water resource situation so as to build resilience within this community of Marikana.

1.7 Theoretical framework

A theoretical framework is a structure of concepts which exists in literature as a guiding map for the study (Wanjohi, 2014). It is important to have a theoretical framework because it provides direction for the researcher as it assists study questions to be fine-tuned and can be used as a

base of comparison once data have been collected and analysed (Wanjohi, 2014). This study could not find one single suitable framework therefore, it adopted various theoretical frameworks which aligned with disaster management in the context of disaster risk reduction and building resilience for sustainable livelihoods. The main theoretical frameworks adopted in this study are the Sustainable Livelihood Framework (SLF), the Sendai Framework for Disaster Risk Reduction, the Climate Change Framework and the South African National Disaster Management Framework (NDMF).

1.8 Research design and methodology

Research design and methodology is covered extensively in chapter four of this study under material and methods used in the study, therefore, it will not be discussed here to avoid repetition.

1.9 Chapter outline

The whole research project of this study is organized into six chapters. The outline of each chapter is as follows - chapter one, which is the introductory chapter, discusses the background of the study area, highlights the problem statement of the study and outlines the research problem, research questions and research objectives of the study. Chapter two explores the legal and institutional arrangements and theoretical frameworks that apply to rainwater harvesting, from the adopted internationally and in South Africa with the aim of building a legal and theoretical foundation for the study. The third chapter, the literature review, critically focuses on a review of secondary information from both published and unpublished sources to link the technique of rain water harvesting to disaster management, climate change adaptation in order to build resilience in the local community. Chapter four on methodology, describes in detail the material and method that were used in conducting the research. Chapter five, data analysis and presentation of results discusses the results from the primary data that were collected from the respondents supplemented by field observations by the researcher. Finally, chapter six, conclusions and recommendations, provides the conclusion of the entire study and outlines possible recommendation in line with the research objectives stated in chapter one of the study.

1.10 Chapter summary

The first chapter of this study is the introduction for the entire research project and provided the general overview of the study. This chapter covered the background and rationale of the study, the research problem, research questions and the research objectives. The theoretical frame of the study was also looked at. The theoretical framework and the legal and institutional arrangements significant to this study will be discussed in detail in the following chapter of this study.

Chapter 2: FRAMEWORKS

2.1 Introduction

This study identifies rainwater harvesting as a possible mitigation and adaptation measure towards water issues in flood and drought situations. Rainwater harvesting technique is a livelihood approach that can be used to tackle habitat problems and has the potential to contribute towards better and effective developmental cities. Rain-water harvesting as a strategy, needs to be exhibited in a suitable framework so as to demonstrate of the overview picture of the entire situation. The framework would then depict possible hazards, household assets, strategies to mitigate possible hazards and the possible outcomes expected after the implementation of these strategies. This chapter is divided into two sections - the first section examines the theoretical frameworks that can be adopted in implementing rainwater harvesting in informal communities and the second section looks at the legislative frameworks related to rainwater harvesting.

A framework is described by Adom, Hussein & Agyem (2018) as a map based on an existing theory, in a field of inquiry that is related and or reflects the hypothesis of a study and it mostly serves as the foundation upon which a research is built. UNDP (2018) refers to a framework as a tool to enhance understanding of the environment in which people reside and the potential hazards likely to be experienced within that particular community. It is, therefore, deemed important that this study adopts frameworks which will act as guidelines, in terms of potential hazards, institutional arrangements, resources, strategies and outcomes, as well as incorporating points from theories and findings from similar studies.

The main theoretical frameworks adopted in this study are the Sustainable Livelihood Framework (SLF), the Sendai Framework for Disaster Risk Reduction, the Climate Change Framework and the South African National Disaster Management Framework (NDMF). These frameworks form part of disaster management, in the context of disaster and risk reduction as well as building resilience for sustainable livelihoods. No specific existing framework was found to directly link with this study, however, the Sustainable Livelihood Framework is preferred, as it explains more explicitly, the vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies and outcomes, as compared to the other frameworks. The other theoretical frameworks, therefore, will be briefly discussed to complement the Sustainable Livelihoods Framework in order to comprehensively, cover the background content of this research.

The legislative frameworks related to rainwater harvesting in South Africa discussed under this chapter will include the South African Constitution, no. 108 of 1996, South African National Disaster Management Act (DMA), Act 57 of 2002, National Water Act (NWA) Act no. 36 of 1998 and the Water Services Act (WSA), Act 108 of 1997. It is more than two decades since these water-related Acts were promulgated in South Africa, yet, South Africa still does not have a specific Act or national policy on rainwater harvesting.

The possibility of introducing rainwater harvesting in informal settlements where there are no tap water, could be a possible strategy in the Marikana community; this could then be the main source of the critical water resource to supply the households. Households engage in such strategies in order to maximize their safety against water-related hazards, reduce vulnerability to disasters and risks as well as to improve the supply of water within their community. The harvested rain water could then contribute to building a resilient community and promoting a sustainable livelihood within such a community. Other issues addressed in this section include the concept, definitions and applications of livelihoods to guide this study. Theoretical frameworks will be discussed next.

2.2 Theoretical frameworks

2.2.1 Sustainable Livelihood Framework (SLF)

The Sustainable Livelihood Framework is described by Krantz (2001) as a model that provides an analytical structure to facilitate a broad and systematic understanding of the various factors that constrain or enhance livelihood opportunities and how they relate to each other. The idea of sustainable development was introduced by the Brundtland Commission on Environment and Development to link the socio-economic and ecological aspects into a cohesive structure (Krantz, 2001). During the 1992 United Nations Conference on Environment and Development (UNCED), in its Agenda 21, the idea of sustainable development was elaborated and advocated for; the Agenda's achievement was envisaged as addressing mainly poverty and resource-related lacks within poor communities (Krantz (2001). Poverty eradication was anticipated through the integration of policies to address sustainable resource management and development (Krantz, 2001). DFID (1999) describes the livelihood framework as a tool to improve the understanding of livelihoods, especially, among the poor people. The framework can also be used in the development of activities that can contribute to improving the livelihoods of those who are vulnerable. This study will focus on how the application of the Sustainable Livelihoods Framework in water-scarce informal settlements may eradicate poverty through the idea of harvesting

rainwater; rainwater is a cross-cutting critical resource for human consumption as well as for environmental, economic and social sustainability. The term 'livelihood' has attracted different definitions from many scholars, however, for the purpose of this study, the DFID definition will be adopted. DFID (2000) defines a livelihood as:

"A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (DFID, 2000).

'Sustainability' according to DFID (2000) refers to the ability to avoid or withstand a devastating event/shock and where the shock cannot be avoided, sustainability enables one to recover from the said stressful event/shock. The sustainable livelihood framework has components of the vulnerability assessment framework but its key elements are the five livelihood assets, also known as 'the capitals' (UNDP, 2017). The other elements of this framework include - transforming structures and processes, livelihood strategies and livelihood outcomes. The latter framework is a people-centered analytical framework which investigates people's objectives, assets and strategies that can be adopted to achieve the set goals (DFID, 2000). Theoretical frameworks act as building blocks towards a strategy that one may want to implement to mitigate the effects of a hazard. Hammill *et al.,* (2005) point out that the sustainable livelihood concept aims at poverty reduction, food security and water security which are dependent on the capability of the people to withstand a disastrous event. The individual components of the Sustainable Livelihoods Frameworks will be discussed in their relevant sections.

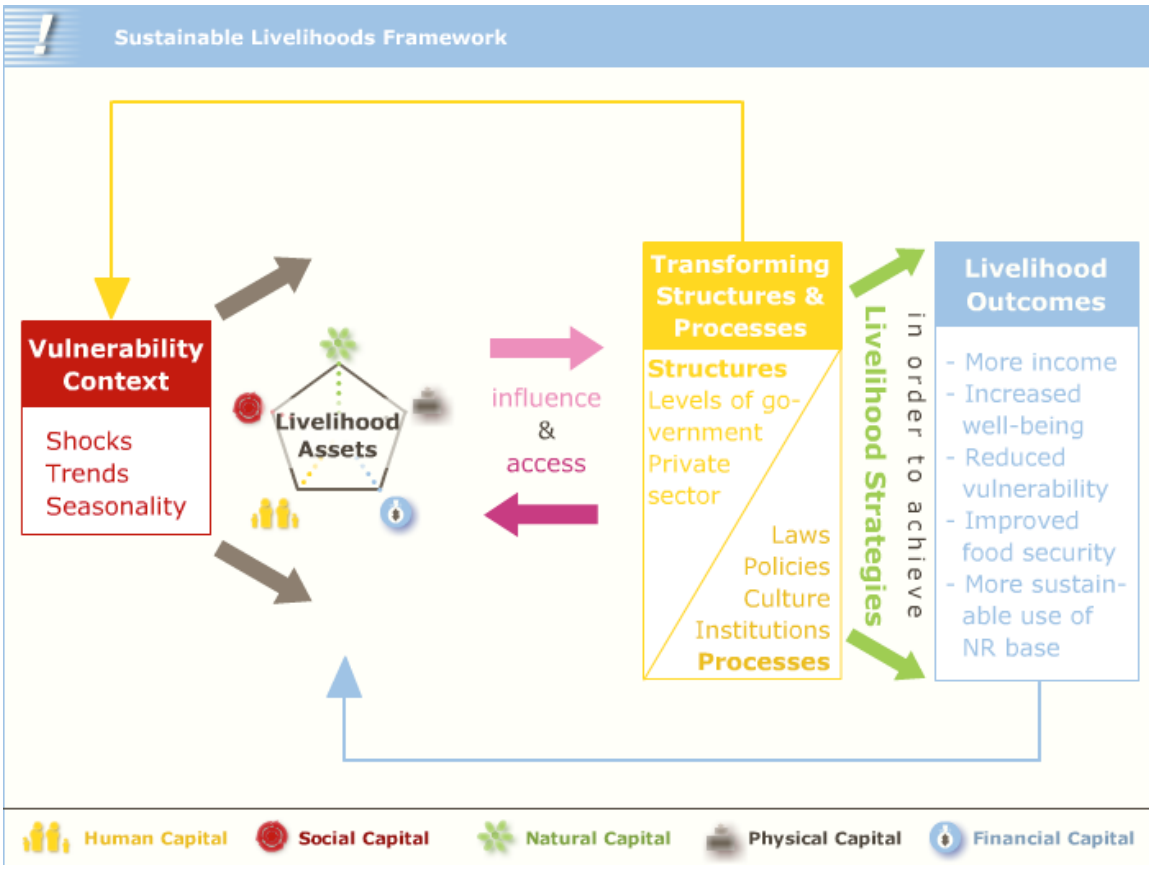


Figure 2.1: Sustainable Livelihoods Framework. Source: (DFID, 2000)

2.2.1.1 Vulnerability context

The vulnerability context depicts the external environment in which people exist and the external forces which affect people's assets and their livelihoods, and over which, the people have limited or no control (DFID, 1999). The vulnerability context comprises of shocks, trends and seasonality factors as depicted in Figure 2.1 above. UNISDR (2009) refers to vulnerability as a condition that is influenced by social, physical, environmental and economic elements, and which increase the susceptibility of a community to the effects of an extreme event; Wisner, Blaikie, Cannon & Davis (2003) expound vulnerability as the inability of an individual or group of people to cope with, resist and recover from the shock of a natural hazard. The impact of the shock indicates the degree to which a livelihood, property and other assets are exposed to the risk.

The vulnerability context is anchored on the notion that people reside in an environment susceptible to shocks and stressors which may negatively influence their assets and livelihoods. Marikana is situated in an area that is prone to shocks like, flash floods, fires and drought. Shocks can be referred to as stresses when they are continuous in occurrence. Stresses are described

by Krantz (2001) as perpetual accumulated pressures which can be at time-predictable and may include factors, such as seasonal shortages of resources and rising populations. Shocks are effects resulting from sudden and unpredictable extreme events, such as fires, floods, epidemics; seasonalities refer to elements like, prices of commodities and employment opportunities, while critical trends comprise of environmental, economic, technological and demographic trends.

The stressors and shocks defined above are events that, for example, the people of Marikana, can anticipate could result in disasters. This community may be exposed to flood risk during the rainy season because of lack of drainage systems, therefore, this may make the place vulnerable to flash floods. Marikana is also susceptible to drought conditions in the dry season when there is insufficient or no rain. In order for the people to deal with such external forces within their vulnerable context, they may need to develop or adapt to strategies which may help them to become more resilient and thus, self-sufficient. Rainwater harvesting, therefore, may help eliminate or reduce the impact should extreme events of drought and floods occur. This study will mainly focus on rainwater harvesting as a strategy to prepare for drought situations.

Drought conditions pose a risk of the community experiencing food and water shortages as secondary effects because most community members depend mostly on their small businesses of car washes, salons and small backyard gardens which need water for their survival. Water scarcity also exposes the community to diseases because hygiene is compromised when there is water shortage. In dry spells when the availability of water is critical, collected rainwater could, thus, be the only source of water for this informal settlement.

Marikana is also at high risk of fires, especially, shack fires which are fueled by the highly combustible materials used to build these structures. Murambadoro (2009) explains that the sustainable livelihood focuses on the risk of shocks and stressors and their impact on households and how they can cope with these risks, on both short and long-term bases because if no survival strategies are in place, the hazards can result in disasters. These happenings, according to Oxfam (2016) rob millions of people of their livelihoods, intensifies vulnerabilities, while pushing the affected communities into deeper poverty.

Seasonality may be seen either positively or negatively; for example, while water shortages can negatively influence food prices to soar, on the other hand, people may opt to capture the minimum rain water received. This can be an employment opportunity for plumbers and water-storage tank installers to earn an income, to support their households. It is possible to notice trends in the likelihoods of communities, hence, there are incidents of poverty and high rates of

unemployment which usually make it difficult for the residents to cope and then they bounce back after the extreme event had come to an end. For example, poor households in such areas cannot afford to purchase water storage tanks in anticipation of a drought season, causing them stress when there is no rain.

The vulnerability context can be managed through investing in positive projects which can help residents to become more resilient. The vulnerability context affects different people in different ways with the poor and the girl children being the most negatively affected. In tough times, households may prefer using their last money to educate boy children rather than the girl children (DFID, 2000). Rainwater harvesting has the potential to minimize the effects of drought, floods and fires on people and the ecosystem. Arrows in the Sustainable Livelihood Framework (Figure 2.1) represent direct links to the various components and indicate the influence of one component on the other, within the framework.

2.2.1.2 Livelihood Assets/Resources

Livelihood assets include a range of assets and activities required for living. Livelihood assets, according to Twigg (2004), describe people's strengths or capacities which can be destroyed as a result of the trends, shocks and seasonality of the vulnerability context. At the center of the framework are assets on which households or individuals rely to build their livelihoods. Assets in a livelihood include tangible assets, such as land, water, trees and equipment; intangible assets may include, claims and access assets. It is important to note that, although, a single physical asset, for example money, can generate multiple benefits, no single asset is, on its own, sufficient to yield all the many varied livelihood outcomes needed for people to survive; land, for example, without water is useless for agriculture or gardening. In an impoverished community, like Marikana informal settlement, assets like water are not available and those assets that are available, such as land, are of poor quality; for example, the land is situated in an area which is susceptible to sinkholes and floods.

Lack of resources, such as water, produces a degree of poverty within different households depending on their levels of capital investment, which can either increase or decrease the outcomes of livelihoods. Assets in the Sustainable Livelihood context are sometimes referred to as 'capitals' and are graphically depicted in the Sustainable Livelihood Framework (Figure 2.1) in a pentagon shape.

The amount of assets people possess determine the sustainability of their livelihood; the more assets the people possess, the stronger their resilience to external forces and the lower the assets, the more vulnerable the affected people are to risks. It is the different assets that people endeavor to convert into positive livelihood outcomes (DFID, 2000). Assets consist not only of the physical and natural resources but the social capital as well. The five capitals of the Sustainable Livelihood Framework include: human, natural, financial, social and physical capitals (Twigg, 2004). The capitals, like the factors of the vulnerability context, have an influence on the structures and processes of the framework and in turn, the structures and processes influence the capitals. Politicians and officials usually have to be lobbied to make improvements to services but the poor tend to have the least political influence thus politicians tend to ignore them prioritize services to their rich counterparts (Twigg, 2004). Below is a brief description of each of the capitals that can help a community to sustain its livelihood.

Human capital - Human capital consists of all the knowledge, skills, good health, physical capability, ability to labor and to find information, to cope, adapt, organize and innovate (Krantz, 2001; Satge, Holloway, Mullins, Nchabaleng & Ward, 2002; UNDP, 2017).

Natural capital – UNDP (2017) refers to natural resources as stocks of naturally occurring resources which cannot be made by human beings but can be used by them as inputs to produce essential goods with additional benefits in order to support livelihoods; examples of natural resources are air, water, trees, oil, wind energy and natural gas. Natural resources are the 'engines' for human life. Everything that a human being has and manufactures originate from the natural resources, yet, most human-induced shocks that devastate the livelihoods of the poor destroy the natural capital (DFID, 2000). The most important of them all is water; the very resource that the community of Marikana does not possess. The idea of successfully implementing rainwater harvesting should, hence, not be compromised, as it might be the primary source of water and, therefore, has the potential to bring about dignity and some kind of resource-ownership among the people of this community. Rainwater harvesting, thus, can help this community to have their own water supply.

Economic or financial capital – Economic capital refers to cash, credit, debt, savings and all other economic assets which can be used in pursuit of monetary gains and which populations employ to achieve their sustainable livelihoods (UNDP (2017). DFID (1999) explains financial capital as financial resources that people use to achieve their livelihood objectives. Economic systems transform the natural capitals into goods and services which are used for every day consumption to satisfy basic human needs.

Financial capital is one of the strongest of the capitals because it can be converted into other types of capital for the achievement of livelihood outcomes; for example, it can be used to purchase food to ensure food security (UNDP, 2017).

Informal settlements are poor communities, however, they are the backbone of many urban areas which thrive on informal economies based in such settlements (Desai & Dodman, 2018). Small businesses, such as car washes and hair salons depend on water for survival, yet, Marikana has no access to her own water. Such a situation makes it almost impossible for them to manage such businesses, therefore, rainwater harvesting could help this community to be self-sufficient in regard to water. Availability of water, hence, can help them to carry out their projects for income generation; this income, in the long run, can be used to provide investment resources for their future endeavors.

Social capital – Shepherd, Pitiya & Evans (2011) refer to social capital as a form of assistance that is critical to encounter the insecurity and vulnerability experienced, especially, by chronically poor people. Such assistance is what most poor people extensively depend on and it comes in the form of assistance from family, friends, ethnic groups, church, political connections, neighbors, social networks and connections, relations of trust and mutual support, informal and formal networks, burial societies and community stokvels where people either boost each other financially or in terms of other services (Ncube & Jordaan, 2017). This is usually achieved by injecting small monthly contributions which act as reserves for desperate times such as when a death strikes within the community or for festivities. Social livelihood strategies require good coordinated actions.

The networks may act as coping mechanisms that help the affected communities to bounce back to their previous livelihoods or even better situations after an extreme event. The money saved by these social clubs could even be used to buy the needed equipment for harvesting rainwater. This could be done by purchasing a few initial equipment to treat as a pilot exercise while raising more money for the rest of the members to purchase all kinds of equipment for investment. Social groups in informal communities can be very strong as they can also help to combat crime in the community.

Physical capital – Physical assets include infrastructure and producer goods that support livelihoods. These include roads, affordable transport services, sufficient water, secure shelter, tools, equipment and access to information sources such as telephones, cellular phones, radio, television and the internet (Satget *et al.,* 2002; UNDP, 2017). Physical assets are essential for

people to carry out livelihood activities, yet, this is not visible within the community of Marikana as this community lacks infrastructure items like - water reservoirs, piping, drainage systems and roads – all of which are crucial in the supply of water resource.

The livelihood approach focuses on how the physical resources can be accessed as facilitators towards achieving the livelihood objectives. Lack of physical infrastructure and resources in Marikana may hinder the implementation of projects, such as those of rainwater harvesting. The area is not easily accessible, due to, for example, no proper roads. The tiny roads available are uneven and become water-ponds in the rainy season, therefore, making it difficult for suppliers to deliver the equipment needed to implement the project of harvesting rain water. The materials used in building people's shacks also may add to the existing challenges as it could be difficult for rain water to flow over the flat roof structures, into water-harvesting containers. In other words, it would be a challenge to channel water gutters on flat roof structures mainly used in informal settlements.

2.2.1.3 Livelihood Strategies

Twigg (2004) elucidates livelihood strategies as methods that determine the ability of people and households to cope with and recover from stressors. The combination of the different types of capitals is required for a good livelihood strategy. A strategy influences people's choices and reinforces any positive aspects which mitigate the impact of stressors. UNDP (2017) indicates that livelihood strategies often vary depending on the ownership of assets, gender, income levels and social stability of households and individuals. It is these variables that define the coping capacity of a household. Coping is explained as any strategy which people put in place using their available resources based on a range of expectations they hope to achieve (Wisner *et al.,* 2003).

Livelihood strategies better known as 'adaptive strategies' can either strengthen or weaken the capitals per household (DFID, 2000). In developing countries, the poor and vulnerable use their assets for consumption, production and exchange in response to changes in what they hope to achieve (Levine, 2014). Strategies which are connected to people's objectives, usually, lead to a variety of improvements to both their economic and non-economic livelihoods. Levine (2014) gives an example of livestock indicating that livestock has many asset values; it has important cultural significance, can be exchanged for cash and it provides milk and meat for the family or the market.

2.2.1.4 Institutional Structures and Processes

Institutional structures and processes within the sustainable livelihood framework are ways of assessing how policies, institutions and cultural norms influence livelihoods within communities. Livelihood strategies are not only dependent on assets or constrained by elements of the vulnerability context, but they also depend on the process of transformation by institutional processes and structures. Structures are referred to as the 'hardware' in the framework because of their ability to make processes function, while processes are regarded as 'software' whose responsibility is to embrace laws, regulations, policies and legislation which guide structures in carrying out their duties (DFID, 2000).

Structures and processes can help enhance livelihoods if properly implemented; for example, policies that improve the access of the poor to natural assets can help improve informal settlements livelihoods. If the government could install water storage tanks in informal settlements for people to harvest rain water, the community could have access to their own portable water (Satge *et al.,* 2002). The absence of good structures can constraint development, especially, in informal settlements where development is desperately needed as a survival mechanism for sustaining livelihoods. UN World Risk Report (2014) points out that it is not only the intensity or magnitude of an extreme event that has influence on disasters and risks, but a multitude of other factors including poor political and institutional structures. Marikana, being an informal settlement, lack formal policies and legislation because of its lack of connectivity to the municipality.

2.2.1.5 Livelihood outcomes

Livelihood outcomes are the results achieved after efficiently and effectively combining the available assets and applying livelihood strategies to address issues of the vulnerability context (Twigg, 2004). Livelihood outcomes flow from livelihood strategies; a combination of different assets is essential for the achievement of positive livelihood outcomes. Such a combination may include the human resources (the people and their skills), the equipment (for example, the tanks, gutters and pipes needed for harvesting rainwater) and the water from rainfall (the critical resource in this study). These resources complement each other and when used strategically, positive outcomes can be achieved. The people's ability to conduct rainwater catchment can be shaped by the interplay of the above resources and influenced by the institutional arrangements and politics around them, which can determine how community members can use the resources and to what effect.

Livelihood outcomes also include the results of harvesting rain-water and how they can effectively influence the livelihoods of the people living in informal settlements; the results may include - sufficient water to be used per household, the health wellbeing and hygiene of the people can be improved in that there could be more water for domestic use, the amount of exposure of vulnerability to shocks and trends could be reduced and people can be more resilient to external forces. The income received from small businesses, such as car washes would bring benefits like, increased food security, better gardens and an increase in people's buying power, hence, the entire livelihood of the community can be improved and sustained due to the availability and increase in water.

2.2.2 Climate Change Framework

The climate change framework exhibits the causes and effects of climate change on both humans and the environment. Climate change and its effects have been intensified by human system drivers which have negative effects on the natural environment. The latter has led to changes in rainfall patterns resulting in either severe shortages of water or excessive water. Climate change has also caused severe changes in temperatures which in turn have impacted negatively on the environment by causing the polar ice to melt and affecting the food seasons, resulting in food insecurity (UNFCCC, 2007). As depicted in the model, human health, water resources and the entire ecosystem is being affected, globally, by the effects of climate change.

Climate change is expected to continue exacerbating water scarcity in already water-strained communities where demand for water already exceeds supply. Ogato, Abebe, Bantider & Geneletti (2017) predict that the change will increase the risk of urban flooding, water shortages, wind storms and dust storms leading to inhabitants being vulnerable to a range of immediate, acute or slow-onset disasters. Souring temperatures and rainfall variations are continuously increasing and intensifying due to effects of climate change (Kahinda, Taigbenu & Boroto, 2010). Prolonged dry spells and a reduction in the amounts of rains received are due to climate change. The emission of gases is a major concern within communities as it causes global warming which in turn contributes to the effects of climate change. The emitted gases also contaminate rain water causing acid rain.

Unpredicted higher temperatures may lead to substantial increases in evaporation of the harvested water where open surface containers are used to harvest the rain water; such actions can contribute to the decrease in water supply, yet, an increase in demand. UN-Habitat (2014) points out that climate change will increase risks in environments where economies depend on

small scale agriculture and rearing of animals; higher temperatures, hence, can directly impair productivity and health of both human beings and livestock (FAO, 2017).

The evidence of climate change and its effects on both the environment and human beings cannot be overlooked, therefore, measures of climate change adaptation (CCA) and mitigation to these effects, need to be put in place to reduce the harsh impacts of this element on the communities and to make them climate-resilient. Rainwater harvesting is one of the strategies that can be considered as both an adaptation as well as a mitigation measure against the fierce effects of climate change. Rainwater harvesting could be used to minimize the effects of excess water, such as flooding, while at the same time, acting as a water reservoirs when there are water shortages. The harvested rainwater would be safe from high temperature which induces evaporation if left in the open water bodies.

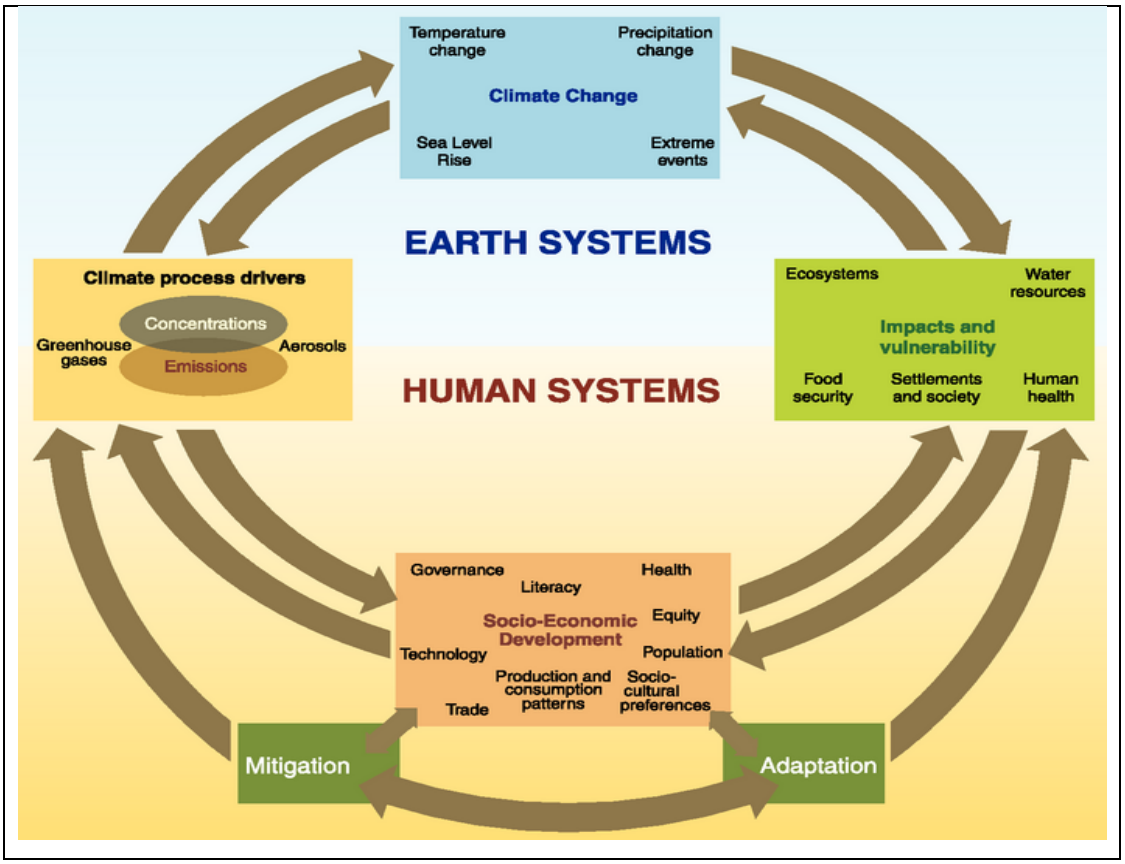


Figure 2.2 Climate change framework. Source: UNFCCC (2007).

2.2.3 Sendai Framework for Disaster Risk Reduction 2015-2030

The Sendai Framework for Disaster Risk Reduction (SFDR) is the predecessor of the Hyogo Framework for Action. The Hyogo Framework for Action (HFA) 2005 – 2015 aimed at disaster risk reduction (DRR) and building the resilience of nations and communities to disasters through its priorities for action (UNISDR, 2006).

The Sendai framework for Disaster Risk Reduction 2015 – 2030 was adopted as the guiding instrument towards achieving the goals of disaster risk reduction (DRR) post the Hyogo Framework for Action 2005 – 2015. It was adopted at the third United Nations World Conference in Sendai, Japan, on March 18, 2015 (UNISDR, 2015). The four priorities of the Sendai framework are mainly to address the issues of DRR at all levels. There is a strong correlation between this study and the Sendai framework, for both aim at reducing disaster risks while strengthening resilience within communities. The goals of the Sendai framework include measures that prevent and reduce exposure to hazardous events and vulnerability to disasters, as well as increasing disaster preparedness for effective response recovery, with the aim of strengthening resilience. UNISDR (2009) refers to resilience as the ability of a community, system or society vulnerable to hazards to withstand, absorb, accommodate and bounce back from the effects of a hazard, in an appropriate and efficient manner, including through the conservation and restoration of its significant basic structures and functions. The four priority areas of the SFDRR include the following:

Priority 1: Understanding disaster risk – Disaster risk management needs to be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment (UNISDR, 2015). The Marikana community may be vulnerable to hazards such as fire; this is mainly because of the highly-combustible materials that the shacks are built from. Floods are also a major hazard that poses a high risk to the people of Marikana because there are no drainage systems in the area to channel the flow of rain water in the rainy season. Drought is another challenge in this area as the people do not have their own water sources but depend on the neighboring areas for water; in dry spells, their neighbors might not allow them to draw water due to the high water tariffs which accompany drought conditions and water shedding.

Priority 2: Strengthening disaster risk governance to manage disaster risk – Disaster risk governance at the national, regional and global levels is vital to its reduction management in all sectors. Governance ensures the coherence of national and local frameworks of law, regulations

and public policies that, by defining roles and responsibilities, guide, encourage and incentivize the public and private sectors to take action and address disaster risk (UNISDR, 2015). Priority 2 in terms of rainwater harvesting in South Africa refers to the laws and regulations related to water. These include the National Water Act, Act no 36 of 1998 and the Water Services Act, Act 108 of 1997. These Acts are guides that help in governing the water bodies and encourage ownership of water among citizens in order to save this critical resource. These guides help in conducting rain-water harvesting appropriately, as they emphasize, for example, the importance of purifying drinking water by adding chlorine and boiling the drinking water to kill bacteria that may be found in rainwater.

Priority 3: Investing in disaster risk reduction for resilience - priority 3 states that investing in strategies of disaster risk reduction and prevention through different structures and dimensions is critical as it enhances the culture of resilience amongst the people, communities, countries and their assets as well as the ecosystem (UNISDR, 2015). These strategies such as rain water catchment can be drivers of innovation, growth and job creation. Such strategies can be cost-effective and instrumental in saving lives, preventing and reducing losses and ensuring effective recovery and rehabilitation should a disaster occur. In terms of priority 3, the practice of rain-water harvesting in Marikana's informal settlement could help build the culture of resilience within this community. The impact of floods, for example, will be cushioned considering that this area has no drainage networks yet it is situated in low lands and faces the possibility of sinkholes. In addition, the people will be more resilient to drought because they will have some water reserved which can sustain them for a period of time before getting help from the government and other stakeholders, should a drought calamity strike. The installation of tanks and other equipment to be used for rain-water harvesting could create employment with preference been given to the skilled citizens within the local community. Job seekers who can be anticipated for these projects include mostly builders and plumbers for installing rainwater harvesting technologies. The practice of rainwater harvesting will reduce risk factors in an extreme event.

Priority 4: Enhancing disaster preparedness for effective response, and to 'Build Back Better' in recovery, rehabilitation and reconstruction: priority 4 of the Sendai framework speaks about strengthening disaster preparedness for more effective response (UNISDR, 2015). Rainwater harvesting is a method of ensuring disaster preparedness in terms of disasters such as droughts; these are slow-onset, in other words, you see it coming because it gives signs, unlike disasters which occur suddenly. Due to drought being slow-onset, the community members have the chance to store water in preparation for when the drought intensifies. The stored rain water

would catalyze a quick and effective response to the affected people during the drought, therefore, rainwater harvesting could also be viewed as a response strategy to historical water shortages in this area as well as a fire fighting tool to the constant shack fires in the area.

2.2.4 South African National Disaster Management Framework, 2005

The South African National Disaster Management Framework (NDMF) was promulgated in April 2005, the same year when the HFA instrument was adopted. This framework is an instrument used to guide the application of the South African National Disaster Management Act, Act no 57 of 2002 (Government Gazette RSA, 2016). The latter recognizes a diversity of risks that Southern Africa is prone to and places extreme emphasis on the issues of disaster risk reduction, prevention and mitigation. This approach is in line with international frameworks, such as the HFA and currently with the Sendai framework priorities of action. NDMF is used for disaster management planning and as a guide towards disaster management at all government levels (Government Gazette RSA, 2016). NDMF has four key performance areas (KPAs) and is supported by three enablers. In Figure 2.4 (Government Gazette RSA, 2016) each KPA is supported by all the three enablers. South Africa bases all its disaster management on these KPAs and enablers which are in line with the priorities of international frameworks (Government Gazette RSA, 2016). The KPAs will be briefly discussed next.

Key Performance Area 1 – KPA1 focuses on the establishment and implementation of relevant institutional arrangements at all levels of government spheres. It insists on the participation and co-operation of all stakeholders in addressing disaster risks and strengthening capacities to reduce the impact of disasters on the communities while strengthening their livelihoods (Government Gazette RSA, 2016). The community members need to familiarize themselves with available institutional arrangements related to rainwater harvesting. This can be achieved through the dissemination of information and communication as indicated in enabler 1 and training and education and research in enabler 2. Participation and co-operation should be encouraged at all times in order to build a cohesive society; if the people do not work together, the implementation of harvesting rainwater as a project, may fail.

Key Performance Area 2 - KPA 2 addresses the importance of disaster risk assessment and monitoring as priorities of disaster risk reduction and surveilling their effectiveness (Government Gazette RSA, 2016). KPA2 insists on the implementation of these instruments within all spheres of government (Government Gazette RSA, 2016). The community leaders and community members should conduct a disaster risk assessment in the Marikana community in order to be on

board with the present water situation and any implementing strategies to cushion the impact of the identified potential hazards, on people and the environment. Disaster risk assessment can be done by talking to people in the neighboring areas who can share their previous experiences and by obtaining records from the Municipality departments such as the Fire and Rescue departments' statistics on the number of fire and flood incidents they had responded to in the past 5 years or more, the extent of the damages and if there were any injuries and/or fatalities recorded.

Key Performance Area 3 - KPA 3 outlines disaster risk management planning and implementation for adopting developmental approaches, programmes, plans and projects meant to achieve disaster risk-reduction goals (Government Gazette RSA, 2016). The rainwater harvesting project in this study can be implemented as an instrument for disaster risk management and towards reducing the community's vulnerability to water-related disasters, including those of floods and drought.

Key Performance Area 4 - KPA 4 insists on the implementation of priorities concerned with disaster response, recovery and rehabilitation (Government Gazette RSA, 2016). This KPA also addresses the requirements of the Act for the integrated and coordinated policy that focuses on rapid and effective response to disasters and post-disasters (Government Gazette RSA, 2016)). This priority focuses on responding to the effects of a disaster and building back structures after the disaster. The KPAs and all their enablers as indicated in Figure 2.3 speak about ensuring that disaster risk reduction is their main priority at both national and local levels of government and using knowledge and education to build cultures of resilience and safety (UNISDR, 2006).

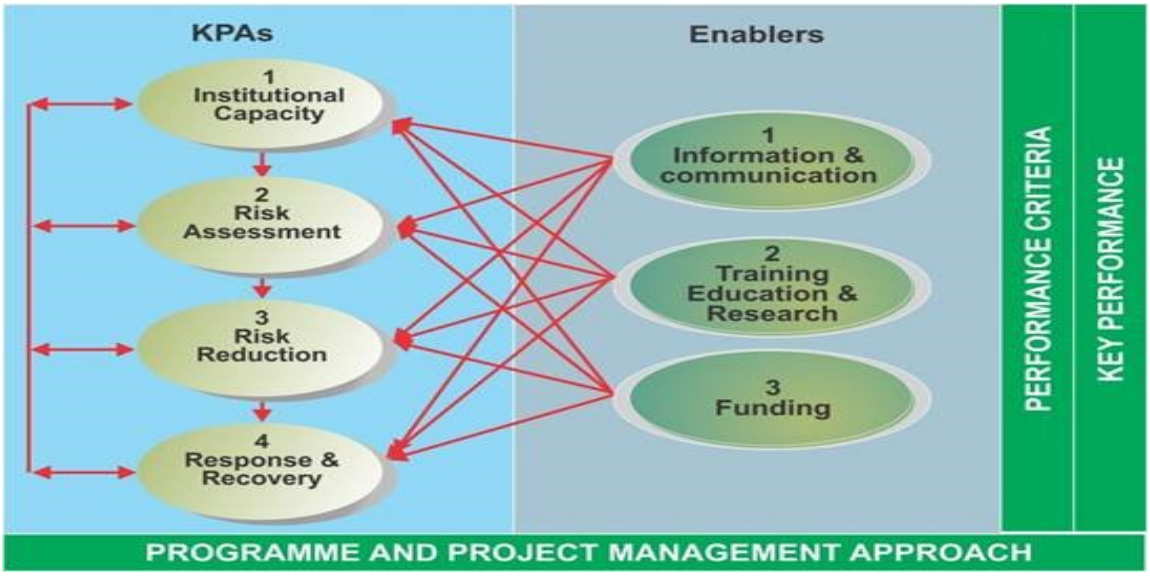


Figure 2.3 South African National Disaster Management Framework. Source: RSA NDMC, (2016).

2.3 Legislative frameworks

2.3.1 The Constitution of the Republic of South Africa, Act 108 of 1996

Laws, regulations and institutional arrangements are important in any country, including South Africa, to guide human behavior and activities as a social group. The Constitution of the Republic of South Africa is the supreme law in the land and within it, there are different sets of the Bill of Rights and Duties; these note the rights accorded citizens as well as the duties that are expected to be performed by the citizens of South Africa (The Constitution RSA, 1996).

The most important section of the South African Constitution that relates to water (although not directly to rainwater harvesting), is section 27 of the Bill of Rights which states that:

> Everyone has the right to have access to
>
> (a) health care services, including reproductive health care;
> (b) sufficient food and water; and
> (c) social security, including, if they are unable to support themselves and their dependents, appropriate social assistance.

There are three types of rights as enshrined in the Bill of Rights. First, is the right to health care services, secondly, the right to the adequate food and water and lastly, the right to households' social security. Water, the central point of this study, is an integral part of the ecosystem and should, therefore, be used sparingly; it is a cross-cutting resource very critical in all the three types of the above Bill of Rights. The government is the custodian of water sources, including dams and rivers therefore, it should progressively realize, within the limits of its resources, that its citizens receive such services. Marikana is an informal settlement which is situated outside of the boundaries within which the municipality renders its services, thus, there is no portable water in Marikana. It is for this reason that this study investigates the possibility of introducing rainwater harvesting in this area as a source of water.

The Republic of South African Constitution also defines the structures of government and their functions within three distinct, interdependent spheres, namely, national, provincial and local governments. The spheres are decentralized in these levels, in order to bring services closer to the people (Macnamara, 2018). Twigg (2004) points out that institutions, policies and legislation all affect citizens' livelihood strategies by influencing access to assets and resources. These policies operate at all levels, from household to international and in all spheres from public to private therefore, every community should be guided by legislation. It is almost impossible to discuss section 27 of the Bill of Rights without mentioning section 26 which refers to housing; the

two Bill of Rights go hand in hand. Section 26 of the Constitution of the Republic of South Africa relates to housing; one cannot talk about water without mentioning housing or vice versa (Macnamara, 2018). Section 26 of the Bill of Rights states that:

(1) Everyone has the right to have access to adequate housing;
(2) The state must take reasonable legislative and other measures, within its available resources, to achieve the progressive realization of this right; and
(3) No one may be evicted from their home, or have their home demolished, without an order of court made after considering all the relevant circumstances. No legislation may permit arbitrary evictions.

Section 26 of the Constitution indicates that every human being has the right to housing, however, obstacles and constraints such as rapid population growth, uncontrollable migration and high rates of unemployment, may make it difficult for the government to realize its mandate of providing adequate human settlements using the available limited resources; as a result, people are forced to build shacks in unsafe areas leading to mushrooming of informal settlements in areas where there are no water and other basic services (The Constitution RSA, 1996).

The Constitution vests the duty of water provision in the municipalities; which then become the main providers of water services based on the knowledge that water resources and the ecosystem should be preserved. Ekurhuleni municipality is the supplier of water services within its municipality but since Marikana is an informal settlement, there is no water supply from the municipality; reasons for this will be discussed in the relevant sections in the literature review. In this context, rainwater harvesting is being proposed, by this study, as a possible strategy for providing water for the informal residents of Marikana.

2.3.2 The South African National Disaster Management Act (DMA), Act 57 of 2002

South Africa has a well-developed disaster management policy and legislation as well as other laws relevant to disaster risk reduction (IFRC, 2011). Most of these instruments were enacted post-1994 after South Africa became a modern constitutional democracy. One of the laws that came into being is the South African National Disaster Management Act 57 of 2002 (DMA). This instrument complements a range of disaster-specific and disaster-related events concerning both natural and human-induced hazards which can lead to disasters. DMA has its central focus on co-ordination, promotion and facilitation of Disaster Risk Reduction (DRR) with institutional and strategic arrangements (Government Gazette RSA, 2016). IFRC (2011) explains that DMA consists of three main institutions, which are responsible for the national policy and coordination

of disaster management. These institutions are the National Disaster Management Advisory Forum (NDMAF), the Intergovernmental Committee on Disaster Management (ICDM) and Provincial Disaster Management Centers (PDMC). This Act is mandatory for adoption by all spheres of government and to be disseminated to community members in every municipal area as it entrenches a detailed policy development and strategic planning framework for disaster management; it provides for both the classification and declaration of disasters and it also addresses the issues of funding of post-disaster recovery and rehabilitation (IFRC, 2011).

2.3.3 The National Water Act (NWA), Act 36 of 1998

South Africa's water is governed by the National Water Act (NWA – Act 36 of 1998) and the Water Services Act (WSA – Act 108 of 1997), although, the custodian of her water is the Department of Water and Sanitation which also ensures that there are sufficient supplies of the resource for the country's needs (Oxfam, 2016). NWA indicates that water resources should be protected against over utilization; the Act also ensures that there is water for economic and social development and water for the future among communities (Government Gazette RSA, 1998). Water resources referred to in the National Water Act include all water bodies such as rivers, wetlands, dams, streams and underground water sources; these act as natural catchments of rain water.

The national government is responsible for ensuring that the water resource is protected through the Minister and the Department of Water Affairs and Forestry (Government Gazette RSA, 2016). The Minister can then delegate some of her duties to the departmental officials, advisory committee members, and waste management and water boards. The National Water Act aligns with the Water Services Act in that both Acts' priority is on water resources (Government Gazette RSA, 2016). It is a national duty to ensure that there is water available for the future, although, it is also the responsibility of the citizens to ensure that they save water for their households through activities such as rainwater harvesting at micro level (Government Gazette RSA, 2016). The National Water Act no 36 of 1998 indicates that a person who owns, controls, occupies or uses the land is responsible for putting measures in place to prevent or mitigate pollution of water sources. It is, however, the responsibility of a household to ensure that the water collected through rainwater harvesting is clean and free from pollutants (Harpe, 1998).

2.3.4 Water Services Act (WSA), Act 108 of 1997

Water Services Act (WSA) deals mainly with the provision of portable water and sanitation services by municipalities to households and other water users and to set national standards,

norm and tariffs (Macnamara, 2018). The WSA places the responsibility for the provision and management of available domestic water supply on the local government in their various municipalities. This Act also speaks about how the municipalities should provide these services with the intervention from the Minister of Water and Sanitation, whenever there is a need. The Water Services Act is very relevant in this study, however, the Water Services Act does not directly apply because the community of Marikana has no tap water supplied by the municipality. The community, therefore, depends on water that they draw from their nearest neighborhood of Extension 3, hence harvesting rain water may be essential for this community as it could become their primary source of water.

2.4 Chapter summary

This chapter provided a synopsis of the different frameworks suitable in the study of rainwater harvesting in Marikana informal settlement. To understand the concept of rainwater harvesting, this chapter was divided into two sections where theoretical frameworks were discussed in the first section and legislative frameworks in the second section. Literature by different authors was reviewed to support this study. Some of the theoretical frameworks that were discussed in this chapter included the Climate Change Framework and the Sustainable Livelihoods Frameworks.

This study was mainly based on the Sustainable Livelihood Framework because of its clear and more comprehensive explanation of its variables which are relevant to the Marikana community. This is a community is vulnerable to many water-related hazards, possesses livelihood assets that depend on water, has structures and processes that may affect their livelihoods and assets and are highly-dependent on water. It is, therefore, imperative that this population put in place strategies like rainwater harvesting to achieve better outcomes such as wealth-creation, food security and DRR to sustain their livelihoods. The second section of this chapter investigated legislative frameworks that relate to rain-water harvesting. These included, the Constitution of the Republic of South Africa, the South African National Disaster Management Act, the National Water Act and the Water Services Act; all these Acts became into being post-1994 when South Africa became a democratic country. It was further established that these frameworks complemented each other in one way or the other.

Chapter 3: LINKING DISASTER MANAGEMENT AND RAINWATER HARVESTING

3.1 Introduction

This chapter forms a review of existing literature related to the research problems. As indicated in chapter 1 of this study, the focus areas is environmental, social and economic perspectives in the context of disaster risk reduction and management. While South Africa is perceived as Africa's most progressive democratic economic hub exhibiting one of the highest Human Development Indexes (HDI), the country has its share of environmental, economic and social problems (Ncube & Jordaan, 2017). Some of these environmental problems include deteriorating air quality and water shortages aggravated by climate change and other social factors including rapid population growth, migration and poverty.

The increasing population of urban cities has caused serious strain on the limited resources of land and water to the extent that FAO (2017) points out that water use has almost doubled due to the rate of population increase. In Gauteng and the City of Ekurhuleni, municipal water sources are fast diminishing due to the high demands for water consumption, from industries and humans. Poor management of water quality, poor legislation to protect water sources and the degradation of wetland ecosystems are some of the factors contributing to the exhaustion of water resource (Mutekwa & Kusangaya, 2006). Lwasa (2014) estimates that half of the African population will be living in the urban areas by 2030; UN-Habitat (2014) reveals that pressures of demand for fresh water will continue to escalate because of continuous population growths, increasing water use due to modern life style and changes in rainfall patterns caused by climate change. The population in urban cities usually increases without any associated expansion of resources and infrastructure, therefore, resulting in people competing for the minimum available resources. Uncontrollable urban population growth affects the social, economic and environmental environment within cities, thus, putting greater numbers of people at risk of natural and human-induced hazards. Extreme of hazards, such as floods and droughts, may turn into disasters, hence, this study focuses on disaster risk reduction and building resilience within poor communities.

The most pressure experienced by urban dwellers comes from the lack of available human habitable land, proper housing and shortages of water. As a result, people resort to building informal settlements in unsafe areas with lack of minimal basic services such as water and sanitation (Sphere Project, 2011). Another major challenge faced by Southern African cities, although it is a global challenge, is the harsh effects of climate change and the degradation of freshwater resources (Lwasa, 2014). Climate change induces rise in temperature, variability in weather patterns, such as varying rainfall amounts and patterns which tend to threaten vital systems in the survival of these cities (UN-Habitat, 2014). Climate change conditions accelerate drought conditions, while increasing severe storms, coupled by rising sea levels that create floods are making populations more vulnerable to famine and disease (IFRC, 2011). The world depends on natural resources for survival, therefore, UN-Habitat (2014) urged African countries to embrace strategies that do not over rely on natural resources as most of these African countries, including South Africa, are vulnerable to resource depletion.

3.2 Water as a critical resource

Water is such a critical resource that, Gleick (1994) indicates that some of the problems among nations are caused by conflicts over water borders, economic issues and competition over water. In the Middle East, water is believed to have been the justification for going to war amongst countries, thus, is a tool for and a target of conflict (Gleick, 1994). Mbote (2007:1) states that in 1998 the former Secretary-General of the United Nations, Boutros Boutros Ghali was quoted as saying "*The next war in our region, the Middle East will be over the waters of the Nile, not politics."* UNDP (2007) lists some of the implications of lack of water as: ill-health (such as, diarrhea which claims over 2 million people per annum), lack of education, extreme hunger, poverty and gender discrimination (in the sense that the poor and women usually suffer the most from deprivation of water accessibility). Water scarcity can lead to people migrating to other areas and it also causes conflicts over its limitedness.

Shortages of water also cause the decline of aquatic biodiversity and loss of ecosystem services; it can also enhance climate change vulnerability and cause weakening of people's livelihoods (IUCN, 2009). Bizimana (2017) contributes to the literature on shortages of water by stating that the scarcity of water resource impacts hard on the agricultural productivity and poses a threat of rising epidemics and loss of life.

Water is inextricably linked to development, it supports human needs, ecosystems, industrial and economic activities and livelihoods, however, unsustainable development pressures and climate

change threaten the availability and quality of freshwater resources. This situation has the potential to jeopardize hard-worn development gains and the prospects of future economic growth in vulnerable countries (UNDP, 2017). It is, therefore, ideal that planned mitigation strategies be identified and implemented to minimize the risk and intensity of future hydro-related disasters.

To ease the burden of the increasing demand for the already exacerbated water resource scarcity, strategies such as rainwater harvesting need to be put in place. Communities' economic growth, development and sustainable livelihoods need a substantial understanding of both emerging and existing hydro-related challenges and their cascading effects on the entire ecosystem (UNEP, 2009). Strategies that may be adopted to deal with such challenges may include the early warning systems, severe water restrictions or total elimination of irrigated agriculture over a long period of time to free reasonable minimum amounts for the masses (Oxfam, 2016). Another community-led strategy that can be adopted is rainwater harvesting to supplement the diminishing sources of water rather than letting the water be wasted as run-offs, especially in urban areas where development is at its peak (UNEP, 2009).

This study looks at rainwater harvesting as a possible mitigating measure against floods and drought, as well as to build resilience and sustainable livelihoods, in informal settlements. Rain water harvesting, hence, may be a way of mitigating the possible harsh effects of disasters. Mitigation is a component of the disaster management cycle. UNISDR (2008) sees disaster management as an approach and practice of managing uncertainty, potential losses and development strategies as well as specific actions to control and reduce risks and losses.

Water is a natural capital and has no substitute, however, according to Oxfam (2016) many of the water resources in South Africa are being over used and altered. Oxfam (2016) points out that while South Africa is classified as a water-scarce country with a low average rainfall, she is also referred to as a water-wasteful country, considering the excessive amounts of water used by individuals, especially the rich city dwellers; these people earn high incomes and as a result, they eat better, diversified and more nutritious food which needs more energy and water to prepare. The rich are immune from issues of malnutrition and food insecurity as they usually can afford to purchase food items regardless of their escalated prices associated with water shortages (Oxfam, 2016). IFRC (2015) indicates that most of South Africa's potential hazards are associated with water, either its excess or its lack of.

FAO (2017) describes water scarcity as a situation when water supply is insufficient to meet demand. Sivanappan (2006) refers to water as a 'liquid gold' due to the nature of its growing

scarcity and price of water supply. Water is very important for all living organisms as it supports life; it ensures the development of socio-economic development and it maintains a healthy ecosystem (UNEP, 2009; Kahinda, Lillie, Taigbenu, Taute & Boroto, 2008). Gleick (1994) highlights that a human being can go for days without food but not without water. Water shortages contribute to the increasing poverty levels by elevating food deficiency and suppressing sustainable development, especially, within the under-privileged communities (Oxfam, 2016).

3.3 Rainfall and its potential benefits

Kahinda *et al.,* (2008) indicate that dry spells from the variations of rainfall amounts received jeopardize agricultural activities, thus, causing reductions in crop yield and poor quality of the crops harvested. Sufficient rainfall is essential for household minimum basic needs of sanitation, drinking water and other domestic use.

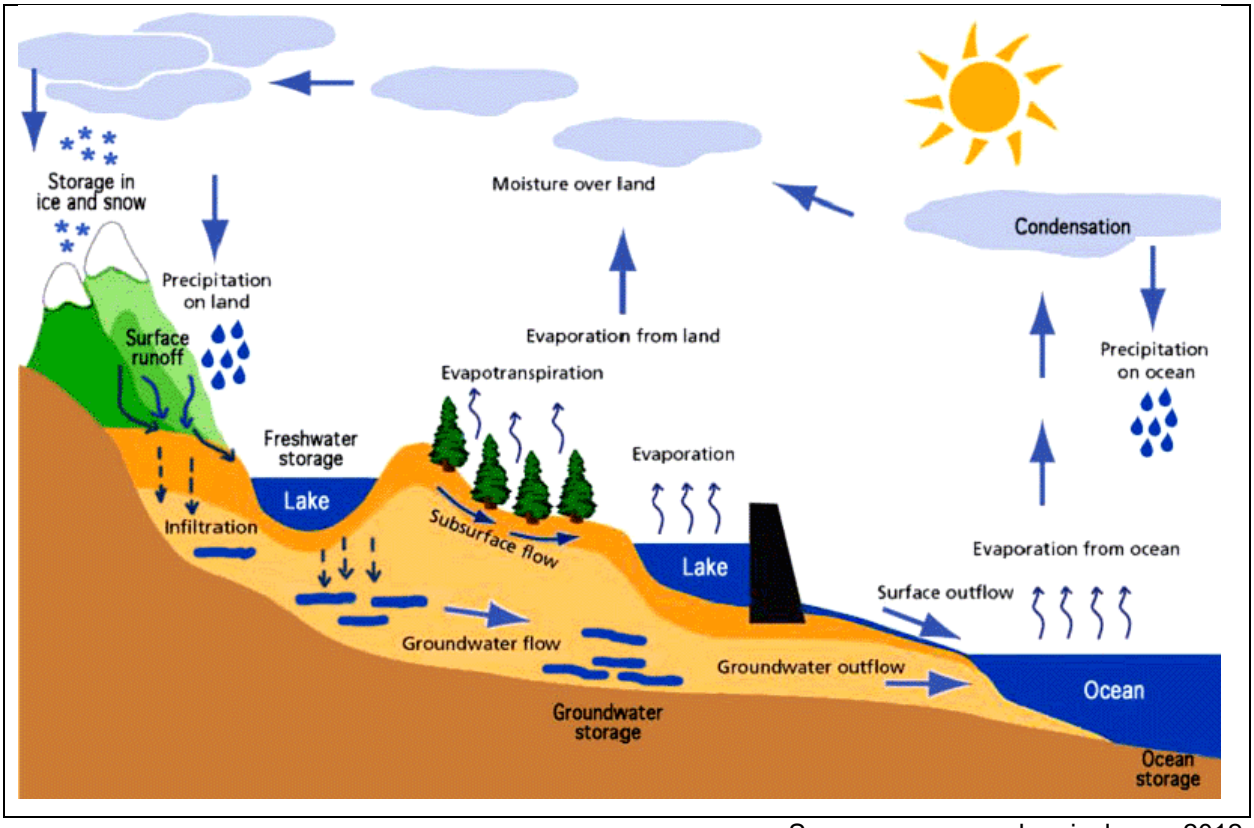
Reed (1997) lists other benefits of water as - maintaining ecosystems, preserving wetlands, replenishment of soil fertility, provision of water for crop irrigation, fisheries and recharging ground water, provision of hydroelectricity, and provision of water to maintain human, animal and plant life. Floods can also flush out pollutants from the waterways. Water sustains the running of mines, factories and industries and it is the main determinant of food security in any country (UN-Habitat, 2014). It is the fulfilment of the above requirements that should drive, the harnessing of the idea of rainwater harvesting in South Africa's informal communities as a source of water and storage technique.

3.4 Water cycle in relation to rainwater

Water comes from rainfall through a process called 'the water cycle'. The water cycle is a natural cycle where water falls from the clouds onto the land in the form of rain (Bisoyi, 2006). Some of the water then seeps into underground aquifers, runs off into channeled drains, a portion of it drains into rivers and streams and the rest of it eventually flow into the sea (Bisoyi, 2006). The water in the open water sources, such as the lakes and seas gradually evaporates into the atmosphere as water vapor and eventually condenses to form rain bearing clouds. Plants also lose water into the atmosphere through a process called 'transpiration' (Bisoyi, 2006). Evaporation and transpiration processes are collectively referred to as 'evapotranspiration'. The water vapor in the atmosphere then condenses to form rain-bearing clouds, a process known as

'condensation' and when finally the water droplets become too heavy to be held in the atmosphere, they fall down as rainfall (Bisoyi, 2006).

The water cycle has in recent times been influenced by environmental factors, such as climate change. Projections indicate that the hydrological cycle will become extremely volatile with increases in the frequency of unusual rainfall events and droughts (UN-Habitat, 2014). FAO (2017) projects that climate change will negatively impact the water cycle by altering rainfall patterns and affecting the quality of surface and groundwater. Water-strained conditions are distinguished by poorly-distributed rainfall, high evaporation and extraordinary runoffs (UNEP, 2009). This can result in either drought or floods.



Source: www.sperchemical.com, 2012.

Figure 3.1 The hydrological cycle.

3.5 Rainwater harvesting

Oxfam (2016) reveals that for nations to overcome the challenges of water scarcity, they need to cultivate the culture of conserving water. This could be achieved through activities such as harvesting rainwater and although there are other alternatives of obtaining fresh water which may include desalination and recycling grey water, these alternatives are very expensive compared to rainwater harvesting (Oxfam, 2016). This study explored rain-water harvesting as a cheaper method of obtaining fresh water as opposed to the other alternatives. Rainwater harvesting is believed to have made significant contributions towards livelihoods enrichment and economic development of many nations.

Rain water harvesting is described by Nketiaa, Forkuob, Asamoaha, Senayaa (2013) as the technique of intentional collecting and storing of rainwater at surface or sub-surface aquifers, by humans to provide a water supply and/or increase the current supply, before it is lost as surface run-off. Rainwater harvesting offers unlimited potential in mitigating the results of water shortages. The technique of harvesting rainwater may help reduce the amounts of stagnant waters which may be a potential site for breeding insects such as mosquitoes.

FAO (2017) supports the idea of harvesting rainwater by stating that the action slows down rainwater runoff, allows more infiltration and helps improve groundwater recharge. South Africa, however, is facing acid mine drainage problems where the ground water gets polluted with acid mine water which may hinder the development of underground animal life and pollute the charged ground water (Oxfam, 2016). Although this matter of acidified mine water may have received a lot of attention thus far, it cannot be resolved due to the country's economic reliance on mining activities (Oxfam, 2016). This problem increases costs of treating ground water to potable standards which in turn is sold to consumers at a higher price. That is what motivated the researcher to look at the possibility of harvesting surface rainwater before it sinks into the ground. Bizimana (2017), maintains that studies conducted in other African countries indicate that about a third of the African continent is deemed suitable for practicing rainwater catchment which can minimize water runoffs. Kahinda *et al.,* (2008) emphasize that harvesting rainwater is one of the significant interventions necessary for achieving the Millennium Development Goals (MDG) goal number 1: to end poverty and hunger and MDG goal number 7: which speaks about environmental sustainability.

Rainwater harvesting enhances water productivity, water management, provides water storage and increases resilience to flooding and drought while at the same time improving the drainage

systems (DeBusk & Hunt, 2014). Heavy rain may cause floods and landslides while insufficient rain may cause drought which can result in economic losses (Bizimana, 2017). The practice of rain water harvesting can help ensure water security through proactive planning and governance. Kahinda & Taigbenu (2011) indicate that rain water harvesting has the potential to improve water supply in informal settlements as an addition to the provision of the first free six kiloliters subsidized by the municipalities in areas where municipal water services are supplied. This strategy can also be a remedy to food security because an increase in water reserves may contribute to agricultural productivity, including back yard gardening (Mutekwa & Kusangaya, 2006).

Rainwater harvesting complements disaster risk reduction objectives as it protects infrastructure and enhances human security against sink holes and on mountainous areas, prevent landslides (IUCN, 2009). The functions act as a barrier to disasters and mitigates the impact of extreme weather events in terms of floods and drought (IUCN, 2009).

Harvested rainwater can be the only source of water in informal settlements where there are usually no tap water supplies. Kahinda, Taigbenu & Boroto (2007) contend that Domestic Rain Water Harvesting (DRWH) can be a direct source of water to individual households which could enable productive small-scale activities and has the potential of supplying water to remote and underdeveloped areas, like informal communities. The technique may help in building reservoirs for water storage during wet periods for use during dry spells. Development in areas, whether rural or urban, helps mitigate the risk of a disaster; rainwater harvesting can be considered as a building block towards development as it can contribute towards improving the livelihoods of members of informal communities, such as Marikana.

Implementing the technologies of rainwater harvesting could ease the burden on women especially in developing countries, where women are usually the ones responsible for managing water resources in their households (O'Reilly, 2011). Women walk long distances in search of water, therefore, abandoning their daily income-generating jobs and social activities Managing drinking water, health and hygiene, cooking, cleaning, washing and caring for young children, the elderly, and the sickly are duties that are put on young girls and women causing them to sacrifice their time and other life issues (O'Reilly, 2011).

If successfully implemented, rainwater harvesting could help the women to concentrate on their livelihood activities, such as spending more time with their families. While O'Reilly (2011) indicates that women are the sole custodians of the household water resources and that their

participation in drinking water systems is considered a key element of sustainability,yet, Moraes & Rocha (2013) argue that women are rarely represented in water management bodies and are hardly involved in the implementation of projects that focus on increased water access. It can be concluded that women are solely responsible for intense water-related activities, yet, they have no say when it comes to making life-changing decisions about water.

In Marikana informal settlement, the water harvested would be mainly used for domestic purposes such as watering gardens, for livestock, washing cars, washing clothes and cleaning. The harvested rain water will not be recommended for drinking and cooking unless laboratory tested and deemed safe for consumption. According to World Health Organization's (WHO), 2015 guidelines for drinking-water quality, include ensuring that the water is free from microbes and parasites that constitute a threat to a person's health. WHO (2015) further indicates that drinking water must also be acceptable in terms of color and odor for it to be considered safe for drinking. Often the quickest political solution to reduce disaster risk in informal settlements is the relocation of the residents, however, there is usually no readily available land to carry out the relocation process thus prolonging the process and leaving the communities to continue being exposed to danger (Desai & Dodman, 2018). In this study an assumption is made that rainwater harvesting might be a possible solution in informal settlements where there is no or limited access to fresh water.

3.5.1 Possible methods of collecting rain water

Bizimana (2017) details that rain water collection can be achieved by harvesting run-off water from the road network, constructing dams, ponds and irrigation channels or from roof top buildings and households., There can, however, be some challenges, such as some religions might not approve of the practice, health risks, social and environmental concerns depending on regulations affecting a particular nation or municipality (Bizimana, 2017).

A positive reaction to the water resource pressures should be more focused on how to increase the water supplies and improve the well-being of the people, even if by harvesting rain water. DWAF RSA (2010) identifies three categories of rainwater harvesting which can be distinguished according to the type of catchment used; these are - in-field, ex-field and domestic - type of rain water harvesting. In-field is the technique used in croplands to increase infiltration while ex-field is the rain water harvesting technique where runoff is channeled from a collection area to the storage structure (DWAF RSA, 2010). Twigg (2004) on the other hand lists methods of harvesting rain water as - building water-storing dams and percolation dams which may slow the rate of water

run-offs, thereby, increasing the absorption of the water into the soil, secondly, using community or domestic water storage tanks, and thirdly lining of water ponds with plastic to improve retention of the water. Some of the methods listed are indigenous methods. For this study, domestic rain-water harvesting will be the main focus because of the geographical location of Marikana and the type of households found in this informal settlement.

Kahinda *et al.,* (2008); DWAF RSA (2010) refer to domestic rainwater harvesting system as a process where rainwater is collected from rooftops, courtyards, compacted or treated surfaces and usually, the rain water captured is stored in rain water harvesting tanks for domestic use. This domestic method of harvesting rain water is believed to be cheaper when compared to the other methods, such as pumping water from remote sources. Labour and some building materials for domestic rainwater harvesting may be sourced from within the local communities.

3.6 Degree of application of rainwater harvesting in various countries

Rainwater harvesting has been practiced in some countries on a larger scale and in South African, mainly in the rural areas and very little in urban areas. The technique of harvesting rainwater is needed the most in urban areas because of the high densities of population living in these areas, hence, the higher demand for water resource.

3.6.1 Africa

Campisano, Butler, Ward, Burns, Friedler, DeBusk, Fisher-Jeffes, Ghisi, Furumai Han (2017) elucidate harvested rainwater as a substantial source of water across the globe. Campisano *et al.,* (2017) reveal that GIS tools have identified opportunities for harvesting rain water in countries such as Botswana, Kenya, Zimbabwe, Zambia, Ethiopia, Mozambique, Uganda, Rwanda and Malawi. The United Nations in its report UNEP (2006) also mapped countries such as Botswana, Kenya, Ethiopia, Zambia, Zimbabwe, Malawi, Mozambique, Uganda and Tanzania as appropriate for the technique. In some rural areas of South Africa, rainwater is considered clean in comparison to borehole and stream water which people normally share with animals. Rainwater harvesting has been a source of domestic water in rural areas of South Africa and other countries for over a century (Campisano *et al.,* 2017). Below are some of the success stories of areas of the world that have either previously or are currently practicing rain water harvesting to sustain their livelihoods.

3.6.2 Asia

Campisano *et al.,* (2017) indicate that rainwater harvesting plays an important role in the Asian countries, such as Japan, Thailand and China where this technique was introduced with the support of local governments. Rainwater harvesting has been actively introduced even in large public and private buildings; this shows that the system is working for it to be introduced on such a larger scale.

3.6.3 Australia

The Australian Bureau of Statistics show that approximately 1.7 million households in Australia are fitted with rainwater tanks to their households for rainwater harvesting purposes (Campisano et al., (2017). This proves that Australia has one of the highest degrees of implementation of rainwater harvesting systems. Rainwater harvesting is encouraged within communities because of the increasing water restrictions imposed by water authorities, rebates provided by the government authorities, unfavorable water regulations and high water pricing (Kahinda *et al.,* 2008).

3.6.4 Europe

The status of the implementation of rainwater harvesting systems in European countries is varied, although, Germany is said to be the leader in promoting the widespread use of this technology for domestic use (Campisano *et al.,* 2017). The local government in Germany offers grants and subsidies to promote the harvesting of rainwater to an extent that almost one third of new buildings are equipped with rainwater collection systems (Campisano *et al.,* 2017). Despite Germany encouraging its citizens to collect rain water, she does not encourage them to consume the collected water due to the high levels of industrial air pollution which results in acid rain. Residents are advised to use the collected rain water for irrigation, toilet flushing and laundry use in Germany (Kahinda *et al.,* 2008).

3.6.5 South America

The semi-arid regions of Brazil periodically experience episodes of moderate to extreme droughts which result in famine, water insecurity and an increase in the number of drought refugees, especially, family farmers (Wamsler & Brink, 2014). The Brazilian communities then decided to adopt the rain water harvesting strategy as an alternative for water supply. This practice has contributed significantly towards increasing the water supplies in Brazil and for supporting farming activities (Lindoso, Eiro, Bursztyn, Rodrigues-Filho & Nasuti, 2018). In areas such as Rio where residents experience extreme hot temperature, some of the harvested rain water is used to repeatedly drench rooftops to reduce the hot temperatures indoors (Wamsler & Brink, 2014).

3.7 Rainwater harvesting indicators

Some of the indicators that can be used to determine a potential area for rain water harvesting are - the amount of rainfall, soil texture, slopes, land use or cover and socio-economic factors such as population density, work force and water laws (Nketiaa *et al.,* 2013). Rainfall is the most important indicator of them all as it is impossible to carry out rainwater catchment in areas such as deserts where there is almost no rain. Nketiaa *et al.,* (2013) used these indicators to establish a suitable area for rainwater harvesting, however, this study does not base the possibility of introducing rainwater harvesting in informal settlements on any of these indicators, rather the study aims to ascertain the possibility of carrying out rainwater harvesting in Marikana informal settlements, however, rainfall patterns and amounts will be discussed next to paint a picture of the amount of rain fall received in the settlement.

3.8 Informal settlements and rainwater harvesting

Informal settlements according to the UN Habitat programme (2015:1) are defined as: "*i) residential areas where a group of housing units has been constructed on land to which the occupants have no legal claim, or which they occupy illegally; ii) unplanned settlements and areas where housing is not in compliance with current planning and building regulations (unauthorized housing).*"

Informal settlements are residential areas where residents have no security of land or dwellings. The residents usually inhabit geographically and environmentally hazardous areas and have no access to basic essential services and the inhabitants are constantly exposed to communicable diseases, violence and threats of eviction (UN Habitat, 2015). Informal settlements are derogatorily referred to as 'slums'; they act as "arrival cities" because of their capability of accommodating those seeking an entry point into the labour market (Marutlulle, 2017). Informal settlers generally have low levels of education, income and access to services. Informal settlements are characterized by their inhabitants' partial or complete lack of institutional, basic rights and legal security (UN World Risk Report, 2014).

The rapidly growing population in cities has resulted in shortages of houses and good affordable habitable land, leaving the poor with little or no choice but to settle on unsafe shanty areas, sometimes on the edge of the city. They have no access to tap water and sanitation as they mostly lie outside the formal water and sanitation distribution networks (UN World Risk Report, 2014). Informal settlements, according to Wamsler & Brink (2014) are often not recognized by city

authorities making it difficult for them to obtain support as recipients of essential services; this situation undermines prosperity and sustainable development in these communities. Custodians of the essential services usually give excuses and threaten that such communities are at risk of eviction. High housing and population densities, in informal settlements magnify the effects of pollution and diseases (Twigg, 2004).

Informal settlements are caused by a combination of factors like - poverty, failure of land regulations, rural-urban migration, lack of affordable housing for the poor, unemployment and displacement caused by climate change and other natural disasters (UN World Risk Report, 2014). Such settlements are often situated in unsafe areas, are vulnerable to environmental factors such as flood lines, areas prone to sinkholes and areas next to mine dumps.

Informal settlements seem to currently be a significant features of urban areas, yet, people who live there suffer from economic and social exclusion. Poor and marginalized people are likely to live in poor quality housing, in neighborhoods without clean water, no drainage systems, no paved roads and no sanitation systems and where garbage collection and public health services are inadequate (Wamsler & Brink, 2014). This makes them vulnerable to a variety of environmental hazards. Lack of toilets and sanitation in informal settlements usually results in the residents using ‘flying toilets’ to relieve themselves. Wamsler & Brink (2014) describe flying toilets as a situation where residents relieve themselves into a plastic bag and then toss it out of the window causing great risk to the environment and to public health. Desai and Dodman (2018) characterize informal settlements as areas that are often highly exposed, vulnerable and at high risk to hazards, hence, have limited capacity to cope with and adapt to the impacts of such hazards. Beside the environmental hazards faced, informal settlements are exposed to challenges such as overcrowding which can contribute to high stress levels, violence, increased problems of drugs and other social problems.

The challenges caused by human informal settlements to the environment are extensive. Fires are a risk in informal settlements because of high densities and the use of fire combustible substances for cooking and heating the households (De Moraes & Rocha, 2013). During winter, some residents make open fires from old tyres to warm themselves. The open fire produces a dark cloud which pollutes the environment and poses a health hazard to the people since it could cause respiratory problems to individuals, especially, children.

Informal settlements are prone to shack fires because of the combustible materials that the residents use to build their shacks. Shacks are mainly built using corrugated iron sheets, boards,

cardboards, plastics, thatch and wood. Twigg (2004) points out that domestic fires - which are a significant risk in houses made of materials that burn easily and packed tightly together - can easily get out of control. Another main cause of fires in informal settlements is the illegal electrical connections which eventually cause short-circuits, power outages and fires which can spread rapidly in dense settlements (Wamsler & Brink, 2014).

The negative impact of human beings on the natural environment increases as the population increases in the urban areas. Such situations exert considerable pressure on the government to create sustainable human settlements and livelihoods of its people. Human settlements, although of critical importance with regard to social and economic issues, are the major contributors to the degradation of the environment from which they obtain their basic elements needed for survival (WHO (2015). Settlements' negative impact on the environment increases with their expansion, increased consumption of the natural resources and population and economic growth. Informal settlements sometimes sprawl in areas where they can alter the natural state of land, threaten biodiversity and fragment ecosystems, as they continue to have high needs for water and energy (World Risk Report, 2014). The informal settlements sometimes congest the urban areas and due to their high population density increase competition for limited resources, causing urban areas to be at a high risk of experiencing extreme damages from shocks. According to Tun Oo, Van Huy lenbroeck & Speelman (2018) informal settlements have the highest sensitivity to climate effects and the highest exposure to natural hazards but, unfortunately, the lowest adaptive capacity score.

3.8.1 Urbanization as the main cause of informal settlements

Southern Africa, according to the UN-Habitat (2014) is referred to as the most urbanized region in sub-Saharan Africa. Southern African cities are experiencing high rate of urbanization as the majority of the countries' population move to cities in search for jobs, housing, social facilities and better living conditions; cities and their population, thus, are growing at an alarming rate. UN-Habitat (2014) predicts that the Southern African urban population will nearly double from about one billion in 2010 to nearly two billion by 2040. Besides the unstructured urbanization process, African cities, including South Africa, need to deal with issues of immigrants who flock into urban cities in search of better living conditions. Immigrants mainly fleeing from their countries due to political unrests, civil wars and economic crisis, add to the population density in the cities. As people crowd into the African cities, they all compete for the same already strained critical services to maintain their livelihoods. Such actions result in the cities experiencing further massive

shortages of resources such as land and water. With informal settlement expansion, social housing delivery for the poor, in all corners of South Africa, has lagged significantly behind demand (UN-Habitat, 2014).

This is evident by the current infrastructure and service delivery deficits which are significant contributors to poor living conditions in informal settlements, hence, service delivery protests in low-income and poor neighborhoods have become a regular feature (Marutlulle, 2017). The need for houses, integrated service and infrastructure provision has remained a key challenge for city governments which at the same time are losing revenue through the illegal connections of electricity and water within the informal settlements (Marutlulle, 2017). Informal settlers sometimes settle on agricultural land thus enhancing economic hardships such as the destabilization of food security. Marutlulle (2017) identifies municipal maladministration, lack of control and corruption as the main administration-related factors that contribute to the housing challenges and ultimately informal settlements. The rapid rate of urbanization in African cities has led to a decrease in farming land and water shortages in urban areas leaving the urban population to rely on rural areas for food security (UN-Habitat 2014).

Urbanization increases levels of unemployment making it difficult for residents to afford paying for basic services including water, thus, resulting in increased levels of poverty. Many people who are in urban areas as a result of urbanization rely mainly on casual work of the informal sector which is vulnerable to disruption; which once it occurs, creates livelihood insecurity among those affected (DFID, 2002). When growth in cities' population from effects of urbanization, exceeds the capacity of the government to maintain and develop sufficient infrastructure, the poor then suffer the most from this lack of no basic resources.

Asati & Deshpande (2006) highlight rapid urbanization and industrialization trends as the cause of over-exploitation of ground water without much focus on its recharge.

High population density puts extreme strain on the scarce resources and makes it almost impossible for the government to facilitate its mandate of service delivery in certain human settlements; this is due to the government either faced with excessive backlogs or no services being rendered at all in certain areas, such as informal settlements. The combination of exposure to extreme events and extreme poor living conditions, may have dire consequences on informal dwellers.

3.9 Floods and rainwater harvesting

Water is precious and must be conserved at all times, however, excessive water either from surplus rainfall which forms floods or melting snow can be damaging to human beings and the environment (Asati & Deshpande, 2006). Floods are common in the 21st century because of global warming and climate change. Floods are sometimes caused not because of excess rainfall but by development in the urban areas which affect the normal penetration of water into the ground (Asati & Deshpande, 2006). Floods, according to Benson & Clay (2004) occur when water on the ground surface covers land that is usually dry or cemented or when water overflows its normal confinements. Reed (1997) indicates that floods are caused by excessive water usually from rainfall or high precipitation due to atmospheric and ocean processes such as the El Nino. Floods can also be caused by tropical storms, burst dams and rapid snow melts. Those who reside in coastal areas stand the risk of experiencing floods due to rising sea levels (Benson & Clay, 2004).

Benson & Clay (2004) contend that abnormal severe flooding can cause disruption to social, environmental and economic activities which in turn may affect the entire economy of the country. The UN-Habitat (2014) insists that floods can fuel landslides and soil erosion risking lives and livelihoods of the population affected. Urban areas are the most affected in a flood disaster because of their higher population density and the high accumulation of assets within their confined geographical areas, including informal settlements. The population in informal settlement, such as Marikana, the study area, may have almost nothing of physical assets such as furniture, yet they still suffer some discomfort from flooding brought about by lack of drainage systems, illegal dumping and the unevenness of the land structure which causes water ponds in the rainy season (UN-Habitat, 2014). Strategies for minimizing floods can be adopted; these may include - cleaning existing drainage channels (where there are people with a sense of ownership), putting sand bags and covering the ground around the houses with plastic sheets (Ogato, Abebe, Bantider & Geneletti, 2017).

This study looks at rainwater harvesting as a strategy to prevent or minimize the impact of flooding in informal settlements. Rainwater harvesting has the potential to successfully minimize the impact of floods on the population and the environment as the amount of water flow can be reduced when some of the rain water is captured; capturing and storing rainwater can also prevent the creation of water ponds in the area.

3.10 Drought and rainwater harvesting

Jordaan (2014: viii) defines a drought as *"a deficiency of precipitation from expected or 'normal' that, when extended over a season or longer periods of time, is insufficient to meet demands."* According to Oxfam (2016) a drought is usually associated with poor rainfall and a stronger El Nino. Drought can impact negatively on the social, economic and environmental sectors of a community. Hammill *et al.,* (2005) contend that extreme drought conditions can lead to loss of life and could exacerbate poverty conditions through the degradation of natural resources. Droughts result in water shortages and interruptions; secondary effects include escalating food prices and income insecurity from job losses and restructuring of people mainly in the agricultural and food-related production as well as the transportation sectors (Jordaan, 2014). Poor communities usually experience normal dry periods as drought because of their higher vulnerability and lack of coping mechanisms in place. Marikana is not an exception to the history of drought conditions experienced in the Gauteng Province. This community usually suffers severely from drought conditions because of its lack of fresh water. Drought is just another outcome of water shortages in Marikana; this area does not have its own available water because it has no connections to the main source of water, therefore, does not have tap water. By harvesting rain water, the community of Marikana could ease the drought burden as the collected water can be used.

3.11 Positive effects of rainwater harvesting on livelihoods

Rainwater harvesting can be promoted as an adaptation strategy towards achieving global water security, sustaining water resources and reaching the MDGs number 1 and 7, which address the need to end poverty and hunger and environmental sustainability, respectively (Dobrowksy, Mannel, Kwaadsteniet, Prozesky, Khan, & Cloete, 2014). Other benefits listed by Oxfam (2016) include the collection and storage of water close to households to improve accessibility and create convenience in terms of water supplies. The benefits of this technique can be classified as socio-economic and environmental benefits to the community and its members.

3.11.1 The socio-economic benefits of rainwater harvesting

Social economic benefits of harvesting rainwater will be discussed below.

3.11.2 The impact of rain water harvesting on education

Rain water harvesting if successfully implemented can relieve the community from the stress of water shortages. Some of the benefits of rainwater harvesting include the reduced workload for women and children who walk for long distances to search for water risking being physically attacked while performing this task (Bisoyi, 2006). In informal settlements, crime is rife because of the high drug abuse in the areas; school girls stand the risk of being raped or physically attacked in such areas when they walk to fetch water. Carrying heavy loads of water may cause spinal injuries as the women and children carry containers of water on their heads. Children sometimes miss school to carry out the task of collecting water; usually the girl children are the most affected (FAO, 2017). Rainwater harvesting could help improve school performance especially for the girl children as they fetch water for their families. Rain water harvesting could improve the availability of water which may help improve the hygiene and vulnerability of school children to diseases.

3.11.3 The impact of rain water harvesting on income and food security

The UN World Risk Report (2014) notes that water is essential for food security and household food production (domestic livestock and vegetable gardens) as well as contributing significantly to nutritional balance and diet variety. Napoli (2011:3) defines food security as *"when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life."* Excess urban population has created a competition between areas used for expanding the informal settlements and the areas used for agricultural production; this has resulted in food security being threatened (FAO, 2017). The consequences of food security are escalated food prices and the development of malnutrition, especially, in infants and the elderly. Water catchment could boost income-generation opportunities such as small gardening opportunities, from which the community members can sell their vegetables to their neighboring households, hence, building both water and food security.

The harvested water can also be used for small businesses such as car washes and hair salons. The income received from these small business activities could be used to purchase more equipment for rainwater catchment to further improve the resilience of this community towards water shortages. Some of the money earned could also be used to buy school uniform and books

for the children. Investing in education is an excellent idea for the community will then be more informed about future potential disasters and will learn skills such as plumbing and building which are helpful towards carrying out more projects of harvesting rainwater. Rainwater harvesting may be a source of income and employment for people who work in the industries that manufacture the storage tanks and for people who install the tanks, such as plumbers and builders, and for the drivers who may have to deliver the storage tanks to various destinations. If the project of harvesting rain water could roll out in Marikana, the local community members would be given the priority in terms of employment. The income received by such workers may be used for the betterment of the livelihoods of families in the settlement.

3.11.4 The impact of rain water harvesting on health and sanitation

Health and sanitation can be improved as the water harvested can be used for cleaning households, washing clothes and for washing hands after using the bathroom. Kahinda *et al.,* (2007) refer to sanitation as a crucial public health measure important for the prevention of diseases. Harvested rainwater could improve conditions of living in terms of hygiene and health standards. Rainwater harvesting could reduce the amounts of stagnant water and prevent vector insects from breeding in stagnant water (UNEP, 2009). The process could also help prevent soil erosion and flooding around the houses (Kahinda *et al.,* 2007; UNEP, 2009). Some residents of informal settlements use pit toilets as there are usually no flushable toilets due to lack of water resources. Stored rainwater has the potential to reduce the amount of ground water which quickly floods pit latrines as the ground water table changes.

Another advantage of rainwater harvesting is that water is collected at household levels so it promotes ownership of the system within communities and individual households can be responsible for the quality of their own collected water. Technology used in rainwater harvesting can be constructed from local available materials and easily installed; the process has proved to be an affordable and sustainable intervention (Twigg, 2004).

3.12 Negative effects of rainwater harvesting on livelihoods

Despite its high potential for alleviating the negative impacts of poverty, climate change and water shortages, the adoption of rainwater harvesting in urban informal settlements is low. Kahinda *et al.,* (2008) confirm that, although, non-governmental organizations, networks and community organizations are advocating for the implementation of rainwater harvesting, its adoption rate is slow. Kahinda & Taigbenu (2011) highlight some of the key challenges that may hinder its

adoption as - insufficient attention towards socio-economic factors, poor current water-related legislations, shortages or lack of finances and lack of or poor coordination from the authorities. Adopting survival strategies such as rainwater harvesting can pose challenges because of the finances needed to implement such projects in poverty-stricken communities. Poverty and vulnerability reduction rely on good understanding of livelihood activities. Bizimana (2017) lists the main barriers to rainwater harvesting as:

- Lack of a good policy on rain water harvesting;
- Insufficient knowledge and low dissemination of rain water harvesting techniques;
- Weak coordination, monitoring and evaluation of interventions at different levels;
- Limited research on rainwater harvesting practices;
- Inadequate and unreliable funding for the rainwater harvesting projects;
- Irregular source of water; and
- Difficulty in attach the gutter systems to certain types of roofs such as thatched roofs which might absorb some of the water.

Some of these challenges will be discussed in the following section.

3.12.1 Lack of a good policy on rainwater harvesting

Bizimana (2017) indicates that there is no existing clear policy on rain water harvesting in South Africa. The existing policies do not directly address rainwater harvesting but water-related issues such as protecting and conserving tap water. Kahinda & Taigbenu (2011) highlight the non-existence of a national umbrella body that coordinates rain water harvesting. Government departments and municipalities lack integration and coordination skills to deal with issues of water scarcity, hence, UN-Habitat (2014) suggest that weak institutions and governance can be overcomed through the promotion of more effective democratic institutions with greater openness and less corruption in the public management of funds. Good governance and good management of finances will help in embracing the implementation of rainwater harvesting in informal settlements.

3.12.2 Insufficient knowledge and low dissemination of rainwater harvesting techniques

Rainwater harvesting is widely practiced, mainly in rural areas of South Africa, however, very few people practice it in urban areas (Kahinda & Taigbenu, 2011). Reasons for it not being popular in

urban areas might be because clean water is readily available in urban households although not in informal settlements. Another contributing factor can be the fear of contamination from the polluted air due to smoke from industries and smoke from the coal stoves and braziers which are very popular in urban townships and informal settlements of South Africa. Lack of knowledge about benefits that may accompany rainwater harvesting makes uninformed people to regard rainwater as dirty, therefore, some people might not see the need to collect and later on use it (Desai & Dodman, 2019)..

3.12.3 Limited research on rain water harvesting

There is not enough research and information from learning institutions on both the technical and management aspects of rainwater harvesting. Further research is recommended on these aspects from Research Centers and higher educational institutions. Linking the research centers and educational institutions is relevant in order to encourage information sharing on rainwater harvesting (Desai & Dodman, 2019).

3.12.4 Rain water harvesting in relation to loss of income

Government institutions may be reluctant to encourage and support informal dwellers on rainwater harvesting projects because of fear of suppliers' loss of income through water services that are rendered to communities. Rainwater harvesting may be viewed as a threat towards the billions in income that the municipalities and suppliers of water such as Rand Water receive from citizens for water services received (Mutekwa & Kusangaya, 2006). Community members might refrain from using as much water as previously used due to the harvested rain water supplementing their daily water usage.

3.12.5 Cost of implementing rainwater harvesting techniques

The government's investment mainly focuses on water supply infrastructure while focusing less on the sources of water and strategies for obtaining fresh water (Desai & Dodman, 2019). Projects such as those of rain water collection are less famous because of lack of support and funding from government institutions, especially, in urban areas (Bizimana, 2017). Kahinda & Taigbenu (2011) confirm that the techniques and labour input required for the implementation of rain water harvesting could be expensive. This could hinder the implementation of rain water harvesting considering that most of the residents of Marikana are unemployed and could not have the means to source external labour therefore, they may have to rely on friends and family members who

might not have the skill to install the equipment. Residents might not even have the capital to purchase the necessary tools to implement rainwater harvesting. The municipality is often not interested in funding rainwater harvesting in informal settlements as it argues that the informal settlements are not legally located and demarcated according to the municipals' by-laws (UN-HABITAT, 2014).

3.13 The negative effects of rainwater harvesting on the environment

Although rain water harvesting is mostly associated with the enhancement of livelihoods within the poor communities, rainwater harvesting can also have a negative impact on the environment. Rainwater harvesting may minimize the water run-offs which in turn may affect the availability of water in the open water bodies which eventually evaporates to form rain clouds. Less rain clouds formation means less rain for future rainy seasons (Bisoyi, 2006). Such actions can also negatively affect the breeding and life of aquatic species such as fish and plant life housed in the open water bodies (Bisoyi, 2006). The consequences of this situation may include loss of income amongst those who depend on aquatic species for their income. These may include fishermen and fish-related industries like fish caning as well as manufactures of fishing equipment as they might lose business resulting in their livelihoods being undermined.

Harvesting rainwater may reduce the ground water absorption, hence, the ground water table may be lowered or dropped in levels (UNEP, 2009). Rain water harvesting may destroy the natural vegetation which depends on rain water for its wellbeing.

3.14 Acid rain and rainwater harvesting

Most of the major cities of the world are beset by environmental problems some of which are water shortages and deteriorating air quality. Air pollution is continuously worsening in cities of developing countries as a result of the rapid growth in population and increased levels of industrialization (UN-Habitat 2014). UN-Habitat (2014) indicates that African countries are low-level contributors to greenhouse gases, however, the quality of air in African cities, including South African cities is continuously deteriorating. Some of the contributing factors to this are the over-reliance of more than half of South African informal settlements, including Marikana, on paraffin, bottled gas, coal and fire wood for cooking and warming up their households (UN-Habitat 2014). All these fuels emit gases that pollute the air causing the air quality to be compromised.

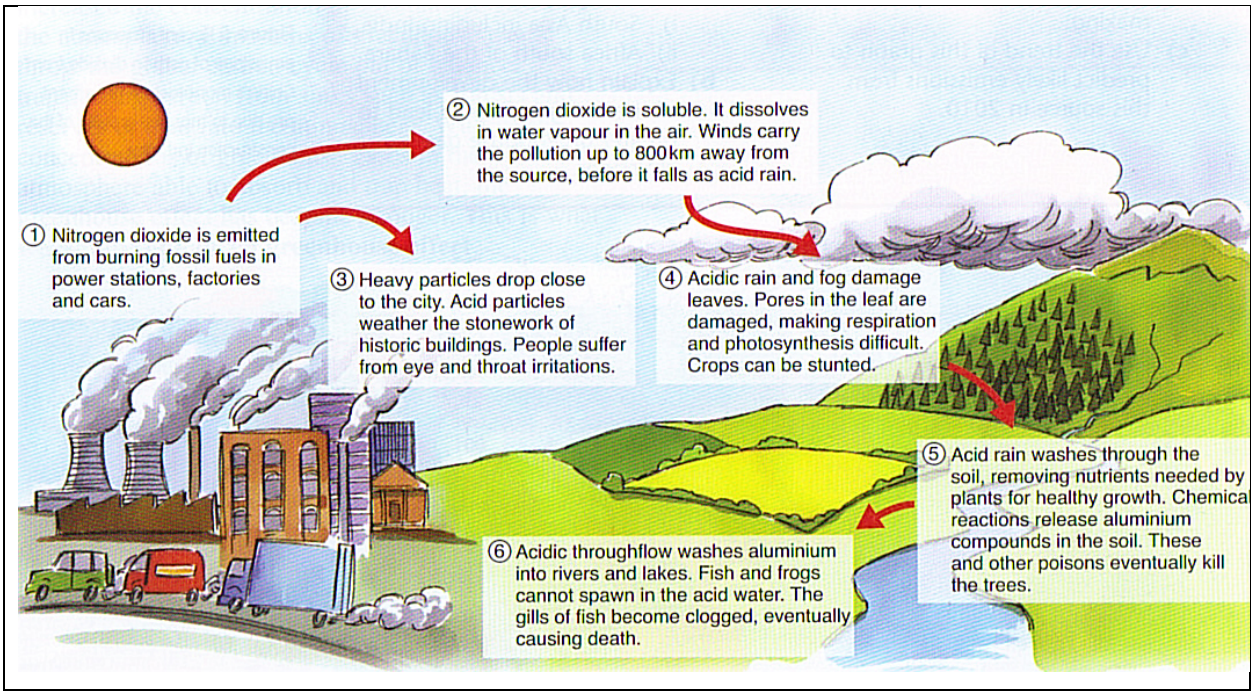
The poor air quality in turn affects the quality of rainfall received as the rainfall contains all the particles and impurities from dust and gas emissions.

Energy production causes more pollutant emissions through the combustion of fossil fuels for household heating and cooking. Large numbers of people, vehicles and concentrations of industrial activities produce high volumes of air pollutants (Asati & Deshpande, 2006). These become trapped in the atmosphere and their concentration increases; their combination with sunshine results in much warmer cities (Wamsler & Brink, 2014). High housing and population densities magnify the effects of pollution and disease. Major air pollutants include sulfur dioxide, nitrogen oxide, carbon monoxide, lead and ozone (UN-Habitat, 2014).These gases collectively contribute to the formation of acid rain which is harmful to both human beings and the environment. Acid rain is defined by Gleick (1994) as rainfall or precipitation of any form that has high levels of acidity due to atmospheric pollution. The pollution is from greenhouse gases and other pollutants that may cause environmental harm to forests, lakes and may affect the quality of rainfall, hence, affecting the quality of rainwater harvested. Other pollutants of rainwater include dust and smoke particles from fires and vehicle exhausts. FAO (2017) indicates that pollution reduces the available beneficial water and increases the costs for water treatment and purification.

The main causes of greenhouse gases are the burning of coal and other fossil fuels and emissions from industries in the form of waste gases; these contain mainly sulphur and nitrogen oxides whose combination with atmospheric water forms acids and eventually acid rain (UN-Habitat, 2014). Again the rich people are the biggest contributors to air pollution because they are the owners of the manufacturing industries which are usually located near informal settlements where the poor people reside. The rich themselves are less affected because in most cases they reside far away from the operation sites in high class suburban areas. Other major contributing factors to poor quality of air include, rapid population growth in cities and growing levels of industrialization which cause increasing demand for energy.

Urbanization, industrialization and economic growth feed each other and are the main driving forces towards air pollution and greenhouse emissions which eventually contribute to climate change (UN-Habitat 2014). Nketiaa *et al.,* (2013) however, argue that rainwater harvesting has been successfully implemented and adopted on larger scales in cities like Japan, London and Melbourne to augment the groundwater table yet these cities' greenhouse gases emitted by industries is far more than that produced in African cities. This should act as a motivation for

African cities to extensively adopt rainwater harvesting regardless of the greenhouse gases emitted daily.



Source: www.mrgscience.com

Figure 3.2: Example of greenhouse gas emissions and formation of acid rain

3.15 Rainwater harvesting and disaster management

Disasters triggered by natural hazards are a major threat to life and to sustainable development, especially in developing countries (Oxfam, 2016). Natural hazards are not new and people have been living in hazard-prone areas for centuries, it is the knowledge of how to respond to and mitigate these threats that is essential to protect themselves and their livelihoods. Disasters if not prevented could erode hard-earned gains in terms of political, environmental and social sectors (UNDP, 2017)

Africa, including South Africa is currently experiencing a significant number of unfolding transitions in political, economic, technological, demographic and environmental dimensions which make it difficult for these countries to concentrate entirely on the issues of disaster management and disaster risk reduction (UN-Habitat 2014). The above transitions have contributed to the shortages of the already-strained resources, including water resource. These transitions have brought about numerous uncertainties about future impacts on both living and non-living organisms and the environment. Governments of various countries tend to concentrate and invest more of their

financial resources in politics while forgetting the importance of investing in disaster risk reduction and management measures (Mucke, 2014).

The relationship between disaster management and rainwater harvesting will be examined with the purpose of building synergy towards disaster risk reduction and promoting the well-being of communities. Disaster management aims to prevent or minimize the potential losses in an extreme event. FAO (2017) indicates that such extreme events are now a common occurence due to the effects of climate change fueled by human activities tempering with the natural environment. Climate change has brought about fluctuations in rainfall patterns and higher temperature leading to more frequent droughts and flooding.

The disaster management cycle portrays the continuous process by which communities, government departments and other organizations intend to reduce the impact of disasters. Appropriate actions such as rainwater harvesting may lead to greater preparedness and reduced vulnerability to disasters, such as drought. Mucke (2014) indicates that even though extreme natural events pose a threat to populations, disasters do not depend entirely on these events intensity, but rather on the vulnerability of the society affected by such an extreme shock. Women's efforts in producing and selling goods and as wage earners are central to household livelihoods. More women are acting as heads of households where their husbands have migrated to find work elsewhere or have abandoned them. Such women tend to take up informal disaster management roles within their communities such as managing scarce food and water supplies (Twigg, 2004).

In informal settlements where usually the majority of the women do not work, the stored harvested rainwater may help them fight hazards like fires which might break out while their male counterparts are away at work. Such actions may prevent disasters that can cause a lot of damage to the residents and the environment. Literature by Twigg (2004) states that women possess considerable indigenous knowledge and skills important for disaster mitigation, for example, preserving drought resistant seed varieties and how to grow them; it is usually the women who are given the responsibility for keeping drinking water clean. Women, therefore should be properly represented during planning and implementation of projects because they take up a larger share of responsibilities within communities. Rainwater harvesting forms part of coping strategy in disaster management.

3.16 Rainwater harvesting as an eco-system based adaptation strategy

Rainwater harvesting serves the purposes of sustainable management, water conservation and restoration with the aim of providing services to the people in the community (IUCN, 2009). Rain water harvesting can be seen as one of the Ecosystem-based Adaptation (EbA) strategies that contribute to reducing vulnerability and to increase resilience to both climate and non-climate risks; this can provide multiple benefits to the society and the environment (IUCN, 2009).

If implemented in Marikana informal settlement, the collected and stored rainwater could be used to water gardens during the frequent dry spells fueled by climate change. Such actions could, in turn, support food security.

3.17 Rainwater harvesting as an adaptation strategy towards climate change

Climate Change (CC) is, according to Kahinda, Taigbenu & Boroto (2010), an additional threat that exerts extra pressure on the already-strained hydrological system. The South African National Disaster Management Act as amended (RSA NDMA, 2002:8) defines 'climate change' as "*a change in the state of the climate that can be identified by changes in the variability of its properties and that persists for an extended period, typically decades or longer."* The effects of climate change are being felt severely, although, sometimes masked by the South African climate variability. Benson & Clay (2004) explicate climatic change as altering the frequency and intensity of extreme events, such as flood hazard events with implications on the scale and nature of vulnerability, this situation is continuously bringing significant uncertainties in future water supply.

According to Gleick (1994) climate change can either increase or decrease average water availability in different times and in different places impacting mostly, agriculture, ecosystem services, health, biodiversity, water availability and quality as well as reducing wetland areas. Climate change has resulted in extreme climatic events with increasing intensity and frequency of events such as drought and floods. It also has the capability of changing a river flow in a catchment and may seriously affect the water supply in urban areas and in informal settlements.

Climate change is expected to continue exacerbating water scarcity in an already water-strained communities where demand for water exceeds supply. Ogato *et al.,* (2017) predicts that climate change could affect urban flooding, water shortages, wind and dust storms leading to inhabitants being vulnerable to a range of immediate and acute or slow onset disasters. The UN World Risk Report (2014) insists that climate change has the potential to affect the land in such a way that it

becomes unsuitable for crop production as well as animal husbandry, thus, negatively affecting food supply. Temperature and rainfall variations are continuously increasing and intensifying due to the effects of climate change (Kahinda *et al.,* 2010). Unpredicted higher temperatures may lead to substantial increases in evaporation which could decrease water supply and increase demand. UN-Habitat (2014) points out that climate change will increase the risk in environments where economies depend on small scale agriculture and animal husbandry; higher temperatures can directly impair productivity and health of livestock (FAO, 2017).

3.18 Linking rainwater harvesting to poverty

Poverty is defined by Monodou (2016:2) as "*the inability to meet one's basic economic needs*." Poverty has a number of harmful health and environmental effects.

UN (1998:1) defines poverty as "*a denial of choices and opportunities, a violation of human dignity. Lack of basic capacity to participate effectively in society. It means not having enough to feed and clothe a family, not having a school or clinic to go to, not having the land on which to grow one's food or a job to earn one's living, not having access to credit. It means insecurity, powerlessness and exclusion of individuals, households and communities. It means susceptibility to violence, and it often implies living on marginal or fragile environments, without access to clean water or sanitation."*

Poverty results in an increase in birth rates among the poor people because they believe that many children will help to fetch water, grow food and work to help their parents (UN-Habitat 2014). In some instances, poverty accelerates the increases of birth rates in informal settlements because some of the settlers take sexual activities as pass-time activities because they lack recreational activities, such as sport. The United Nations Development Program (UNDP) (2007) estimates that it costs $12 billion a year to provide basic services such as safe water and sanitation in poor developing countries while first world citizens like Americans and Europeans, spend equivalent amounts on perfumes per annum (UN-Habitat 2014). Informal traders tend to take advantage of the situation of water scarcity and sell water at high prices making handsome profits for themselves (UN-Habitat 2014). The informal traders contribute to the high rates of poverty because they only think of making profits for themselves without considering how much they actually rip off the poor people.

Poverty forces people to live in the most polluted and dangerous areas categorised as 'urban waste-lands', where there are no legal titles to property (Monodou, 2016). People live in fear of

eviction as they have little or no incentives to invest in private or communal mitigation measures. According to UN Habitat (2015) the majority of people from informal settlements work as unskilled laborers getting paid the very low wages. WHO (2003) also indicates that poor families which have no access to safe water more often find themselves even poorer as lack of safe water may lead to ill-health; poor people often work as daily cheap laborers, hence, ill-health immediately disqualifies them from getting their pay whenever they are absent.

De Moraes & Rocha (2013) point out that the lack of access to water undermine efforts to suppress the degree of poverty in any community. The practice of rainwater harvesting can therefore, contribute to poverty eradication and economic growth as it has the potential to improve the agricultural system which may in turn generate jobs and income for the employees to support their households (FAO, 2017). DFID (2002) in its Agenda 21 insists that poverty can be eradicated by improving the provision of basic utilities such as water, sanitation, energy and waste management. This assertion is viable because if harvested, rainwater can be used to water gardens, children would perform better at school because they could have more time to attend to their school work instead of spending most of their time fetching water, and small businesses, such as car washes would survive better because of the availability of harvested rainwater. Rainwater harvesting, therefore, may improve livelihoods within the poverty-stricken communities like Marikana.

3.19 Chapter summary

In this chapter, the researcher has investigated literature related to disaster risk reduction and building resilience in urban informal settlements with specific reference to rainwater harvesting. A number of issues emanating from the review point to the fact that rainwater harvesting activities are associated with both positive and negative consequences. It highlighted the importance of rainwater harvesting in impoverished informal settlements where there are no basic resources needed to sustain livelihoods. Causes of the mushrooming of informal settlements in urban areas, urbanization, were looked at. Rainwater harvesting may contribute to sustaining livelihoods for people using their various capitals as discussed in chapter 2 of this study. This chapter also highlighted rainwater harvesting as having the potential to reduce the impact of drought, fires and flood hazards while building resilience within the communities. The discussions also indicated that the availability of stored harvested rain water could help save lives, property and the environment as it could be used to extinguish events like fires, in areas such as Marikana where shack fires are frequent due to the type of materials used to build the shacks being highly

combustible. This chapter also linked rainwater harvesting to poverty eradication and as a possible strategy to support the priorities of disaster risk reduction and management.

Chapter 4: MATERIALS AND METHODS

4.1 Introduction

This chapter describes the research design and methods that were followed to address the research questions and objectives as stated in chapter 1 of this study. The chapter is divided into two sections. The first section covers the research approach that was adopted in this study to collect data and then details the actual methods that were used to carry out the research, including the target population and sample size, the sampling method and sampling process. The data collection instrument and processes are also explained and finally, an explanation is given on how the collected data were analyzed and presented, to determine whether the set research questions and objectives were met.

The second section outlines the problems that were encountered during the research process under a limitations section; issues regarding reliability and validity of the research instrument that was used to collect data are also discussed here. Matters regarding compliance to the rules of guiding academic studies are addressed under ethical considerations. This chapter, thus, expands on the research methodology that was briefly highlighted in chapter 1 of this study. The research design is discussed next.

4.2 Research design

Pandey & Pandey (2015) describe a research design as a framework or plan for a study that is used as a guide in collecting and analyzing the data; sometimes it is referred to as a 'blueprint' that is followed to conduct a study. A research design, according to Pandey & Pandey (2015) may have a strong influence on the results obtained. The function of the research design is to provide for the collection of relevant evidence while minimizing the effort applied, time and monetary expenses (Kothari, 2004).

This study adopted the mixed methods approach by involving both quantitative and qualitative research methods. Mixed methods research is defined by Creswell & Garrett (2008:322) as "an approach to inquiry in which the researcher links, in some way, both *quantitative and qualitative data to provide a unified understanding of a research problem."* Creswell (2003) traces the origin of this concept of mixing different methods to approximately 1959 when multiple methods were used to study psychological and validity traits in subjects.

The mixed methods approach was embraced in this study because the researcher took cognizance of the limitations and bias that might be inherent in one single research method and felt that through the use of mixed methods, some of such limitations might be neutralized (Creswell, 2003). Johnson, Onwuegbuzie & Turner (2007) support the use of mixed methods research by insisting that the approach attempts to consider multiple viewpoints, positions and perspectives of both qualitative and quantitative methods thus bridging the schism between quantitative and qualitative researches. Some of the merits in using the mixed research method as listed by Creswell (2014) include - its ability to address predictive and explanatory research questions simultaneously, its provision of stronger inferences as opposed to a single method approach and its ability to combine different strengths from different paradigms to overcome the weaknesses of each approach. In addition to the advantages listed above, Johnson *et al.,* (2007) lists some of the advantages of using the mixed methods approach as - the boosting of researchers' confidence in their research results, collection of thick and richer data, the uncovering of contradictions and its potential of leading to well-formed synthesis. All these advantages motivated the researcher to embrace the use of the Mixed Methods approach in this study.

Mixed research method is divided into four typologies for simplification, these include the triangulation, embedded, explanatory and exploratory designs (Johnson *et al.,* 2007). This study employed the triangulation design of the mixed methods approach. Triangulation is believed to validate a methodology by providing an examination of the results from several perspectives. Triangulation according to Creswell (2003) focuses on the convergence of qualitative and quantitative data through simultaneously collecting and analyzing both qualitative and quantitative data. This method is said to have the ability to simultaneously use the gathered information from different sources thus displaying the results in an efficient manner (Almalki, 2016).

Using triangulation does not make conducting the study easy as it also has its own impediments. Blaikie (2000) indicates that even though the data may be analyzed simultaneously using triangulation, the results may generate two incorrect but similar conclusions: this might deceive the researcher who might come up with wrong conclusions on the subject matter. Creswell (2003) also warns that the use of mixed methodology may be time-consuming as two different types of data must be analyzed - text and numerical data. The researcher however, opted to adopt this methodology despite the warnings, on the assumption that the advantages of using such an approach outweigh the disadvantages.

4.3 Methodology

4.3.1 Population

Population, according to Salkind (2014) refers to a group of potential participants to whom the researcher wants to generalize the results of a study. The target population for this study are the people residing in Marikana informal settlement in Kwathema township in Ekurhuleni Metropolitan Municipality. There are no formal records regarding the actual population in this study area since it is an informal settlement, however, the community leader of Marikana informal settlement indicated that there are approximately 550 shacks in this informal settlement; each shack contains families or individual occupants who form the households.

4.3.2 Sample size and the sampling process

The extent of the population in this area signaled the extent of resources, such as time and finances, needed to conduct the study. The constraint on the available resources, meant the researcher opted to choose the sample the population very judiciously, ruling out any possible circumstances that could lead to a compromise of the representativeness and quality of the data collected.

Sampling is referred to as a way of selecting a given number of subjects from a defined population to represent the entire population (Pandey & Pandey, 2015). Sampling is ideal in this study because it saved time as well as human and financial resources, however, it has disadvantages such as, it does not cover the entire population but only an estimate of the population (Kumar, 2011). The researcher decided to use a sample size of 102 to collect raw data after critically considering the total population and the available resources. Data were collected using primary and secondary sources, with the primary source being the selected sample of respondents and the secondary information to confirm the primary data. Secondary information that were used consisted of published sources, including textbooks, journals, previous research and online scholarly articles to support and or critique the raw data collected. The targeted sample as primary sources of data were the heads of each selected household, regardless of whether the head of the household was male or female. The primary data were collected using questionnaires together with field observation of the overall environment by the researcher. Photographs were also taken using a smart phone to form part of this study.

This study adopted simple random sampling which is a probability sampling to collect raw data from the respondents. Pandey & Pandey (2015); Creswell (2014); Kothari (2004) assert that in simple random sampling, each element of the entire population has an equal and independent chance of being selected as a representative of the population. The sample size of 102 respondents were selected for the study as an optimum sample size because the researcher felt that such a sample amount would be suitable to yield viable results for the study. An optimum sample is, according to Kothari (2004) one that fulfills the requirements of representativeness, efficiency, reliability, flexibility and budget. The sample were selected randomly using a door-to-door transect walk through the area of Marikana where a head of a household was present to participate in the study.

4.3.3 Data collection instrument – Questionnaire

This study opted for the use of questionnaires to collect data. Pandey & Pandey (2015:58) define a questionnaire as *"a form prepared and distributed to secure responses to certain questions. It is a device for securing answers to questions by using a form which the respondent will fill by himself."* A questionnaire was used to collect primary data for this survey because of its easiness to prepare and administer. Kothari (2004) supports the use of questionnaires in a study by outlining that a questionnaire is less expensive, saves both financial and human resources and that its use is convenient to both the user and the recipient. Kumar (2011), however, critiques the use of a questionnaire by indicating that its use might be limited to a sample that can read and write and that in some cases, the structured responses cannot be supplemented with other information. To overcome such a challenge, the researcher verbally explained, where necessary in vernacular, to the participants any wording or concepts that the participants did not clearly understand to avoid wrong responses, which could negatively affect the research findings. The questionnaire was prepared very carefully so that it could be effectively used to collect the relevant information for this study. An example of the questionnaire is attached as Appendix 1.

The questionnaire contained both closed and open-ended questions. The open-ended questions were utilized in instances where the opinion of the respondent was required without the researcher limiting their responses. Kumar (2011) believes that open-ended questions may provide a wealthy and great variety of information provided that the participants are comfortable in expressing their opinions. The closed-ended questions were answered by choosing an appropriate answer from the optional statements depicted by numbers 1 to 5. Some of the questions included Likert scale sort of questions where respondents were given a chance to

record the extent of their agreement or disagreement (Creswell, 2014). Prior to being dispensed, the questionnaire was sent to the researcher's study supervisor to critically examine each question and its meaning as may be understood by the respondents. The questionnaire was also examined for their comprehensibility, completeness, consistency and reliability. Only after the supervisor's approval was the questionnaire deemed ready to be distributed to the respondents. The researcher requested for permission to conduct the study in Marikana informal settlement from the community leader through a written letter which is attached as Appendix 2. The services of two research assistants were solicited; the research assistants were both active members of the Community Emergency Response Team (CERT) in the City of Ekurhuleni (CoE) therefore, they were familiar with the study area.

The researcher commenced the process of the distribution by discussing the entire questionnaire with the research assistants in order to familiarize them with the study and its intentions. The researcher with the assistants, then administered the questionnaires to the heads of household who were randomly selected. The aim of physically administering the questionnaires to the respondents was to be able to identify them and to attend to any possible problems that could arise in understanding the wording and whether the respondents understood the questions the same way that the researcher intended. This approach was advantageous because the researcher was available to re-examine or re-phrase the wording to make it clearer and unambiguous should such a need occur.

102 questionnaires were randomly distributed to the head of the household present at the time. Out of the 102 questionnaires distributed, one was inaccurately completed, hence, leaving the researcher with 101 valid questionnaires for analysis.

4.3.4 Data analysis and presentation of results

Data analysis and presentation of results will be discussed next.

4.3.4.1 Data analysis

Data analysis is described as a process of studying raw data to turn it into information (Pandey & Pandey, 2015). The completed questionnaires were then numbered from 1 to 101 and stored in a lock-up cupboard before being coded on the Microsoft excel spreadsheet as a starting point for the data analysis process. The main purpose of analyzing the data is to turn it into usable

information that can address the research problem. The use of closed-ended and open-ended questions in the questionnaires enabled the use of both statistical and text analysis to analyze the data collected (Creswell, 2014).

The collected data were classified into quantitative and qualitative data. The latter were then coded on the Microsoft excel spreadsheet and entered into the Statistical Package for Social Science (SPSS) software to transform it into information. The open-ended questions of the questionnaires together with the informal field observations formed part of the data that were analyzed qualitatively using themes summarized from the direct statements of the respondents' i written answers. The researcher solicited the services of an agricultural economist from the Department of Disaster Management Training and Education Centre for Africa (DiMTEC) at the University of the Free State (UFS) to assist with data analysis using the SPSS software.

4.3.4.2 Presentation of results

The analyzed data were then presented using percentages of the outcomes and various charts, including the pie charts, bar charts and photographs to determine the possible relationships amongst the different variables within the study and whether introducing rainwater harvesting in Marikana could be viable.

4.3.5 Validity and reliability of the collected data

4.3.5.1 Validity

Validity is, according to Kumar (2011), the ability of an instrument to measure only that which it is designed and anticipated to measure. In this study the notion of validity was applied to the questionnaire which was used to collect primary data to address the research questions. Validity also led the researcher to the issue of reliability because the two notions are related to each other.

4.3.5.2 Reliability

Pandey & Pandey (2015) refer to reliability as repeated consistency in the results of a measurement activity. Kumar (2011) confirms the definition of reliability by stating that the greater the degree of consistency and stability in an instrument, the greater its reliability. The questionnaire was a suitable reliable tool for this study.

4.4 Ethical considerations

Every profession is guided by a code of conduct, and academia are no exception. Academia has its own code of conduct that researchers adhere to including ethical standards that govern the way research matters should be carried out. Kumar (2011) refers to ethical adherence as behavior in accordance with principles of conduct that are considered correct. Ethics helped the researcher to avoid bias and the use of inappropriate research methodology in conducting the research.

The researcher acquired an ethical clearance certificate from the ethical committee of the UFS and is attached as Appendix 4. Participants signed the front page of the questionnaire indicating their interest to participate in the study before completing the questionnaires. Some of the participants entered their names on the questionnaires out of their own free will even after the researcher insisted that it was not necessary for them to do so. The researcher acknowledged the use of secondary information by referencing the authors whose ideas were used in the text and by listing them at the end of the entire research.

The aim of the research on harnessing the idea of rainwater harvesting to mitigate against potential disasters and to build water resilience in the community of Marikana was disclosed to the respondents. The research participants were also assured of the issues of confidentiality and that their opinion would not be shared for any other purpose except that of the study.

4.5 Limitations of the study

This study contains certain limiting conditions, however, careful thought was given as to how these limitations could be addressed to minimize their possible impact on the study. Limitations refer to influences, shortcomings or conditions that the researcher cannot control yet they may place restrictions on methodology and conclusions of the study (James & Murnan, 2004). Some of the problems encountered during the study were that it was difficult to acquire the data from the heads of the households as some of them were working and they left their homes very early in the morning and only returned late in the evenings. This nevertheless did not deter the efforts of the researcher to conduct the research, who arranged for suitable times to meet the head of the household. On rare occasions, a representative of the head of the household, either the spouse or the eldest child took the responsibility to fill in the questionnaire.

The researcher experienced a challenge of respondents being hesitant to provide information freely. This was partially because respondents thought that the study was linked to the election

campaigns that were taking place in the area as it was around the time of the national and provincial elections. The respondents were suspicious despite the researcher clearly indicating to them both on the questionnaire and verbally that the study was strictly an academic study.

The researcher also faced the challenge of water-logging. This was possible considering that the survey was conducted during a time when the area was experiencing its heavy end of season rains. Water-logging made it almost impossible to freely navigate the area but because of determination, the researcher conquered the challenge by wearing suitable gear, such as rain boots, to continue with the study.

Although not really a challenge, the researcher felt that it should be mentioned that the shacks in Marikana are built very close to each other and are almost identical in structure, therefore, the responses to some of the questions might be the same as the respondents' experiences are similar.

4.6 Chapter summary

This chapter provided a detailed description of the research methodology adopted for the study. A mixed methods research design was employed in this study thus involving both quantitative and qualitative approaches. A total of 101 questionnaires were administered to generate primary data. The primary data were then analyzed using Microsoft Excel spreadsheets and SPSS to transform it into information. The data was finally presented using graphs, pie charts, and photographs. Issues of the academic code of conduct through observation of ethical principles were addressed under the section on ethical considerations. Finally, limitations which could have been potential stumbling blocks towards the accomplishment of this study were highlighted and solutions that were applied to address these issues were revealed in this chapter.

Chapter 5: DATA ANALYSIS, PRESENTATION AND DISCUSSION OF RESULTS

5.1 Introduction

This chapter explores how the data collected from the field were analysed to address the research objectives. This chapter is generally regarded as the final step in a survey where the findings are interpreted in the light of the research questions of the study (Creswell, 2014). Interpretation, according to Kothari (2004) refers to the point where the researcher seeks to explain the findings on the basis of some theory, also known as generalisation. The results presented here are used as the foundation for the conclusions and recommendations for the entire study.

The data were condensed into five manageable sections for analysis. The first section presents the demographics of the respondents while the second section explores their socio-economic dimensions. Awareness and perceptions of the respondents on issues of rainwater harvesting are presented in section three of this chapter. The fourth section examines the issues of preparedness of the respondents in terms of potential water-related hazards. Finally, the fifth section presents the potential challenges of rainwater harvesting. Table 5.1 below shows how the questions were grouped within the questionnaire under the five sections.

Table 5.1: Sectional guide in primary data analysis

Section	Question in the questionnaire	Data collection tools
1. Demographics of respondents	A1-A6	Questionnaire
2. Socio-economic dimensions of respondents	B1-B6	Questionnaire
3. Awareness	C1-C8	Questionnaire
4. Preparedness	D1-D5	Questionnaire
5. Resources	E1-E16	Questionnaire

Source: Field survey (2019)

SECTION 1

5.2 Demographic charateristics

This section provides the demographic characteristics of the respondents, in terms of gender, age group and household size. Hundred and one (101) respondents in the study area completed the questionnaire and Table 5.2 below summarises their demographic background.

Table 5.2: Summary of demographic background of respondents

Parameter	Number	Percentage %
Gender		
Female	59	58.4
Male	42	41.6
Age		
18-25	7	6.9
26-45	45	44.6
46-60	33	32.7
60+	16	15.8
Modal age	26-45	44.6
Household size		
1-3	23	22.8
4-6	75	74.3
7+	3	3.0
Years lived in the area		
0-5	34	33.7
6-10	61	60.4
10+	6	5.9

Source: Field survey (2019)

5.2.1 Gender of respondents

From the total of 101 respondents to whom the questionnaires were administered, 59 (58.4%) were females and 42 (41.6%) were males. Field observation confirmed this split and out of curiosity, the researcher asked the respondents why there were more females heading households than men. The females who completed the questionnaires when verbally asked by

the researcher if they were the heads of the household, indicated that they were either the main members of the household or indicated that they represented the male heads of their households who were absent because they had gone for work. This shows that women are the most affected by the water scarcity because often they were the ones present to see that the household duties are taken care of and to ensure that there is enough water in their houses to prepare food and for their male partners to take a bath after returning from work and before going for work the next day. If properly enlightened, it shows that these female respondents would gladly embrace the technique of harvesting rainwater in order to ease the burden of walking for long distances in search of water.

5.2.2 Age of respondents

The modal age range of the participants was 26-45 or 44.6%. This was probably because this age group is of working age and the most active age group. This age group is usually out of school and ready to fend for themselves, thus, decreasing their dependency on their parents and legal guardians. The majority of such a population migrate to cities where they find themselves in areas such as Marikana 'arrival cities' while they try to establish themselves. This age group although physically fit and energetic to walk long distances in search of water, can, if well mentored, be the best advocates for rain water harvesting; their main interest is to find economic opportunities, therefore, cannot afford to spend most of their time fetching water as it is time consuming. Some of the respondents 33(32.7%) fell between 46-60 age group. This age group can easily embrace the idea of harvesting rainwater as they may start suffering from aches and pain as they grow older, hence might not want to continue walking long distances in search of water. Basarada (2019) confirms this by indicating that 9 in 10 people experience age-related illnesses as they grow older; some of the common diseases include arthritis and high blood pressure. Such conditions could make it difficult for the affected people to walk for longer distances hence, they would opt for options such as harvesting rain water rather than walking far to search for water.

Furthermore, 16 (15.8%) of the respondents fell in the above-60 age group. Older persons, above age 60, tend to be underrepresented amongst people living in informal settlements due to the fact that once the population are above 60 years, they tend to go back to the homelands after retirement and leave their children in the urban areas. The 16 above-60-years respondents indicated that they knew about rainwater harvesting based on indigenous knowledge and that they informally collected rain water on a smaller scale. This population therefore, showed a lot of

interest in the whole concept as they pointed out that they suffered from some health issues which were affecting their ability to fetch water from long distances. From the 101 respondents, 7 (6.9%) were between 18-25 years. These respondents represented their parents who were absent even after the researcher had made an appointment to meet with them. These respondents did not show any interest in harvesting rainwater and gave the impression that such issues were the responsibility of their parents.

5.2.3 Household size

One significant consideration that influences the amount of water usage, per day per household, is the size of the household. The results as presented in Table 5.2 show that the majority, 75 (74.3%) out of the 101 respondents indicated that their families had between 4-6 members and 23 (22.8%) of the respondents indicated that there were between 1-3 members of their household living together. Only 3 (3.0%) of the respondents indicated that there were more than 7 members living in the same household. The amount of water used per household depends on the number of people living in a particular household. The higher the number of household members the more water they would need. The households with more members should be the first to be considered in the implementation of a pilot study on rainwater harvesting and they should be seriously encouraged to adopt the technique considering that they use more water. The initiative should be followed by those who indicated that there were between 4 and 6 members in their household as they were the households with the second highest number of occupants.

5.2.4 Years lived in the area

The results indicate that a majority of the respondents (60.4%) have lived in the community between 6-10 years. Furthermore, 34 respondents in Table 5.2 showed that they had lived in the area for 5 years or less. Quite a small number of respondents (6) indicated that they had lived in Marikana for 10 years and more. Marikana community is said to have been established in 1993 (Ekurhuleni voice, 2013), hence, this shows that some of these respondents had lived in the area since it was established. In the context of the Sustainable Livelihood Framework which was adopted for purposes of this study, residents of Marikana are exposed to vulnerabilities including floods caused by adverse weather conditions. Such conditions bring about hazards such as floods, which can cause devastating conditions. It is therefore, important to note that residents who had lived in the area for a long period, (10+ years) can display indigenous knowledge and better coping strategies to hazards such as floods. These residents indicated that they practiced

rainwater harvesting on a small scale, as a way of preventing their surroundings from becoming water-logged. This was in addition to the sand bags and plastic sheets that they placed around their shacks as coping mechanisms to reduce the negative impact that any flood hazard may cause (Ogato *et al.,* 2017). This shows that these residents had experience and better knowledge about the area and coping capacities to build resilience. This will form part of the recommendations that residents who lived longer in the area pass over such valuable knowledge to the rest of the residents in the area.

SECTION 2

5.3 Social-economic dimensions of respondents

This section represents the social-economic dynamics of the respondents. These dynamics include the levels of education, the employment status of respondents, their total income per month and the type of materials that their shacks are built from. Table 5.3 summarises the socio-economic characteristics of the study respondents.

Table 5.3: Summary of socio-economic dimensions of respondents

Parameter	Number	Percentage %
Education level		
No formal education	1	1.0
Primary	9	8.9
Secondary	66	65.3
Certificate	24	23.8
Diploma	1	1.0
Degree	0	0
Post Graduate	0	0
Employment status		
Public sector	25	24.8
Private sector	26	25.7
Self-employed	11	10.9
Unemployed	39	38.6
Household total income per month		
R100-R1000	30	29.7
R1001-R2000	28	27.7
R2001-R3000	7	6.9

R3001-R4000	32	31.7
R4001+	4	4.0
Building material used		
Corrugated iron sheets	96	95
Bricks and cement	5	4.9
Cardboards	0	0
Mud and rocks	0	0
Wood and plastics	0	0

Source: Field survey (2019)

5.3.1 Level of education

Out of the 101 respondents who completed the questionnaire, 1 (1%) indicated that she had no formal education; 9 (8.9%) stated that they had primary level education; 66 (65.3%) indicated that they had secondary level education; 23.8% had attained college certificates while 1(1%) male respondent had obtained a diploma in his education career. None of the respondents had achieved either a degree or a post-graduate qualification. The overall educational results of this study show that 100 (99%) participants of this survey had obtained some formal education.

The participants were knowledgeable since some of them had different skills which might be relevant in the implementation of rainwater harvesting as most of them are either high school or technical school leavers who migrated to this area in search of jobs. This supports literature from UNDP (2017) which states that formal education, although vital, is not the only means by which human capital can be improved but also through skills and indigenous knowledge. Literature by Desai & Dodman (2018) also supports this statement by insisting that informal settlements are often sites of ingenuity, creativity and resilience, hence these residents make up a significant share of the labour force, delivering essential services such as transport, waste management, construction and water and sanitation to their middle and high class neighbourhoods. Despite the fact that they provide such services, informal dwellers themselves usually lack access to the same basic public services which they render.

5.3.2 Employment status

A total of 51 (50.5%) respondents indicated that they were in employment, either in the public or private sector. Those in the private sector constitute 25.7%; the private sector here represents those who work in firms, supermarkets and retail stores in the neighbouring towns of Springs and Brakpan. Those who indicated that they work in the public sector (24.8%) mentioned that they

worked in schools and clinics in the neighbouring townships as low-paid employees, such as cleaners and gardeners. The above-mentioned respondents although in employment, could not afford to purchase for themselves decent houses because of their low salaries, therefore, they continued to live in this informal settlement. 11 (10.9%) indicated that they were self-employed, meaning that they were running their own businesses, such as hair salons, car washes, informal fast foods, small grocery, and fruit and vegetable shops. Some of the respondents mentioned that they picked up waste products, such as empty cold drink containers and cans for recycling so that they could get some income. Most of these small businesses depend on water resource for survival. These could be good candidates of rainwater harvesting as it can save the working class time and sustain small businesses that depend on the water resource. The rest of the participants 38.6% (39) stated that they were unemployed. This was a relatively big number of the respondents who were not in employment.

Marikana is a poor community, about 50% (10.9% self-employed and 38.6% unemployed) had no formal employment so they depended on the government's social grants for survival. Some of the government's social grants that they depended on include child support grants (for children between the ages of 0 and 18 years old whose parents have no formal employment), the disability grants (for the physically and mentally-impaired citizens) and the old age grant (whose qualifying citizens are those aged 60 years and above). In some instances, small businesses are the only source of income in some households where there are no members who qualify for any of the government's social grant categories.

The availability of harvested rainwater could improve the livelihoods of the unemployed in the study area by, for example, the breeding of livestock which increase rapidly in their numbers. The community can rear chickens and keep goats for consumption as well as for selling within their neighborhood for an income. If rainwater is harvested, women and girl children who often walk long distances in search of water could now use their valuable time to do other things like school work for girls and handcrafting for the women which can earn them a skill as well as an extra income to support their families. Social capital, in the form of acquired skills is essential for good human wellbeing and sense of belonging in the community. DFID (2000) emphasizes that poverty analysis show that the ability of people to break free from poverty depends upon their accessibility to assets.

5.3.3 Monthly income

The results in Table 5.3 indicate that 30 (29.7%) of survey respondents had a total monthly income of R100-R1000, 28 (27.7%) had a sum of between R1001-R2000 a month; 7 (6.9%) respondents and 32 (31.7%) respondents marked on their questionnaire the categories of R2001-R3000 and above R3001-R4000 respectively. Only 4 (4%) responded that they earned a total of R4001+ per month. These levels consisted of combined income in a household either from government social grants or from salaries and or any other forms of income that the household received on a monthly basis. The results in Table 5.3 show that 29.7% revealed that their total household income per month fell within the bracket of R100-R1000; this is a small income for a family to survive on while also purchasing water. These low income levels show that the respondents are living below the poverty line, hence, most of them depend on the government's social grants for survival. These income proportions show the potential of increasing poverty levels amongst the residents, as such low incomes cannot support people to bounce back in an extreme event of a disaster. These low incomes prevents residents from accessing insurance opportunities as they cannot afford to pay insurance premiums.

Enninful (2013) supports the idea of harvesting rainwater stating that it has benefits, such as enabling households to save money which could instead have been used to pay for water for everyday household requirements. These results again support lack of resources (money) as a contributing factor to the community not owning containers for harvesting rain water. Besides the reasons stated above, the researcher strongly felt that ignorance could be the main reason this community did not practice rainwater harvesting; most use containers to fetch water from the communal taps; these , therefore can be used for rainwater storage containers, although, they may not be very conducive for this activity. It is evident in Marikana that those who rear chickens and goats sometimes sell their livestock and vegetables and their proceeds can be used to purchase some equipment required for harvesting rainwater and other household products.

5.3.4 Building material used

The majority 96 (95%) indicated that their houses/shacks were made out of corrugated iron sheets while only 5 (4.9%) of the participants stated that they built their shelter from bricks and cement. These results show that this area is dominated by shacks. The fact that the majority of the shacks in this area are built from fire prone materials indicates the possibility of fire dangers in the area and that these homes would not be spared from any high temperatures fuelled by effects of

climate change. Harvesting rainwater stored could be used as a proactive measure in case of a fire where the stored harvested rainwater could be used to fight fires

SECTION 3

5.4 Awareness regarding issues of rainwater harvesting

The respondents were asked to indicate whether they had any knowledge about water scarcity and rain water harvesting by indicating either “yes” or “no” to the statements on the questionnaire.

Table 5.4: Water is a scarce resource

	Water is scarce resource	
	Percentage (%)	Frequency
Yes	40.6	41
No	59.4	60
Total	100	101

Source: Field Survey (2019)

The results in Table 5.4 show that 41 (40.6%) of the participants agreed that water is a scarce resource while 60 (59.4%) disagreed. It was observed that the majority of the respondents disagreed that water was a scarce resource because they seemed not to have any knowledge about environmental issues. The fact that they did not know or believe that water is a scarce resource was quite worrying to the researcher, since these respondents are the same people who would be executing ideas on rainwater harvesting. This shows that the levels of awareness regarding water and water related issues are low amongst the residents in the area.

Table 5.5: “I have heard about RWH”

	“I have heard about RWH”	
	Percentage (%)	Frequency
Yes	87.1	88
No	12.9	13
Total	100	101

Source: Field survey (2019)

When asked to indicate whether they had heard about RWH (Table 5.5), the majority 88 (87.1%) of the respondents indicated that they had heard about RWH. Some respondents (12.9%) indicated that they had never heard about rain water harvesting. From the responses, it can be deduced that the greater number of respondents had heard about rain water harvesting.

Table 5.6: “I know the meaning of RWH”

	“I know the meaning of RWH”	
	Percentage (%)	Frequency
Yes	94.1	95
No	5.9	06
Total	100	101

Source: Field survey (2019)

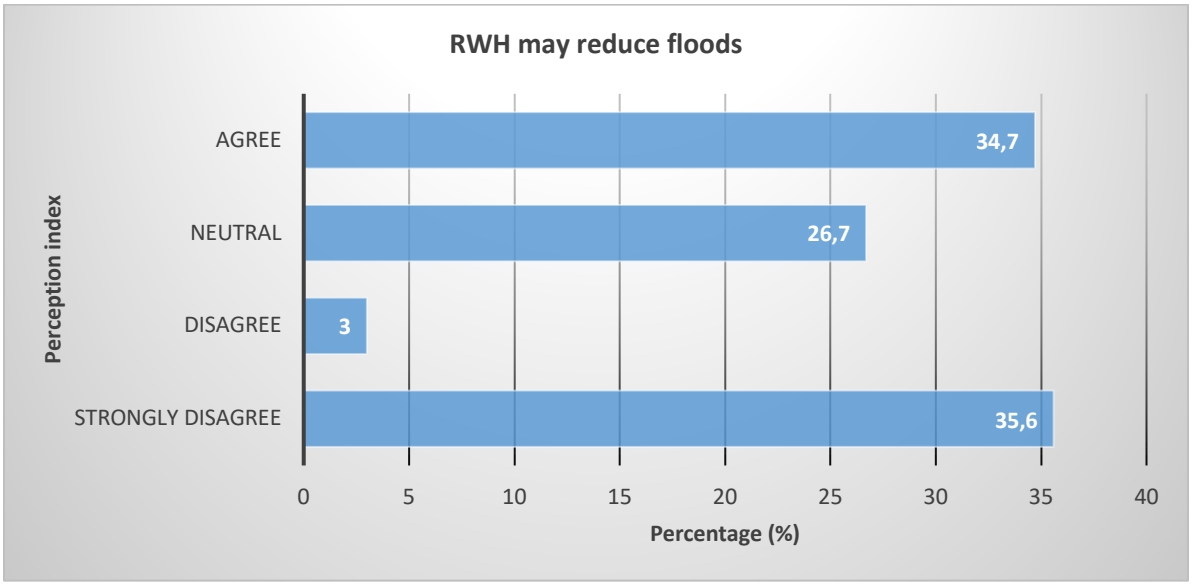
The respondents were asked if they knew the meaning of rainwater harvesting. Most, 95 (94.1%) indicated that they knew what rainwater harvesting meant while only 6 (5.9%) did not know. Although 95 respondents indicated that they knew the meaning of RWH as compared to 6 respondents who said they did not know, Figure 5.5 shows that only 17 of the respondents practiced rainwater harvesting. This reveals that respondents were either ignorant, lacked resources or were simply not interested in the idea of harvesting rainwater.

Table 5.7: “Community leaders educate us about RWH”

	“Community leaders educate us about RWH”	
	Percentage (%)	Frequency
Yes	1.9	2
No	98.1	99
Total	100	101

Source: Field survey (2019)

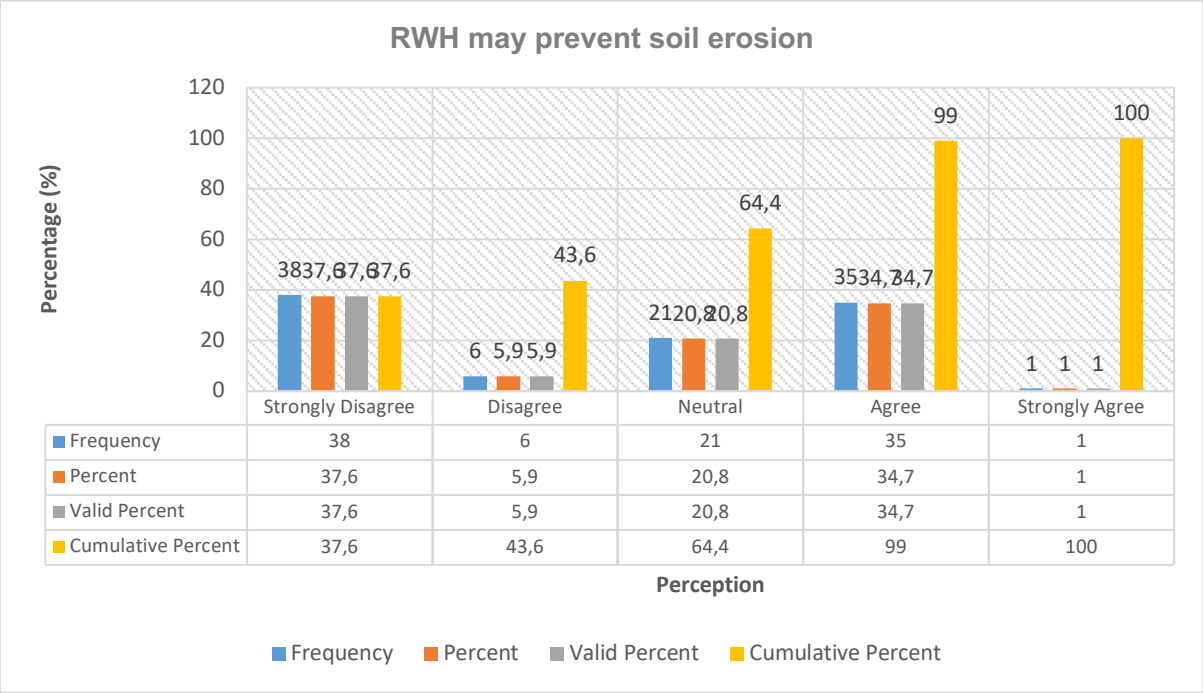
As shown in Table 5.7, 95 (94.1%) respondents pointed out that they had never received any form of education or training on rainwater harvesting issues. A very tiny percentage of 1.9% (2) of respondents indicated that they had received education or training from community leaders on RWH. This is contradictory, as during the administration of the questionnaire, it was clear that those who had indicated that they had received training did not really know what RWH was; it could be they had confused the training that they had received on another subject with that of RWH. This could indicate a lack of knowledge about the subject.



Source: Field Survey (2019)

Figure 5.1 RWH may reduce floods in the community

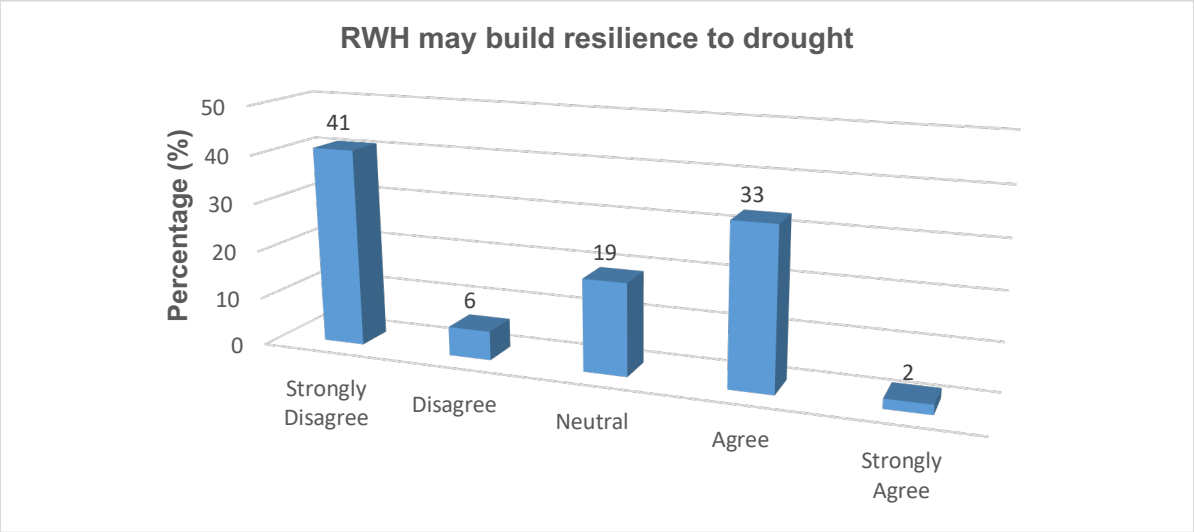
The figure above (Figure 5.1) shows that 35 (34.7%) of the respondents *agreed* to the statement that RWH could reduce floods, while 27 (26.7%) of the respondents were *neutral* on the statement. A high number of study respondents 36 (35.6%) *strongly disagreed* and 3(3.0%) *disagreed* to the statement that RWH could reduce floods. This can be explained by many factors. Firstly, field observations showed that the area was low lands with no drainage systems, therefore, this could contribute to the area being a recipient of rainwater coming from higher grounds. Secondly, the structure of the shacks and their flat roofs displayed very slim possibilities of capturing rain water. Thirdly, the closeness of the shacks to each other, showed that one's efforts of capturing rainwater to reduce flooding could be in vain if one's ambitions are not the same as those of the immediate neighbours'. Any efforts, therefore, of collecting rainwater to reduce flood intensity could easily go unnoticed.



Source: Field Survey (2019)

Figure 5.2 RWH may prevent soil erosion

Literature from RSA DWAF (2010) support the fact that RWH may reduce or prevent soil erosion. When asked what they (Marikana resident respondents) opine about RWH preventing soil erosion, many of the respondents (37.6%) did not perceive RWH as having any mitigation effects on soil erosion; 5.9% *disagreed*, while 20.8% did not have a stand on the issue. On the other hand, a significant number of respondents (35) *agreed* that RWH can prevent soil erosion and 1 participant of the survey was very optimistic by *strongly agreeing* that RWH can indeed prevent soil erosion.



Source: Field Survey (2019)

Figure 5.3 RWH may build resilience to drought

The results indicate that a high percentage (40.6%) 41 of the respondents *strongly disagreed* that RWH may build resilience to drought while (5.9%) 6, *disagreed* with the statement; (32.7%) 33 and (2%) 2 of the respondents *agreed* and *strongly agreed,* respectively. Almost 20% of the respondents were uncertain on whether to agree or disagree that RWH could build resilience in a drought should such an episode prevail within their community. These results motivated the researcher to link them to those in Table 5.5 and Table 5.6 where ignorance and lack of interest were pointed out as the main factors that led to a good number of the respondents not knowing what was going on around them concerning water issues and rainwater harvesting.

Table 5.8: Water shortages and disease outbreaks

Valid	Frequency	Percentage	Valid percentage	Cumulative percentage
No	27	26.7	26.7	100.0
Yes	74	73.3	73.3	73.3
Total	101	100.0	100.0	

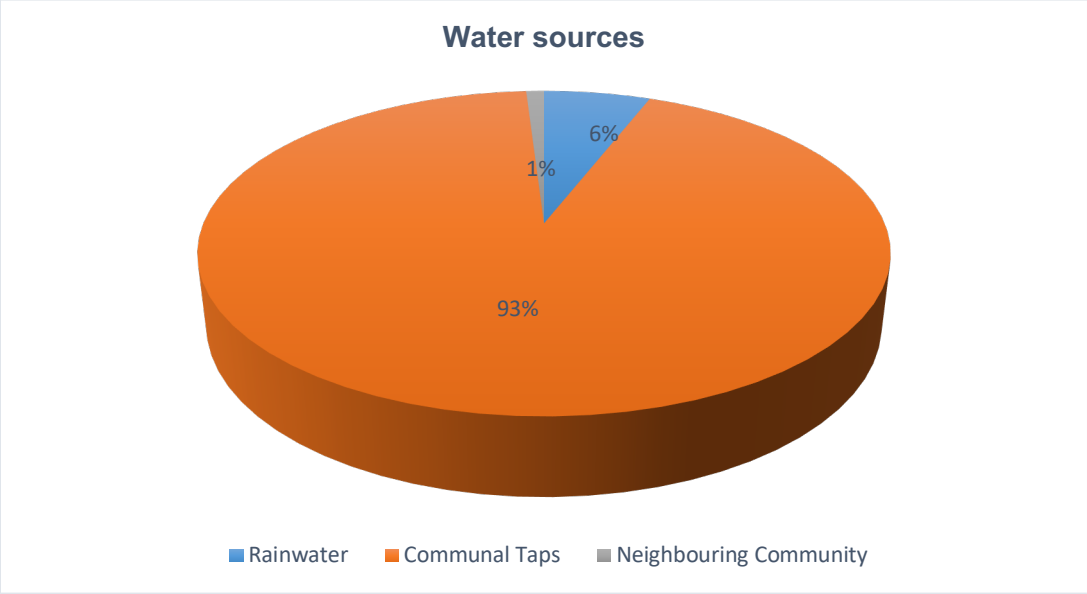
Source: Field Survey (2019)

It was important to find out what the sampled population think about water shortages in relation to disease outbreaks. From the results presented in Table 5.8 above, 73.3% (74) of the respondents *agreed* that water shortages may cause disease outbreaks while 26.7% (27) *disagreed*. This shows a high level of awareness from the respondents regarding the impact of

water shortages on the community with regard to disease outbreaks. In order to achieve the objective of this study, it was necessary to know from the respondents the sources from which they got their water from to use on daily basis (Figure 5.4).

SECTION 4

5.5 Preparedness

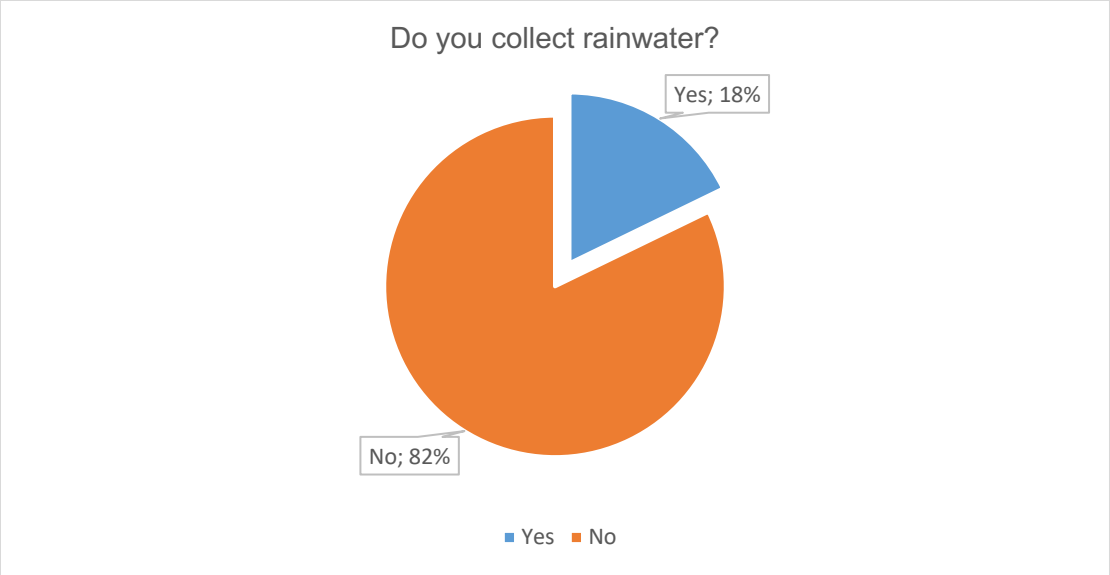


Source: Field Survey (2019)

Figure 5.4 Sources of water

The results above indicate that communal taps are the main source of water in Marikana community. The majority of the respondents (93.1%) indicated that they source their water from communal taps, however, 5.9% of the respondents indicated rainwater as their water source, while about 1% indicated that they sourced their water from the neighbouring community. These results show a link to those in Table 5.2 where 16 above 60 years old respondents indicated that they collected rainwater on a small scale complementing indigenous knowledge as the base of their actions. Overall, it can be concluded that rainwater is not really a common water source for the respondents in this community, instead, they would rather walk for long distances to the communal taps in search of water. From field observation, there were only 2 communal taps were the residents of this community could fetch water from. The residents had to walk approximately 25-30 minutes a single trip to the taps, almost 1 hour for a return trip and had to stand in long queues waiting for their turn to draw water from the taps. This action is time consuming for the

respondents who could probably use this time for more productive activities, including those for income generation and is contrary to the United Nations Sphere Project (2011) which indicates that 250 people should be allocated per tap and that there should be a maximum distance of 500 metres from any household to the water source. The respondents also highlighted that there are times when the communal taps run dry due to broken underground pipes; in addition, communal taps are frequently tempered with by individuals in their quest to illegally connect their households directly to the communal taps. Hence, it is projected that the adoption of rainwater harvesting could improve the livelihoods of the study community in terms of water accessibility.



Source: Field Survey (2019)

Figure 5.5 Do you collect rainwater?

The results show that the majority 83 (82%) of the respondents did not collect rainwater while only 17 (18%) indicated that they did. These results showed the researcher that rainwater harvesting was unpopular and still in its infancy in Marikana informal settlement. The researcher was convinced that the 17% (Figure 5.5) could constitute the same 5.9% (Table 5.6) who indicated that they did not know the meaning of RWH, hence, justifying the reason why they did not collect rainwater.

Previous studies however, show that rainwater harvesting is well implemented in some rural areas. Possible reasons for its success in rural areas could be partly because of the good support received from the government and or due to lack of options of water sources in some rural areas where there are no communal tap water available (Kahinda *et al.,* 2008).

Rainwater harvested can be used to cool the roofs of the shacks in Marikana, especially in the hot season when iron sheet roofs tend to get very hot in the souring temperatures and heat waves fueled by climate change. In areas, such as Rio in Brazil, where residents experience extreme hot temperature, Wamsler & Brink (2014) indicate that the residents use some of the harvested rain water to repeatedly drench rooftops to reduce the hot temperatures indoors.

Table 5.9: “Do you have containers for RWH?”

Valid	Frequency	Percentage	Valid percentage	Cumulative percentage
No	83	82.2	82.2	100.0
Yes	18	17.8	17.8	17.8
Total	101	100.0	100.0	

Source: Field Survey (2019)

The results (Table 5.9) indicate that 83 (82.2%) of the respondents do not have the containers appropriate for RWH, while only 18 (17%) indicated that they have. This result can be explained by many factors. Firstly, the researcher noticed that these results (Table 5.9) are exactly the same as those in Figure 5.5, where the respondents were asked if they collected rainwater. Secondly, lack of resources such as funds to purchase the containers could be a contributing factor to respondents not possessing containers needed to practice the technique of harvesting rainwater. These results (Table 5.9) could also be linked to the ones in Table 5.3 where 38.6% of the respondents indicated that they were unemployed, therefore it implies that they cannot afford to purchase the containers needed for rainwater harvesting.

The respondents who indicated that they had containers and collected rain water, were then asked to indicate what type of containers they use to carry out this activity. Their responses were recorded in Table 5.10 below.

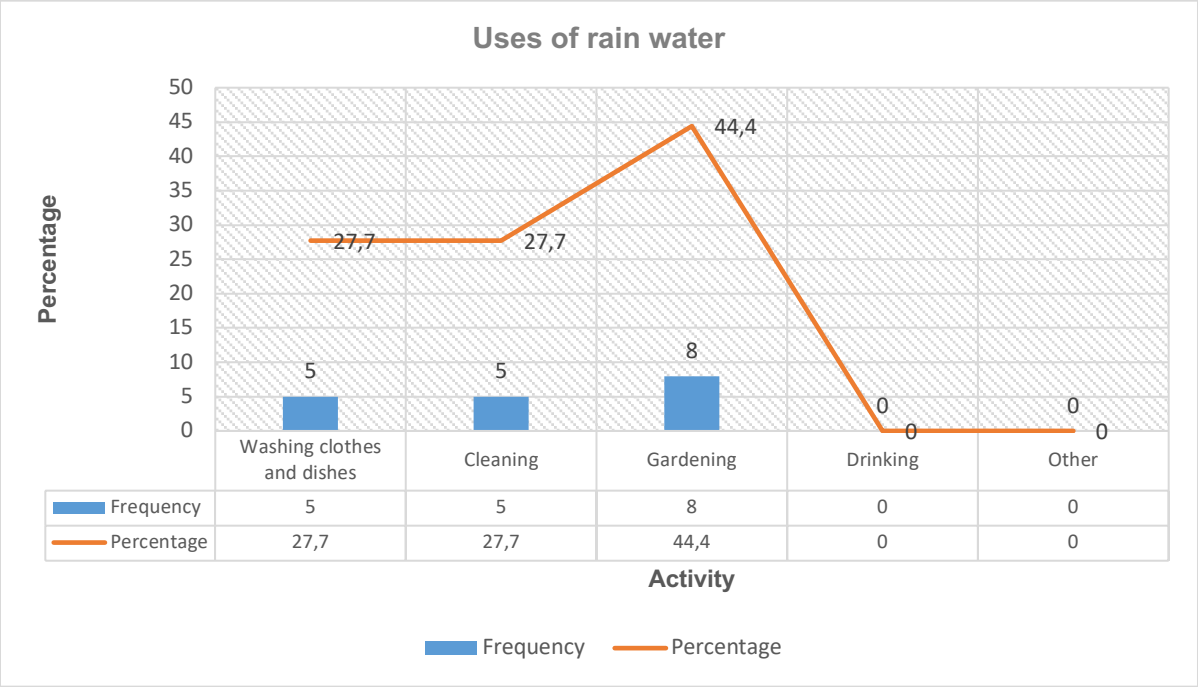
Table 5.10: Type of container used for RWH

Type of container	Frequency	Percentage	Ranking
20 litre plastic container/bucket	11	61.1	1
80 litre plastic drum	5	27.8	2
250 litre steel drum	2	11.1	3
Total	18	100.0	

Source: Field Survey (2019)

Question D4 in the questionnaire required the respondents who had previously revealed in Table 5.9 that they had containers to indicate the type of containers they possess for the purposes of rainwater harvesting. Out of the total number of 18 respondents who said they had containers, 11 (61.1%) indicated that they owned and used 20 litre containers or buckets to collect rain water; 5 (27.8%) indicated that they collected rain water using 80 litre plastic drums and 2 (11.1%) of respondents indicated that they use 250 litre steel drums. The researcher was interested to know why only 2 of the respondents indicated that they used 250 litre steel drums when such drums had the advantage of storing more litres of water. When the researcher verbally posed the question, the respondents then informed the researcher that even though the 250 litre steel drums can store a lot more water, their main disadvantage was the difficulty in manoeuvring them. Another reason was the issue of lack of finances to purchase such containers as they cost more than the other types of containers as indicated in Table 5.10.

It was, therefore, established that the 20 litre plastic containers were lighter and easy to determine the amount of impurities in the water as compared to the steel drums that were dark inside making it difficult for the user to notice any debris and or dead animals such as rats that could have fallen inside. Thus, the plastic containers were more convenient to carry and move around, less costly and easier to clean unlike the steel drums which were massive. It was therefore, established that the advantages of using the plastic containers outweighed those of the steel drums.



Source: Field Survey (2019)

Figure 5.6 Uses of rainwater

Collected rainwater can be used for different activities, although they may vary depending on individual household needs. Results in Figure 5.6 show that 5 (27.7%) of respondents who indicated that they collect rain water (Figure 5.5) use it for either washing clothes or dishes; another 5 (27.7%) indicated that they use it for cleaning (houses, vehicles and others); the highest percentage (44.4%) 8 respondents stated that they use the rain water for gardening purposes. None of the respondents indicated that they use the water for consumption. These results show that the respondents might be aware that the quality of rainwater could be compromised by pollutants such as smoke and other impurities such as bird droppings. This perception is supported by literature by Campisano *et al.,* (2017) who states that despite the fact that Germany encourages her citizens to collect rainwater, she does not encourage them to consume the harvested rainwater because of the high levels of pollution found in the rainwater. This reveals to the researcher that the respondents who collected rain water used it to complement the water that they fetched from the communal taps and that they do not depend entirely on the harvested rainwater.

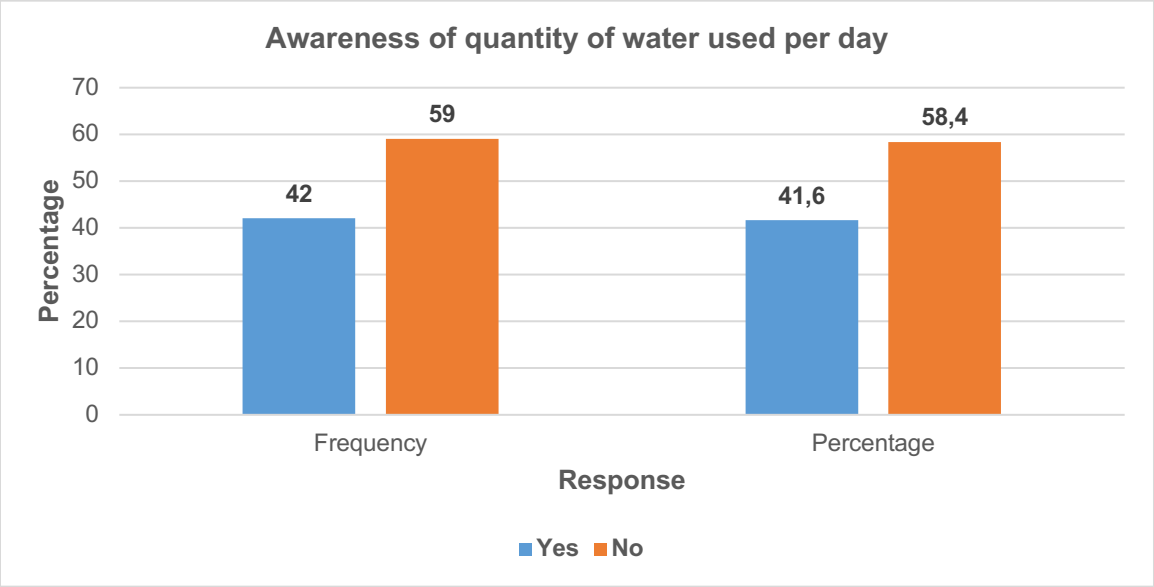
Example of a beans and maize garden watered by collected rain water. Source: Author's own (2019)

Figure 5.7: An example of a vegetable garden in Marikana

SECTION 5

5.6 Resources

Respondents were asked if they had any idea on how many litres of water they use per day for their everyday livelihoods. Their responses were captured in Figure 5.7 below.



Source: Field Survey (2019)

Figure 5.8: Awareness of quantity of daily water consumption

The results in Figure 5.8 show that 41.6% (42) of the respondents were aware of the amount of their daily water consumption, but the majority, 58.4% (59) of the respondents were not aware. Such a high percentage of people who did not know how much water they used per day is quite worrying. It raised concerns that if the respondents did not know the amount of water they consumed per day then how would they save the precious water and later on think of harvesting rainwater. Once again these responses showed a high level of ignorance within the Marikana community. One way that the researcher believes can determine the quantity of water used per household per day is to know at least the amount of water that 1 member of the household uses per day, the result can then be used to multiply by the number of people living in a single household taking into consideration their daily activities which could differ from one person to the other. Thus, applying the principle that the more the people living in a single household, the more the quantity of water they would use per day and vice versa.

The respondents were asked to list at least one and a maximum of five possible challenges that could hinder or hindered them from practicing rainwater harvesting, their responses were captured in Table 5.11 below.

Table 5.11: Suggested challenges that may hinder rain water harvesting possibilities in Marikana community

Number	Challenge	Frequency
1	Poor flat roof structures	38
2	Lack of roads	35
3	Lack of material resources	25
4	Lack of funds	25
5	Floods	24
6	Lack of space	19
7	Polluted/ dirty water rain water	15
8	Lack of awareness on potential rain water benefits	13
9	Lack of sufficient rain	10
10	Unhealthy environment	7

The study respondents gave various challenges faced within the community which could affect the possibility of harvesting rainwater in Marikana community. The challenges are ranked from the most popular to the least popular challenge depending on the score as indicated by the respondents. Popular among the challenges was the flat roofs of the house/shack structures in the area with the least popular being the unhealthy environment as indicated by the respondents (Table 5.11).

The issue of floods in the area was very prominent amongst the listed challenges (Table 5.11) as it was in the top 5 of the listed challenges as indicated by the respondents. The researcher did not anticipate floods to be associated with the challenges that could affect the harvesting of rainwater but instead, the researcher's thoughts supported by related literature were that harvesting rain water could be a mitigating factor towards the flood risk. Upon investigation and field observation, the researcher noticed that apart from rainfall in the area, the flood waters originated from the nearby developed surrounding highlands of the neighbouring communities as Marikana is a low lying area. The attendant high risk of floods even with the slightest rains was due to constructed roads and poor drainage systems, evident in the neighbouring communities; Marikana, hence, was a recipient of the flowing rain waters. This helped the researcher to associate the justification here with the results in figure 5.1 where approximately 38% of the respondents *disagreed* that RWH could reduce floods in their community and about 27% of the respondents were not sure as to whether harvesting rain water could reduce floods in Marikana.

Some local community members perceived rain water as dirty or waste water (number 7 in Table 5.11) hence, they were not interested in collecting it. The respondents are partially correct in their opinion, however, it does not mean that rain water cannot be used for other purposes besides drinking. Rain water is usually perceived to be clean water in its original form as it falls from the clouds, however, it could get contaminated before reaching the ground due to various factors such as, rusted and dust-filled corrugated iron sheets which could harbour impurities such as dead leaves, bird droppings and other atmospheric impurities such as smoke and dust particles which may also pollute rainwater. The concentration of such impurities depends on the area and the life style of the people living in the area (RSA DWAF, 2010; O'Brien, 2014).

Pollution could be another possible threat to rain water. In Marikana, the community members use fire wood and coal for cooking and warming up their homes. Sometime,, while socialising, the young boys tend to burn old vehicle tyres to warm themselves up, especially, in the winter season when it is cold. Such actions may cause harm to the natural environment as the smoke particles may pollute the air and when rain falls, the rain water could get polluted before falling to the ground or into the receiving rain water containers. It is, however, beyond the scope of this study to establish the degree of pollution found in rain water as this study aims to determine whether harvesting rain water could be viable, in urban informal settlements, as a source of water.

A. Garbage (Example of unhealthy environment

B. Example of bad roads and poor drainage systems

Source: Authors own (2019)

Figure 5.9 Challenges faced by the Marikana community

5.7 Discussion

5.7.1 Lack of awareness of the technique and potential benefits of rain water harvesting

RSA DWAF (2010) states the lack of awareness of the potential benefits as a disincentive to greater uptake of RWH. 13 respondents (Table 5.11) indicated that they were not aware of RWH. Lack of awareness can be supported by these findings whereby 5.9% (Table 5.6) of the sampled respondents indicated that they did not know the meaning of rainwater harvesting and 82% (Figure 5.5) stated that they did not collect rain water. When the researcher suggested having joint session with other stakeholders to workshop the residents of Marikana about DRWH and its potential benefits, some of them informed the researcher that it was not their responsibility to learn about water issues, and continued their misconception by reiterating that it was the duty of the current government to supply them with free water. This misconception led to the researcher's conclusion that the community members were either suffering from dependency syndrome or high levels of ignorance. Shepherd, Pitiya & Evans (2011) refer to dependency syndrome as a situation where recipients become permanently dependent on "hand-outs" and lose any inclination to improve their circumstances.

5.7.2 Amount of rainfall received

Marikana's average annual rainfall according to EEO (2011) is 450mm per annum. The amount of rainfall received per annum can vary due to changing weather conditions. RSA DWAF (2010) insists that rooftop domestic rainwater harvesting systems are influenced entirely by the annual rainfall amount, its variability from year to year and its distribution within a single year. This shows that rain water harvesting is completely dependent on the amount of rainfall yield, which is sometimes unpredictable considering the effects of climate change on weather patterns (O'Brien, 2014). Rainfall amounts and patterns are continuously becoming unreliable.

5.7.3 Type and surface area of roof structure and tank capacity

The amount of rainwater collected is determined by *inter alia* the size of the roof of the house/shack and the size of the tank used to collect the rainwater (Fisher-Jeffes *et al.,* 2017). The larger the surface area of the roof and gutter, the more the potential it has to collect more water and vice versa. Roof design could also be another factor; houses (shacks) with flat roofs such as

those in Marikana have difficulties in capturing of rainwater and enabling it to flow down into the receiving containers. Wanyonyi (2005) studied challenges in RWH in Kenya and argued that no matter how well designed a rainwater harvesting system, if it is not technically efficient, it cannot deliver or perform the anticipated functions. The author continued by saying that most projects are not sustainable or cannot be replicated due to inadequate technical interventions, for example, the poor construction of roof catchment systems and poor tank capacities; the equipment also require detailed technical instruction for effective implementation. The lack of proper resources may result in high failure rates.

O'Brien (2014) states that in general the 2kilolitre and 5kilolitre tanks are the common sizes of tanks used in South Africa for harvesting rainwater, however, it is almost impractical to place such tanks in informal settlements like Marikana where there is not enough space around the houses, as the shacks are built very close to each other due to the lack of suitable habitable land. These resources form part of assets. Assets are an important component of the Sustainable Livelihood Framework (Adopted in chapter 2 of this study) from which people build their living, yet the residents of Marikana lack most of these fundamental assets needed to help them to overcome their vulnerability.

5.7.4 Financial implications and material resources

Results in Table 5.11 (no. 3 and 4) show that there is a link between the lack of funds and lack of material resources with the frequency as indicated by the study respondents. The results, therefore, show beyond any reasonable doubt that there is a relationship between finances and resources. Kahinda *et al.,* (2011) blame financial implications such as budget constraints and lack of funds as the main contributing factors to respondents not practicing RWH. The high unemployment rate of (38.6%) as indicated in Table 5.3, is supported by literature (Kahinda *et al.,* (2011). Lack of income, hence, implies that the respondents cannot afford to acquire for themselves the equipment and materials needed for rainwater harvesting, such as the tanks, containers, gutters and pipes.

The low income and high rates of unemployment in Marikana (Table 5.3: 38.6% are unemployed and 57.4% earn R2000 and below per month), result in community members purchasing food stuffs from informal markets where they believe that they are cheaper compared to supermarkets where their rich neighbours buy their food; additionally, between 60 to 80 per cent of their household income is spent on staple food (Desai & Dodman, 2018). The lack of sufficient funds

will hinder the implementation of an effective rainwater harvesting strategy in this community since everything that the community members earn gets spent on food items.

The community members indicated that because of the high unemployment rate and low income, they were members of social groups as backup systems in case of emergency. The community leader explained that there is a hierarchy within their social networks, with the highest in the ranks being the chairperson working side by side with his deputy, the secretary and his deputy then the treasury and his deputy. These are the agents who are responsible for the smooth running of the networks and their responsibilities including, collecting and banking monthly contributions. When the community experiences a calamity, the agents are the first line of communication who then try to stabilize in any way possible the affected households who are their members. This shows that there are strong social cohesions amongst the members of this community, therefore, it can be concluded that this community's social asset is one of the strongest assets as depicted in the SLF adopted in chapter 2 of this study.

The researcher saw it as almost impossible for the residents to purchase equipment for harvesting rain water since they could hardly afford a meal which is vital for human survival. In some households, poverty was so severe that some households could not even afford to buy the much-needed food items for survival. The newspaper article below gives a pragmatic view of the conditions that the community of Marikana is living under, confirming the poverty and high unemployment rates.

The majority of the community members in this community own ordinary cellular phones and not SMART phones. This is a challenge as they cannot connect to the internet to check on items like the weather as an early warning sign when bad weather, for example, floods, are predicted by the South African Weather Service The residents here also lack communication channels such as televisions and radios because of the lack of electricity in the area and as well as the lack of buying power. The weak physical capital in this community increases vulnerability to hazards, potential disasters and is considered to be a core dimension of poverty for the people of this community (DFID, 2000).

Helpers feed Marikana

The Covenant Helpers have started a weekly soup kitchen to help the people of Marikana informal settlement.

"As Christians, we feel God is using us to give to other people," says Qhamukile Mulabisani, one of the soup kitchen facilitators.

According to Nobantu Mgcina, another facilitator, Marikana was selected because it is close to them and they see how unemployment is affecting the residents.

"Many of the parents are unemployed and the children go to bed hungry and we wanted to do something about that," she says.

The soup kitchen has been well received as indicated by the long queue of people waiting for food before the group arrives.

"We buy the food from our own pockets and as such can only cover one day a week (Wednesday).

"As time goes on, we would like to cover more days because we worry about what they eat on the other six days that we don't cover," says Mulabisani.

The group is looking for donations of any kind to help them serve the community.

"We accept any donations, it does not have to be cash.

"It can be a can of beans, or your time to help us cook or dish up," says Mgcina.

To donate contact Mulabisani on 082 [illegible]

Source: Springs Advertiser (20/06/2019)

Figure 5.10 Challenges faced by Marikana community (High unemployment)

5.8 Chapter summary

This chapter analysed, presented and discussed the data that were collected from primary sources using a questionnaire and field observation. Information from secondary sources were used to supplement the primary data in order to address the research questions and objectives as outlined in chapter 1 of this study. It was found that the sampled community did not embrace the idea of rainwater harvesting, due to issues such as lack of space and equipment to establish the technique. The findings show that the majority of residents in this area were unemployed hence, some cited the lack of funds as a factor that made it impossible to collect rainwater as they could not afford to acquire the equipment needed to implement the technique. Little or no knowledge about rain water harvesting was displayed among the sampled community members. In some cases, ignorance was identified as another strong contributing factor to this community not practicing the technique of collecting rainwater. The next chapter focuses on the conclusions and possible recommendations on the issues of rain water harvesting discussed in this chapter.

Chapter 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter discusses the collected and analyzed data with reference to the stated research questions and objectives. The primary data and secondary information were blended in order to give credence to the information that was used in drawing up the conclusions and proposing recommendations towards the possible adoption of rain water harvesting in Marikana community. This chapter is divided into two interlinked sections - conclusions and recommendations for the study. Recommendations were offered to alleviate the challenges explained and to answer the research questions outlined in the first chapter of the study.

6.2 Conclusions

This research sought to investigate the possibility of introducing rainwater harvesting in Marikana informal settlement as a way of building resilience and improving the socio-economic livelihoods of the local community.

This research is necessary to make water conservation everyone's business so that everyone will value water. Every household in the community needs to be involved in both the provision and protection of water resources, hence, rainwater harvesting will go a long way towards reducing the government as well as individual households' spending on water.

It was noted from the study that rainwater harvesting in urban informal settlements was not as popular as compared to the rural areas (Kahinda *et al.,* 2008).

Marikana is an informal settlements with no formal rules that she abides by, although the citizens together with their community leaders have drafted basic rules to help make the area governable.

Based on the study findings, it can be concluded that social capital is one of the capitals which is strong in Marikana as the residents display social coherence through their membership in social networks within the local community.

It can be concluded from the data collected and field observations that most residents of this community are black, self-employed or unemployed, and that they all have at one time or another gone through the formal education structure.

Lack of comprehensive knowledge of the technique and potential benefits of rainwater harvesting should be a concern for the study area.

In rural areas, the use of harvested rainwater is a norm since it is regarded as a reliable source of water and in some instances, it is the primary source of household water. It is, therefore, anticipated that a strong interest in domestic rainwater harvesting continues to be encouraged.

Harvesting rainwater will promote resilience and local sustainable development within the water scarce communities.

The findings show that some respondents believe that rain water is dirty water therefore, such a misconception amongst the local community could be cleared through proper education and training on rain as the main source of water and the potential benefits of collecting rainwater.

6.3 Recommendations

Rainwater harvesting if properly implemented can bring immense socio-economic and environmental benefits to any local community. Based on the findings and conclusions of this study, the following recommendations are made:

The high levels of unemployment (38.6%) as indicated in Table 5.3 were worrying to the researcher who concluded that the lack of employment could have a negative impact on issues of harvesting rainwater due to the fact that most of the residents could not afford to purchase rainwater equipment due to lack of funds. On the other hand, it can be recommended that the government introduce skills development courses those of plumbing, building and welding in order to help equip the unemployed with some skills, such skills can therefore be used in projects such as those of rainwater harvesting.

It was found that the community of Marikana lacks awareness on the issues of rainwater harvesting, therefore it is recommended that stakeholders join hands to raise awareness among the community members on water scarcity and the possibility of adopting rainwater harvesting. This can be done by introducing curriculum in schools based on water problems, effects of climate change on water availability and the introduction of the adoption of strategies such as rainwater harvesting to ease the burden. It is recommended that such a curriculum be introduced at the very early stage in school education, as early as during Early Childhood Development in order to instill the idea in the young minds who will then grow with the idea of harvesting rainwater and using it sparingly. The formation of rainwater harvesting forums where different stakeholders

including the community members can meet to discuss issues of rain water harvesting, are also recommended.

In order for the idea of rainwater collection and its implementation to be successful, residents need to understand the past and present usage of water resources, the current water status and the impact of external forces such as climate change on rainwater availability as well as the ways through which water sustainability can be achieved (Enninful, 2013).

The respondents who were above 60 years indicated that they practice rainwater harvesting on a small scale (Table 5.2). The respondents further indicated that they practiced rainwater harvesting based on indigenous knowledge that they might have inherited from their forefathers. Such knowledge can be vital in a community such as Marikana where water is a serious issue. The researcher recommends that such knowledge be passed over to the residents who can put it into practice. Effective management of rainwater harvesting requires knowledge of the hydrological cycle and rainfall patterns and seasons although the impact of climate change has made it hard to predict the future rainfall patterns.

The National Water Services Act and National Water Act refer to water in general and do not specifically mention anything with regard to rainwater harvesting. It is recommended that the government establish enabling policies with regard to rainwater harvesting so that the practice can be taken seriously and people must take ownership of water

The key role of harvesting rain water in disaster risk reduction and the impacts of disasters on the community and the environment and building resilience cannot be over emphasized.

6.3.1 Issues of finances and material resources

The findings of this study show that the majority of the respondents are living on the poverty threshold and therefore, lack of financial resources was seen as a serious issue hindering the acquisition of rainwater harvesting equipment and materials in the Marikana community. It is, therefore, recommended that the government intervenes by allocating sizable inhabitable land for the residents to build their homes which could then house water tanks such as the ‘jojo’ tanks which are mainly used in rural areas, to the local community members in order to encourage them to practice rain water harvesting (Kahinda *et al.,* 2008).

6.3.2 Education and training

Water conservation should be promoted as a key ingredient in response to water shortages. Awareness programs for local communities should be rendered and where these are already available should be increased to achieve sustainable development (Ogato *et al.,* 2017). This is supported by Krantz (2001) who states that raising the levels of education and awareness in terms of water shortages, air and water pollution may have positive effects on the health standards of the people which in turn will improve their livelihoods. The researcher, therefore, suggests that the Marikana community should be offered training and educational workshops and programs. This can be achieved by involving officials from the Municipality and from the water bodies such as Rand Water to avail themselves and capacitate the residents in this area.

6.3.3 Recommendation for future research

This study centered on the possibility of introducing rain water harvesting in Marikana community to build resilience which could in turn improve their livelihoods within the local community. Further studies can be undertaken on the actual implementation of the rainwater harvesting techniques within the community of Marikana. This study did not determine the quality of rain water in the study area, therefore, further studies to carry out scientific tests on the quality of rainwater in the study area are recommended.

It is also recommended that further studies be conducted for all the informal settlements in the whole City of Ekurhuleni Municipality using a larger sample size, on the same topic.

6.4 Chapter summary

This chapter provides the conclusions and recommendations based on the primary data collected and analyzed, supported by reviewed literature where necessary. Recommendations were made in line with the research questions as outlined in the first chapter of the study. Based on the findings of this study, follow-up research gaps were identified, therefore, recommendations were made for further research.

6.5 General discussions of the study

This research explored the possibility of introducing rainwater harvesting to build resilience through, *inter alia,* DRR and CCA strategies in the local community of Marikana. The main problem identified in the study area was the lack of water supply from the local government due

to the fact that the study area is an informal settlement. Water is a scarce resource and has posed major challenges around the globe therefore, the aim of the study was to introduce the idea of practicing rainwater harvesting which could help in building resilience, so that the local community can withstand hydrological hazards and sustain their livelihoods.

In order to address the identified problem and to achieve the aim of the study, a number of frameworks were adopted to guide the study. These included the Sustainable Livelihood Framework (SLF), the Sendai Framework for Disaster Risk Reduction, the Climate Change Framework and the South African National Disaster Management Framework (NDMF).

In terms of methodology, the mixed methods approach was employed in the study. Simple random sampling was used to select 101 respondents who were heads of the households. Data was collected using a questionnaire and field observations. The data collected was then analyzed using the Microsoft Excel program and SPSS software. The analyzed data was then presented and discussed with the aid of tables, figures and photographs.

The main conclusions are that rainwater harvesting if successfully implemented could build resilience and improve water sufficiency within the local community. It was observed that the lack of legal and institutional arrangements directly linked to rainwater harvesting in South Africa has led to this technique not being forcefully encourage in its implementation. A lack of comprehensive knowledge and ignorance about rainwater harvesting values and potential benefits were clearly displayed among the community members in the study area.

The main recommendations were that the South African government should formulate policies which will be directly linked to rainwater harvesting seeing that water scarcity is continuously increasing and should be addressed from the National government level cascading to the local government level. This is in line with KPA1 whose main focus is on the establishment and implementation of relevant institutional arrangements at all levels of government spheres (Government Gazette RSA, 2016).

There is a serious need for education, training and awareness services to be rendered to the local community members on RWH and its benefits in fulfilment of Enabler 2: which speaks about training, education and research (RSA – NDMF, 2005). Further research was recommended for the implementation of the technique of RWH and also to determine the quality of rain water in the study area. The main limitation of this study was the small sample size and that the area had limited accessibility due to poor roads and the fact that the field survey was conducted towards the end of the rainy season. Another limitation was that the study was conducted towards the

national elections period, therefore, the respondents were a bit hesitant to openly complete the questionnaires, wrongfully thinking that the study was linked to the political campaigns that were taking place in the study area at the time.

6.6 Concluding remarks

Based on the findings of this study and in line with the research questions and research objectives, it can be concluded that the overall goal of this research, which was to explore the possibility of introducing the practice of harvesting rain water in Marikana informal settlement to build resilience was partly achieved.

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APPENDIX 1

QUESTIONNAIRE FOR STUDY RESPONDENTS

Informed consent for participating in an academic research project

April 2019

EXPLORING THE POSSIBLE INTRODUCTION OF RAIN WATER HARVESTING TO BUILD RESILIENCE IN MARIKANA INFORMAL SETTLEMENT IN EKURHULENI METROPOLITAN MUNICIPALITY

Dear Respondent,

My name is Beauty Moyo, a Masters student at the Department of Disaster Management Training and Education center for Africa (DiMTEC) at the University of the Free State. I am conducting an academic research on exploring the possible introduction of rain water harvesting to build resilience in Marikana informal settlement in Ekurhuleni Metropolitan Municipality.

Your participation in this study will contribute to a better understanding of harnessing and using water sustainably as water is a scarce resource yet critical for everyday running of every household.

Please note the following regarding your participation in the survey.

- It is anticipated that completing the questionnaire will take approximately 15 minutes, hence, it would be appreciated if the questionnaire could be completed in one sitting.
- Participation in this survey is voluntary, therefore, you may withdraw from participating at any given time, without any consequences.
- Information shared in this questionnaire will be treated confidentially and no personal information will be shared with any third party.

- It is important that you answer the questions in the questionnaire honestly and fairly, as it will assist greatly in achieving the purpose of this research.
- The collective results of this research may be presented to the University of the Free State, Disaster Management Centres, government departments and other relevant stakeholders in order for them to contribute towards the possibility of achieving the goal of introducing rain water harvesting in Marikana informal settlement. The results may also be used in scholarly journals.

If you have any questions regarding the survey, please do not hesitate to contact Ms. Beauty Moyo on **beauty.sinothile@gmail.com** or 011 811 9533.

Please sign the form to indicate that:

- You have read and understood the information provided above.
- You give your consent to participate in the study on a voluntary basis.

_____ _____

Respondent's signature **Date**

Official use only	
Questionnaire number	
Date submitted	

Please mark your response with an (x) in the appropriate box

SECTION A: Demographic information

A1.Gender of the respondent:

(1) Male	
(2) Female	

A2. Age of the respondent:

(1) 18-25	
(2) 26-45	
(3) 46-60	
(3) 60+	

A3. Number of members per household:

(1) 1-3	
(2) 4-6	
(3) 7+	

A4.Race group of the respondent:

(1) Black	
(2) White	
(3) Indian	
(4) Coloured	
(5) Other (please specify)	

A5. How long have you lived in this area?

(1) 0-5 years	
(2) 6-10 years	
(3)10+ years	

A6. What tribe are you?

(1) English	
(2) IsiZulu	
(3) IsiXhosa	
(4) Sesotho	
(5) Sepedi	
(6) Afrikaans	
(7) Other (Specify)	

SECTION B: Social-Economic

B1. What is your highest level of education achieved?

(1) Primary	
(2) Secondary	
(3) College	
(4) Diploma	
(5) Degree	
(6) Post graduate	
(6) No formal education	

B2. Where do you work?

(1) Public sector	
(2) Private sector	
(3) Self-employed	
(4) Unemployed	

B3. What is your household's total income per month?

(1) R100-R1000	
(2) R1001-R2000	
(3) R2001-R3000	
(4) R3001-R4000	
(5) R4001+	

B4. Do you receive any form of government grant?

(1) Yes	
(2) No	

B5. If yes to B4, please specify what type of grant?

(1) Child	
(2) Foster	
(3) Old age	
(4) Disability	
(5) Other (Specify)	

B6. What material is your house/shack built from?

(1) Corrugated iron sheets	
(2) Bricks and cement	
(3) Cardboards	
(4) Mud and rocks	
(5) Wood	

SECTION C: Awareness

		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
C1	I know that water is a scarce resource	1	2	3	4	5
C2	I have heard about rain water harvesting	1	2	3	4	5
C3	I know the meaning of rain water harvesting	1	2	3	4	5
C4	Community leaders educate us about collecting rain water	1	2	3	4	5
C5	Collecting rain water may reduce flooding	1	2	3	4	5
C6	Harvesting rain water may prevent soil erosion	1	2	3	4	5
C7	Collecting rain water may build resilience to the drought impact	1	2	3	4	5

C8. Are you aware that water shortages can contribute to disease outbreaks?

(1) Yes	
(2) No	

SECTION D: Preparedness

D1. Where do you source your water from?

(1) Rain water	
(2) Communal taps	
(3) Neighbouring community	
(4) Water tanker	
(5) Other (Specify)	

D2. Do you collect rain water?

(1) Yes	
(2) No	

D3. Do you have any containers to use for collecting rain water?

(1) Yes	
(2) No	

D4. What do you use to collect and store the rain water?

(1) Empty 20 liter plastic containers	
(2) 210 liter steel drums	
(3) 80 liter plastic drums	
(4) 20 liter plastic buckets	
(5) Other (Specify)	

D5. What do you use the collected rain water for?

(1) Drinking	
(2) Washing clothes and dishes	
(3) Cleaning	
(4) Gardening	
(5) Other (Specify)	

SECTION E: Resources

E1. What type of toilet do you use?

(1) Flushable individual	
(2) Flushable communal	
(3) Mobile non-flushable	
(4) Pit latrine	
(5) Other (Specify)	

E2. If you use a flushable toilet where does the water come from?

(1) Rain water	
(2) Communal taps	
(3) Neighbouring community	
(4) Water tanker	
(5) Other (Specify)	

E3. Do you wash your hands after using the toilet?

(1) Yes	
(2) No	

E4. If yes to E3 where do you get the water to wash your hands after using the toilet?

(1) Rain water	
(2) Communal taps	
(3) Neighbouring community	
(4) Water tanker	
(5) Other (Specify)	

E5. In your opinion, rain water is…….

(1) Good	
(2) Bad	
(3) Not sure	

E6. Motivate your answer in E5…….

……

……..

E7. Are there any other ways of collecting rain water that you know?

(1) Yes	
(2) No	

E8. If yes to E7, please explain some of them…….

…….

…….

E9. Are you aware of how many liters of water you use per day?

(1) Yes	
(2) No	

E10. If yes to E9, please indicate how many liters…….

E11. Do you plan on combining the collected rain water with water from other sources?

(1) Yes	
(2) No	

E12. Do you have space to place a desired storage tank or container?

(1) Yes	
(2) No	

E13. Does this area have vegetation which can cause a lot of leaf debris?

(1) Yes	
(2) No	

E14. Do you think harvesting rain water can have an impact on your life?

(1) Yes	
(2) No	

E15. Please explain your answer to E14……

……..

……

E16. List some of the main challenges in rain water harvesting in your area? (Maximum 5 challenges)

……

……

……

THE END OF THE QUESTIONNAIRE

THANK YOU FOR PARTICIPATING

APPENDIX 2

LETTER OF PERMISSION TO CONDUCT RESEARCH

Disaster Management Training and Education Centre for Africa
University of the Free State
205 Nelson Mandela Avenue,
Bloemfontein,
9300.

The Councillor /Community Leader
City of Ekurhuleni
Marikana informal settlement
Kwathema

April 2019

Dear Sir /Madam

REQUEST TO CONDUCT AN ACADEMIC RESEARCH IN MARIKANA INFORMAL SETTLEMENT IN EKURHULENI METROPOLITAN MUNICIPALITY

My name is Beauty Moyo, a Masters student at the Department of Disaster Management Training and Education centre for Africa (DiMTEC) at the University of the Free State. I am conducting an academic research on exploring the possible introduction of rain water harvesting to build resilience in Marikana informal settlement in Ekurhuleni Metropolitan Municipality.

I am requesting your permission to conduct this study within your area through the issue of questionnaires to the head of each randomly selected household.

If you have any questions regarding the survey, please do not hesitate to contact me on **beauty.sinothile@gmail.com** or 011 811 9533.

Your assistance in this regard will be highly appreciated. Looking forward to hearing from you.

Yours faithfully,

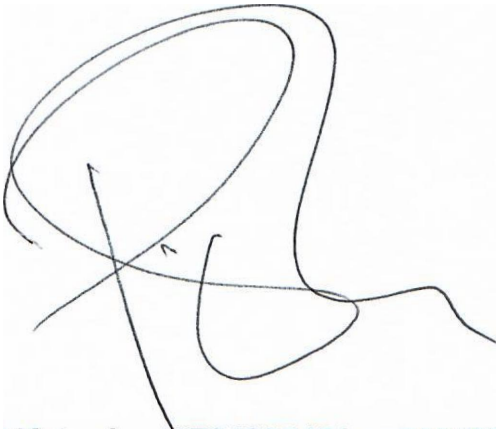
Beauty Moyo

APPENDIX 3

LETTER FROM THE EDITOR

13 July, 2019

This is to indicate that I, **Dr. P. Kaburise,** of the English Department, University of Venda, have proofread the research report titled - **AN ASSESSMENT OF THE POSSIBLE INTRODUCTION OF RAINWATER HARVESTING TO BUILD RESILIENCE IN MARIKANA INFORMAL SETTLEMENT, IN EKURHULENI MUNICIPALITY, SOUTH AFRICA -** by Beauty Moyo (student no. 2016333029). I have indicated some amendments which the student has undertaken to effect, before the final document is submitted.



Dr. P. Kaburise (0794927451)

Dr. P. Kaburise: BA (Hons) University of Ghana (Legon, Ghana); MEd University of East Anglia (Cambridge/East Anglia, United Kingdom); Cert. English Second Language Teaching, (Wellington, New Zealand); PhD University of Pretoria (South Africa)

APPENDIX 4

ETHICAL CLEARANCE FOR THE RESEARCH