

# WATER SECURITY IN RURAL LIMPOPO IN A CHANGING CLIMATE: A STUDY OF THE GREATER-GIYANI LOCAL MUNICIPALITY, SOUTH AFRICA

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## DECLARATION

I, Elelwani Mmbadi, hereby declare that this dissertation submitted to the department of Geography and Geo-Information Sciences for the award of Masters in Environmental Sciences at the University of Venda, has not been previously submitted for a degree at this or any other institution. This is my own work in design and execution, and all reference materials contained herein have been fully acknowledged.

Signature.....Date.....

## DEDICATION

*This work is dedicated to my late Aunt, cousin and my little angel in Heaven ~ Joyce, Jeanette & Pfarelo*

*Till we meet again, Love You Always!!*

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## ABSTRACT

Many rural communities of South Africa are living without adequate water supplies mainly due to historical lack of infrastructure and effective water reticulation systems. Day to day challenges of accessing water from distant boreholes and rivers are a reality particularly for women and children in rural Limpopo. This study investigates the nature and extent of water supply problems and how communities are living without adequate water in three rural communities of Greater-Giyani Local Municipality in South Africa. The study area lies in a semi-arid region which regularly experiences climate extremes such as droughts and floods which can reduce the ability of the municipality to supply water. Primary data was collected through questionnaires, key informant interviews and field observations while population, climate and hydrological data are also analyzed. A mixed methods research design was employed using qualitative methods such as content analysis whilst quantitative methods were dominated by time series analysis techniques and online interactive climate platforms such as the Climate Engine. It was found that households, schools and clinics in the study area rely mainly on boreholes for water supply but sometimes rivers supply those living nearby. An incomplete and poor water reticulation system coupled with erratic and shortening summer rainfall seasons are some of the major causes of water shortages in the study area. In order to cope with inadequate water, community members and public institutions in the study area have drilled boreholes and the sustainability of groundwater in the area is not well established. During summer, most households and institutions practise rainwater harvesting while a few resort to purchasing water from vendors. Despite these challenges which are not well documented, it was concluded that most of the rural poor households and institutions in the study area are well adapted to cope with water scarcity in the short term, while being vulnerable in the long term due to population growth and climate change. The study recommends the need for government and municipalities to invest in water reticulation systems in the long term whilst providing water to affected rural communities through water tankers, drilling more boreholes and maintenance of existing ones. Lessons learnt from this study may be useful to other municipalities across South Africa that are grappling with challenges of water access and supply.

**Keywords:** Water resources, water supply, water scarcity, water resources, changing climate, coping strategies, Greater-Giyani Local Municipality.

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## LIST OF ACRONYMS

COGTA	: Cooperative Governance and Traditional Affairs
CUMEC	: Cubic Meter Per Second
DEAT	: Department of Environmental Affairs and Tourism
DPLG	: Department of Provincial and Local Government
DWA	: Department of Water Affairs
DWAF	: Department of Water Affairs and Forestry
DWS	: Department of Water and Sanitation
ENSO	: El Niño-Southern Oscillation
GGM	: Greater Giyani Municipality
GHG	: Green House Gases
IDP	: Integrated Development Plan
ITCZ	: Inter-Tropical Convergence Zone
IPCC	: Intergovernmental Panel on Climate Change
MAR	: Mean Annual Runoff
MDM	: Mopani District Municipality
MENA	: Middle East and North Africa
NWA	: National Water Act
RDP	: Reconstruction and Development Programme
SADC	: Southern African Development Community
SAWS	: South African Weather Services
SPSS	: Statistical Package for Social Sciences
Stats SA	: Statistics South Africa
TCs	: Tropical Cyclones

UN	: United Nations
UNEP	: United Nations Environmental Programme
UNESCO	: United Nations Educational, Educational, Scientific and Cultural Organization
UNFCCC	: United Nations Framework Convention on Climate Change
USA	: United States of America
USAID	: United States Agency for International Development
WSA	: Water Services Act
WSP	: Water Service Provision
WSRS	: Water Sector Reform Secretariat
WHO	: World Health Organization
WVO	: World Water Organization

## CHAPTER 1: INTRODUCTION

### 1.1. Background to the Study

The most basic component that supports the life system of the earth is water (Kundzewicz, 1997). It is vital in the sustenance of any life form and almost every human activity. Freshwater resources are significant in environmental and economic spheres of any country. However, these resources differ in distribution patterns across countries, with arid regions often having limited freshwater to the level that demand for water can be met only by going beyond maintainable use in terms of quantity (Organization for Economic Co-operation and Development [OECD], 2005). Water supply is a public utility that has been worst hit by rapid population growth and development of unprecedented residential areas, as water facilities are essential commodities in domestic and municipal activities (Food and Agricultural Organization [FAO], 2008).

Water supply can pose serious problems for developing countries to an extent that some areas only get water for a few hours every day while others only get water after a few days in a week (Water U.N, 2007). Water supplies in most African countries are provided by governmental institutions funded through tax funds or by external donors, where available (Dovi, 2007).

Water resources are essential as they foster economic growth and social development within and amongst countries. According to the International Labour Organization [ILO] (2013) there are more than a billion people who are working in fisheries, agriculture and forestry sectors which are all threatened by freshwater shortages. Half of the worldwide labour force is employed in water and natural-dependent industries; hence water shortages will have negative consequences for the global economy (United Nations Environment, 2018). According to Malzbender and Earle (2007), water is essential to economies of the Southern African Development Community [SADC] region, as it is a vital input for the agricultural, industrial, mining and power generation sectors. In addition, to achieve global food security and poverty eradication, water resources are paramount requirements, as they contribute towards the achievement of such efforts.

In South Africa, as a way of ensuring access to water is realized in recognition of it being one of the human rights embedded in the country's constitution, the government has developed several measures to ensure that everyone has access to it, at least the basic level of services for free (Mothetha *et al.*, 2013). Water has been framed as a human right due to various reasons - the need to ensure that everyone has access to clean water as a way to reduce waterborne diseases

that affect millions of people nationally and globally; to ensure that there is equitable access to water, as water privatization leads to water being viewed as a commodity; and thirdly, due to rises in water scarcity which threatens the quality of water in the current fast-paced world (Mnisi, 2011).

The free basic water policy introduced in 2000 assigned to municipalities the responsibility of supplying free basic water of at least 6000 litres/household per day (which is 25 litres/person/day) as a way of ensuring that such services are received by those who are unable to afford such services (Mothetha *et al.*, 2013). Mothetha *et al.* (2013) indicated that the Municipalities received annual grants from government as a way of ensuring that small municipalities have the capacity to provide this mandatory services.

Municipalities are required to provide the necessary infrastructure by spending allocated funds that will allow them to supply potable water at 25 litres/person/day with a distance of 200 meters of a household (Department of Provincial and Local Government [DPLG] (2007). They were also required to supply the water at a minimum flow of 10 cubic meters per minute (in the case of communal water points) or supply 6000 litres of potable water per formal connection per month (in the case of yard or house connections). They could also upgrade or build new infrastructure up to a basic level of service in existing formal settlements (Department of Provincial and Local Government [DPLG] (2007).

The Water Services Act 108 of 1997 ensures the right of everyone to a basic water supply and basic sanitation, and every water service institution must take urgent measures in the realization of these rights (Van Der Linde and Ferries, 2010). According to this Act, the Water Service Authority is the district (or authorized local municipality) within which the area of jurisdiction the district is located. Section 5 of the Act further states that, if the water services provided by an institution of water services cannot meet the needs of all its existing consumers, they must give priority to basic supply of water and basic sanitation (Van Der Linde and Ferries, 2010). Further, the Water services White Paper states that “All people living in South Africa have access to an appropriate, acceptable, safe and affordable basic water and sanitation service” in one of its sector goals (Busari and Jackson, 2006). Provision of water to all consumers may be affected by many factors that might include, rainfall amount, governance, ineffective institute, and lack of robust infrastructure.

The Mopani District in South Africa’s Limpopo Province is an area characterized by lower mean annual rainfall as compared to the rest of the country. Thus, the district has limited water resources to sustain the growing demand which are further strained during times of drought

(Mopani District Municipality IDP, 2016/2017). Mopani District Municipality sources its water from the Letaba River Catchment (Great Letaba rivers and Lepelle/ Olifant River) with Ba-Phalaborwa Municipality sourcing its water from the Lepelle river and Groot Letaba rivers while Maruleng Municipality gets its water from the slab weir in Mopani District (Mopani District Municipality IDP, 2013/2014).

The district has about twenty (small and large) dams and nine of these supply water for domestic, industrial and commercial consumption, while the remainder supply irrigation water (Mopani District Municipality IDP, 2016/2017). The dams combined yield is 273 million m<sup>3</sup> per annum and the majority (70%) of the water is used by the agricultural sector, while the remaining 30% is used by other water users (Mopani District Municipality IDP, 2013/2014). There are a number of bulk water supply schemes that provide the district with water. Most of these schemes are surface water schemes at different levels of development to ensure that water is distributed to every potential consumer (Mopani District Municipality IDP, 2016/2017). About 77.3% of households in the Ba-Phalaborwa Municipality have access to Reconstruction and Development Program (RDP) standard water, followed by Greater-Tzaneen (53.6%), Greater-Letaba (60.7%), Greater Giyani (57.3%), with the least number of beneficiaries residing in Maruleng (49.9%) (Mopani District Municipality IDP, 2013/2014).

All municipalities within the district are supplied free basic water, with 6000 litres supposed to be provided to every household per month as a way to address water challenges within the district. To assist with the process, the Department of Water and Sanitation is constructing the N'wamitwa Dam, while also raising the wall of the Tzaneen Dam (Mopani District Municipality IDP, 2016/2017). Within the Greater-Giyani Municipality, a bulk water supply pipeline project has been started and it will get its water from the Nandoni Dam in Vhembe District Municipality (Mopani District Municipality IDP, 2013/2014).

However, current water sources that include surface water and groundwater from the Middle Letaba Dam and the Nsami Dam are not adequate enough to provide water to the whole population of Greater Giyani Municipality. This could be due to a higher demand that exceeds supply in the area as a result of high rate of water extractions and frequent drought conditions that lead to water shortages (GreaterGiyani Municipality IDP, 2013/2014). The district is only able to supply 56 ml/day of water which is not sufficient due to increased demand from the growing population in the municipality (Greater-Giyani Municipality IDP, 2011).

The water situation may likely be made worse by impacts of climate variability and change. Climate variability and change pose one of the largest challenges and are expected to have severe implications for water resources through altering the quantity, timing and intensity of precipitation (Adams and Peck, 2008).

Several research studies have been done on the impact of climate on water resources. However, the predicted impacts of climate variability and change on water resources will vary according to regions; hence the need to identify locally specific impacts. Given the variations on the impact of climate change on water resources, it is expected that each region will develop unique ways of dealing with their specific challenges and consequences of climate impacts. Communities may reduce the negative effects of water shortages through development of region specific adaptive strategies. According to Global Water Action, (2009), adaptation can be used as a means of reducing both the human and social ill-effects of climate change, and for development and poverty alleviation procedures. However, it is important to find out if these strategies are suitable to the specific areas and whether they are sustainable in the long term.

## **1.2. Problem Analysis and Motivation**

Greater Giyani Local Municipality is a water-scarce area, mainly due to historical lack of water reticulation infrastructure in many rural areas of the Limpopo Province. The municipality is the responsible authority tasked by the Water Service Authority with water distribution services. However, a lack of capacity, infrastructure and low dam levels result in frequent water shortages which affect rural livelihoods. Inadequate water infrastructure in the area which, according to Netshipale (2016), is brought about by a number of factors. These include the South African Government policy of providing and sustaining water supply as a free basic need; the financial insufficiency of service providers that leads to lack of upkeep; non-compensation for water services by community members; lack of recovery costs for water services, which includes insufficient monitoring of meters and communal street stand pipes by communities due to the existence of water boards, which are controlled by water supplying services. The municipal area is characterized by low summer rainfall and affected by recurrent drought conditions which also compound the water problem (Maluleke and Mokwena, 2017).

According to Statistics SA (2011), there has been a decline in households having access to water in Greater Giyani from 18,94% in 2007 to 11,26% in 2011 highlighting water distribution challenges within the municipality. Water supply shortage is a severe problem for many rural communities and the climate factor will compound the problem. In this regard, the Minister in the

Department of Water and Sanitation (DWS) created a task team to help assist in addressing the water issues in the Greater-Giyani Local municipality through giving the Lepelle Northern Water Board the responsibility of ensuring there was adequate water in Giyani area (Department of Water and Sanitation, 2014).

Recently, the emergency water project that was being constructed to draw water from the Nandoni Dam in Vhembe District Municipality to the arid town of Greater-Giyani Local Municipality was halted (Ecowash.co.za, 2017; Citizen, 2017) denying the local villages of KaDzumeri, KaHomu, Muyexe, KaNgove and Mageva access to adequate water. As such, villagers travel long distances to fetch water from hand-dug boreholes and rivers, increasing the risk of disease outbreaks as a consequence of using unclean water.

Whilst clearly the main problem is with lack of or inadequate infrastructure for water supply in the study area, climate variability also impacts negatively on water resources both in quantity and quality and when coupled with increasing population, the need to address the problem is urgent. Future effects of climate variability can be mitigated if necessary adaptation is made and coping strategies are put in place. This research also evaluates the effects of climate variability on water resources in Mopani and analyzes coping strategies that the local population have put in place.

This dissertation also assesses the various water sources, uses and challenges faced in availability/supply of water. Such information may be used to influence policy makers in their selection of action plans to reduce the effects of climate change on water resources at local levels (Balica, 2012). The assessment of climate patterns within this area would assist the local planners, water users, municipal managers and other stakeholders in the management of natural hazards. It will further assist in development of strategies to be used in the future to combat problems of water scarcity and supply.

### **1.3. Research Questions, Aim and Objectives**

#### **1.3.1. Aim**

The aim of the study is to investigate the nature and extent of water supply problems in Greater Giyani Local Municipality and establish the extent to which three rural communities are coping with water scarcity in the midst of a changing climate and a growing population.

### **1.3.2. Research questions**

1. What is the contribution of rainfall variability on challenges of water availability and the ability of households, schools and healthcare facilities to access it? (Chapter 4)
2. What are the institutional challenges that hinder sustainable supply of water to households, schools and healthcare facilities? (Chapter 5)
3. How do rural households, schools and healthcare facilities access water in the Greater-Giyani Local Municipality? (Chapter 5)
4. Which strategies are used by rural households and institutions to cope with lack of water and how effective are these strategies? (Chapter 6)

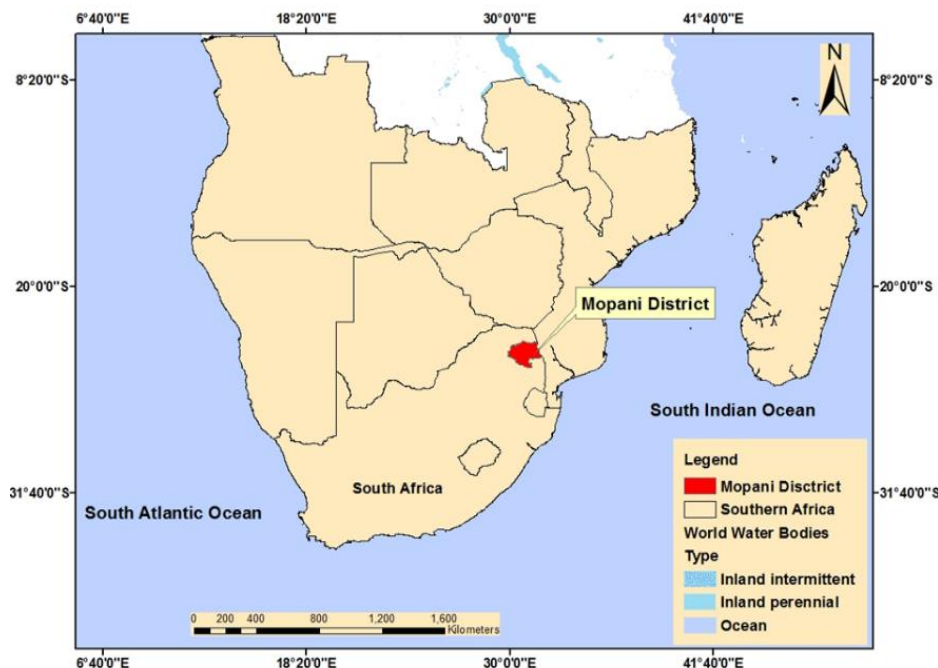
### **1.3.3. Specific Objectives**

The specific objectives of this study are:

- ❖ To examine the impacts of climate variability and change on water availability from year to year
- ❖ To establish the main sources and uses of water for households and public institutions in the study area
- ❖ To determine the challenges faced by rural households and institutions in accessing water
- ❖ To evaluate strategies for coping with water insecurity in households and selected local institutions

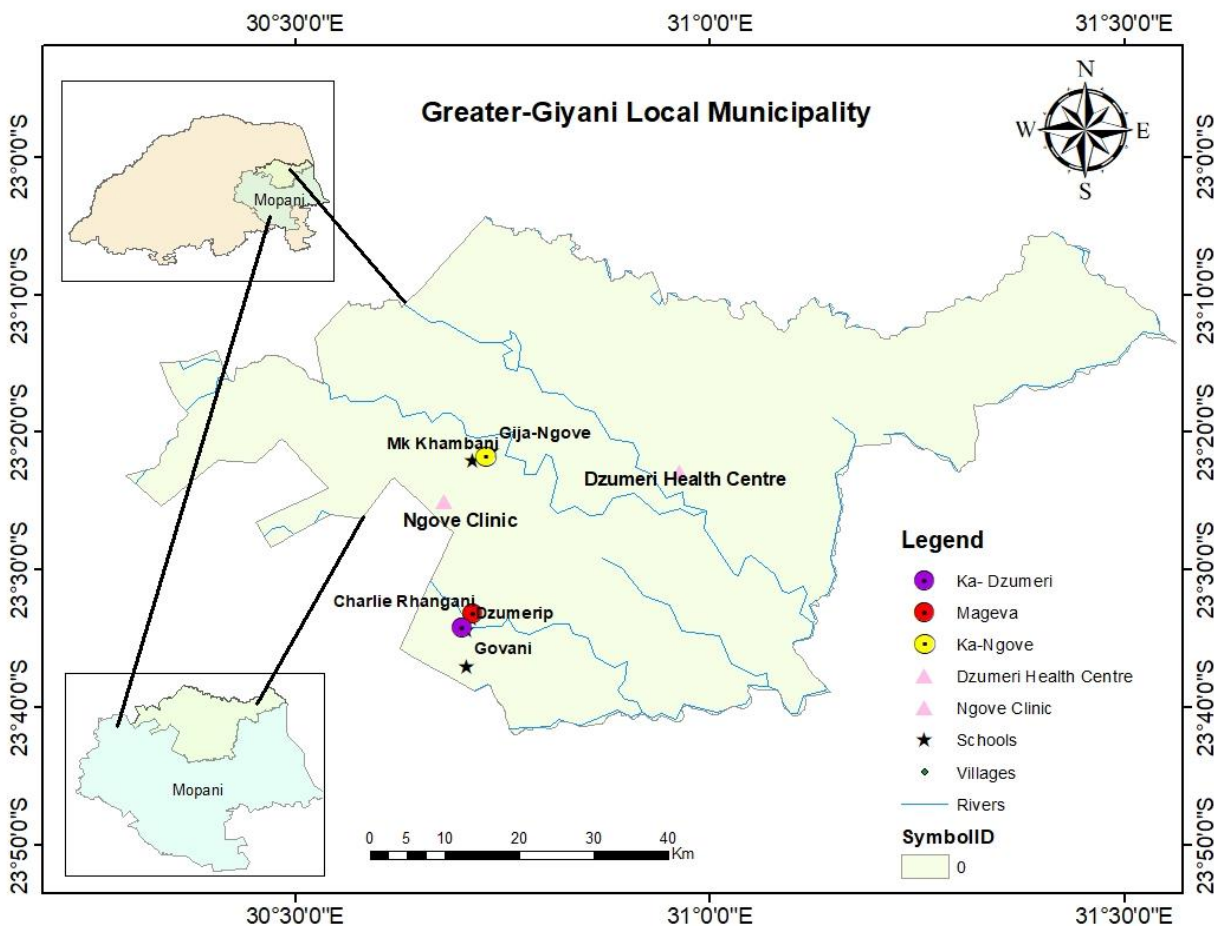
### **1.4. Description of the study area**

The study was conducted in the Greater-Giyani Local Municipality in South Africa's Limpopo Province (Figure 1.1) where there are a large number of communities without adequate access to basic water services. The rural villages of KaDzumeri, Mageva, and KaNgove (Figure 1.2) were the main focus of this study, selected due to high levels of poverty and huge shortfalls in water access and availability (Statistics SA, 2011).



**FIGURE 1. 1** A MAP SHOWING THE LOCATION OF THE STUDY AREA (MOPANI DISTRICT) WITHIN SOUTH AFRICA AND THE SOUTHERN AFRICA REGION. SOURCE: MUNYAI (2017).

KaDzumeri village covers an area of 5.6 km<sup>2</sup> with a total population of about 6,436 and the number of households is about 1,477 with an average household size of 4.4. (Statistics SA, 2011). Mageva village has a total population of about 7,324 covers an area of 6,62 km<sup>2</sup>, with 1,965 households of 3.7 members per household. KaNgove Village has a total population of about 6,376, covers an area of 5,49 km<sup>2</sup>, with the number of households at 1,545 and an average household size of 4.1 (Statistics SA, 2011). The climate of Giyani is characterized by relatively low rainfall with a very hot summer due to its position in the Lowveld. This municipal area receives between 200 – 400 mm of rain annually (Greater Giyani Municipality, 2013/2014). The rainfall has a direct impact on development, especially on agriculture, resulting in surface water shortage, thus leaving the municipality to rely on ground water. All rivers (Middle Letaba, Nsami and Molototsi) are mostly perennial and they all feed into the Letaba River in the south. Other rivers such as Malatsi, Mbaula and Molototsi are tributaries of the Greater-Letaba River (Greater Giyani Municipality, 2013/2014).



**FIGURE 1. 2** THE STUDY AREA (KA-DZUMERI, MAGEVA AND KA-NGOVE) AND THE MAJOR WATER RESOURCES WITHIN THE GREATER-GIYANI LOCAL MUNICIPALITY. SOURCE: RESEARCHER'S OWN DESIGN.

### 1.5. Operational definition of significant terms

**Adaptation** in this study meant, being able to access adequate and clean water during the period where in there is water shortage.

**Climate Change** refers to the change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (UNFCCC, 2014; IPCC, 2007).

**Sustainable water supply** in this study means having access to 25 Lites of water per day in each household.

**Water scarcity** in this study means not having adequate access to clean water for more than two or more than two days or accessing water over long distances.

**Water Supply** in this study means the transportation of water from the dams to households, school and clinics.

## 1.6. Organization of the dissertation

This section shows the structure of the dissertation which is as follows:

-Chapter 1: This chapter has presented the background to the problem, the study objectives, and the statement of the problem. The research questions of the study, the description of the study area, and justification for the study were also provided.

-Chapter 2: A comprehensive literature review on the importance of water, water supply system, climate variability and change, factors leading to poor water supply, coping and adaptation mechanisms to the effects of climate change in the water sector are covered in this chapter. The role that climate and population play in water supply shortages was critically analyzed in this chapter from international to local point of view.

-Chapter 3: This chapter presents the design of the research, the target population to be sampled and sampling techniques that were employed. The methods for data collection and methods of analysis as the study seeks to address the objectives of the dissertation were also presented here.

-Chapter 4: The impacts of climate variability and change on water availability are presented in this chapter. The mean spatial patterns, annual cycles for both rainfall and temperature as well as interannual rainfall variability are also presented here. A few case studies of climate extremes that have affected the study area are presented to highlight the problem. This chapter also explores the variation of hydrological variables to determine changes in water availability.

-Chapter 5: The main sources and uses of water in Greater Giyani are presented in this chapter. The challenges that lead to poor water supply and frequent water shortages in the study area are also addressed here.

-Chapter 6: This chapter deals with household and institutional coping mechanisms and adaptation strategies to water scarcity. Interventions by government and other key stakeholders are also explored..

-Chapter 7: The synthesis of the key findings is done in this chapter, together with recommendations, possible future research and conclusions.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

The aim of this chapter is to present a review of research on water scarcity and how the contribution of climate variability and population growth affects water supply. The available literature addresses delivery of water services, water supply issues in typical rural communities, challenges of rural water supply and an assessment of water and sanitation problems. The impacts of climate variability on water sources, supply and demand are also discussed. Factors influencing equitable distribution of water supply and sanitation services as well as factors affecting the sustainability of a community water supply project are also addressed in this chapter.

#### 2.2 Importance of Water Resources

Water is an essential resource for the continued existence of life on earth. Life as we know it, would never have evolved without water (Chaplin, 2001). It is used daily for drinking, cooking, bathing and washing and many other essential activities. Water is a key component of cells, tissues and organs and thus it is vital for life (Jéquier and Constant, 2009). According to Ritz and Berrut (2005), water acts as our bodies' regulator, as it maintains important aspects of our bodies such as the vascular size and the circulation of blood. All organs and tissues of the body cannot function without it. A human body without water would thus become dehydrated and unable to sustain life, leading to body function failure (Netshipale, 2016).

Globally, water is seen as an essential resource that fosters sustainable development (Kundzewicz, 1997). Water resources are essential for several sectors including industrial, agricultural, household and recreational activities. In order for these sectors to function optimally, fresh water is required. This is a challenge as only about 2.5% of water on the earth is fresh water (Ngima, 2015). According to Naimi-Ait-Aoudia and Berezowska-Azzag (2014), human development and well-being can be assessed by the access people have to fresh water, as this acts as an indicator of development. Water is the most significant contributor to life, allowing both human and animals to survive.

According to the World Mining Frontiers (2015), water is an irreplaceable natural resource with potential for improving social, cultural, environmental and economic growth. It is also a crucial component in human health and improvement as well as the functioning of ecosystems whose

role includes ensuring life on earth is sustained. Howard and Bartram (2003) reiterate that without access to adequate water, it becomes a challenge to properly sustain life beyond a few days and to curb the spread of diseases. Water is a basic human requirement, but also a limited resource that has measurable limitations and quality susceptibility (Hoffman and Nkadimeng, 2016).

Water is used for various human activities and the increasing demand for fresh water resources has the potential to threaten these activities (Hoekstra *et al.*, 2005). In agriculture, major proportions of water are sourced as abstractions from rivers for irrigation, as well as from rainwater and soil moisture, that are more apparent in croplands and forests (Dooge and Selborne, 2004). Most water used in agriculture is in the developing countries, compared to developed countries where water is used mostly (60%) in industries (Scheele and Malz, 2007).

In the mining industry, water is a crucial resource used in the processing of minerals, generation of power, dust management and in staff drinking and hygiene services (World Mining Frontiers, 2015). Industries cannot exist without the presence of water resources. In a survey conducted in India, it was found that surface water (41%) was the main water resource used in industries while groundwater was the second most used water source at 35% highlighting the importance of water in industries in India (Mission, 2011). In Europe, approximately 10% of water is used in industries without including water for cooling and power generation processes (Scheele, and Malz, 2007). Domestic water use entails the use of water resources in households, where it is used for drinking, cooking, washing, and for hygiene purposes. Scheele and Malz (2007) highlights that a person requires at least 5 litres per day of water in order to meet his/her basic human needs, including drinking, cooking and washing.

In this study, water is viewed as an essential life support system whose inadequate access and availability bring about challenges for a population dependent on water resources for many uses. Subsistence farming is the main livelihood source for the communities in rural Giyani; hence a decline in water resources will exacerbate the levels of poverty in the area. The same could be said for the industries within the municipal jurisdiction; a decline in water resources will hamper their productivity. This could lead to loss of employment for people employed in such industries and ultimately, contributing to increased poverty levels. This scenario highlights the need for a study of this nature, one that intends to investigate the impacts and the extent to which the rural communities within the Greater-Giyani are coping and adapting to water challenges, arising from lack of infrastructure, population growth and effects of a changing climate.

## 2.3 Water supply systems and climate change

### 2.3.1 A global overview

The rise in the global mean temperatures is set to contribute to the intensification of the global hydrological cycle. Expected impacts of increased global temperatures include increased atmospheric water vapor content, changes in precipitation with greater variability, intensity and extremes, and potential widespread deterioration in water quality with many forms of water pollution such as the presence of high quantities of salt, pathogens and pesticides (IPCC, 2008a). According to the United Nations World Water Assessment Programme ([www.unesco.org/water/wwap](http://www.unesco.org/water/wwap), 2017), it is estimated that climate change will affect the availability of water resources by changing the amount and distribution of rainfall, soil moisture, glacier and ice / snow melt, river and groundwater flow. Global average temperatures are expected to rise by about 2-5.4° by 2100 as a result of the emissions from greenhouse gases (GHG) (IPCC, 2007b).

From the earth's total water volume, about 2.5% is freshwater, while on land the largest proportions of water are found underground (Okello *et al.*, 2015). However, due to population growth water pollution and advancement in technologies, the demand for water has greatly increased. With all these factors combined together, uncertainty in freshwater availability has risen as freshwater resources across the globe decline at an alarming rate (Okello *et al.*, 2015).

It has been established that climate change is largely the result of global warming due to the increase in greenhouse gas (GHG) concentrations caused by burning fossil fuels and land use changes since the European industrial revolution (The Royal Society, 2010). Numerous global changes have since been observed - increases of more than 0.6°C in average global temperature; changes in cloud cover and precipitation, melting of ice caps and glaciers and reduced snow cover; average global sea level rise and increases in frequency and intensity of extreme weather events (IPCC, 2007a). There is increasing awareness that climate change will severely hamper the availability of water resources. Research shows that the timing, availability, and variability of water supply and demand will be directly affected by climate change (Da Cunha *et al.*, 2007).

Global climate change is a worldwide concern, posing one of the largest challenges to water resources. It is expected to have severe implications for water resources, with impacts on the quantity, variability, timing, form and intensity of precipitation (Adams and Peck, 2008). The agricultural sector is a major source of food production. It has been projected that this sector will be significantly affected by climate change, with most impact on regions depending mainly on

rain-fed agriculture (Monprapussorn, 2014). The greatest impacts are expected to occur in the summer seasons, contributing to reduced levels of soil moisture and increased occurrence and severity of agricultural drought (Adams and Peck, 2008). Drought events that arise as a result of climate change will thus generate serious water resources management implications (Dai, 2011). A consequence of climate change, therefore, will be the reduced ability of people to secure safe and sufficient water supplies, as this will be impeded by the climate variability and water-related extreme events (Monprapussorn, 2014).

Gleick (2003) maintains that over the years the United States has experienced water resources pressures as a result of the growing population and the changes in climate. Climate change is likely to increase the intensity of precipitation, variability, and form more rainfall than snow (Sun *et al.*, 2008). In Western U.S., climate warming is expected to contribute to snow melting, reduced snow pack and to alter the patterns of stream flows (Sun *et al.*, 2008). In Bolivia, Chile, Ecuador and Peru, along the Andean Cordillera, people presently rely on the seasonal discharge from glaciers as their water source due to pollution of rivers by mines and oil extractions (UNFCCC, 2014). Higher economic recession rates correspond to higher water flows, causing erosion, flooding and mudslides in the lowlands. However, as the glaciers disappear such as the Chacaltaya Glacier in Bolivia, which is predicted to disappear within the next 15 years, flows will tail off dramatically. This may lead to serious water shortages, reduced hydropower, greater risks of drought, flooding, hence, serious environmental degradation in Bolivia (UN, 2007).

In Australia's Sydney, as a result of recent drought conditions experienced, an understanding of climate variability and climate change has become an important topic as a way for people to fully grasp weather conditions' effect on water supply and demand (Yue-Cong and Barry, 2010). A study in Indonesia, found that most of the people had poor access to services, including water supply provision (Water U.N, 2007). Over 40 million people lack access to a quality water source. From a report by Harvey and Reed (2006), issues such as lack of education on water supply, perceived lack of ownership by communities, poor management of systems and increased demand in communities contribute towards low rates of sustainability of water supply systems

Callaway (2004) asserts that Africa is one of the continents most vulnerable to changes in climate due to its low adaptive capacity. The southern Africa region is said to be the most susceptible to climate change (IPCC, 2007a). The effects of climate variability and change on water resources in future will become more pronounced than in the past. The results would be both directly and indirectly experienced, as it will affect the socio-economic and biophysical environment (Arnell, 1999; Bates *et al.*, 2008; Kundzewicz *et al.*, 2008; Rutashobya, 2008; Schulze, 2005).

In Nigeria, some of the results of climate variability include limited water provisions for use in farming, hydro-power generation and for domestic use. It has also been observed that the late arrival of the rainy season in northern Nigeria is spreading to more areas in the tropical southern region, thus, this region is now experiencing early termination of the rains, shorter rainy and cropping season, water shortages and drought conditions (Urama and Ozor, 2010). Additionally, desertification is spreading, resulting in variations and alterations in the agroecological regions, progressive exhaustion of the forest resources of West Africa as well as a threat to food production and security.

In Cameroon, low rainfall has led to a sequential occurrence of cumulative and over-time droughts and floods (Molua and Lambi, 2006). Molua and Lambi (2006) highlighted that climatic information has revealed that over the years, rainfall has been on the decline. Drought events have become more severe, resulting in the visible reduction of Lake Chad, the vanishing of Lake Fianga and a total crop failure in 1984 which necessitated food aid (Molua and Lambi, 2006). This picture clearly show that effects of climate variability are unpredictable in places such as the Cameroon.

Rural water distribution in Africa is lower than urban water distribution, as a result of the high levels of poverty in most rural areas and inadequate water reticulation systems. Poverty hinders levels of service sustainability, thus highlighting the need to focus more on provision of potable water to rural communities in Africa (World Health Organization, 2000). In Kenya, a study conducted by Maina (2010) indicated that as a way of ensuring that the entire population in Kenya received adequate access to water and sanitation services, certain measures were put in place by the government, including the establishment of the Water Sector Reform Secretariat (WSRS), whose responsibility was to cover the transitional gap while the water reforms institutions were being established.

Even though the impact of climate change on water resources in Africa will be felt in both rural and urban areas, there is a greater need for focusing on rural water supply. This is because these communities are more susceptible and vulnerable to the effects of water scarcity, due to their low adaptive capacity. Adaptive capacity can be defined as a resource vector and an asset base from which adaptation actions and investments can be made (Vincent, 2007). Rural areas tend to be neglected due to their low contribution in the economic spheres of the local and national government, where urban areas receive more attention as they are the economic hub of many governments. This study, will therefore investigate the possible effects of climate change on rural

water resources and the adaptation methods employed by these communities as ways of coping with water shortages.

### 2.3.2 South Africa

South Africa is a semi-arid, water-constrained nation, having rainfall average of approximately 450 mm below the global average of approximately 860 mm per year (Department of Water and Sanitation, 2015). Worldwide, South Africa is the 30th driest country (EWN, 2018). The status of South Africa as a water-scarce country can be seen in the formulation of the countries legislative framework relating to water, as emphasis has been placed, by the legislative, on the scarcity of water (Algotsson *et al.*, 2009). This is to ensure that justice and equality are promoted in relation to water availability and ensuring proper use of water resources.

According to Kusangaya *et al.*, (2014), South Africa is likely to experience a decrease in rainfall intensity and most likely, the country will experience longer spells of dry periods due to climate change. Such changes might lead to increased occurrence of floods and drought events. Hewitson *et al.* (2005) indicate that climate models show that the east side of South Africa would likely experience higher rainfall, while the southwest will experience shorter winters and the far west will receive the lowest rainfall. Water supply will be affected by a rise in temperatures through higher evapotranspiration rates and decreasing water run-off; these changes to the rainfall frequency and intensity will contribute to an amplified occurrence of droughts and floods (Carter and Gulati, 2014).

In a study conducted in the KwaZulu-Natal coastal metropolitan area, it was found that there was a huge water backlog that threatens water security of the area. Without adequate rainfall dams will run dry impacting the local economy greatly (Van Wyk, 2011). In most rural areas of Limpopo, Eastern Cape and KwaZulu-Natal, about 80% of people have inadequate access to water and sanitation services (Makale, 2015). With the water service backlogs in KwaZulu-Natal an estimated 40-60% of the population in the province lack water access (Department of Water Affairs and forestry, 2002). Another study that was conducted in the Bushbuckridge Local Municipality (Mpumalanga) found that there was insufficient water supply to meet the demand of communities, resulting in most of the villages using water from rivers and hand-dug wells that can present serious health consequences (Mnisi, 2011).

The majority of the population living in rural areas depends mainly on water from rivers, ponds and wells. These waters are not properly treated and may pose a health risk as most are contaminated with faecal wastes (Netshipale, 2016). Hunter *et al.* (2009) postulated that poor

access to clean water may lead to the poor population being at risk of infections from waterborne diseases. Momba *et al.* (2004) maintains that it is the responsibility of water authorities to ensure that the water is treated to the highest standard before supplying to consumers. This is in order to ensure access to water in South Africa is recognized as a basic human right, with the policy and law stipulating that the supply of basic water must be sufficient, safe, accessible and affordable (Netshipale, 2016).

The National Water and Sanitation Programme was developed with the aim of ensuring that sustainability is achieved on this basic human right (Muller, 2002). The water rights are inter-linked with other rights such as the right to food, housing and living in a healthy environment. As a result, the state has an increased obligation to provide clean water for the consumption of humans, to conserve water and provide sanitation as a basic service, as well as ensuring the protection of the environment (Department of Water Affairs, 2013). Before South Africa's first non-racial democratic government came into power, the country had a population of about 40 million of people. From this number, about 15.2 million (with 12 million living in rural areas) of the population lacked basic water supply, while 20.5 million lacked access to basic sanitation (Muller, 2002). Within the poorer black rural areas, these backlogs were more severe than in the urban areas, which were mostly inhabited by whites and affluent people (Department of Water Affairs and Forestry, 2004).

The year 1994 in South Africa was a breakthrough year, as apartheid was finally dismantled presenting many challenges for the newly-elected government, especially with the issue of past-apartheid service inequalities and disparities (Department of Water Affairs and Forestry, 2004). A new water supply and sanitation policy was established with the aim of regulating the water sector and ensuring that national programmes address issues of water backlogs and sanitation with special reference to those people who had had no access to these basic services, especially, the rural poor (Muller, 2002). The Department of Water Affairs was selected to regulate water resources to ensure everyone had access to adequate water and sanitation. It was also tasked with ensuring that the newly-created local government institutions had the capacity to provide water services in a manner that ensures sustainability of water resources (Nkuna, 2012).

The new government's building block was the Reconstruction and Development Programme (RDP) which became its policy foundation. RDP included four pillars required to be met, with access to basic water and sanitation being one of the crucial pillars of the policy (Department of Water Affairs and Forestry, 2014). The RDP policy on basic water supply stipulated that a

household must have a standpipe that would supply about 25 L/capita/day within a 200 m distance of the household and with a minimum flow of 10 litres/second (Department of Water Affairs and Forestry, 2014). After the Reconstruction and Development Programme (RDP), the White Paper on Water Supply and Sanitation policy followed, with special emphasis that the water services development has to be driven by demand (Tissington, 2011).

After the enactment of the Constitution in 1996, the Local Government Municipal Structures Act 117 of 1998 was established, which provide for the construction of municipalities and power of functions to be shared across those municipalities based on their categories - metropolitan, local or district (Algotsson *et al.*, 2009). The Municipal Systems Act 32 of 2000 was enacted with the purpose that municipalities ensure that the local communities are provided with municipal services in both financially and environmentally-sustainable manner. “Environmentally sustainable means: ensuring that the risk of harm to the environment and to human health and safety is minimized to the extent reasonably possible under the circumstances; the potential benefits to the environment and to human health and safety are maximized to the extent reasonably possible under the circumstances; and legislation intended to protect the environment and human health and safety is complied with.” (Algotsson *et al.*, 2009).

In South Africa, the Department of Water and Sanitation (DWS) leads and regulates the water sector, develops policies and strategies and supports the water industry. DWA is governed by two acts, the National Water Act ( 1998) and the Water Services Act (1997) and, in conjunction with national strategic objectives, governance and regulatory frameworks, provides an environment for efficient water use and management (Department of Water Affairs, 2013). The legislation responsible for water services (either water supply or sanitation) is the Water Services Act (Act 108 of 1997) and the National Water Act (Act 36 Of 1998). Providing water to consumers is the responsibility of the Water Services Act and dealing with water in its natural state is the responsibility of the National Water Act (Maake and Holtzhausen, 2015).

The authorities which act as role players in the water service business are the Department of Cooperate Governance guarantees that local government delivers water services, controls the municipals partnerships, and allocates funds to local government (Department of Water Affairs, 2013); the Department of Health that ensures that all the clinics and hospitals have provisions of adequate water and sanitation facilities (Department of Water and Sanitation, 2015); and the Department of Education that is accountable for the identification of schools which lack access to water services. Van Ginkel (2011) explains that the provision of safe and adequate water for

drinking in South Africa depends mainly on the availability of freshwater resources. The fact that South Africa is a semi-arid country, and that water is a factor that can limit the development of the country, any changes in water distribution might result in serious consequences for many economic sectors (Mukheibir, 2007).

In South Africa, as a way of managing the surface water runoff disparities and as a means of improving water supply to economic locations, comprehensive water resource infrastructure has been constructed, including 794 dams, whose storage capacity, when combined is in the order of 31 billion m<sup>3</sup> (Department of Water affairs, 2013). This is higher than two thirds of the country's mean annual runoff (MAR) (Department of Water affairs, 2013). DWS has the authority to operate all the elements of the water cycle across all spheres of government (national, provincial and local levels); cycles from the management of water resources, abstraction of water, its processing and final distribution of the portable water, to the end users (Department of Water and Sanitation, 2015).

This study, within the national level, will inform policy makers by influencing the selection of action plans that can reduce the effects of climate change on water resources in the rural areas of South Africa. The study will also provide a climate-change impact assessment that will assist the local planners, water users, municipal managers, and other stakeholders in the management of water resources in the context of climate change; it should also assist in the development and evaluating of both new and existing adaptation strategies used by rural communities within South Africa. The study's results will, in turn, enhance stakeholders' decision and planning processes, and ultimately, identify essential coping strategies for climate change challenges.

### **2.3.3 Limpopo Province**

Most studies that have been conducted in Limpopo Province have indicated that water supply is a problem that is more common in rural communities as compared to urban areas (e.g. Matji, 2003; Dau, 2010; Manamela, 2010; Netshipale, 2016; Mothetha *et al.*, 2013). According to Berkowitz *et al.* (2009), water supply problems are mostly significant in small municipalities that serve rural communities, while the larger municipalities and metropolitan areas do not experience such problems.

In most rural communities of Limpopo there are major water supply backlogs, wherein weeks and months would pass without any running water. The major contributing factor that has been a common thread in most investigations is lack of operators and municipal officers to maintain water

schemes (Mothetha *et al*, 2013). The Department of Cooperative Governance and Traditional Affairs (COGTA) (2009) has indicated that one of the biggest contributing factors in rural water supply problems in South Africa arises from the 2007 Project framework, where there was assignment of powers and functions and various other governance activities that had neglected the significant capacity limitations of the different municipalities.

The Limpopo Province is dependent on surface water resources with limited groundwater aquifers as a result of the geology of the province (Department of Economic Development, Environment and Tourism, 2015). However, in rural areas groundwater is a major water source for domestic use (Department of Economic Development, Environment and Tourism, 2015). One of the implications of over reliance on groundwater is a decline in the water-table as the population continues to rise. In 2011, only about 52.3% of the population in South Africa had adequate piped-water access within households, while 14% had no access (Statistics SA, 2011). Furthermore, approximately a quarter of a million people and close to 300 schools had no formal water infrastructure at all, as of 2010 (Statistics SA, 2011).

In a study conducted by Mothetha *et al*. (2013), it was found that the water supply systems were inadequate for most rural communities. The study concluded that more needed to be done to address the challenges as a way of improving water supply processes in small municipalities. Another study conducted in Thulamela Municipality by Dau (2010) found that the municipality had a huge backlog in water supply services. This was a result of lack of funds for service provisions, however illegal connections were another major factor contributing to the municipality experiencing a serious water service backlog. A study in Mabokelele Village under the Polokwane Municipality by Manamela (2010) found that the area had inadequate piped-water supply to sustain the growing demand from the village, even water supply from dams could not provide enough water to the communities, who then depend on privately-owned boreholes.

Climate change studies in Limpopo have projected that the river-basin's future water supply availability will become a significant challenge (Zhu and Ringler, 2012). Davis (2010), predicts some changes in Limpopo as the climate is changing - the water in rivers will decrease due to an increase in temperature, increased evaporation, unpredictability in rainfall intensity and quantity, more frequent floods from heavy rainfall intensities. Heavy rainfalls would have an impact on the water supply infrastructure, and increased rivers and sediment scouring which will result in higher costs for water treatment (Davis, 2010). These predictions highlight the need for a study of this nature, that would investigate the adaptation strategies already in place and their efficiency in

cushioning the local people from the eminent scarcity of rain water that would soon lead to water shortages both in surface and groundwater.

The findings of these studies show that even though municipalities do provide water, they are just unable to adequately address the growing demands for water supply in the Limpopo Province. Additionally, there are other localized factors that contribute to water shortage such as population growth and climate change.

### **2.3.4 Mopani District**

The Mopani District is located within the water catchment areas of Groot Letaba River, which supplies water for Greater-Letaba and Greater-Tzaneen Municipalities. The Olifant catchment supplies water for Maruleng and Ba-Phalaborwa Municipality, while the Klein Letaba catchment supplies water for the Greater-Giyani Local Municipality (Mopani District Municipality IDP, 2016/2017). The Mopani District is categorized mostly as a low rainfall zone, with areas such as the lower-lying Giyani and Ba-Phalaborwa receiving the lowest rainfall per annum in comparison to all the other municipalities within the district (Mopani District Municipality IDP, 2013/2014). As a consequence, there are limited water resources, culminating in the municipality having a huge backlog in water services exacerbated by the occurrence of drought conditions (Greater-Giyani Municipality IDP, 2013/2014).

Municipalities in South Africa have been given power to manage and facilitate the provision of the water policy to supply free basic water to those who cannot afford to pay for water. They are obligated to provide access to 6000L (25L per person) of water to each household in the communities (Mothetha *et al.*, 2013). The Mopani District is the water service authority in the Greater-Giyani Local Municipality and has prioritized water services provided by the local municipalities which have a Water Service Provision (WSP) agreement with the Mopani District (Mopani District Municipality, 2011/2016).

Existing water sources within the Mopani District Municipality are streams, wells and boreholes which depend on rivers as their main source. Based on data from the Department of Water and Sanitation (2015) website, the current dam levels indicate the need for more rainfall in order to have consistent and adequate water abstracted from the rivers. There were only three dams that were at least between 94% and 100% full, with the Middle Letaba dam having the lowest level at 37% full as at 28 June 2015 (Maake and Holtzhausen, 2015). It was believed that if this situation continued, this would put a strain on the underground water sources leading to them either running dry or being highly stretched (Department of Water and Sanitation, 2015).

### **2.3.5 Greater Giyani Local Municipality**

The Greater-Giyani Local Municipality is constrained to surface water and groundwater, the Middle Letaba Dam (getting its water from the Middle Letaba River, the Koedoes River, Brandboontjies River and small streams) and the Nsami Dam (obtaining its waters primarily from Nsami River) being the key surface water resources (Greater-Giyani Municipality IDP, 2011). The existing infrastructure in the Greater-Giyani Local Municipality is insufficient to meet the requirements for supplying water to the whole municipal area s(Greater Giyani Municipality IDP, 2013/2014). In 2009/10, due to the drop in water level at the Middle Letaba Rriver and high levels of drought, the Minister declared the Greater Giyani area a disaster area, which then allowed the government to provide emergency funding to help alleviate the drought conditions (Greater Giyani Municipality Adopted IDP, 2013).

The Greater-Giyani Local Municipality has inadequate water supply infrastructure because the villages in the areas are spatially scattered; as such it becomes a hard and expensive task in providing water to all these villages (Mopani District Municipality IDP, 2016/2017). The other factors contributing to water shortages are related to the communities' characteristics and behaviour. These include infrastructure vandalism, (particularly, of communal boreholes), unwillingness of consumers to pay for basic water services and illegal water connections on bulk pipelines, although, this is more prevalent in rural areas than in the urban areas (Mopani District Municipality IDP, 2013/2014). This situation has motivated this study which will investigate the possible causes of water supply shortages, the impacts of climate variability on water resources and coping strategies employed by rural communities of Greater-Giyani Local Municipality.

### **2.4 Water sources for households, schools and health facilities**

Inadequate water supply in most cases results from the area not having a reliable water source. Within the regions that are known to be traditionally water-lacking, the deficiency of water has become more critical, not only due to population growth but because of the decreasing quantities of rainfall (Cobbing, 2013). There are various sources of water that support a region's population. While ground water occurs in the pore spaces within rocks and alluvium, in fractures, and in solution openings or conduits in areas underlain by soluble carbonate rocks, such as, limestone.

Furthermore, in Limpopo the infrastructure identified included reservoirs, reticulation networks, street-taps and boreholes pumps (Mothetha *et al.*, 2013). There are however, variations in water infrastructure in the wider Limpopo, thus the need to identify the existing infrastructure in the

different municipalities, especially rural municipalities. Therefore, this study investigates how rural communities in the Greater-Giyani Local Municipality are accessing water in the face of unreliable supply from the municipality, the challenges they face and how they surmount these challenges particularly within a variable climate.

## **2.5 Factors affecting water availability**

Climate variability and change affect the availability of water through changes in precipitation (total amount and seasonal timing). If an area receives more precipitation the net water supply might not be affected. However, if an area receives the same or less precipitation the net water supply would decrease, thus affecting the water supply in an area (Watershed academy web, 2017). Due to climate extremes, tropical storms might become prevalent and with increased strength. They could lead to the damaging of water infrastructure through the increased flooding, lead to the pollution of water and thus, ultimately, affect water distribution to communities.

According to the IPCC (2008b), river basins on the global assessment scale are defined as being water-stressed when their water availability per capita is lower than 1,000 m<sup>3</sup> (based on long-term average runoff); having a volume of 1,000m<sup>3</sup> per year would mean the country has more water that would be enough for domestic, agricultural, and industrial water uses. Areas with similar water-stressed basins can be found in North Africa, Mediterranean region, Middle East, Near East, South Asia, Northern China, Australia, USA, Mexico, North East Brazil and South America's West Coast, with populations ranging from 1.4 billion to 2.1 billion (IPCC, 2008a). Within the coming 100 years, changes in temperature are anticipated to be at -16,11 °C to -13,89 °C. However, any changes that might occur will depend largely on changes in carbon dioxide concentrations within the atmosphere; changes in the concentrations also rest on human activities that releases carbon into the atmosphere causing global warming (Watershed Academy web, 2017).

The situation is worse in Africa, with around 300 million people not having access to safe drinking water and about 313 million people not having access to sanitation (Beyene, 2012). These findings highlight that the African continent has the lowest total water supply coverage, as compared with other continents across the globe (African Development Fund, 2005). Water is critical to the survival of humans, and variations in its supply from surface flowing rivers can potentially have negative consequences, mostly in Africa, as most of the population depend on native rivers for water (De Wit and Stankiewicz, 2006). Maake and Holtzhausen (2015), in their study conducted in Limpopo, found that the factors that affect water distribution included: in-

decisive leadership, poor implementation of water service by-laws, inadequate water resources, changes in climate, financial mismanagement, and lack of capacity of the water infrastructure. These factors, however, may differ from municipality to municipality hence the need for studies on different parts of the province.

### **2.5.1 Climatic Factors**

#### ***Temperature***

The effect of global climate change on temperature is perhaps the most obvious and especially important because temperature is a driver of many other hydrological variables (Da Cunha *et al.*, 2007). Increased temperatures will alter the patterns of precipitation that will have direct impact on water availability. The most significant impacts are likely to be borne by rural communities that possess low financial and technical capacity to adapt to climate variability. Warburton *et al.*, (2005) concurred that over southern Africa, the rise in temperatures naturally leads to the hydrological cycles accelerating due to increases in evaporation and rainfall. This means that any changes in rainfall patterns could be a result of changes in temperature, which also leads to changes in spatial and temporal circulation of river overflow, soil moisture, groundwater reserves, and a rise in the frequency of droughts and floods (Schulze *et al.*, 2011). Subsequently, within southern Africa, changes in temperature pose a direct threat to the availability of water resources as amplified temperatures will modify the patterns of precipitation (Kusangaya *et al.*, 2014).

Several researchers have made projections that temperature over southern Africa is increasing by around 3°C (Kusangaya *et al.*, 2014). Examples include, Hewitson and Tadross (2011) whose study projected a 3°C maximum temperature increase for South Africa, Swaziland and Lesotho; Mujere and Mazvimavi (2012) anticipated a 3°C maximum temperature increase for the Mazoe catchment in Zimbabwe, and Graham *et al.*, (2011) who projected a 3°C maximum temperature increase for Thukela Catchment, South Africa. This increased warming anticipated will have an effect on tropical storms frequency and strength, in the Indian Ocean, thus subjecting coastal areas to flooding due to an increased sea level (Rahmstorf, 2010). Temperature increases vary as regions are characterized by varying temperature ranges (Kusangaya *et al.*, 2014), for example, parts of the Democratic Republic of Congo and Zambia (wet tropical areas near Equator) are dominated by low changes in temperature as compared to parts of Zimbabwe and South Africa (dry regions). From the projections by the IPCC (2008a), climate change is expected to result in the arid and semi-arid regions becoming drier than humid parts, in countries such as Tanzania and Zambia.

Future-climate projection models have concluded that southern Africa's climate is expected to become hotter (Kusangaya *et al.*, 2014) with the interior and semi-arid regions of southern Africa, the Sahel and central Africa expected to be the warmest. Christensen *et al.*, (2007) also found that temperature changes over the central, southern land mass that extends over Botswana, parts of north-western South Africa, Namibia and Zimbabwe will be warmer by temperature ranges of 0.2 – 0.5°C for every decade.

### **Precipitation**

Together with temperature, any variations or changes in precipitation directly influence evapotranspiration quantity and runoff (quality and quantity) (Kusangaya *et al.*, 2014). In South Africa, a higher inter-annual variability characterises its rainfall (Kruger 2006; Kane, 2009). Climate change has been predicted to lead to a decrease in rainfall levels, such a decline means a decline in global water resources (IPCC, 2007a).

Griggs and Noguera (2002), determined that various models have predicted that southern Africa's rainfall will decrease by 5 to 15% during the planting season (December-February), while studies by Hulme (1992) and Mazvimavi (2011) projected that rainfall in southern Africa will decrease by 5 – 10% and 3- 23% respectively, thus highlighting the challenges that will be faced by rural communities in accessing water. Christensen *et al.*, (2007), found that the patterns of rainfall are expected to change under climate variations in their intensity and frequency, this will lead to occurrences of extreme weather events. Communities' demand for water, across southern Africa has increased as a result of population growth and communities' dependence on rain-fed agriculture, hence, may leave them stranded in poverty due to a reduction in future rainfall frequency and intensity (Thornton *et al.*, 2009).

Other models, however, have projected increases in southern Africa rainfall under climate change scenarios. Examples include, models by Schulze *et al.* (2011) and Tadross *et al.* (2011), who found that the regions on the north-eastern parts of South Africa will experience rainfall increases during climate change situations. These differences simply highlight the difficulty and uncertainties in predicting the future effects of climate change. It is nevertheless important to understand the role played by precipitation in enabling communities to access water in southern Africa.

### **Heat waves**

Heat waves may be defined as an extended period of abnormally hot weather (Nairn and Fawcett, 2011). They usually occur during summer in southern Africa, although there might also be some occurrences during other seasons. In addition to heat waves, South Africa also experiences extreme drought events from time to time (Seneviratne *et al.* 2012; Lyon 2009; Mbokodo 2017). Several studies have shown that the occurrence of heat waves is associated with drought events, often occurring together (eg Lyon 2009; Williams 2014; Mazdiyasi and AghaKouchak 2015).

There are varying factors responsible for heat waves occurring, such as low troposphere warming and deficiency in rainfall and temperatures in summer resulting in lack of soil moisture (Brabson *et al.*, 2005). Heat waves also present negative effects on the agricultural sector in South Africa. As noted by Lyon (2009), southern Africa experienced a loss of 3 million tons of grain production due to drought and heat wave in the period 1991/92; heat waves are also associated with increasing water stress in most regions of the country (Sivakumar, 2006). Heat waves, therefore have drastic effects on two of the countries' major valuable resources - water and agriculture.

### **Drought and Floods**

Drought is a period of time that persists from one year to the next without substantial rainfall, it is a normal part of almost all climatic regions, including high and low average rainfall areas (Dai, 2011). ENSO has been described as a combined ocean-atmosphere phenomenon that usually occurs after every two to seven years in the equatorial Pacific Ocean (Driver, 2014). It is characterized by tropical sea level pressure variations between the eastern and western regions of the Pacific Ocean that are followed by weakening or strengthening trade winds across the Pacific Ocean. In southern Africa, drought is usually experienced during the rainy season (December-March) following the development of an El Niño event (Thomson *et al.*, 2003). South Africa experienced the most severe drought in 2015, resulting in a decline in dam levels to 48% (in November) from 93% (in March) (Donnenfeld *et al.*, 2018). During this season, South Africa underwent prolonged dry conditions that presented various challenges. Several provinces were declared drought disaster areas as water availability, production from agriculture and livestock rearing were greatly affected by the drought during the 2015 period (Botai *et al.*, 2016).

Drought intensities are expected to increase as climate continues to change, from increased heat wave intensity (Chami and Moujabber, 2016). Solomon *et al.*, (2007) postulated that climate change will be mostly observed on annual temperatures and declining rainfall. Drought occurrences result in depletion of ground and surface water levels, thus having a huge knockon

effect on the South African agricultural sector which solely depended on rainwater to flourish (Donnenfeld *et al.*, 2018).

The Limpopo Province is one of the provinces in South Africa that is vulnerable to flooding. According to Le Roux and Van Huyssteen (2010), provinces such as North-West, Eastern Cape, KwaZulu-Natal and Limpopo are most vulnerable to flood occurrences. During 2015 floods, parts of the Limpopo Province (Vhembe, Mopani and Lephalale) were declared flood-disaster zones (Munyai, 2017). Flooding can result from cut-off lows that produce anomalously high rainfall in a few days, while tropical cyclones, tropical storms and continental tropical lows are sometimes also responsible for bringing heavy rainfalls over the province (Malherbe *et al.*, 2012).

### **2.5.2 Human Factors**

The growth in population is a key contributor to water scarcity across the globe, since increases in populations means there would be more demand for water to be used in agricultural, industrial, municipal and domestic uses (UN, 2007). The global population is expected to increase by 65% in nearly 50 years (Sauer *et al.*, 2008); hence, population growth together with increased income per capita, as a consequence these factors would lead to increased water demand (Wallace, 2000). Given the trends in population and consumption, water demand will exceed the available water by 56% and about 1.8 billion people would end up living in water-scarce areas by 2025 (World Water Organization, 2010). Such situations are a result of the fact that developing countries (with water stresses), still contribute the highest growth rates; thus more people are born into areas already without enough water.

The effects of human activities contribute to the river run-off levels reduction, as water is withdrawn from rivers, thus affecting watershed dynamics. In developing countries such as South Africa, it was found that deforestation occurring as a result of growing demand for land from growth in population, contributed to soil stripping over slopes. This has led to increased rates of run-off, and depositing of materials into the river streams (Sichilima *et al.*, 2015). These materials accumulate on river beds, reducing the storage capacity in reservoirs (Sichilima *et al.*, 2015).

The burden on the freshwater system remains a challenge as more water is required for domestic, agriculture, industry and energy use as well as for the disposal of effluents. These challenges are not only because of the population increase but also as a result of change in lifestyle of the people (Sharma, 2003). The steady growth in population and mounting expansions contribute more stress on the already scarce basic infrastructure, such as housing, water supply, security, education, health and waste management mechanisms (Asoka *et al.*, 2013). The hard surfaces

in urban areas and impermeable roads surface reduce base flow of rivers during dry periods, as such surfaces replace the permeable soils and vegetation, volume, velocity and temperature thereby increasing run-offs (Sichilima *et al.*, 2015). According to the United Nations (2007), the majority of countries within the Middle East and North Africa (MENA) region are struggling to meet their present water demand.

## 2.6 Coping strategies and building resilience

In some areas of Iran, communities have been using water collected from residential or commercial roofs of buildings as a practical way of supplying water for irrigation and are partly meeting potable and non-potable water demands (Mehrabadi *et al.*, 2013). In a study conducted in Kenya, it was found that the communities addressed water scarcity problems by fetching or collecting water when available at running taps and then storing the water in larger containers as a way of ensuring that they have water available for later when there is no longer water running in the taps (Ngima, 2015).

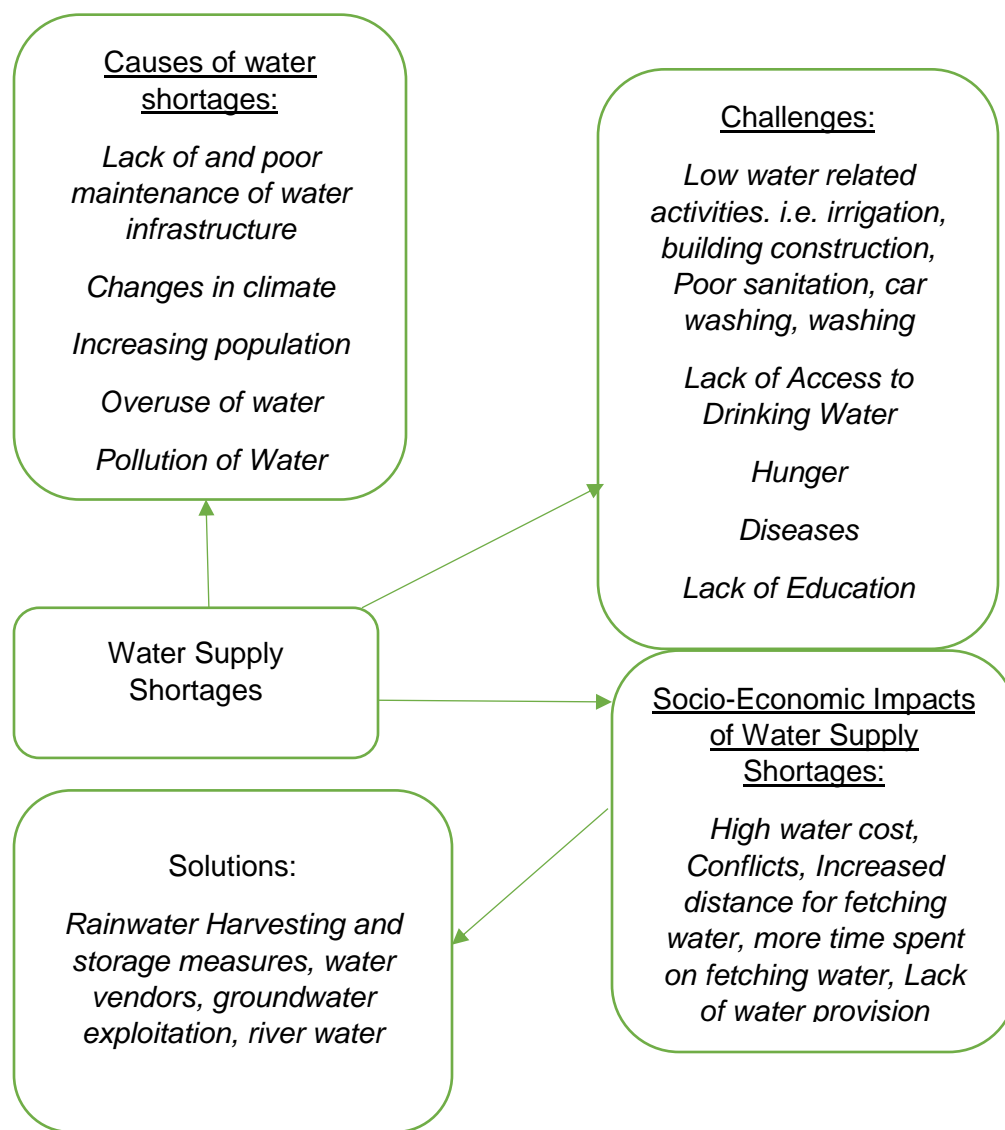
Additional measures included regulating of the water that was available as a way of preventing wastage, harvesting of rain water during rainy seasons and recycling of water that had been used for washing clothes in flushing toilets and house cleaning. In another study conducted in the Western Cape, it was recommended that in order for the municipality to tackle water shortages, there was a need for the following - promotion of rain water harvesting, public showers and taps at beaches disconnected, public taps disconnected on municipal property (for example, at graveyards), presentations done at all schools to educate learners on saving water, presentations for business groups (hoteliers, estate agents, school principals, Chamber of Commerce) (Baatjies, 2014).

In a study conducted at Ga-Kgapane township in Limpopo, Machethe (2011) found that communities were well adapted to water scarcity, as they were using various methods to control water loss. These included - surface water capture and storage, groundwater exploitation, long distance conveyance, desalination and control on water pollution (Machethe, 2011). In this study, adaptation was viewed as a matter of survival for the rural communities of Greater-Giyani, who lack access to adequate water supply, largely as a result of historical lack of water reticulation infrastructures amid a growing population. This study seeks to identify the coping and adaptation strategies used by rural communities as a way to deal with lack of water supply which may become worse due to effects of climate variability and change.

## 2.7 Conceptual Framework

The study adopted and modified the conceptual framework from a similar study by Ngima (2015). This conceptual framework (Figure 2.1) below, highlights the connection amongst the variables of the study - dependent (challenges and socio-economic impacts) and independent (water shortage and climate variability and change). The study identified the probable causes of water shortage and the resultant socio-economic effects of water shortages. The study also proposed other mechanisms that could be used by the communities to address water shortages, whilst assisting households, schools and health facilities in performing their normal functions.

From Figure 2.1 lack of and poor maintenance of water infrastructure, overuse of water, pollution of water and lack of governance, changes in climate (increased rates of evaporation, prevalence of drought conditions) and increasing population were the main causes of water supply shortages. The resultant effects of this were poor sanitation, low production in water-linked activities, more time consumed in gathering water, lack of adequate water, conflicts and more money being spent to obtain water. Some of the challenges also included lack of access to drinking water, hunger, diseases, and lack of education. The framework also highlights that not everyone was affected by the water shortages, as some started selling water from their boreholes and make money.



**FIGURE 2. 1** THE CONCEPTUAL FRAMEWORK MODIFIED FROM NGIMA (2015). THE CAUSES OF WATER SUPPLY SHORTAGES, CHALLENGES, SOCIO-ECONOMIC EFFECTS AND PROPOSED SOLUTIONS. SOURCE: RESEARCHER'S OWN DESIGN.

## 2.8 Summary

It was found that access to water and water supply challenges exist in many rural communities in Africa. The main problem is the lack of water reticulation infrastructure which is the role and responsibility of governments and local authorities. This may be due to past colonial inequalities, but current authorities could do more to improve access to water in marginal rural areas. Greater Giyani lies in the subtropics where rainfall is generally unreliable, and as the climate warms, changes in rainfall may worsen this decades long problem. Population growth also induces stress

on already limited water resources. How communities in Greater Giyani are coping with these challenges may provide lessons for other regions that are grappling with access to water.

## CHAPTER 3

### RESEARCH METHODOLOGY

#### 3.1 Introduction

This chapter presents the data and methods used in this dissertation. Firstly, it begins by a description of the research design adopted in order to achieve the aim and objectives of the study. Secondly it provides the description of the study population and sampling procedures, whilst the methods used in data collection and analysis are also detailed.

#### 3.2 Research Design

This study used mixed methods that combined both qualitative and quantitative research methods. The mixed methods approach presents a researcher with several advantages such as giving researchers more confidence in their results, more options for collecting data and leads to theory synthesis (Johnson *et al.*, 2007). It also provides one with a more substantial way of data interpretation; hence, more robust results (Muskat *et al.*, 2012). In this study, the qualitative approach entailed using open-ended discussions allowing respondents to provide information that might not have been fully captured in questionnaires, while a quantitative approach was used in structuring the households' questionnaires.

#### 3.3 Data Collection

To address the specific objectives of the research and to determine the extent to which the Greater Giyani Municipality is adapting to water scarcity, and water supply challenges as a result of climate variability, this study used both primary and secondary methods for data collection. Making use of both primary and secondary data sources helped strengthen the legitimacy and validity of the research outcomes. Primary data was collected through structured questionnaires, key informant interviews and field observations, whereas secondary data was collected through Census report 2011 and from regional and global climate and hydrological centers.

### 3.3.1 Field work (Primary data)

#### 3.3.1.1 Target Population

The target population for this study was heads of households, primary schools (school principals) and health facilities (head of the department) from three villages KaNgove, Mageva and KaDzumeri within the Greater-Giyani Local Municipality.

#### 3.3.1.2 Sampling Technique

Systematic random sampling was used in selecting the study population. Systematic sampling is a probability technique for sampling in which all elements of the population are known and provides all with an equal prospect of being selected (Tongco, 2007). This sampling technique provides a probability for every household within the study villages to be selected for participation in the research, thus reducing the likelihood of the researcher being biased. The starting household in each village was picked randomly, allowing all the households to have an equal chance of being selected. The subsequent ones were picked after every  $k^{\text{th}}$  number based on the total number of households in each village.

In KaDzumeri with 1477 households, 1 household was selected after every 40th household to obtain a sample of 40 households. At Mageva with 1965 households, 1 household was selected after every 55th in order to obtain the sample of 36 households. Finally, KaNgove with 1545 households, 1 household was selected after every 43 in order to obtain 36 households. Either members or heads of households were selected and requested to respond to the questionnaire. Groves *et al.*, (2011) argues that systematic sampling is useful in obtaining a sample from a population where a list does not exist and depends upon the arrangement of the population being studied based on a hierarchical order and choosing elements within an ordered list, at regular intervals.

The study targeted heads of households from the sampled households, but where the head of household was absent during the time of administering the questionnaire, the eldest member of the household above 18 years was picked. Where none of these people was available, then the researcher moved to the next nearest household. Primary schools and health facilities were selected based on their proximity and existence within the study villages.

### 3.3.1.3 Sample Size

According to Statistics South Africa (2011) Greater Giyani Local Municipality has a total population of 244,217 (in an area covering 58.54 km<sup>2</sup>) people. Greater Giyani Municipality spreads over 85 communities and the total number of households is 63548 (15.23 km<sup>2</sup> area) (Statistics South Africa, 2011). The study, however, comprised of three communities which either did not or had inadequate access to basic water services from the municipality in KaDzumeri, Mageva, and KaNgove.

Greater Giyani has a total of 28 health centres including clinics servicing about 10176 out of 244,217 population (Mopani District Municipality IDP, 2016/2017). The area has mobile clinics providing services to rural areas, within the municipality that have no clinics at set visiting points. In Greater Giyani, there are 165 schools - 66 of which are secondary, 97 are primary, one is combined and another is for learners with special educational needs (Mopani District Municipality IDP, 2016/2017).

The three rural communities and the total number of households were as follows: KaDzumeri (1,477), Mageva (1,965), and KaNgove (1,545) (Statistics SA, 2011). The sample sizes were calculated online at: <https://www.surveymonkey.com/mp/sample-size-calculator/> with the use of the following formula:

$$\text{Sample Size} = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1 + \left(\frac{z^2 \times p(1-p)}{e^2 N}\right)}$$

Where:

N = Population Size

P = Sample proportion

e = Margin of error (e is percentage, put into decimal form e.g. 3% = 0.03).

Z = Z-score,

Hence, the sample size for each village was as follows: KaDzumeri (37), Mageva (36), and KaNgove (36). The confidence level (95%) and the margins of error (10%).

$$\text{KaDzumeri} = 1477 / 37 = 40$$

$$\text{Mageva} = 1965 / 55 = 36$$

$$\text{KaNgove} = 1545 / 43 = 36$$

The total number of households was =  $40+36+36=112$ .

#### **3.3.1.4 Questionnaire (Household interview)**

Babbie and Mouton (2001) asserts that the basic objective of a questionnaire is to acquire facts and opinions about a phenomenon, from people who are knowledgeable on the specific issue. A household questionnaire was administered to heads of households. It contained both closed and open-ended questions, while closed-ended questions were aimed at obtaining information on demographic characteristics of the respondents and other direct questions that did not require explanations. Open-ended questions allowed respondents to add their views and opinions to their responses. The questionnaire covered the following: identification of the main water sources used by the community, the households coping strategies and effects of climate variability on water shortages as indicated in Appendices A-G.

#### **3.3.1.5 Key Informant Interviews**

Key informants were selected based on purposive sampling so that they could provide specific detailed information about the water shortage experiences. Purposive sampling allows the selection of stakeholders believed by the researcher to be the best candidates to provide information required (Tongco, 2007). The key informant interviews (10) were conducted as a way of acquiring expert opinions. The interviews were held with representatives from Department of Water and Sanitation (DWS), Department of Health (DOH), Department of Education (DOE), Greater Giyani Municipality and Mopani District Disaster Management Centre authorities. These key informant interviews covered aspects on municipal/institutional coping strategies from water distribution shortages and impacts of water shortages. They also responded to questions on water quantity, availability, health (water quality), infrastructure and reliability in supplying services, as indicated in Appendices D-F.

#### **3.3.1.6 Field Observations**

This is a method of data collection where the investigator is fully immersed in the study area, observing the physical landscape and activities taking place in the area. To comprehend the realities of the water supply system, field visits were conducted. Field observations were also carried out to observe the physical landscape and other visible outcomes from extreme weather

events (events with extreme values of some important meteorological values (Stephenson *et al.*, 2008)), such as damaged dams, damaged infrastructures and others. The following data sets were collected through the visual condition survey: construction standards, the condition of the contributing watershed, the type of water point. The waiting period to collect water and distance between the water point and households were also determined. A camera was used to capture pictures of damaged infrastructure, burst pipes, illegal connections and water sources used.

### **3.3.2 Secondary data**

#### **3.3.2.1 Population data**

Census (2011) data provided useful information about the total population within the Greater-Giyani Municipality and also information on levels of water access across the villages within the municipality. It further provided data on schools and the health facilities (clinics and hospitals) with different levels of water access.

#### **3.3.2.2 Hydrological data**

Water levels of key dams supplying water to Greater Giyani were analyzed to determine the changes in available water for the period from 1984-2017. Variation of dam level data may be due to a number of factors including dam releases and abstractions upstream. This analysis was helpful in determining changes in available water and how impacted water supply to the rural population of Greater Giyani.

The most significant and useful data in hydrological analysis are those data describing the flows (or streamflow) of rivers (Rees *et al.*, 2004). This is because the river flow is the only stage at which the hydrological cycle water is restricted in well-defined channels that allow for precise quantification to be made of quantities involved. Within the study area, there was only one major river system, which is the Letaba River. The station data was obtained and analyzed for the Letaba River station on the one basin that has an extensive record of observations. River flow data is associated with several challenges, including missing data or missing data being entered as zero flows (Rees *et al.* 2004) and also discrepancies in reporting periods (Chikoore 2016).

Dam level data and mean river flows in the Klein Letaba catchment was obtained from the South Africa's Department of Water and Sanitation (Hydrological Information System) and the verified hydrological data was obtained for Letaba River at Limpopo B8H009 (-23.8°S, 31.6°E) for the period from 1984-2017. The monthly peak flows were obtained from [www.dwaf.gov.za](http://www.dwaf.gov.za) and then

analyzed. Natural flows were recorded at Letaba station as there are no dams or diversions upstream. River flow data does not necessarily represent point data, but conditions in the catchment upstream of the gauging station (Chikoore, 2016).

### 3.3.2.3 Climate data

Due to the absence of long-term and continuous station rainfall and temperature observations in the study region, gridded data from global centers was preferred. Monthly surface air temperature data was obtained from Climate Research Unit of the University of East Anglia (CRU TS3.10 dataset). Surface air temperature is the air temperature adjacent to the earth surface and is usually measured at 2 m above the ground. According to Harris *et al.*, (2014), the CRU TS3.10 dataset is a high-resolution global dataset of monthly climate observations that cover the world's land surface, between 60°S and 80°N interpolated at 0.5° × 0.5° resolution and could be accessed at <http://www.cru.uea.ac.uk/>. The CRU TS3.10 dataset is an upgrade from the CRU TS dataset which unlike CRU TS3.10 was not specifically homogeneous and could only be used for analysis of climate trends, hence its analysis had to be complemented by comparisons (Harris *et al.*, 2014).

This study made use of the GPCC version 6 (Becker *et al.*, 2013) rainfall data acquired from station data and rain-gauges in the analysis of gridded monthly and yearly rainfall observations over the world. This dataset stretches from long-term is obtained at latitude-longitude resolutions of about 0.5° × 0.5° global grids (Becker *et al.*, 2013). The GPCC were obtained and manipulated via the KNMI Climate Explorer (<https://climexp.knmi.nl/start.cgi>).

To analyze daily fields, reanalysis data was also used to for temperature and rainfall during seasons of extreme weather. Reanalysis refers to observations that have been interpolated and gridded via a numerical weather prediction system (Chikoore 2016). In this study, the Climate Forecast System Reanalysis (CFSR) daily maximum temperature and precipitation datasets are used to provide detail of the extent of extreme events analyzed. The CFSR reanalyses are obtained from the National Centers and Environmental Prediction (NCEP) and have been detailed by Saha *et al.* (2010). Timeseries of this data is plotted via the Climate Engine at <https://app.climateengine.org/>.

Potential evaporation is defined as the quantity of water that would evaporate if there was an unlimited supply of water present within a catchment (Kay and Davies, 2008). Potential evaporation data is often derived in climate models which are data-intensive (depending on temperature, humidity, radiation and wind speed data). This study made use of potential evaporation to determine how evaporation may affect water levels in dams and rivers as well as

soil moisture within the study areas. The potential evaporation map presented here was obtained from a Water Research Commission study by Schulze and Maharaj (2007).

### **3.4 Methods of Analysis**

#### **3.4.1 Numerical methods and graphical methods**

Numerical methods are comprised of numbers and values (Peck *et al.*, 2009); when describing them it is most common to report a value that acts as a representative of the observations. Numerical methods that were used in the analysis of data include: descriptive statistics that were used to analyze the factors affecting water distribution, socio-economic characteristics, impacts and coping strategies, the mean, median, the interquartile range and percentiles. The statistics were generated through Statistical Package for Social Sciences (SPSS) 23.

These data were coded, arranged, entered into an MS Excel spreadsheet and converted to SPSS to create more descriptive statistics. After generation of descriptive statistics, cross-tabulation were used to compare the relationship between different variables and demographic characteristics in relation to adaptation of the households to climate change conditions. It was also used to compare the findings from the three communities - KaDzumeri, Mageva and KaNgove. Cross-tabulation refers to the process of analyzing relationships between two variables (White, 2004). The graphical methods that were used in data presentation include - comparative bar graphs, histograms, tables and pie charts were used for presentation and grouping of data. The entered data were summarized into percentages and frequencies.

#### **3.4.2 Thematic Analysis (Content analysis)**

Thematic analysis is a distinct application of organized observation of personal documents and mass media material, this also involves open-ended questions and the contents of comprehensive interviews. The process allows the content of these sources to be scrutinized systematically to record the relative frequency of themes and the way in which these themes are represented (Welman *et al.*, 2005). According to Braun and Clarke (2006), thematic analysis is a qualitative method used for categorizing, analyzing and reporting patterns (themes) that exist within the data.

Thematic analysis has proven to be a good analytical method in similar studies (Baatjies, 2014; Ngima, 2015). In this study, thematic analysis was used in the analysis of the key informants (Department of Water and Sanitation, Department of Health, Department of Education, Greater Giyani Municipality and Mopani District Disaster Management Centre authorities), interview

responses, thereafter the answers were arranged into themes. Themes and answers were then grouped into identical categories, classified and synthesized. Descriptive narrative technique was then employed to describe the results of key informants' interviews.

### **3.4.3 Trend Analysis (Regression)**

Trend analysis is a specific form of single-df comparisons when a quantitative independent variable is manipulated (Kivikunnas, 1998). Linear regression analysis was also used for the trend analysis of each station with available climatic data. In this study, trend analysis was used to analyze dam levels trends over the Greater Giyani Local Municipality for a period of 34 years (1984-2017). Trends in annual average temperature and precipitation were calculated for the whole Greater-Giyani Local Municipality for the same period. The study also analyzed river flow trends for the same period.

### **3.4.4 A case study approach**

Bromley (1990) describes a case study approach as a systematical investigation focused on an event aimed at defining and clarifying a phenomenon under investigation. Researchers have made use of case study approach as way to seek answers to questions such as “why?” and “how?”. According to Maree (2010), a case study approach provides a platform for understanding what previously was poorly understood in relation to an event under study.

The case study approach was used in this dissertation to analyse the impacts of climate variability and change in water availability during dry (1991/92 and 2015/16) and wet (1999/00 and 2011/12) periods and their related extreme (events with extreme values of some important meteorological values (Stephenson *et al.*, 2008) impacts on three communities. The four seasons were selected following an analysis of anomalies by rank wherein the wettest and driest were analyzed. The case study approach ensures that one has a deeper understanding of the dynamics relating to impacts of climate variability and change in Limpopo province.

## **3.5 Data display**

### **3.5.1 KNMI Climate Explorer**

The KNMI Climate Explorer is a collaborative web-based climate analysis tool that can be used to extract climate data and provide statistical analyses. These include seasonal cycles and mean plots. Climate explorer also provides a platform for users to upload their own time series and examine them, while also allowing them to view, correlate and detrend time series. The Climate

Explorer may be retrieved online at [www.climexp.knmi.nl](http://www.climexp.knmi.nl) and was used in the generation and manipulation of GPCP rainfall and CRU maximum temperature. A time-series of river flow data was also uploaded onto the KNMI Climate Explore to create an annual cycle and a monthly time plot.

### **3.5.2 Statistical Package for Social Sciences (SPSS)**

The IBM SPSS software platform offers advanced statistical analysis, an immense library of machine-learning algorithms, text analysis, open-source extensibility, combination of big data and seamless deployment into applications. Its ease of use, flexibility and scalability make IBM SPSS reachable to users with all skill levels and projects of all sizes and complexity to help the user or organization to discover new prospects, improve productivity and minimize risk.

### **3.6 Ethical Considerations**

The research study followed key ethical aspects as suggested by Wolf *et al.*, (2015), as follows:-

- ❖ To maintain confidentiality of the respondents, their privacy was protected and sustained thus no respondents' personal information was disclosed.
- ❖ All respondents were well informed about the nature of the study and the researcher asked for their consent before conducting the study.
- ❖ All findings of the study were recorded and reported in an honest and worthwhile manner.
- ❖ For the purpose of this study permission from the local authority (Greater Giyani Local Municipality) and the University of Venda Ethics Committee (Appendix J) was obtained before the research project went to the field.
- ❖ Clearance was obtained for the project as well as developments from it.
- ❖ A letter requesting permission to conduct the study was sent to the local community members as well as a consent letter to the householders wherein the project was explained.
- ❖ Contact numbers were provided, and the benefits or risks of participation were clearly stated.
- ❖ The respondents were told they could withdraw or refuse to take part in the study at any time.

### **3.7 Summary**

This chapter described the data sets and data sources used in the study and methods of analysis. The primary data sets were from households' interviews and key informant interviews whilst secondary climate and hydrological data were also analyzed. Thematic analysis was used for the analysis of key informants interviews whilst the SPSS statistical software was employed in the analysis of the households questionnaire. Time series analysis was used to analyse climate and hydrological datasets. The above data sets, methods of analysis should ensure the achievement of the specific objectives of this study.

## CHAPTER 4

# CLIMATE AND WATER AVAILABILITY IN GREATER GIYANI LOCAL MUNICIPALITY

### 4.1 Introduction

Availability of surface water resources in rivers, dams and other reservoirs is strongly dependant on rainfall which also varies from season to season in the study area. The aim of this chapter is to analyze the recent climate record and how changes in rainfall from season to season affect the surface water resources and therefore the amount of water available for community use. The main climate variables analyzed here are rainfall and temperature (which itself influences evaporation of water from dams) as well as aspects of extreme climatic events. The hydrological response to climate variability is presented through analysis of dam levels and river discharge.

### 4.2 Rainfall variability in Limpopo

#### 4.2.1 Mean Spatial Patterns

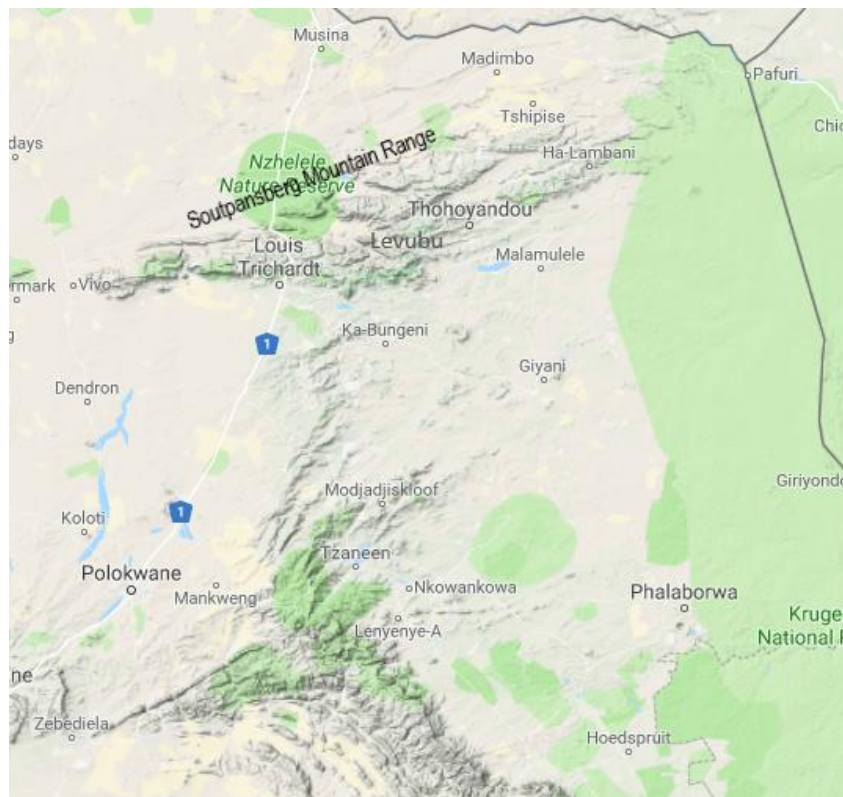
The Limpopo Province is located in the northern-most side of South Africa and characterized by complex topography which regulates the regional climate (Figure 4.1). The region experiences high spatial variations in annual rainfall from west to east and from south to north, whilst topographic effects are clearly discernible in the mean pattern (Figure 4.2). The area is largely semi-arid with annual rainfall less than 500 mm and some areas in the far north receive even less than 300 mm per year on average. It is also significant that some of the highest rainfalls (exceeding 1000 mm) in South Africa are also found in Limpopo along the northeastern escarpment extending north-south through Mopani and Vhembe Districts (Figures 4.1 and 4.2). High rainfalls are also found on the windward (south) slopes of the Soutpansberg Mountain range with a west-east orientation through Makhado and Thohoyandou.

Rainfall received over the northeastern escarpment supports large scale commercial agriculture which is the dominant economic activity in Tzaneen and Levubu (Figure 4.1). Plantations of fruit trees (e.g. bananas, macadamia, mango), sugar cane, tea estates, vegetables are supported here. Maize is also grown here but to a limited extent. The leeward (north) side of Soutpansberg Mountain range is drier and hotter and dominated by shrubs and short grasses. The area east and north of the escarpment is commonly referred to as the Limpopo Lowveld and is mostly

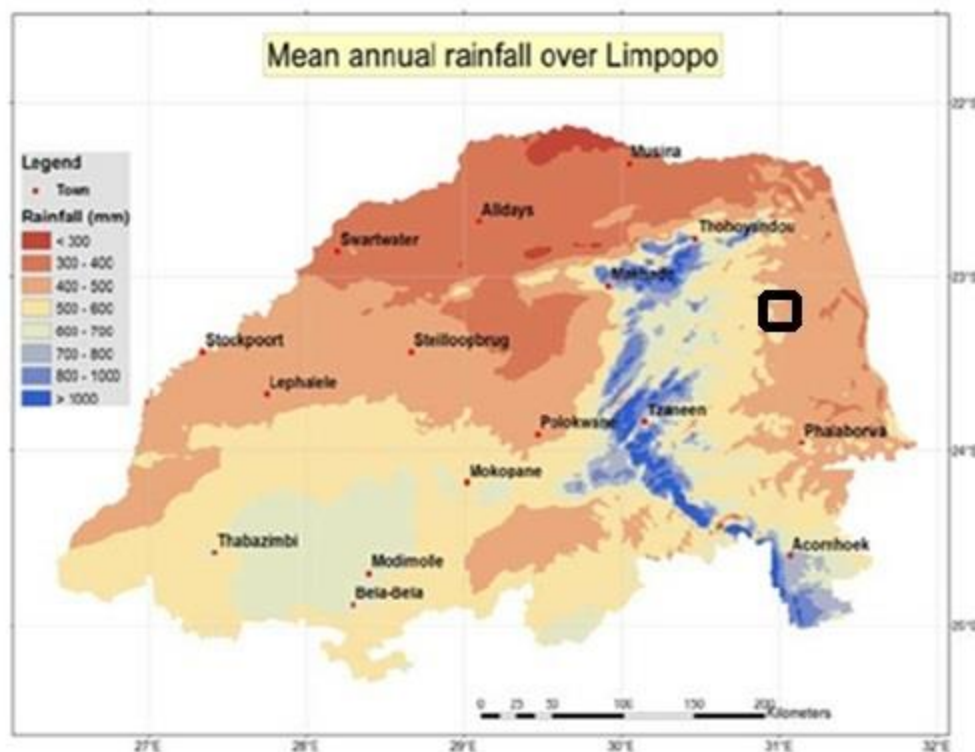
unsuitable for rainfed crop husbandry such that it is dominated by game (wildlife) farming and cattle ranching.

With the establishment of the Inter-Tropical Convergence Zone (ITCZ) over tropical southern Africa during the austral summer, the Angola low acts as a source for tropical-extratropical cloudbands, bringing most summer rainfall across the Limpopo Province (Driver, 2014). Whilst cloud bands are the main rain-bearing systems over Limpopo providing between 30-50% of annual rainfall (Hart *et al.*, 2013), the lowveld is also highly vulnerable to tropical cyclones that originate from the southwest Indian Ocean and the Mozambique Channel (Malherbe *et al.*, 2012) and approach through Mozambique. These storms have been linked with overwhelming floods over southern Africa during the late austral summer season (e.g. Reason and Keibel, 2004).

The Greater Giyani municipal area is located between the wetter escarpment to the west (e.g. Tzaneen) and the drier Kruger National Park (e.g. Phalaborwa) in the east (Figure 4.2) bordering Mozambique. The mean rainfall in Greater Giyani ranges spatially from about 300 – 400 mm per year with lower rainfall in the east.



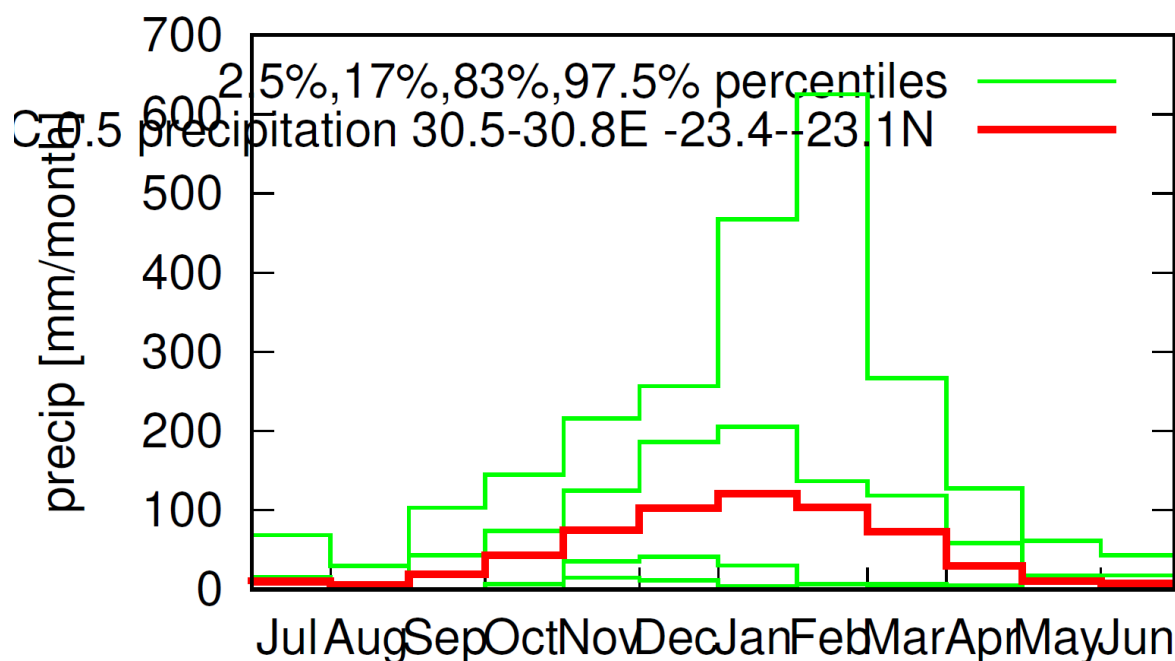
**FIGURE 4. 1** MAP SHOWING KEY FEATURES OF THE COMPLEX TOPOGRAPHY IN LIMPOPO PROVINCE. (SOURCE: GOOGLE MAPS). GIYANI LIES BETWEEN THE ESCARPMENT AND KRUGER.



**FIGURE 4.2** LONG TERM MEAN SPATIAL PATTERNS OF STATION RAINFALL (MM) OVER SOUTH AFRICA'S LIMPOPO PROVINCE (SOURCE: AGRICULTURE RESEARCH COUNCIL, 2018).

#### 4.2.2 Mean Annual Cycle

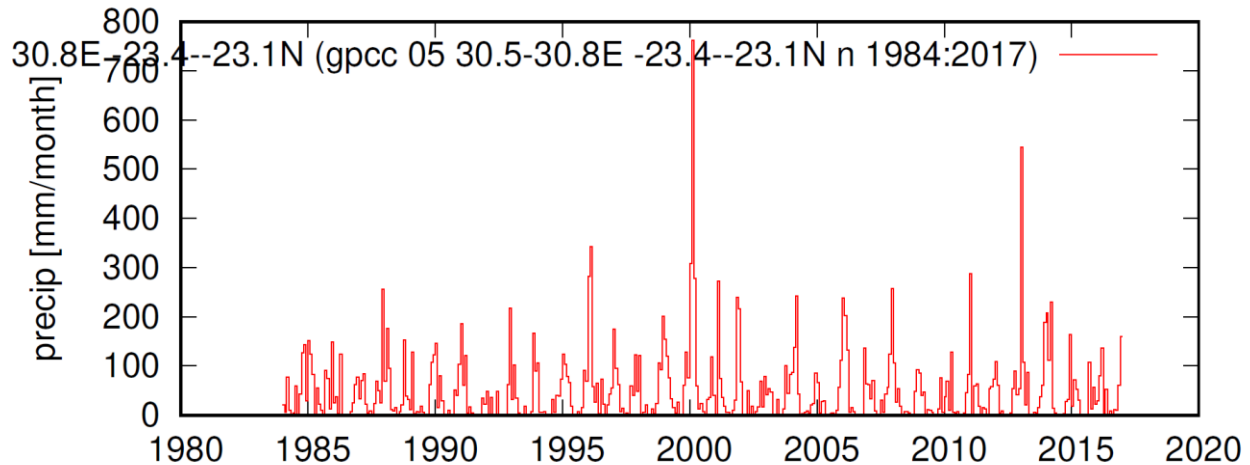
The mean annual cycle of rainfall in Greater Giyani exhibits a strong seasonality with most rainfall occurring during the austral summer months spreading from October to March (Figure 4.3). The bulk (> 250 mm) of the rainfall is received during November to March. The winter months are predominantly dry. In a study of drought in South Africa, Rouault and Richard (2003) found that the biggest difference between summer and winter rainfall amounts is found in this region – the northeastern interior. The percentiles shown in green in Figure 4.3 demonstrate that the study area experiences very high variability in summer rainfall. Extremely high rainfall is typically associated with tropical cyclonic rainfall whilst the drier (drought) years (2.5% and 17.5% percentiles) are characterized by an early peak in December which suggest early cessation. There is not much variability in dry season rainfall over the Greater Giyani Municipality.



**FIGURE 4. 3** MEAN ANNUAL CYCLE (SHOWN IN RED) OF GPCP RAINFALL OVER GREATER-GIYANI LOCAL MUNICIPALITY (1984-2016). THE 2.5%, 17%, 83%, 97.5% PERCENTILES ARE ALSO SHOWN IN GREEN IN ORDER FROM BOTTOM TO TOP.

#### 4.2.3 Interannual Rainfall Variability

The rainfall timeseries exhibits high variability on a number of timescales with distinct periods of very high rainfall and also intense droughts (Figure 4.4). The wettest rainfall season in the study area occurred during February 2000 largely due to above normal rainfall received across much of the Limpopo River basin following landfall of the devastating tropical cyclone Eline over southern Mozambique. A secondary rainfall peak corresponds to the 2011/12 rainfall season when tropical cyclone Dando affected the area (e.g. Chikoore *et al.* 2015). The worst drought on record in Greater Giyani occurred during the 1991/92 summer season which caused widespread impacts across southern Africa (Vogel, 1994). The most recent 2015/16 drought season was also severe. Most, but not all droughts in Limpopo occur during the presence of El Niño events in the equatorial Pacific Ocean (Chikoore, 2016). La Niña events generally (not all the time) favour wetter conditions in the region (Reason *et al.*, 2000; Meque and Abiodun 2015).



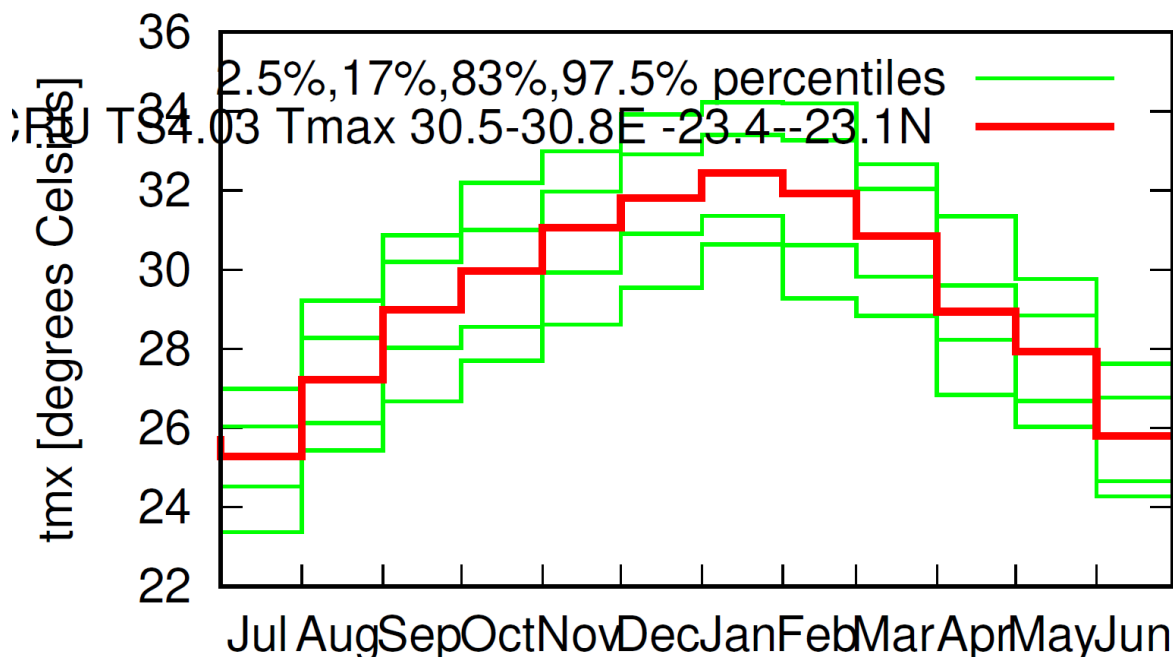
**FIGURE 4. 4** VARIABILITY OF MONTHLY GPCC RAINFALL (MM/MONTH) IN GREATER-GIYANI FROM 1984 TO 2016.

### 4.3 Surface air temperatures in Limpopo

Long-term mean summer temperatures are higher than 30°C over much of the lowveld. In this region, the lowveld is endemic to malaria transmission as it favors the proliferation of the *anopheles* mosquito and the *plasmodium* parasite. This happens following stagnation or ponding of water after rainfall events supporting breeding of mosquitos (Machimana, 2016). The low altitude of the Limpopo valley and its location under the descending limb of the subtropical high pressure systems contribute to the high temperatures experienced in this region (Chikoore, 2016).

#### 4.3.1 Mean Annual Cycle

The mean annual cycle of maximum air temperatures in Greater Giyani averaged over the period 1984-2017 is shown in Figure 4.5. As with rainfall, the air temperatures peak during December to February with a minimum during June – August (Figure 4.5). The hottest month occurs mostly in January, and there is also considerable variability in the annual cycle of maximum temperatures. The generally high summertime temperatures in the study area imply high evaporation rates, more strain on available surface water resources and higher risk of heat-related diseases. High temperatures increase risk of cardiovascular and respiratory diseases and also raise the levels of ground level ozone and other pollutants in the air (Glazer, 2005).

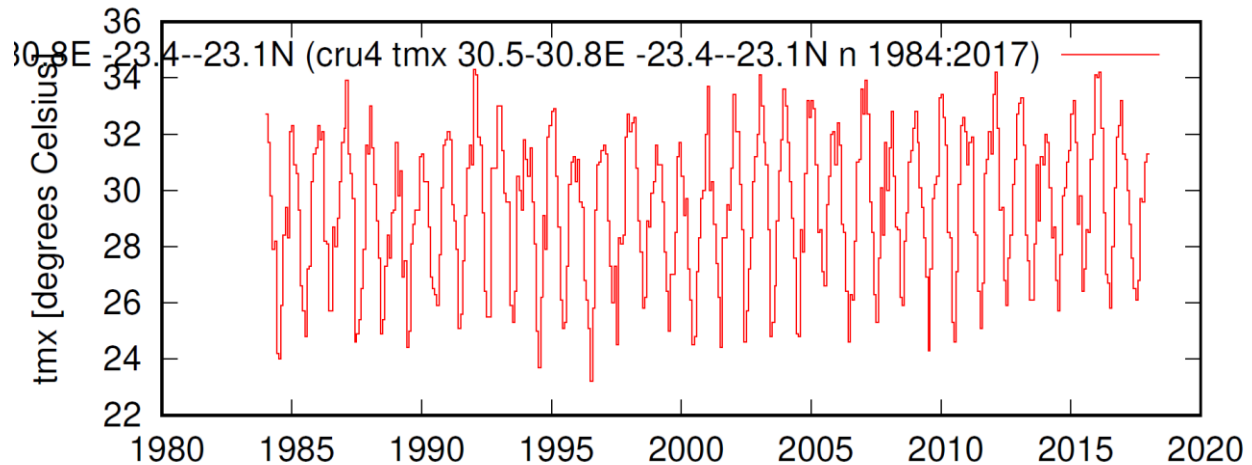


**FIGURE 4. 5** MEAN ANNUAL CYCLE (SHOWN IN RED) OF CRU Ts4 MAXIMUM TEMPERATURE (°C) OVER GREATER GIYANI (1984-2017). 2.5%, 17%, 83% AND 97.5 PERCENTILES ARE SHOWN IN GREEN FROM BOTTOM TO TOP RESPECTIVELY.

#### 4.3.2 Trends in surface air temperatures

The annual cycle of mean monthly maximum temperatures (Tmax) in Greater Giyani exhibits fluctuations between 24-34°C (Figure 4.6). The warmest seasons in the time series have occurred during the drought seasons of 1991/92 and 2015/16. The 2011/12 season also shows was also warm despite the few cyclone days.

Climate change projections suggest an increase in mean air temperatures by a range of 1.4°C to 5.8°C (IPCC, 2007b), while the northeast of South Africa (Limpopo) is projected to warm by up to 4°C (Engelbrecht *et al.*, 2015). The number of heat wave and fire danger days was also projected to increase in future in the northeast (e.g. Engelbrecht *et al.*, 2015). High fire danger days may also imply an increased risk of veld fires especially in the drier areas of the province which include Greater Giyani. A recent study by Kruger and Nxumalo (2017) found that rainy seasons are becoming shorter while dry (burning) seasons are becoming longer as the rainy season onsets retreat. The observed trends coupled with projected future climate may result in reduced water availability in Greater-Giyani and indeed much of Limpopo.



**FIGURE 4. 6** MEAN MONTHLY CRU MAXIMUM TEMPERATURE(°C) OVER GREATER GIYANI FROM 1984-2017.

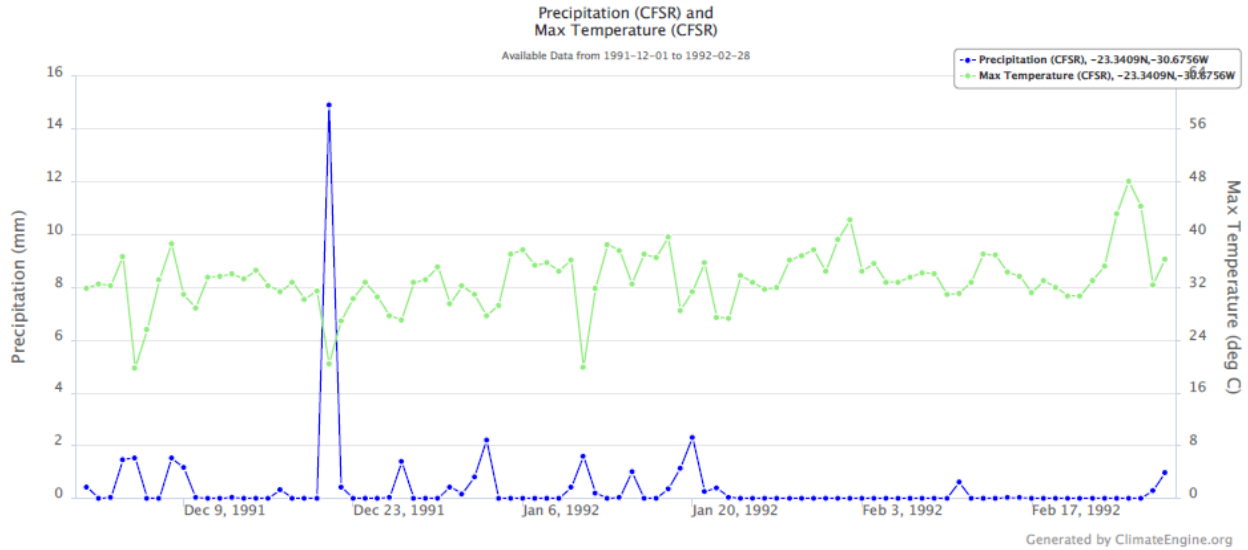
#### 4.4 Rainfall extremes and remote influences

In this section, case studies of extreme climate events are presented that resulted in severe droughts/floods during the study period from 1984-2017. The 1991/92; 1999/2000; 2011/12; 2015/16 seasons were selected based on the magnitude of the rainfall anomalies after ranking the data from least to highest.

##### 4.4.1 1991/92 drought event

A moderate 1991/92 El Niño event coincided with one of the driest seasons on the climate record of the Greater-Giyani Local Municipality. This event occurred as a result of increased sea surface temperatures over the equatorial Pacific Ocean which resulted in dislocation of the cloud bands away from the southern Africa mainland. Sea surface anomalies in the tropical oceans have a greater association with anomalies of rainfall in several regions (Boer *et al.*, 1992). Below normal condition refers to the amount of rainfall received being lower than the long term climatological mean whereas above normal condition refers to amounts of rainfall greater than the long term mean (Mulugisi, 2015). The highest daily rainfall amount during the entire season was recorded in December 1991, typical with an early cessation.

During the 1991/92 drought event (Figure 4.7), maximum temperatures across Greater Giyani ranged from 31°C to 35°C (Figure 4.7), highlighting the amount of heat associated with dry conditions. Previously, it was found that drought events in Limpopo are often accompanied by heat waves (e.g Lyon 2009; Nkuna and Odiyo 2016).



**FIGURE 4. 7** DAILY PRECIPITATION (MM) AND MAXIMUM TEMPERATURE (°C) OVER GREATER GIYANI DURING DECEMBER – FEBRUARY 1991/1992.

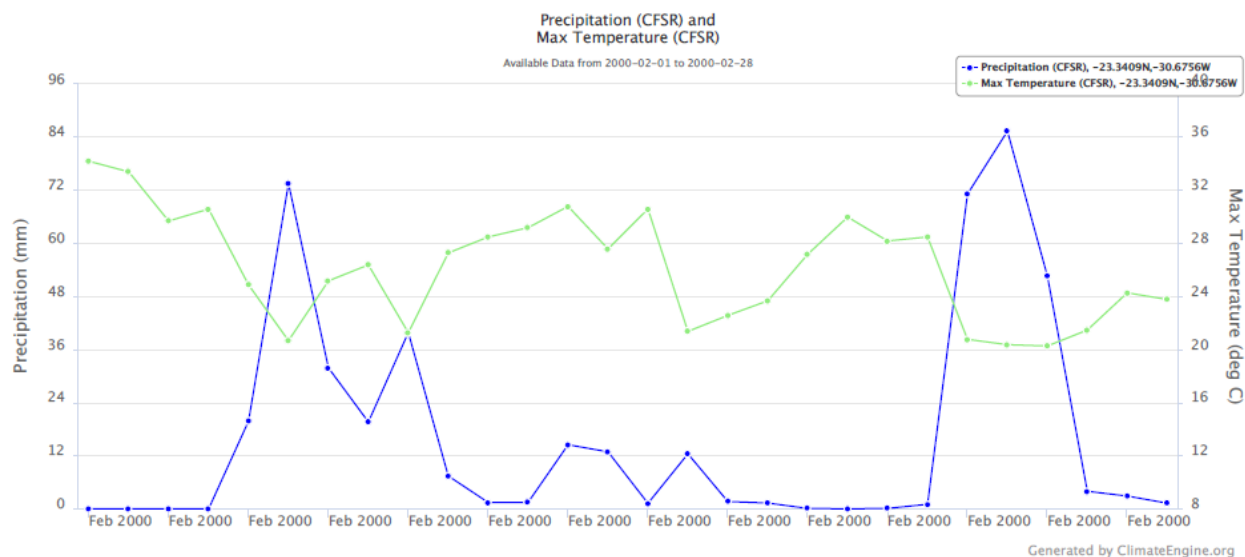
The 1991/92 drought event had direct effects on South African agricultural productivity, which incidentally contributes to about 25% of all industrial raw materials used for production (Vogel, 1994). It also resulted in the poor contribution by the agricultural sector into the country's GDP. Reduced water in rivers encouraged communities to drill 132 boreholes in Venda (National Drought Forum, 1992). Furthermore, there were 96 000 cattle that died in Lebowa during 1991/92 drought event (National Drought Forum, 1992).

#### 4.4.2 1999/2000 flood event

The 1999/2000 season is the wettest season ever recorded in the Greater-Giyani Local Municipality. Whilst the season was generally wet, the occurrence of tropical cyclone Eline that affected southern Africa in February 2000 (Dyson and Van Heerden, 2001) caused heavy rainfalls across the sub-continent. Flooding is most likely in areas that have been affected by tropical cyclones (Konrad *et al.*, 2002). Dams in the study area overflowed and also had far reaching effects on local communities selected in this study as the flooding resulted in loss of property and livelihoods. Flood waters also affect the water quality often resulting in water borne diseases such as cholera.

During this flood week (23-25 February 2000), Greater Giyani experienced heavy rainfall in 3 days (exceeding 50 mm/day). During February 2000, maximum temperatures in Giyani were moderated by clouds, rainfall and moist soils, being mostly below 30°C (Figure 4.8).

The February 2000 floods had devastating impacts in many areas as the cyclone traversed the southern Africa region from Mozambique to Namibia. In South Africa, 100 people were killed by this flood event (Reliefweb.int, 2000) which also caused a decline in agricultural yields thereby negatively affecting the regional economy (Maluleke and Mokwena, 2017). The greatest impacts were in Mozambique where 800 lives were lost due to floods or vector borne diseases in the wake of Eline (Pri.org, 2011).



**FIGURE 4.8** DAILY PRECIPITATION (MM) AND MAXIMUM TEMPERATURES (°C) OVER GREATER GIYANI DURING FEBRUARY 2000.

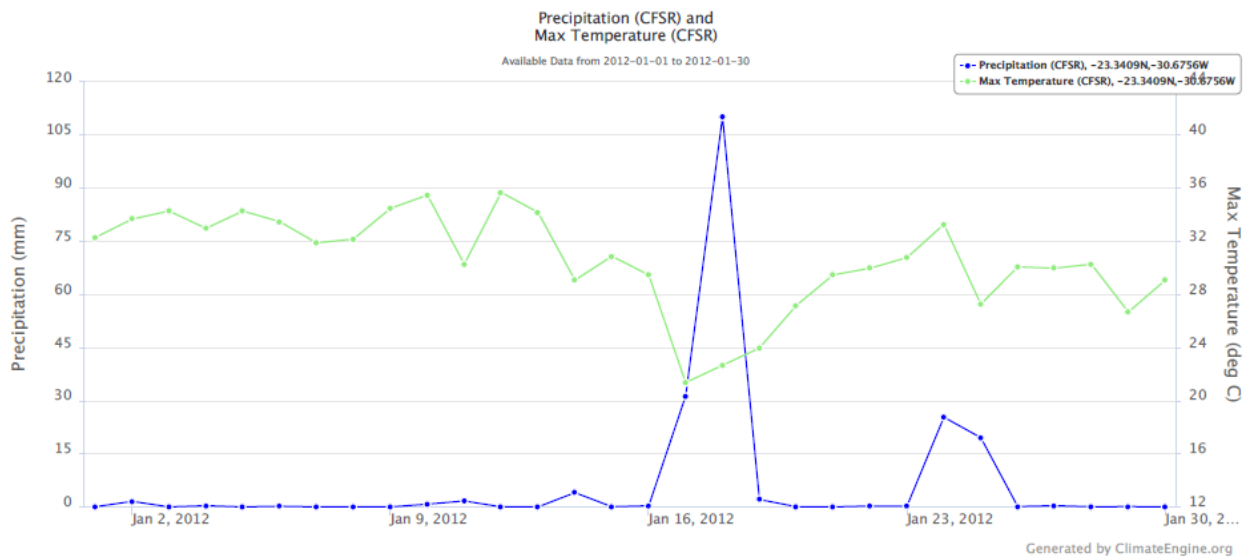
#### 4.4.3 2011/12 flood event

Another anomalous wet season that affected the Greater-Giyani Local Municipality coincided with the occurrence of a La Niña event over the equatorial Pacific Ocean during 2011/12. In January 2012, the SW Indian Ocean was warmer than normal, creating conditions for cyclogenesis (Chikoore *et al.*, 2015). Despite being a La Niña, the 2011/12 season was a dry season (Umlindi, 2012-01) over much of southern Africa. It is further evidence that not all La Niña events result in a wet season. However, during January 2012, tropical cyclone Dando made landfall over southern Mozambique and flooded the eastern periphery of South Africa. The Kruger National Park bordering Mozambique was flooded whilst over 100 mm of rainfall fell in 24 hours over the Greater Giyani area (Figure 4.9).

Tropical cyclone Dando resulted in damages in excess of R58.92 million in the Mopani District Municipality (Fitchett *et al.*, 2016). For context, before tropical cyclone Dando occurred, several farmers had lost an average of 30 cows each due to the dry and hot conditions that prevailed in

Vhembe District (Maluleke and Mokwena, 2017). The Mopani District was the worst affected, with three of the five local municipalities (Greater Giyani, Maruleng and Ba Phalaborwa) being declared disaster areas (Timeslive.co.za, 2012). In the Kruger National Park, there were about 20 international tourists who were airlifted as the floods had inundated the roads guest houses (IOL.co.za, 2012).

During January 2012, temperatures in Greater Giyani also dropped significantly during the period (~16 January 2012) of the heavy rainfall (Figure 4.9).

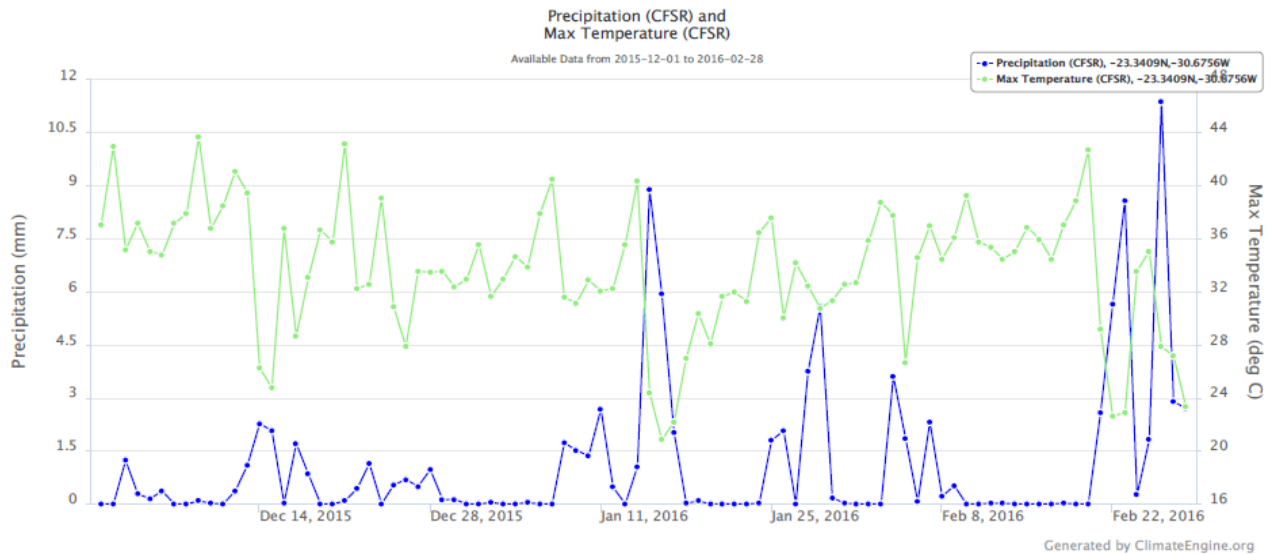


**FIGURE 4.9** DAILY PRECIPITATION (MM) AND MAXIMUM TEMPERATURE (°C) OVER GREATER GIYANI DURING JANUARY 2012

#### 4.4.4 2015/16 drought event

An intense drought event occurred during the 2015/16 summer affecting large areas of southern Africa. It was also the hottest season on record globally (World Meteorological Organization, 2015). This event resulted in loss of large herds of livestock and a dangerous decline in surface water resources in Limpopo (Manderson *et al.*, 2016). During the summer from December 2015 to February 2016, maximum temperatures in Greater Giyani were mostly above 30°C apart from a few rainy days (Figure 4.10). On a few occasions the maximum temperatures rose above 40°C. The few rainy days were characterized by low rainfall (<12 mm/day) amounts throughout the drought season (Figure 4.10). These high temperatures and low rainfall would have affected the availability of water resources in a study area which is already semi-arid. It was reported that during this drought event, Greater Giyani experienced water strains that resulted in the decimation

of livestock and wilting of rain-fed crops (Timeslive.co.za, 2015). About five of the country's nine provinces were declared as disaster areas as a consequence of the extreme drought (Phys.org, 2015).



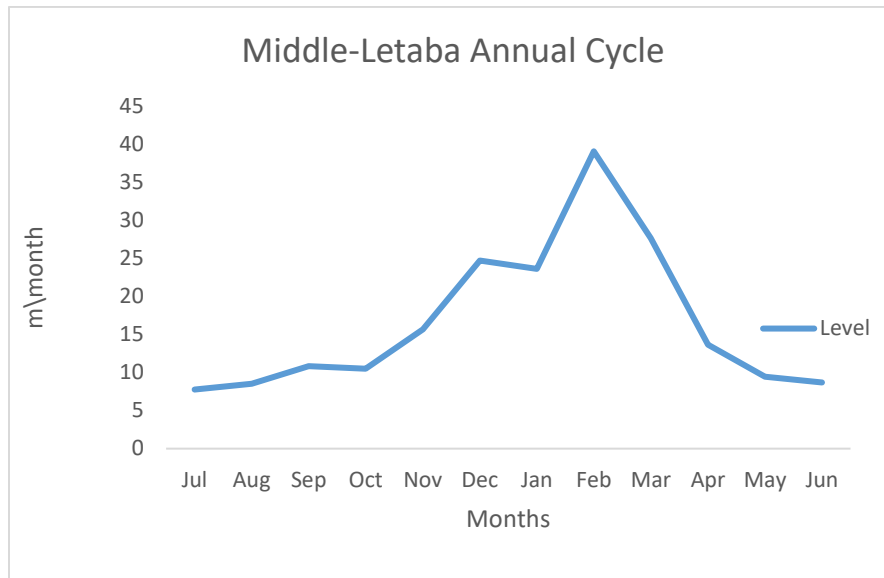
**FIGURE 4. 2** DAILY PRECIPITATION AND MAXIMUM TEMPERATURE (°C) OVER GIYANI DURING DECEMBER-FEBRUARY 2015/2016.

#### 4.5 Hydrological response

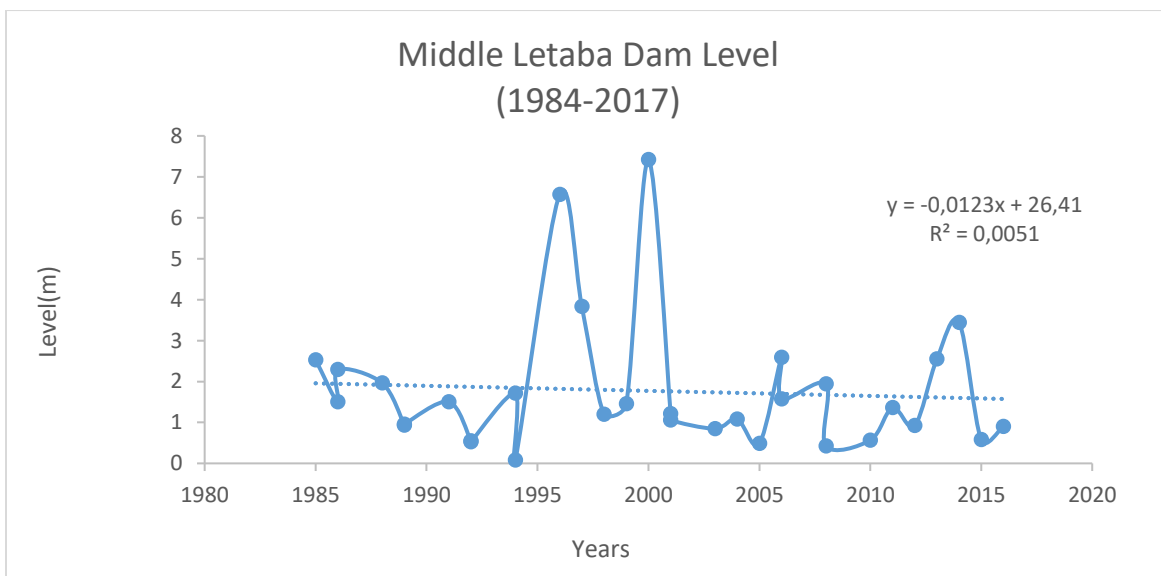
Rainfall is the most significant driver of hydrological processes (Schulze, 1997), providing the main input for dams and reservoirs (Nath and Bolte, 1998). The hydrological response of a dam refers to the dam's reaction to rainfall (Kongo and Jewitt, 2006) which is determined largely by the climate of the region (Tshikolomo, 2012). During high rainfall seasons, water is stored in dams to be used during periods of low rainfall. This means water availability for supply to communities is dependent on rainfall and the available storage capacity in dams (Mostert, 2008). However, some areas are supplied by water derived from distant places as is the case with Rand Water which is supplied by water from the Lesotho Highlands ([www.randwater.co.za](http://www.randwater.co.za)).

Greater Giyani Local Municipality has one major dam (Nsami Dam) that provides water to the local villages. The Middle Letaba Dam lies upstream and feeds untreated water into Nsami Dam. The annual cycle of dam levels in the Middle Letaba shows a peak during the late summer to early autumn (February to April) following the rainfall peak which occurs during December to February (Figure 4.11).

Distinct peaks of dam levels occurred during 1996 and 2000 (Figure 4.12) with the latter peak being the result of remnants of cyclone Eline as discussed earlier. Linear trends for Middle Letaba Dam are generally neutral but may be sensitive to the extreme events of 1996 and 2000. Water abstraction, population growth and increased evaporation of water due to rising temperatures might reduce water availability further in future. Environmental problems such as eutrophication, sedimentation and siltation may also affect the quality of the water in the dams.



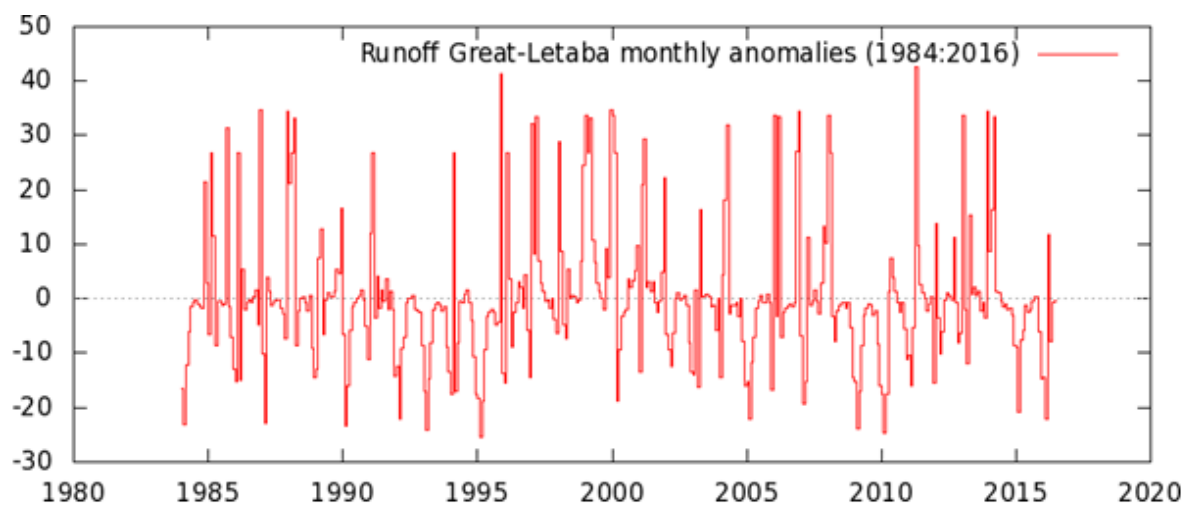
**FIGURE 4.3** ANNUAL CYCLE FOR MIDDLE LETABA DAM LEVELS DURING 1984-2017.



**FIGURE 4.4** VARIATION OF DAM LEVELS FOR MIDDLE LETABA DAM DURING 1984-2017.

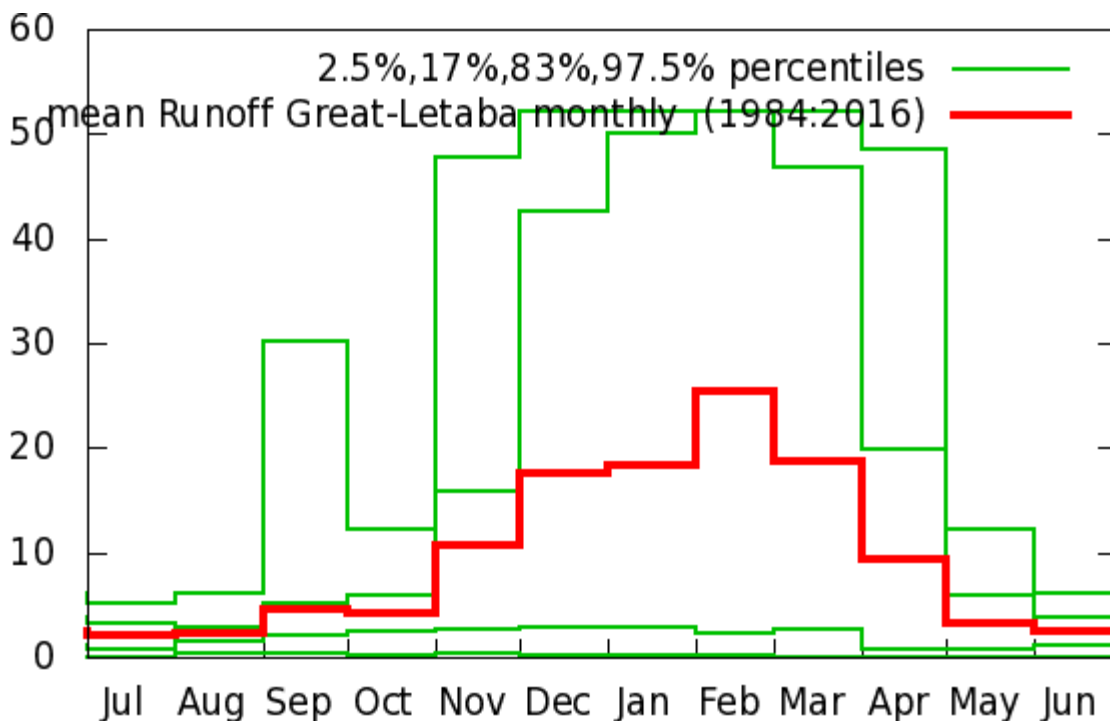
Water supply for the dams in the Greater-Giyani Local Municipality is dependent on runoff amounts which are influenced by rainfall. Low rainfall amounts generally lead to low runoff in an area resulting in water shortages or stress. Water stress results when an area's annual water supply per capita dips below  $1,700 m^3$  and absolute water scarcity results when supplies drop below  $500 m^3$  (Water U.N, 2007).

The drought of the 1991/92 summer season also resulted in a reduction in surface water resources of Greater-Giyani as the dam level of the Middle Letaba Dam fell to only 1 m (Figure 4.12) whilst the discharge anomaly was at  $-20 m^3/s$ . During 2011/12, the Great-Letaba river runoff was above average ( $45 m^3/s$ ) (Figure 4.13). This was due to flooding that occurred from tropical cyclone Dando that affected parts of southern Africa.



**FIGURE 4.5** GREAT-LETABA RIVER DISCHARGE ANOMALIES (1984-2017)

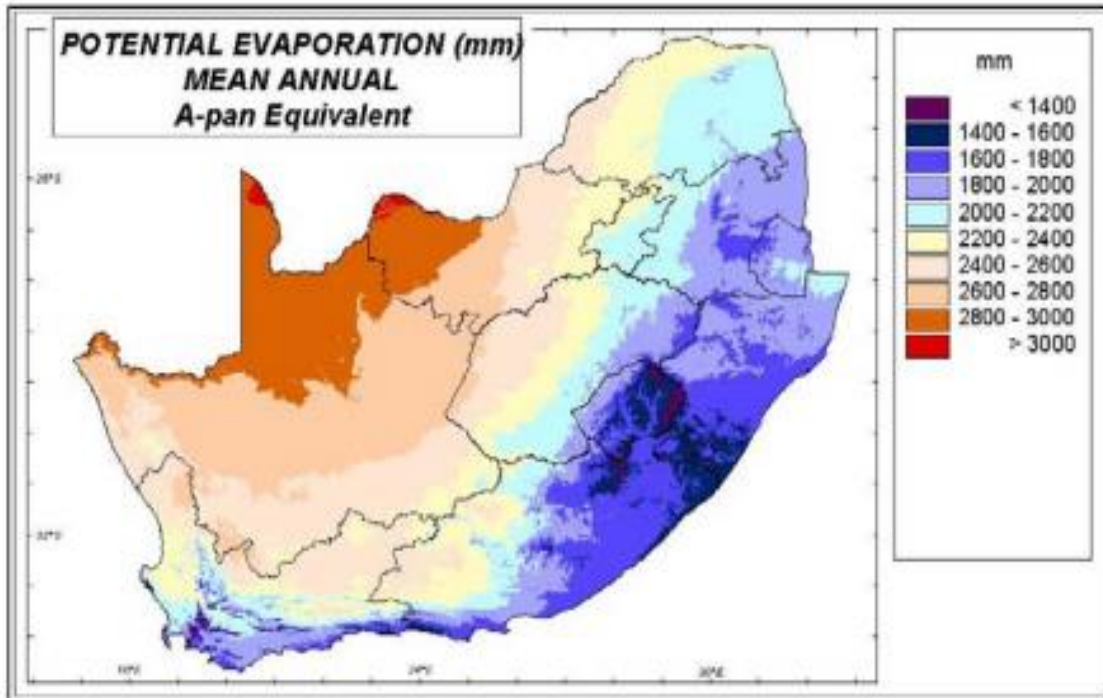
During the 2015/16 season, Great-Letaba River runoff was  $-20 m^3/s$  below average, while the dam level was at 0,5 m (Figure 4.13). This was due to the severe drought that season which ultimately contributed to local communities being unable to receive water from the municipality. Over the period 1984-2017 river discharge exhibited high variability consistent with rainfall variability. As with dam levels, river discharge is highest during February to March immediately after the rainfall maximum as stated earlier (Figure 4.14).



**FIGURE 4.6** MEAN ANNUAL CYCLE (SHOWN IN RED) OF GREAT-LETABA RIVER DISCHARGE MEAN ANNUAL CYCLE (1984-2017).

#### 4.6 Potential evaporation

Potential evaporation is presented here instead of actual evaporation due to a lack of evaporation monitoring stations in the study area. Potential evaporation is defined as the quantity of water that would evaporate if there was unlimited water present within a catchment (Kay and Davies, 2008). Warm climates and desert areas are generally considered as regions of high potential evaporation. It is shown in Figure 4.15 that the northwest of South Africa has the highest potential evaporation with the lowest values over the mountains in the southeast. Much of eastern Limpopo (including Greater Giyani) has a mean annual potential evaporation of between 2000 and 2200 mm, which is considerably high. Erratic rainfall and high evaporation rates may be a reason why some areas in Greater Giyani can no longer support rain-fed crop production for such crops as maize. Rising surface temperatures will result in a greater demand for water vapour by the atmosphere suggesting more problems in future in terms of water supply to communal areas in the municipality.



**FIGURE 4.7** LONG TERM MEAN ANNUAL POTENTIAL EVAPORATION (A-PAN EQUIVALENT) IN MM OVER SOUTH AFRICA (SOURCE: SCHULZE AND MAHARAJ, 2007)

#### 4.7 Summary

This chapter dealt with the “climate factor” in regard to water problems in the Greater-Giyani Municipality. It was shown that the rainfall is highly variable and unreliable in this area. Temperatures area also high particularly during periods of drought with significant implications on evaporation of soil moisture and from open water bodies. Whilst the main dam that supplies the area is fed from upstream outside the study area, the dam levels are generally low and also vary significant largely “in concert” with rainfall.

## CHAPTER 5

### WATER SUPPLY IN GREATER GIYANI LOCAL MUNICIPALITY

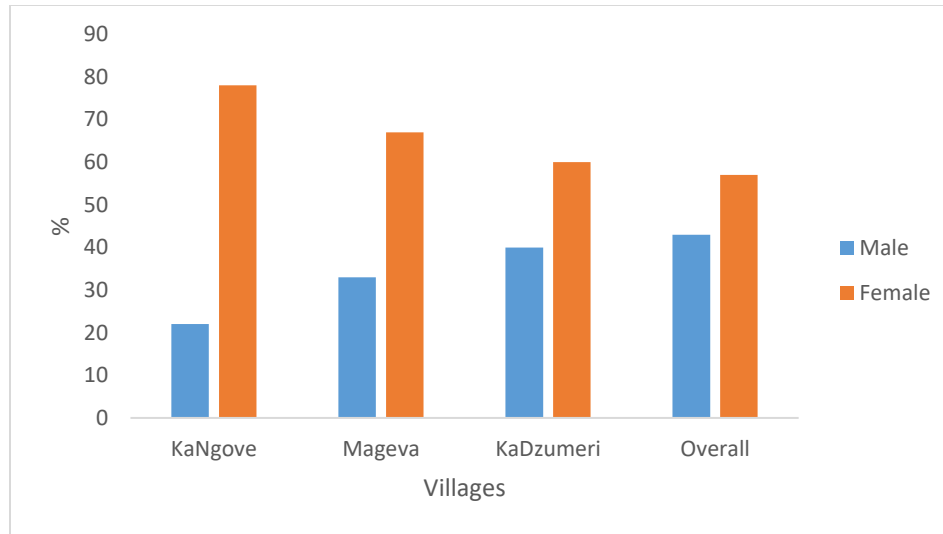
#### 5.1 Introduction

The aim of this chapter is to determine the main water sources for rural households and public institutions in the Greater-Giyani Local Municipality and the challenges facing water supply in the area. In order to examine variations in access and challenges facing water supply, it was important to collect data on the demographic profiles of the respondents' households. This was also done in similar studies by Netshipale (2016) and Machethe (2011) where demographic profiles were used to give a clear picture of the respondents' characteristics.

#### 5.2 Demographic Characteristics of Respondents

Figure 5.1 shows the sex ratio of the respondents (heads of households) who participated in the study. The field survey showed that a bulk of the respondents (57%) in the three study areas, were female while 43% were male. Within kaNgove village about 22% of the respondents were males and 78% were females. In Mageva village 33% of the respondents were males, while 67% were females and in KaDzumeri village, 40% were males with 60% females. In this study there were more female respondents than males and this may suggest that men had migrated into other provinces in search for jobs as women remained to take care of the children. Netshipale (2016) also found that females were the majority in rural settings and determined that husbands had travelled to the big cities.

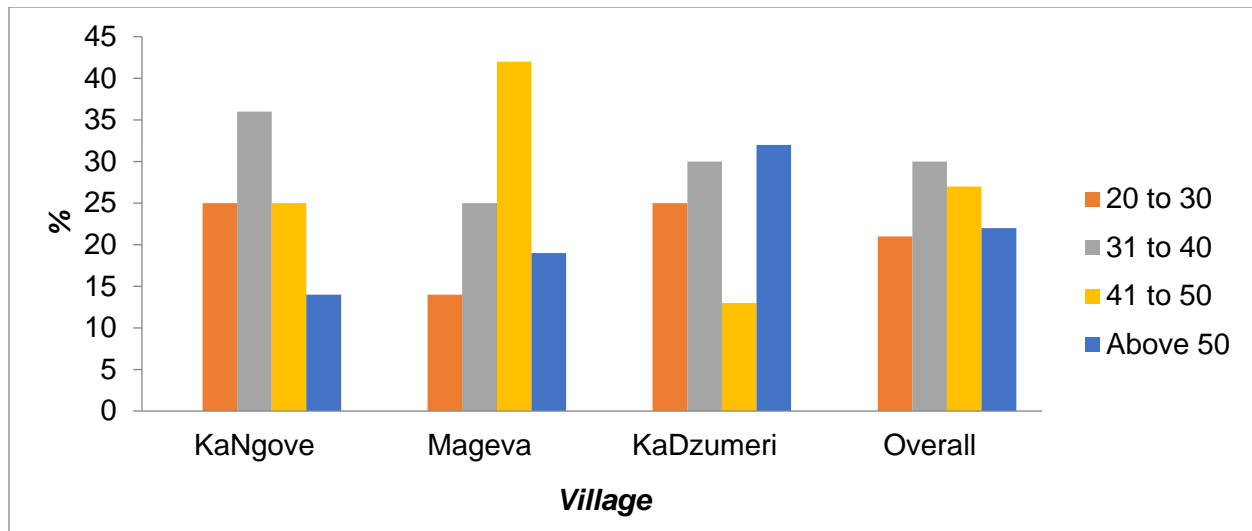
In this study an analysis of demographics indicated that other factors such as large number of divorcees, widows and separations have contributed to the large number of females in the study sites. This implies that women are taking over the responsibility of heading households and in terms of the challenge of water scarcity, this translates into an additional burden as women due to the nature of their social responsibility handle most household chores that require water. Despite this, Arouna and Dabbert (2012) and Mezgebo and Ewnetu (2015) found that females enjoy an advantage over their male counterparts in accessing water due to their greater awareness of water uses in the household, location of water sources and daily collection of drinking water.



**FIGURE 5. 1** GENDER OF RESPONDENTS WITHIN THREE VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

It is believed that age impacts on water accessibility, as older people (aged between 70-80 years) are more likely to have knowledge of water sources and seasonal changes in water availability. On this basis it was in the interest of the study to establish the age of the study subjects. Figure 5.2 depicts the age group of the respondents which ranged from under 20 to above 50 years old, in the three study areas. In KaNgove 36% of the respondents were in the age group between 31 to 40 years old; in Mageva 42% of the respondents come from the age group 41 to 50 years old; while in KaDzumeri nearly a third of respondents (32%) are older, above 50 years old. Since the target population was heads of households, the study did not capture the ages of other members of the households. The presence of a significant number of younger and energetic heads of households may be an advantage as they can walk long distances to obtain water, during scarcity.

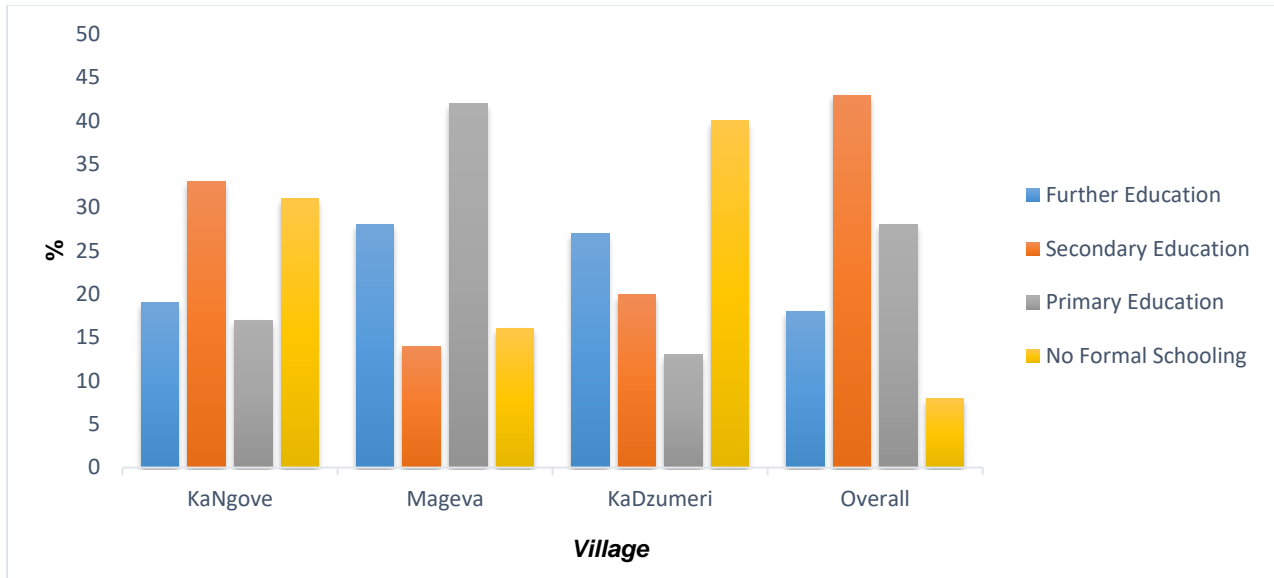
The study further sought to establish the educational status of the respondents. Figure 5.3 shows the highest educational status of the respondents, within the three case study villages. In KaNgove, 33% of respondents had secondary school education, 17% had primary school education, 31% of the respondents had no formal education, while 19% had tertiary education. In Mageva, 42% of the respondents had primary school education, 28% had tertiary education, 14% had secondary school education while 16% had no formal schooling. Within KaDzumeri, 40% of the respondents had no formal schooling, 13% had primary school education, 20% had secondary school education, while 27% of the respondents had tertiary education.



**FIGURE 5. 2** AGE GROUP OF RESPONDENTS WITHIN THREE VILLAGES. SAMPLE SIZE (N=112).  
SOURCE: FIELD SURVEY, 2018.

The field survey largely discovered that within this area, a significant proportion of respondents in the sample had basic education (primary and secondary school education). This may be attributed to low income levels that hinder families from taking their children for higher education as well as cultural beliefs that discourage females from acquiring higher education. The dominance of secondary level of education among respondents could imply that they are able to comprehend water issues under investigation. In a study on the causes and impacts of water shortages on households in GaKgapane Township in Limpopo Province, Machethe (2011) found that most household respondents had Grade 8-12 level of education, a fact that made them knowledgeable on water issues.

On the basis of the relationship between gender of the respondents and educational levels, Table 5.1 shows that the majority (66.7%) of females had no formal education, while 33.3% of males appeared to have no formal education. The study found that about 53.1% of females had primary education, while 46.9% of males had primary education. The study further discovered that 78.8% of females had secondary education, while there were 21.3% of males with secondary education. It was also found that there were more females (66.7%) with tertiary education, while a about 33.3% of males had access to tertiary education.



**FIGURE 5. 3** HIGHEST EDUCATIONAL STATUS OF THE RESPONDENTS WITHIN THE THREE VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

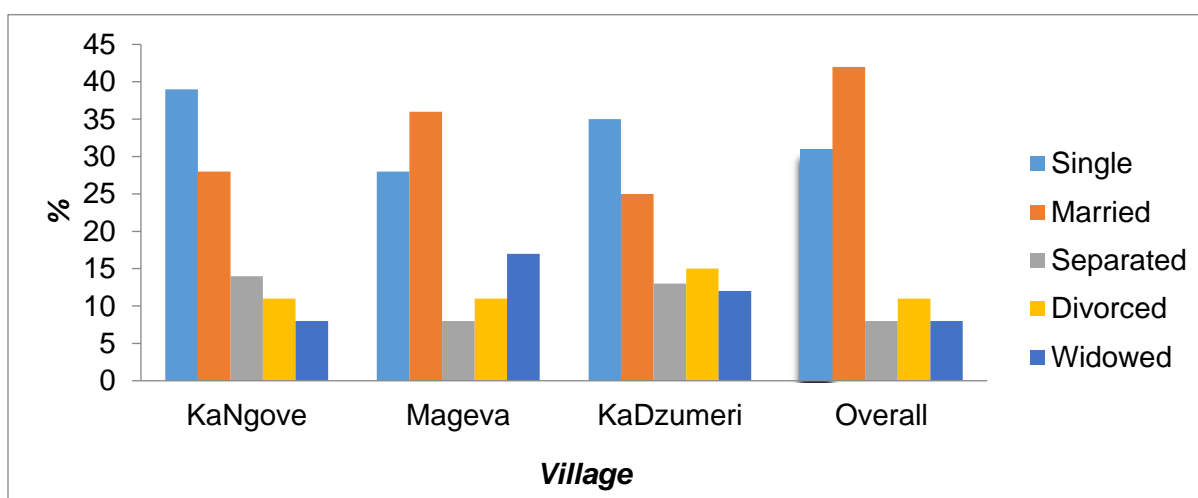
It was found that there was no significant differences between female and male respondents in terms of educational level (Table 5.1). These findings compared unfavourably with those of Arouna and Dabbert (2012) and Mezgebo and Ewnetu (2015) who found that female-heads of households had slightly higher education in rural areas than male headed households. This is likely to present them with an advantage over their male counter parts due to higher level of awareness in terms of water uses, location of water sources and daily collection of drinking water, as well as being better adapted to water shortages.

On the basis of marital status, Figure 5.4 shows that 34% of respondents within the three-study villages were married. In KaNgove 39% of respondents were single, 28% married and 14% were separated, while 11% were divorced and the remaining 8% were widowed. In Mageva, 28% of respondents were single, 36% were married, 8% were separated, 11% were divorced, while 17% were widowed. In KaDzumeri, there were 35% of respondents who were single, 25% were married, 13% were separated, 15% were divorced and 12% were widowed.

**Table 5. 1** Crosstabulation Of Gender And Education Level In The Three Study Villages. Sample Size (N=111). Source: Field Survey, 2018.

**Gender of the Respondents \* Respondents Highest Educational Level Crosstabulation**

			Respondents Highest Educational Level				Total
			No formal Schooling	Primary School	Secondary School	Tertiary School	
Gender of the Respondents	Male	Count	3	15	11	6	35
		% within Respondents Highest Educational Level	33.3%	46.9%	21.2%	33.3%	31.5%
		% of Total	2.7%	13.5%	9.9%	5.4%	31.5%
	Female	Count	6	17	41	12	76
		% within Respondents Highest Educational Level	66.7%	53.1%	78.8%	66.7%	68.5%
		% of Total	5.4%	15.3%	36.9%	10.8%	68.5%
Total	Count	9	32	52	18	111	
	% within Respondents Highest Educational Level	100.0%	100.0%	100.0%	100.0%	100.0%	
	% of Total	8.1%	28.8%	46.8%	16.2%	100.0%	



**FIGURE 5. 4** MARITAL STATUS OF THE RESPONDENTS WITHIN THE THREE VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

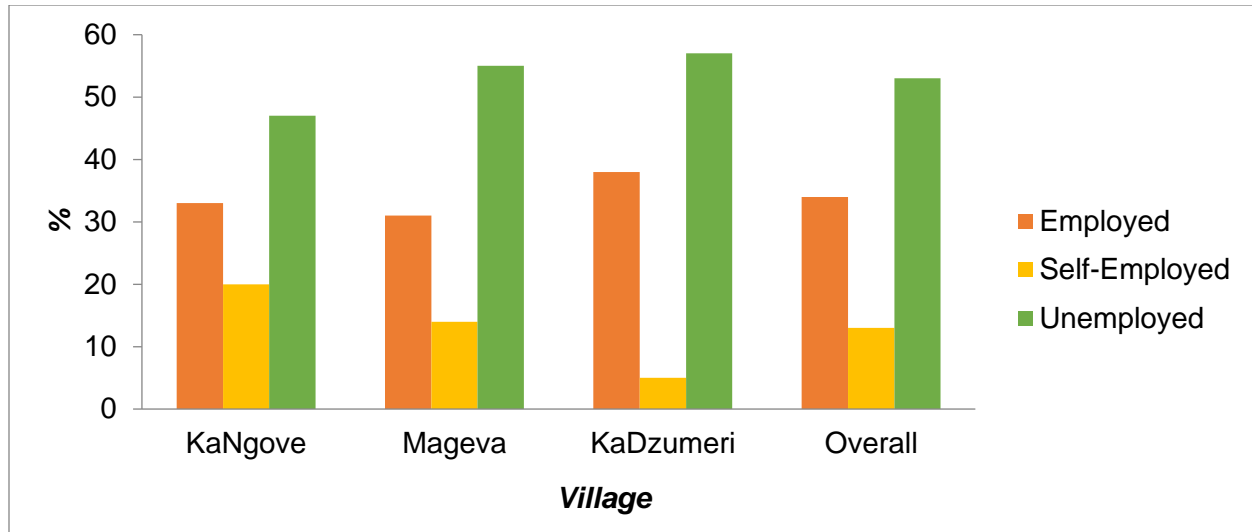
In terms of employment status, about half of the respondents (54%) were unemployed within the three study areas (Figure 5.5). The survey indicated that 47% of the respondents were unemployed in KaNgove, 20% were self-employed, while 33% were employed (Figure 5.5). In Mageva, 55% of the respondents were unemployed, 14% were self-employed and 31% were employed (Figure 5.5). Within KaDzumeri, 57% of the respondents were unemployed, 5% were self-employed and 38% were employed (Figure 5.5). Overall, this survey showed that there were more unemployed people (53%) than those employed (34%) in the study areas (Figure 5.5). The

respondents were interviewed during weekends so as to ensure that every household randomly selected had a representative in the study.

The rate of employment in any given society plays a crucial role in economic growth and development. This also affects the level of adaptation of the respondents in terms of their response and recovery to emergencies. Coping strategies and adaptation methods used by an employed and unemployed person may vary as the former has more access to economic resources increasing his/her capacity to cope. In this study, the few respondents who are employed are likely to afford and have access to various types of water sources. This has also been highlighted by Dau (2010) in a study in Thulamela Local Municipality also in Limpopo Province, where heads of households who were employed were highly likely to be better adapted to flood disasters due to steady income that presented them opportunities for different coping measures.

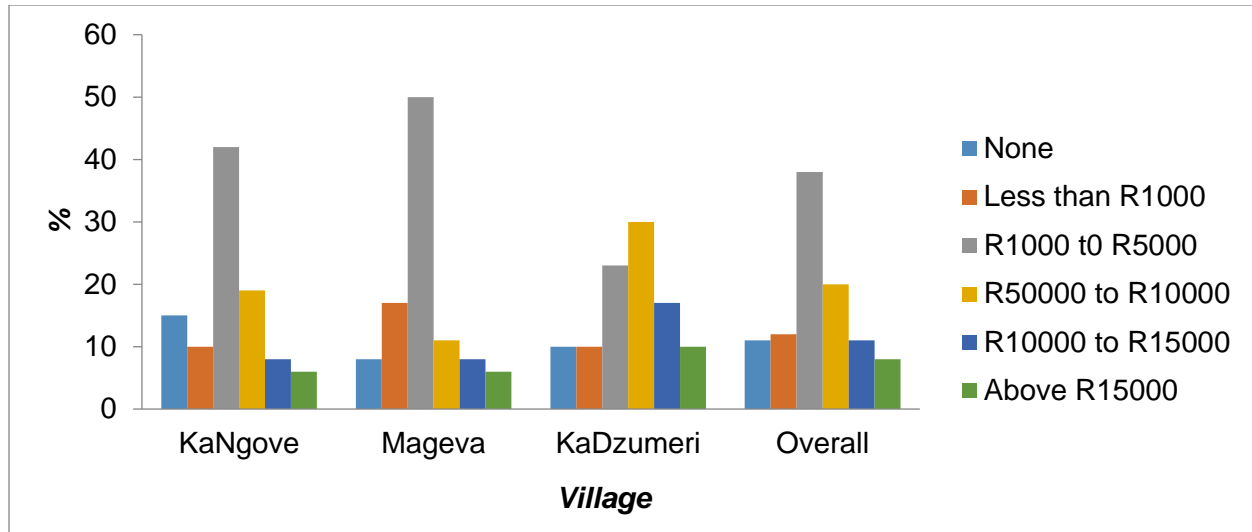
Income determines the ability of individuals to save and prioritize their earnings. This might ensure that they have adequate economic resources to afford buying water. However, although the overall rate of unemployment for all the populations was high, there were more employed females than males. This could be attributed to the fact that more women were self-employed working, for example, as hairdressers, street vendors as well as cooking and selling at schools. Others were doing seasonal jobs on farms, while most employed males were working on the farms. These results differ with findings by Mnisi (2011) in Bushbuckridge Local Municipality who found that more males were employed as compared to females, thus giving them an edge in terms of addressing water challenges.

Based on the survey it was discovered that 38% respondents within the three villages were earning between R1000 to R5000 per month (Figure 5.6). In KaNgove, 15% of the respondents indicated that they were not earning any monthly income, 10% were earning less than R1000 per month, 42% were between the R1000 to R5000 bracket per month, 19% were between the R5000 to R10000 brackets per month while 8% were between R10000 to R15000 bracket per month; 6% indicated that they were earning above R15000 per month (Figure 5.6).



**FIGURE 5. 5** PERCENTAGE OF THE RESPONDENT'S EMPLOYMENT STATUS. SAMPLE SIZE (N=112).  
SOURCE: FIELD SURVEY, 2018.

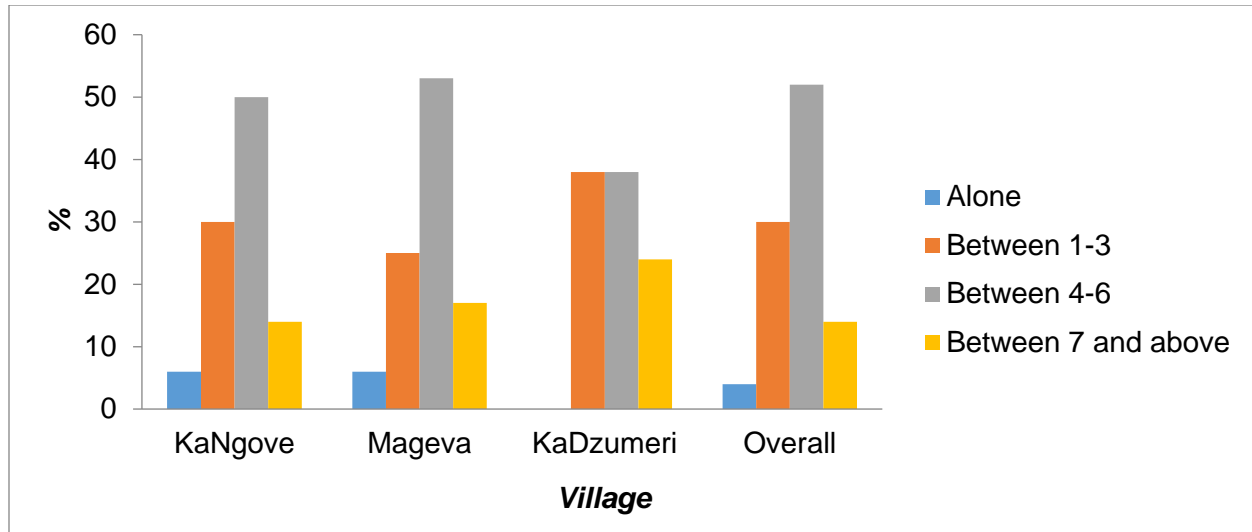
Within Mageva, 8% indicated they had no monthly income, 17% were earning less than R1000 per month, 50% were earning between R1000 to R5000 per month, 11% were between R500 to R10000 bracket per month, 8% were earning between R10000 to R15000 per month, 6% were earning above R15000 per month (Figure 5.6). In KaDzumeri, 10% of the respondents were not getting any income per month, 10% were earning less than R1000 per month, 23% were earning between R1000 to R5000 bracket per month; 30% were earning between R5000 to R10000 per month, 17% were earning between R10000 to R15000 bracket per month, while 10% were above the R15000 bracket (Figure 5.6).



**FIGURE 5. 6** HOUSEHOLDS MONTHLY INCOME WITHIN THE THREE STUDY AREAS. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

The survey found that 52% of respondents had between 4-6 members within a household, 30% had between 1-3 members per household, 14% had between 7 and above members per household, while 4% were staying alone (Figure 5.7). In KaNgove, half of the respondents (50%) had between 4-6 in the households, while 30% had between 1-3 within households, 14% had between 7 and above members in the households and 6% of respondents were staying alone within the households (Figure 5.7). In Mageva, most respondents (53%) between 4-6 members within the households, 25% had between 1-3 in households, 16% had between 7 and above, while 6% of respondents were staying alone in the households (Figure 5.7).

Within KaDzumeri, 38% of the household sizes had between 1-3 members and between 4-6; the remaining 24% had between 7 and above in their households (Figure 5.7). The comparatively large family sizes in the study area implied that water demand was also high, as larger family sizes meant that more litres of water were required to sustain the family. The majority of households had between 4-6 people, indicating that more pressure was on families to have adequate access to water that could sustain the whole family. To better understand the dynamics of family sizes, it is important to link them with income as those with a high income could appear to be best suited to cope, unlike those with lower income and large family sizes.



**FIGURE 5. 7** FAMILY SIZE WITHIN HOUSEHOLDS IN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

The study further sought to cross-tabulate the relationship between family sizes and households income as a way to illustrate the situation that may arise with water accessibility. The study established that households with 7 and above members were earning the highest incomes with 64.7% earning between R1000-R10000 per month, while households with family sizes of 4-6 had the second highest monthly income with 61.8% earned between R1000-R10000; households with 1-3 members were earning the second lowest income per month, with 57.8% earning between R1000-R10000 monthly (Table 5.2). Households with only one member had the lowest income with 100% of the respondents earning no income on a monthly basis. The findings reveal that family size in the study area influences average income. This may be as a result of a combined earning, however, it also means that large amounts of water are required by the bigger families which may use a significant amount from their earnings and hence have a negative impact on accessibility to services including access to quality water resources.

**Table 5. 2** Crosstabulation Of Family Size And Income In The Three Study Villages. Sample Size (N=112). Source: Field Survey, 2018.

**Respondents Monthly Income \* Total number of people within household Crosstabulation**

			Total number of people within household				Total
			Between 1-3	Between 4-6	7 and Above	Alone	
Respondents Monthly Income	None	Count	2	6	0	2	10
		% within Total number of people within household	5.3%	10.9%	0.0%	100.0%	8.9%
		% of Total	1.8%	5.4%	0.0%	1.8%	8.9%
	< than R1000	Count	6	4	1	0	11
		% within Total number of people within household	15.8%	7.3%	5.9%	0.0%	9.8%
		% of Total	5.4%	3.6%	0.9%	0.0%	9.8%
	R1001-R5000	Count	11	18	6	0	35
		% within Total number of people within household	28.9%	32.7%	35.3%	0.0%	31.2%
		% of Total	9.8%	16.1%	5.4%	0.0%	31.2%
	R5001-R10000	Count	6	16	5	0	27
		% within Total number of people within household	15.8%	29.1%	29.4%	0.0%	24.1%
		% of Total	5.4%	14.3%	4.5%	0.0%	24.1%
	R10001-R15000	Count	11	7	3	0	21
		% within Total number of people within household	28.9%	12.7%	17.6%	0.0%	18.8%
		% of Total	9.8%	6.2%	2.7%	0.0%	18.8%
	R15000+	Count	2	4	2	0	8
		% within Total number of people within household	5.3%	7.3%	11.8%	0.0%	7.1%
		% of Total	1.8%	3.6%	1.8%	0.0%	7.1%
	Total	Count	38	55	17	2	112
		% within Total number of people within household	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	33.9%	49.1%	15.2%	1.8%	100.0%

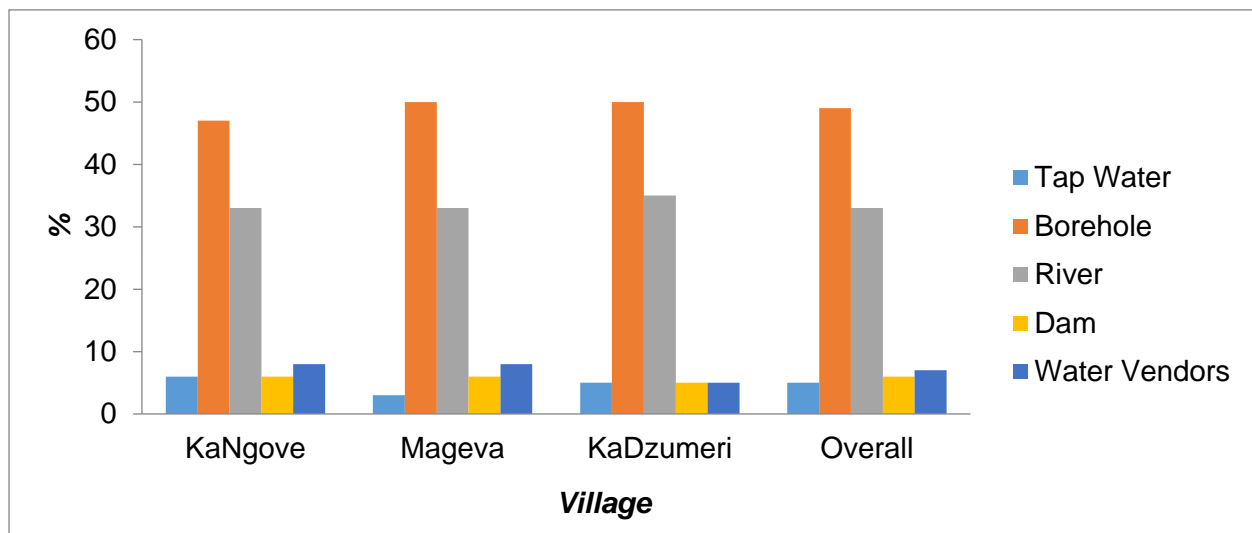
### 5.3 The Key Water Sources for Households, Primary schools and Health facilities

#### 5.3.1 Main source of water and frequency of access to clean water

##### 5.3.1.1 Households

The survey found that nearly half (49%) of household's main water sources within the three study areas were borehole water, 33% used river water, while 7% bought water from water vendors or neighbors (Figure 5.8). In KaNgove, it was found that 47% of households used borehole water as their main source of water, 33% used river water, 6% used tap water and another 6% used dams and 8% bought water from vendors (Figure 5.8). It was further found that in Mageva, 50% of households used borehole water as their main source, 33% used water from the river, 3% used tap water; 6% used water from the dams while 8% bought water from water vendors (Figure 5.8). In KaDzumeri, the study found that half (50%) of households used borehole water as a main source, 35% used rivers as main sources, 5% used tap water; 5% used dam water and 5% bought water from water vendors as main water source (Figure 5.8). Thus groundwater is a major source of water across the municipality, and whether it will remain sustainable is another factor which may require investigation.

On the basis of the relationship between main water sources and age, Table 5.3 shows that the main water source for the majority (67.5%) of the respondents from the age group 21-40 was rivers, while there were 32.4% of the respondents from age group 41 and above using rivers as a main source of water. The study also discovered that 50.9% of the respondents from age group 21-40 were also using boreholes, while 49.1% of the respondents from age group 41 and above were using boreholes as main source of water. The study further found that 66.7% of respondents from age group 21-40 were also using water from the municipal pipes, while those from age group 41 and above (33.4%) were also using municipal piped water. It was further found that the majority (60%) of the respondents from age group 41 and above use water vendors as main water source point, while 6% of respondents from age group 21-40 use water vendors as their main source of water.



**FIGURE 5. 8** HOUSEHOLDS MAIN WATER SOURCES (MOST FREQUENT) IN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112) SOURCE: FIELD SURVEY, 2018.

The study found that the main water sources for households, within the study villages, were boreholes (i.e, ground water) as their formal form of water supply, the second common source was water from the rivers. The findings from this study are similar to those of previous studies by Telmo (2002) in Gouansolo Village (Mali), Mothetha *et al.*, (2013), and Netshipale (2016) in Mukondeni Village (Limpopo Province) that identified boreholes and rivers as the main water sources in rural villages.

One difference between this study and others was that there was no piped water from municipal taps in KaDzumeri and Mageva but in KaNgove there was one household (among the sample)

that had piped water drawn from a nearby municipal dam, while other water sources were water vendors. In KaDzumeri, 73% of the respondents indicated that even when there is water from the municipal borehole taps, they had to wake up early around 4 am and go queue for water, highlighting the extent of water challenges within the area.

**Table 5. 3** Cross Tabulation Of Age And Main Water Source In The Three Study Villages. Sample Size (N=112). Source: Field Survey, 2018.

**Age of the Respondents \* Main water source for Members of the Household Crosstabulation**

			Main water source for Members of the Household					Total	
			Tap water	Borehole	River	Dam	Water Vendors		Buy water
Age of the Respondents	21-30	Count	3	12	8	1	2	0	26
		% within Main water source for Members of the Household	50.0%	21.8%	21.6%	33.3%	20.0%	0.0%	23.2%
		% of Total	2.7%	10.7%	7.1%	0.9%	1.8%	0.0%	23.2%
	31-40	Count	1	16	17	1	2	0	37
		% within Main water source for Members of the Household	16.7%	29.1%	45.9%	33.3%	20.0%	0.0%	33.0%
		% of Total	0.9%	14.3%	15.2%	0.9%	1.8%	0.0%	33.0%
	41-50	Count	1	13	5	0	6	0	25
		% within Main water source for Members of the Household	16.7%	23.6%	13.5%	0.0%	60.0%	0.0%	22.3%
		% of Total	0.9%	11.6%	4.5%	0.0%	5.4%	0.0%	22.3%
	51 and Above	Count	1	14	7	1	0	1	24
		% within Main water source for Members of the Household	16.7%	25.5%	18.9%	33.3%	0.0%	100.0%	21.4%
		% of Total	0.9%	12.5%	6.2%	0.9%	0.0%	0.9%	21.4%
Total	Count	6	55	37	3	10	1	112	
	% within Main water source for Members of the Household	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	% of Total	5.4%	49.1%	33.0%	2.7%	8.9%	0.9%	100.0%	

The study also found that although the municipal boreholes were present, there were times when the boreholes were not always operational, and this limited respondents from access to water daily, pushing the respondents to use river water as an alternative. This was further supported by municipal officials who indicated that although boreholes exist, most of them are not functional leading to people using water from rivers or buying water. The municipal officials also stated that Ngove village depends solely on boreholes that pump water at least once a week. One official also pointed out that central taps for villagers were erected and sometimes communities could spend a month without water. This was also identified by Mothetha *et al.* (2013), who found that communities in Vondo cluster and Govhu village (Thulamela Local Municipality) end up using springs and wells as ways to augment water supply due to unfunctional boreholes.

Field observations revealed that the municipal borehole water (Figure 5.9A) and water ponds were also being used by livestock (Figure 5.9B), increasing the risk of households using contaminated water. The other factor for consideration is the fact that the borehole locations were

near rivers, thus increasing the risk of contamination during flood events (Figure 5.10). Field observations also revealed the state of some of the sources of water in rural Greater Giyani and these are shown in Figures 5.11 to 5.16.



A

B

**FIGURE 5. 9** MUNICIPAL BOREHOLE (A) AND A WATER POND (B) USED FOR DRINKING BY LIVESTOCK'S IN KADZUMERI. SOURCE: FIELD SURVEY 2018.



A

B

**FIGURE 5. 10** MUNICIPAL BOREHOLE (A) LOCATED NEAR A NON-PERENNIAL RIVER (B) IN KADZUMERI. SOURCE: FIELD SURVEY 2018.



A

B

**FIGURE 5. 11** WATER CONTAINERS IN A CAR HIRED TO FETCH WATER (A) AND A HIRED TRUCK FILLING A WATER TANK (B) AT KANGOVE VILLAGE. *SOURCE: FIELD SURVEY 2018.*



A

B

**FIGURE 5. 12** A BOREHOLE (B) AND A GROUND LEVEL WATER STORAGE TANK (A) IN KADZUMERI. *SOURCE: FIELD SURVEY 2018.*



**FIGURE 5. 13** A STANDPIPE WITH WOMEN COLLECTING WATER AT ONE OF THE HOUSEHOLDS IN KANGOVE. SOURCE: FIELD SURVEY 2018.



A

B

**FIGURE 5. 14** A STANDPIPE (A) AND CHILDREN COLLECTING WATER FROM A PRIVATELY CONSTRUCTED BOREHOLE (B) IN KADZUMERI. SOURCE: FIELD SURVEY 2018.



**FIGURE 5. 15** A STANDPIPE FROM A MUNICIPAL BOREHOLE IN KADZUMERI. SOURCE: FIELD SURVEY 2018.



A

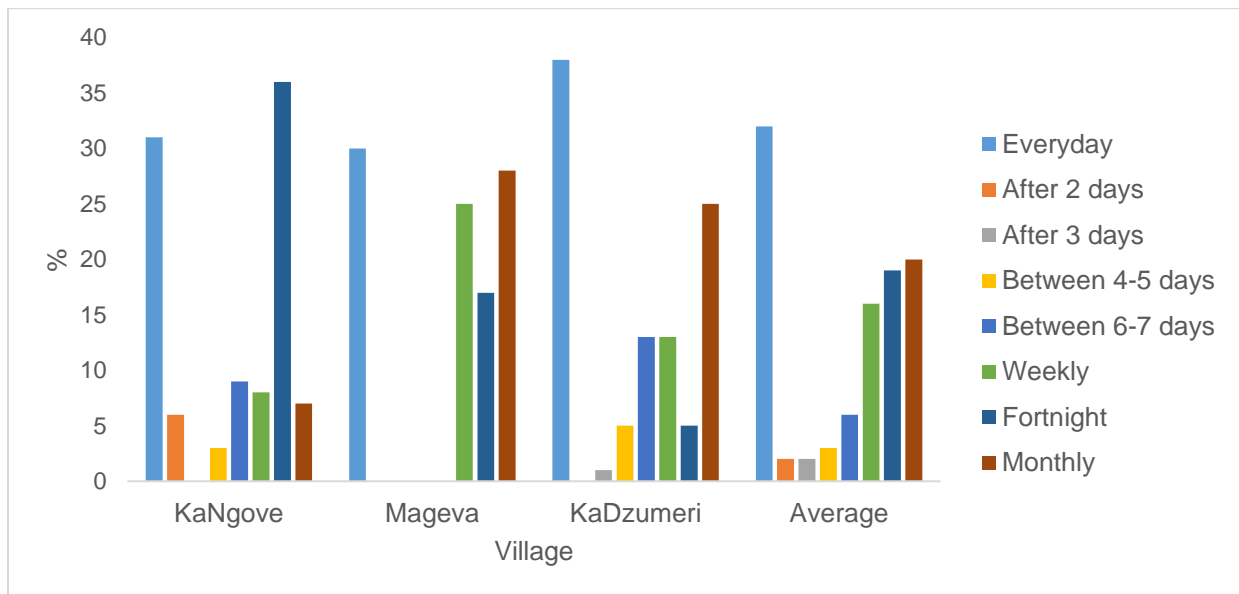
B

**FIGURE 5. 16** AN UNFUNCTIONAL MUNICIPAL BOREHOLE IN KADZUMERI (A) AND AN UNFUNCTIONAL STANDPIPE IN MAGEVA (B). SOURCE: FIELD SURVEY 2018.

In terms of water access, Figure 5.17 depicts the respondents water access frequency within the three study areas. About 32% of the respondents in the three villages had access to water daily, 20% had access to water once a month, 19% had access to water every two weeks, 16% had

access after a week, 6% had access between every 6-7 days, 3% had access between 4-5 days and 2% had access to water after 2 days and 3 days simultaneously.

In KaNgove, 36% of the respondents had access to water after every two weeks, 31% had access to water daily, 8% had access to water weekly, 9% had access between 6-7 days, while 6% had access to water after 2 and 3 days simultaneously and 6% had access to water after 2 days. In Mageva, 30% of the respondents had access to water daily, 28% had access to water after a month and 25% has access to water after a week, whereas 17% had access to water after two weeks. In KaDzumeri, 38% had access to water daily, 1% had access to water after 3 days, 5% had access to water between 4-5 days, 13% had access to water weekly and between 6-7 days simultaneously, 5% had access to water after 2 weeks while 25% had access to water after a month.



**FIGURE 5. 17** FREQUENCY OF WATER ACCESS FOR HOUSEHOLDS IN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

The study found that most of the households (68%) did not have access to water daily as respondents indicated that there were times when there was no water, while 32% had access to water daily because of having boreholes in the households' yards. When asked why they did not have access to water daily; respondents indicated that it was due to break down of the water pumps used for municipal boreholes, which would take months to be replaced, thus limiting the households' access to water.

The other reason was the households not having pipelines within their yards and also due to respondents not being able to afford to buy water as a large number of them were unemployed and living under the poverty line. The findings agree with those of Mnisi (2011) in New Forest (Bushbuckridge Local Municipality) who found that people living under the poverty line were less able to cope with water shortages from inadequate infrastructure. The findings by Dau (2010) were similar in that communities would spend a few days without water, but the municipality would provide them with water using trucks. However, communities in this study were left to fend for themselves as there was no assistance from the municipality in terms of provision of water during days when there was no water from municipal boreholes. The only time communities would get water by trucks from the municipality was when there was a funeral within a household.

Sigenu (2006) observed that populations with the lowest status and wealth within the communal pyramid are often subject to excessively poor service deliveries; hence, the poor suffer more from water shortages. The study found that water access in the 1980s was not a problem as respondents indicated that people in those days used to get water daily, but presently water shortages have worsened. This agrees with the findings by Machethe (2011) that the frequency of water problems had become worse overtime, with the respondents previously having access to water daily.

The study findings are also similar to those of Ngima (2015), who identified that respondents in Guthurai ward (Kenya) would go for weeks and months without having any access to water from municipality boreholes and taps. Respondents were less able to cope with such challenges as only those getting high incomes could afford water and the unemployed could not. Mnisi (2011) and Machethe (2011) in their studies also found similar reports as their respondents in New forest (Bushbuckridge Local Municipality) and Ga-Kgapane Township (Limpopo Province) experienced perennial water shortages.

This study found that water access was affected by several reasons, for example 30% of the respondents indicated that they had reduced access to water during the dry season, while 13% had limited or no access to water during the wet seasons. Up to 39% had inadequate access to water during both seasons, while 50% indicated that the seasons had nothing to do with their reduced access to water. This shows that during the dry season (April to October), the frequency of accessing water was reduced due to the villages receiving lower rainfall, while during the wet season (November to March) water access was hampered by lack of municipal water-connected taps and sometimes erratic rainfall. This study further found that during both seasons access to water was low due to poor maintenance of municipal boreholes and rivers running dry during

winter and in summer from limited rainfall. These findings are similar to those of Mnisi (2011), who found that causes of water shortages in Bushbuckridge Local Municipality were largely due to unfunctional municipal pipes.

### **5.3.1.2 Primary schools and Health facilities**

This study also had respondents from five primary schools and two clinics within the three study villages including Mk Khambani Primary, Dzumeri Primary, Charlie Rhangani Primary, Ngove Vahlave Primary and Govani Primary schools. The clinics that were part of the study were: Ngove Clinic and Dzumeri Health Center. The Dzumeri Health Centre was the only clinic within the whole of Giyani that serviced all the villages and operated throughout the day and night (24/7). The study found that the main water sources for primary schools and health facilities in the three study villages were also boreholes. The main reason for these relying mainly on boreholes was because within the school yard and the health facilities there were no pipelines functioning nor was there running water from the municipality.

This study also found that some school boreholes were located outside the school yards due to the lack of ground water within the school yards. The lack of running water within schools and health facilities indicated the extent of the water problem within the study villages and also the lack of municipal interventions to assist in providing water to public institutions. This was reiterated by the health and education officials who indicated that there was no forthcoming assistance from the municipality in terms of water provisions; as a result they have to depend on boreholes for water. When asked how often they supply water to schools and clinics, municipal officials replied that there were boreholes, supporting the claim that the municipality does not supply water to the clinics and primary schools. Figures 5.18 and 5.19 depict water sources at selected primary schools and clinics.



**FIGURE 5. 18** TWO ELEVATED BOREHOLE WATER STORAGE TANKS AT NGOVE VAHLAVE PRIMARY SCHOOL. SOURCE: FIELD SURVEY, 2018.



A

B

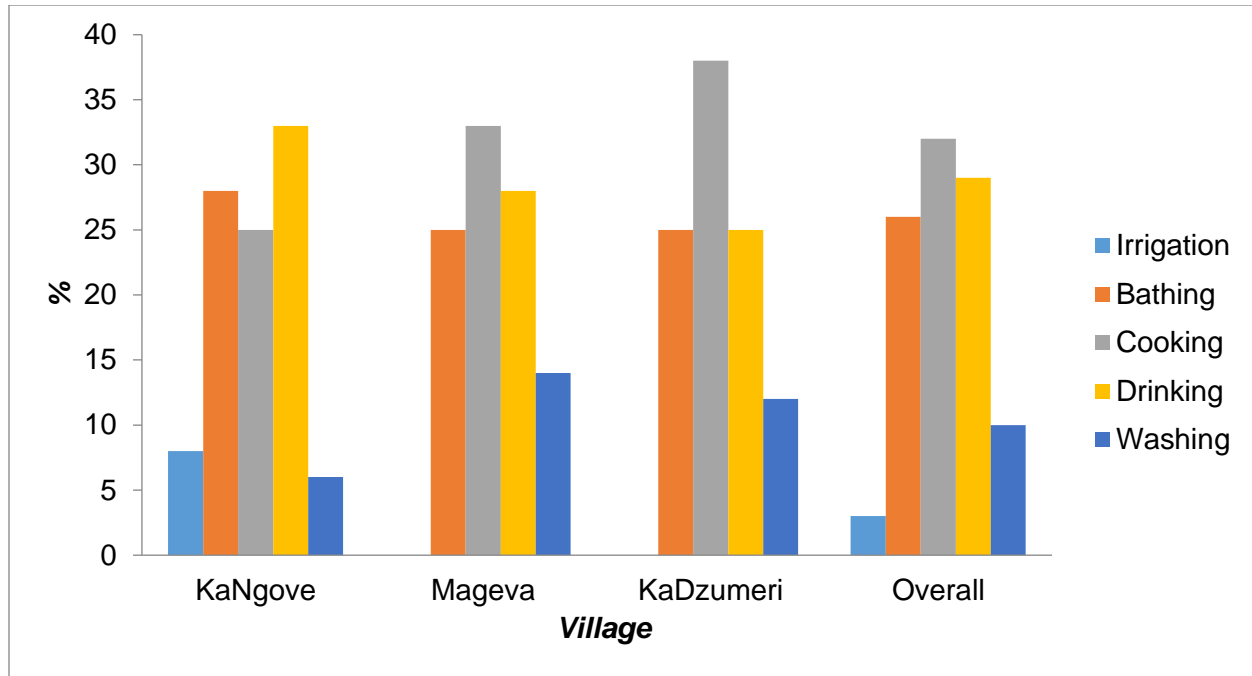
**FIGURE 5. 19** TWO ELEVATED BOREHOLE WATER STORAGE TANKS AT NGOVE (A) AND DZUMERI (B) CLINICS . SOURCE: FIELD SURVEY, 2018.

## 5.3.2 Main Water Uses and Litres of Water Consumed Within a Day

### 5.3.2.1 Households

Figure 5.20 shows the main water uses by households within the three study areas. About 32% of respondents mainly used water for cooking, while 3% mainly used water for irrigation. In KaNgove, 33% of respondents mainly used water for drinking, 28% mainly used water for bathing, while 25% mainly used water for cooking and 8% mainly used water for irrigation; a low 6% mainly used the water for washing. Within Mageva, 33% of the respondents mainly used the water for cooking, 28% mainly used it for drinking and mainly 25% used water for bathing, while 14% used water for washing and none used water for irrigation. In KaDzumeri, 38% of the respondents mainly used water for cooking, 25% mainly used the water for bathing and drinking simultaneously. Whereas 12% of the respondents mainly used water for washing, none used it for irrigation.

It was found that there was high water demand for cooking, drinking and bathing, while water was less used for washing and irrigation. This was mainly because within the study villages irrigation practices and livestock rearing had been reduced due to the erratic rains and very hot summers. Additionally, with the rise in the population there is increased demand for water for domestic use. These findings concur with those of Tabane (2017), who found that in Barakalalo village (North-West Province, South Africa) from 2010 to 2015, subsistence irrigated and rainfed farming had declined due to water being expensive and unavailable, but domestic water demand continues to be on the rise. Mnisi (2011), in Bushbuckridge Local Municipality (Mpumalanga Province, South Africa) also arrived at similar results since most respondents indicated that water shortages affected their livestock and gardening opportunities, thus supporting the claim from this study that water shortages have resulted in reduced water-related activities. It was also found that the crops that require less water such as sweet potatoes are being preferred (Figure 5.21B). The study also found that households with boreholes within their yards were also using the water for gardening as indicated by the 3% in Figure 5.20; these farms were blossoming, thus showing the advantage of having access to water frequently (Figure 5.21A).



**FIGURE 5. 20** MAIN WATER USES IN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

The study further sought to determine the relationship between gender and main water uses within the study via cross-tabulation (Table 5.4). It was found that 64.7% of the female respondents mainly used water for bathing, while 35.3% of the male respondents mainly used water for bathing. Female respondents using water mainly for washing were 100%, while there were no male respondents using water for washing. The study further established that 70% of the female respondents were mainly using water for cooking, while 30% of the male respondents were mainly using the water for cooking. It was also found that majority (59%) of the female respondents were using water for drinking in comparison with 41% of the male respondents. Water use for irrigation was found among females (60%), while 40% of males were using water for irrigation. This shows that the burden of collecting water and the major water related activities lies with females, and traditionally females have the sole responsibility for collecting water.



A

B

**FIGURE 5. 21** BLOSSOMING GARDEN COMPOSED OF SPINACH AND RADISH REQUIRING WATER FOR SURVIVAL (A) AND GARDEN WITH SWEET POTATO THAT REQUIRES LESS WATER FOR SURVIVAL (B) IN KADZUMERI (A-B). *SOURCE: FIELD SURVEY 2018.*

These findings support the claim that females are the individuals mostly connected with water use which may also be due to cultural norms (e.g Ngima 2015; Mnisi 2011). The study further discovered that the lack of males using water for washing and minority using water for bathing could have been attributed to the fact that most males in rural areas prefer to go and bath at the rivers and few do house chores like washing. It was found that within the study villages, water was mainly used by females for cooking, washing and bathing although much fewer males would also use the water for the same things. This led to the conclusion that females are more likely to be affected most by water shortages as they are the main users of domestic water and also the majority respondents in this study.

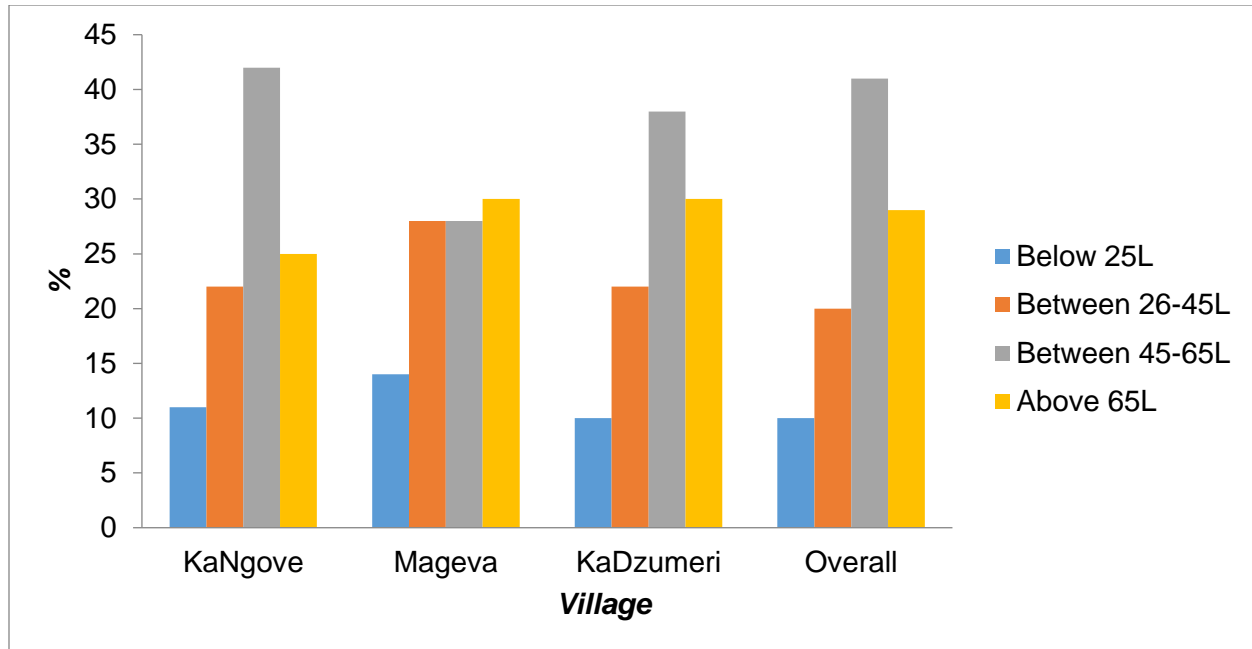
**Table 5. 4** Crosstabulation Of Gender And Main Water Uses. Sample Size (N=112). Source: Field Survey, 2018.

**Gender of the Respondents \* Respondents Main water Use(s) Crosstabulation**

			Respondents Main water Use(s)					Total
			Drinking	Irrigation	Cooking	Washing	Bathing	
Gender of the Respondents	Male	Count	16	2	12	0	6	36
		% within Respondents Main water Use(s)	41.0%	40.0%	30.0%	0.0%	35.3%	32.1%
		% of Total	14.3%	1.8%	10.7%	0.0%	5.4%	32.1%
	Female	Count	23	3	28	11	11	76
		% within Respondents Main water Use(s)	59.0%	60.0%	70.0%	100.0%	64.7%	67.9%
		% of Total	20.5%	2.7%	25.0%	9.8%	9.8%	67.9%
Total	Count	39	5	40	11	17	112	
	% within Respondents Main water Use(s)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	% of Total	34.8%	4.5%	35.7%	9.8%	15.2%	100.0%	

Based on Figure 5.22, about 41% of the households consumed between 45-65 L of water daily, while 10% consumed less than 25 L of water daily. In KaNgove, 42% of the respondents consumed between 45-65 L of water daily, while 25% consumed above 65 L, 22% consumed between 26-45L, and 11% of the respondents consumed below 25L of water daily. In Mageva, 30% of the respondents indicated that they consumed above 65L of water daily, 28% of the respondents consumed between 26-45L and 45-65L of water daily, with 14% consuming below 25L of water daily. In KaDzumeri 38% of the respondents were consuming between 45-65L of water daily, 30% were consuming above 65L daily, while 22% were consuming between 26-45L daily and 10% were consuming less than 25L of water daily.

This research found that within the study area there was a high water (about 45-65 L) consumption rate in terms of litres per day, as most respondents used up to and above 45-65L of water per day. This highlights the high demand for water in the study; which coupled with the current water shortage within the villages could lead the community severely affected.



**FIGURE 5. 22** HOUSEHOLDS' LITRES CONSUMPTION IN A DAY IN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

The study further sought to establish the relationship between family sizes and water consumption via cross-tabulation (Table 5.5). As expected, it was established that households with 7 and above family members were the highest water consumers with 94.2% consuming above 46L of water daily, households with 4-6 members were the second highest water consumers with 78.2% consuming 46L of water and above daily, and households with 1-3 members were the second lowest water consumers with 63.1% consuming 46 L of water and above daily. Households with only one member were the lowest water consumers with 100% consuming below 25 L of water daily. This showed that households sizes were the major determinants of water consumption within the study. This may suggest that the more the population grows in water stressed communities, demand for water will exceed supply leading to depletion of the already scarce water resource.

**Table 5. 5** Crosstabulation Of Households Water Consumption And Family Sizes. Sample Size (N=112). Source: Field Survey, 2018.

**Household's water (Litres) consumption within a Day ^ Total number of people within household Crosstabulation**

			Total number of people within household				Total
			Between 1-3	Between 4-6	Between 7 and Above	Alone	
Household's water (Litres) consumption within a Day	Below 25 L	Count	2	4	0	2	8
		% within Total number of people within household	5.3%	7.3%	0.0%	100.0%	7.1%
		% of Total	1.8%	3.6%	0.0%	1.8%	7.1%
	26-45 L	Count	12	8	1	0	21
		% within Total number of people within household	31.6%	14.5%	5.9%	0.0%	18.8%
		% of Total	10.7%	7.1%	0.9%	0.0%	18.8%
	46-65 L	Count	13	29	8	0	50
		% within Total number of people within household	34.2%	52.7%	47.1%	0.0%	44.6%
		% of Total	11.6%	25.9%	7.1%	0.0%	44.6%
	Above 65 L	Count	11	14	8	0	33
		% within Total number of people within household	28.9%	25.5%	47.1%	0.0%	29.5%
		% of Total	9.8%	12.5%	7.1%	0.0%	29.5%
Total	Count	38	55	17	2	112	
	% within Total number of people within household	100.0%	100.0%	100.0%	100.0%	100.0%	
	% of Total	33.9%	49.1%	15.2%	1.8%	100.0%	

### 5.3.2.2 Primary schools and Health facilities

The study found that the primary schools used water mainly for drinking and for cooking learners' lunch. They also used water for irrigating vegetable gardens that supply vegetables consumed by both learners and teachers. All the five schools indicated that they treat water from the boreholes with chemicals to make them safe to drink as a way of preventing any waterborne diseases within the school yards. The health centers mainly used the water for drinking, although nurses staying within the clinic's residences also used the water for cooking and bathing, while a small portion is used for irrigation. It was found that the health facilities were using a water purification system (R<sup>2</sup>0) to purify water from the boreholes which was only for drinking purposes. The study findings also indicated that the total enrolment in schools and clinic visitations had increased over the past 5 years, indicating a greater demand for water.

### 5.3.3 Distance Travelled and Hours Spent Collecting Water

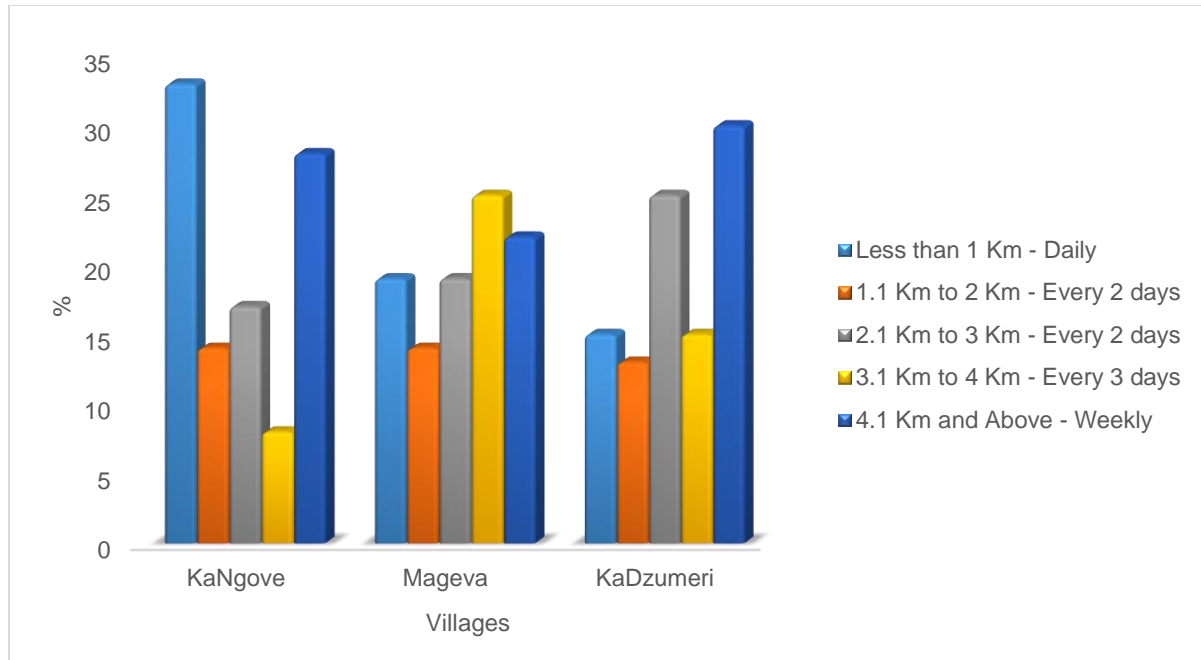
The study also sought to establish the distance travelled and hours spent daily, weekly and monthly when fetching water for household use. The results of the study showed that the majority of the respondents (56%) travelled long distances (3 km and above) to access water, while only

44% indicated that they travelled short distances (Less than 1 km to 2.9 km). There were variations on this point between villages. For example, while 69% of the household respondents in Mageva travelled long distances (3 km and above) to water sources, for KaDzumeri this was 53% while for KaNgove it was 47%. In KaNgove, 33% of the respondents travelled less than 1 km daily, 14% travelled between 1.1 km to 2 km after every two days, 17% travelled between 2.1 km to 3 km after every two days, 8% travelled between 3.1 km to 4 km after every three days while 28% travelled for 4.1 km and above weekly.

In Mageva, 19% travelled less than 1 km daily, 14% travelled between 1.1 km to 2 km after every two days, 19% travelled between 2.1 km to 3 km after every two days, 25% travelled between 3.1 km to 4 km daily, 22% travelled 4.1 km and above every two days to water source. In KaDzumeri, 15% travelled less than 1 km daily, 13% travelled between 1.1 km to 2 km after every three days, 25% travelled between 2.1 km to 3 km daily, 15% travelled between 3.1 km to 4 km after every two days, 30% travelled 4.1 km and above on a weekly basis to water source (as shown in Figure 5.23 and Table 5.6).

The findings of this study therefore indicate that most households in the study area travelled long distances (3 km and above) to access water on a daily or weekly basis. The respondents who travelled less than 1 km daily to access water had boreholes within their households (or their neighbors) or were living near rivers. Those travelling between 1.1 km to 3 km after every two or three days were either buying or getting water from those with boreholes in their yards, with those who could not afford to buy water or hire a carto bring water travelled long distances. Respondents travelling 3.1 km and above daily and weekly were obtaining water from the rivers within the village boundaries, while others had to travel to neighboring villages to access water.

It was also found that respondents with boreholes within their yards and those close to the rivers were better equipped to deal with water access than located those far from these sources. It is important to note however, that those who are dependent on river water are likely to be exposed to pathogens that cause water-borne diseases, such as diarrhea, typhoid and cholera particularly if they do not treat the water before use. This study findings are similar to those of Ngima (2015) whose study found that people in the Githurai ward (Kenya) travelled long distances to access water as the water points were located at distant areas. Similarly, Mnisi (2011) found that respondents in New Forest community (Bushbuckridge Local Municipality) travelled long distances to access water, while those with boreholes and staying close to the river travelled less to access water.



**FIGURE 5. 23** DISTANCE TRAVELLED TO WATER SOURCE WITHIN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112) SOURCE: FIELD SURVEY, 2018.

The study further sought to determine the relationship between gender and distance travelled to collect water within the study. It was found that 65.5% of females travelled an average of 4.1 km and above to collect water, while there were 34.5% males travelling the same distance. It was also found that there were 63.6% of females travelling an average of 3.1 km to 4 km to collect water, with 36.4% males travelling the same distance. There were 73.9% female respondents travelling an average of 2.1 km to 3 km to collect water, while males were 26.1%. The study also determined that there were 69.7% of female respondents travelling less than 1 km on average to access water, as compared to 30.3% males within the study. These findings show that more females were travelling long distances to obtain water in comparison to males. Thus, apart from being the most users of water in rural areas, women travelled long distances to obtain the commodity (as shown in Figure 5.24). Since women are the main users of water, they are likely to suffer more from the consequences of water scarcity; hence the need to equip them with knowledge on how to conserve and adapt to water scarcity.

Apart from the distance travelled to fetch water, the study established that 24% of respondents spent an hour fetching water, 21% spent less than 10 minutes, 25% spent between 11-30 minutes, 14% spent between 31-50 minutes and another 14% spent 1 hour 30 minutes, 1% spent 2 hours and the other 1% spent 2 hours 30 minutes, while up to 2% spent more than 3 hours. In KaNgove,

33% of the respondents spent 1 hour fetching water, 14% spent between 31-50 minutes; 19% spent between 11-30 minutes; 28% spent less than 10 minutes fetching water.

In Mageva, 33% spent between 11-30 minutes, 11% spent less than 10 minutes, 14% spent between 31-50 minutes, 17% spent an hour, 22% spent 2 hours. While in KaDzumeri, 23% spent less than 10 minutes, 18% spent between 11-30 minutes, 15% spent between 31-50 minutes, 23% spent an hour, 15% spent 1 hour 30 minutes, 3% spent 2 hours 30 minutes, while another 3% spent 3 hours and above fetching water from the source (Figure 5.25).

**Table 5. 6** Crosstabulation Of Gender And Distance Travelled To Access Water. Sample Size (N=112). Source: Field Survey, 2018.

Gender of the Respondents \* Distance travelled to Water Source Crosstabulation

			Distance travelled to Water Source					Total
			< than 1 Km	1.1 Km - 2 Km	2.1 Km - 3 Km	3.1 Km - 4 Km	4.1 Km & Above	
Gender of the Respondents	Male	Count	10	6	6	4	10	36
		% within Distance travelled to Water Source	30.3%	37.5%	26.1%	36.4%	34.5%	32.1%
		% of Total	8.9%	5.4%	5.4%	3.6%	8.9%	32.1%
	Female	Count	23	10	17	7	19	76
		% within Distance travelled to Water Source	69.7%	62.5%	73.9%	63.6%	65.5%	67.9%
		% of Total	20.5%	8.9%	15.2%	6.2%	17.0%	67.9%
Total	Count	33	16	23	11	29	112	
	% within Distance travelled to Water Source	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
	% of Total	29.5%	14.3%	20.5%	9.8%	25.9%	100.0%	



A

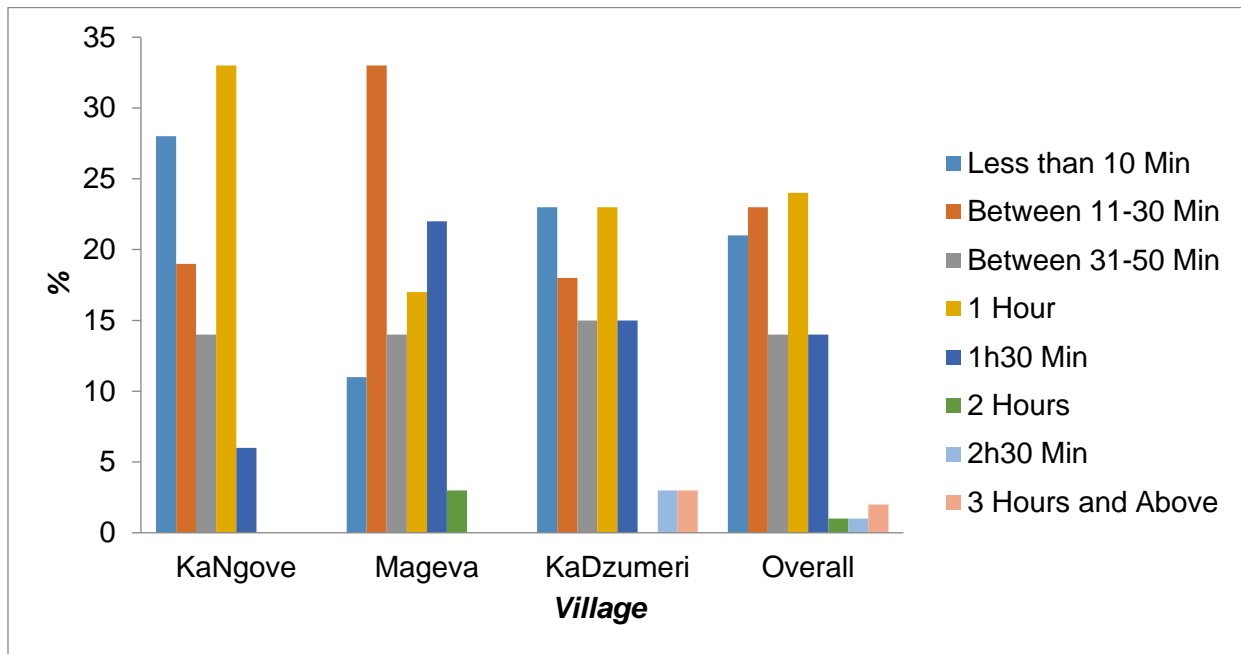
B

**FIGURE 5. 24** WOMEN CARRYING WATER GALLONS IN WHEELBARROWS FROM A MUNICIPAL BOREHOLE IN KADZUMERI AND A MUNICIPAL TAP IN KANGOVE (B). SOURCE: FIELD SURVEY, 2018.

The study found that on average, in the three study villages, 24% of respondents travelled for an hour to access water and they were accessing the water from rivers that are located within the village boundary. Respondents (21%) who spent less than 10 minutes when fetching water had access to water from their yards since they had boreholes in their yards. Respondents (23%) who spent between 11-30 minutes fetching water were getting water from the rivers, while others were getting water from their relatives with boreholes. 14% of respondents spent between 31-50 minutes, 14% spent 1 hour 30 minutes and had to queue for long periods of time at the municipal borehole taps before collecting water.

Respondents spending 2 hours and above fetching water were staying at distance from the water source; when they got to the municipal borehole taps they had to join the queue that was already long. Others would have to move across the river in search of water, as the water in the rivers were inadequate due to the erratic rains; this limited the respondents time to focus on other important house chores (cleaning, cooking, and laundry) that needed their attentions. These findings are similar to those of Ngima (2015), who found that people in Githurai ward (Kenya) had

to queue for long hours for water, indicating that most households spent most of their time fetching water, leaving less time for them to do other house chores.



**FIGURE 5. 25** TIME SPENT (TO AND FROM) BY RESPONDENTS FETCHING WATER FROM WATER SOURCE WITHIN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY, 2018.

### 5.3.4 Individuals Collecting Water

The study collected data on who among the members of household was responsible for collecting water for household use. The finding of this research revealed that in the three villages of KaNgove, Mageya and KaDzumeri, women were the ones tasked with collecting water (e.g. Figure 24). This finding agrees with the set-ups of many rural villages in Africa where women are the ones who are responsible for most household chores. Mnisi (2011) observes that in many African cultures water collection is regarded as a woman’s responsibility. Similar results have also been reported in urban settings in Africa.

For example, Ngima (2015) found that within Githurai ward, a residential area in outskirts of Nairobi, Kenya, women were mostly responsible when it came to fetching water and water-related household activities. This study noted that most respondents explained that due to their cultural practices it was the prime duty of women to fetch water, thus explaining why more women were fetching water in the three villages than men (as shown in Figure 5.26).



A

B

**FIGURE 5. 25** WOMEN AND A GIRL FETCHING WATER IN KANGOVE (A) AND KADZUMERI (B). SOURCE: FIELD SURVEY, 2018.

The relationship between respondents' gender and methods used in transporting water within the three study villages was also established (Table 5.7). It was found that 61.1% of female respondents were using hosepipes to transport water from boreholes and other shallow surfaces near the households, while 38.9% of males were using hosepipes. It was also determined that 69.1% of female respondents were transporting water by wheelbarrows, while 30.9% males did the same. All (100%) respondents transporting water on heads were found to be females while no males carried water on his head. The study also found that, both males and females were transporting water by cars; however, males (55.6%) edged out the females (44.4%) in this method of transportation. These findings indicate that the proportion of respondents transporting water in the study were females (67.6%), while males (32.4%) appeared to dominate the transportation of water by car. However, the picture remains clear as to who are the individuals most tasked with water collection. The findings that females mainly transport water by wheelbarrows and on their head while men used cars illustrate the difficulties many women undergo in accessing water.

**Table 5. 7** Crosstabulation Of Gender And Water Transportation Methods. Sample Size (N=111).  
Source: Field Survey, 2018.

**Gender of the Respondents \* Method(s) used to fetch water (Transport) Crosstabulation**

			Method(s) used to fetch water (Transport)				Total
			Head?	Wheelbarrow ?	Car	Pipe	
Gender of the Respondents	Male	Count	0	17	5	14	36
		% within Method(s) used to fetch water (Transport)	0.0%	30.9%	55.6%	38.9%	32.4%
		% of Total	0.0%	15.3%	4.5%	12.6%	32.4%
	Female	Count	11	38	4	22	75
		% within Method(s) used to fetch water (Transport)	100.0%	69.1%	44.4%	61.1%	67.6%
		% of Total	9.9%	34.2%	3.6%	19.8%	67.6%
Total	Count	11	55	9	36	111	
	% within Method(s) used to fetch water (Transport)	100.0%	100.0%	100.0%	100.0%	100.0%	
	% of Total	9.9%	49.5%	8.1%	32.4%	100.0%	

### 5.3.5 Water Storage and methods used to transport water

In analyzing water sources and uses, the method of transporting water for household use and type of storage was also investigated. According to the research findings in three study villages, the majority (64%) of the households stored water in drums, 16% stored water in tanks, while the other 20% stored water in containers and buckets (Figure 5.27). The study also found that most of households used containers to store water to ensure that they had enough water to use since accessing water within the area is difficult. Respondents indicated that to ensure maximum storage they bought tanks (2500 L; 3000 L; 5000 L) as this enabled them to go for long periods without having to worry about water scarcity. The majority (60%) of respondents used containers in carrying water during collection, while 5% used tanks as they were also selling the water. Up to 21% used buckets and 14% used drums as a means of collecting water. These findings are similar to those of Mnisi (2011) who found that almost everyone in New Forest (Bushbuckridge Local Municipality) had access to buckets and drums for water collection and storage.

This study also found that in the three study villages nearly half of the respondents (51%) used wheelbarrows to carry water from the water source to their households. Others indicated that they carried the water on their heads (10%), while 12% used cars and 27% used pipes to transport water from source to their households. Respondents using wheelbarrows to carry water indicated that they did not have money to hire a car to transport water for them as they had to travel over

long distances to the water source and also return home. Those carrying on their heads indicated that they were collecting water from a source that was close by to their households; next to rivers or having boreholes in their yards.

Respondents using cars to transport water indicated that they had money to hire cars, while others were using their own cars to fetch water. They indicated that they could not travel long distances carrying water using wheelbarrows as they were collecting water from neighboring villages (as previously shown in Figure 5.11). Those using hosepipes had boreholes within their households. The observation on those who use cars in transporting water are similar to Mnisi's (2011) sentiments that those with access to money hired cars to collect water for them.



A

B

C

**FIGURE 5. 26** WATER STORAGE TANK (B), DRUMS (C) AND GALLONS (A) IN MAGEVA, KANGOVE AND KADZUMERI. SOURCE: FIELD SURVEY, 2018.

## 5.4 The Challenges Leading to Water Supply Issues at The Greater-Giyani Local Municipality

### 5.4.1 Frequency of water shortages

This research found that in the three study villages water shortages had been occurring for years. Most respondents (80%) indicated that they had never had access to water from the municipality, while those (20%) who had had access indicated that over the past 10 years they have not had access to piped water. This means that water was available previously; however, over the course of the years water access has become difficult within the study area. According to water services

officials, it has been difficult to meet the growing demand for water, as there are not enough water resources to supply the whole municipal jurisdiction. This results in reduced frequency of water from the municipal pipes to the local villages. Another municipal official stated that the municipality supplies water daily and water rationing during periods of harsh drought conditions.

A small portion (15%) of respondents indicated that they did not access water for a few days only as they had boreholes in their households, however, they indicated that from the municipal tap they had not received water for several years. Similar findings were obtained by Mnisi (2011) and Machethe (2011) in neighboring regions of New Forest (Bushbuckridge Local Municipality) and Ga-Kgapane Township of Limpopo Province, where respondents indicated that they had been experiencing perennial water shortages over the years.

#### **5.4.2 Perceptions of poor water supply**

Within the three study villages, the study found that water shortages were due to several factors. About 39% indicated that there was a pipeline that was being constructed to draw water from the Nandoni Dam in Vhembe District, but it was never completed, hence they believed that the municipality was the cause of lack of water supply within their villages. They also indicated that due to poor maintenance of water infrastructures by the municipality, the situation had become worse. Up to 22% of the respondents believed shortages were due to changes in climate, as the wet seasons are becoming shorter with drier hot seasons becoming more common, leading to high evaporation of water from soils, dams and rivers.

According to 13% of respondents shortages were due to population growth as more demand was being placed on the already scarce water resources. It was also found that within Greater-Giyani, a water treatment plant built in 2014 was no longer operational contributing to communities' inability to access clean water (Figure 5.30). The plant was only operational during the first year, leaving the municipality facing a tough challenge on how to deliver clean water to rural communities as result of poor maintenance and mismanagement of funds.

Some municipal officials explained the leading cause of water shortages as most of the dams/streams are damaged by illegal sand mining and this has impacted the dams' abilities to hold water (increased water runoff) making it harder for water to be stored in dams. Other officials believe that due to the position of Ngove village which is situated in a mountainous area where steep slopes have an impact on the surface water runoff. Surface water is flooded to the low lying area of the village instead of being infiltrated and due to extreme high temperatures more water

is lost through evaporation. The municipal officials further stated that poor water supply was also caused by the fact that it cost more money for the municipality to render services to the villages, which are situated far apart (traveling cost for maintenance of infrastructure, transportation for delivering diesel for boreholes), and boreholes are vandalised.

These findings agree with those of Mnisi (2011), Mothetha *et al.* (2013), Magombo and Kosamu (2016) and Ngima (2015) whose studies found that poor maintenance, lack of governance, population growth and depleted water resources were major causes of lack of water supply within rural areas and some crowded parts of urban settlements. Figures 5.28 and 5.30 illustrate some of the major causes of lack of water supply within the study areas.



A

B

**FIGURE 5. 27** DAMAGED STANDPIPE (A) AND EXPOSED BOREHOLE PIPE (B) IN KANGOVE AND KADZUMERI. SOURCE: FIELD SURVEY, 2018.



A

B

**FIGURE 5. 28** WATER PUMP STATION FOR A BOREHOLE THAT WAS INSTALLED BUT HAS NEVER FUNCTIONED SINCE ITS INSTALLATION IN KADZUMERI (A-B) DUE TO LACK OF GROUNDWATER. SOURCE: FIELD SURVEY, 2018.



A

B

**FIGURE 5. 29** AN UNOPERATIONAL WATER TREATMENT PLANT IN GREATER-GIYANI (A) AND FILTERS FULL OF SAND INDICATING THEIR NON-USE (B) DUE TO POOR MAINTENANCE AND MALADMINISTRATION OF FUNDS. SOURCE: FIELD SURVEY, 2018.

## 5.5 Summary

This chapter investigated the main water sources and uses by households and public institutions within the three study villages of KaNgove, Mageva and KaDzumeri in the Greater-Giyani Local Municipality. The study identified groundwater as the main water source for households, primary schools and clinics with rivers also being used to augment water supply. The main causes of lack of water supply were identified as being the poor maintenance and poor governance of the available water resources by the local municipality. An important key finding was how women bore most of the burden of fetching water in the study villages.

## CHAPTER 6

### COPING WITH WATER SCARCITY IN GREATER GIYANI LOCAL MUNICIPALITY

#### 6.1 Introduction

The previous chapter has detailed the challenges of water supply and lack of reticulation infrastructure which is endemic to the study region. The aim of this chapter is to determine the extent of the problem - how households, clinics and schools are coping and living without adequate water. The lack of access to adequate water supply may render rural households and institutions in the municipality highly vulnerable taking into cognizance projected impacts of climate change.

#### 6.2 Households coping mechanisms and adaptation strategies to water supply problems

The findings of this study revealed that the main adaptation strategy for households during periods of water shortages in the three study villages was boreholes (29%), this was followed by buying water from vendors or water points (28%), then rivers (25%) and lastly rainwater harvesting (18%) (Figure 6.1 and 6.2). In KaNgove, 36% of the respondents bought water regularly, 25% obtained their water from boreholes, 23% used rivers, while 16% practiced rainwater harvesting during the rainy season. In Mageva, 38% of the respondents bought water, 30% used boreholes, 16% used rivers and 16% practiced rainwater harvesting. In KaDzumeri, 38% of the respondents used rivers, 32% used boreholes, 20% practised rainwater harvesting and 10% bought water during periods of water shortage.

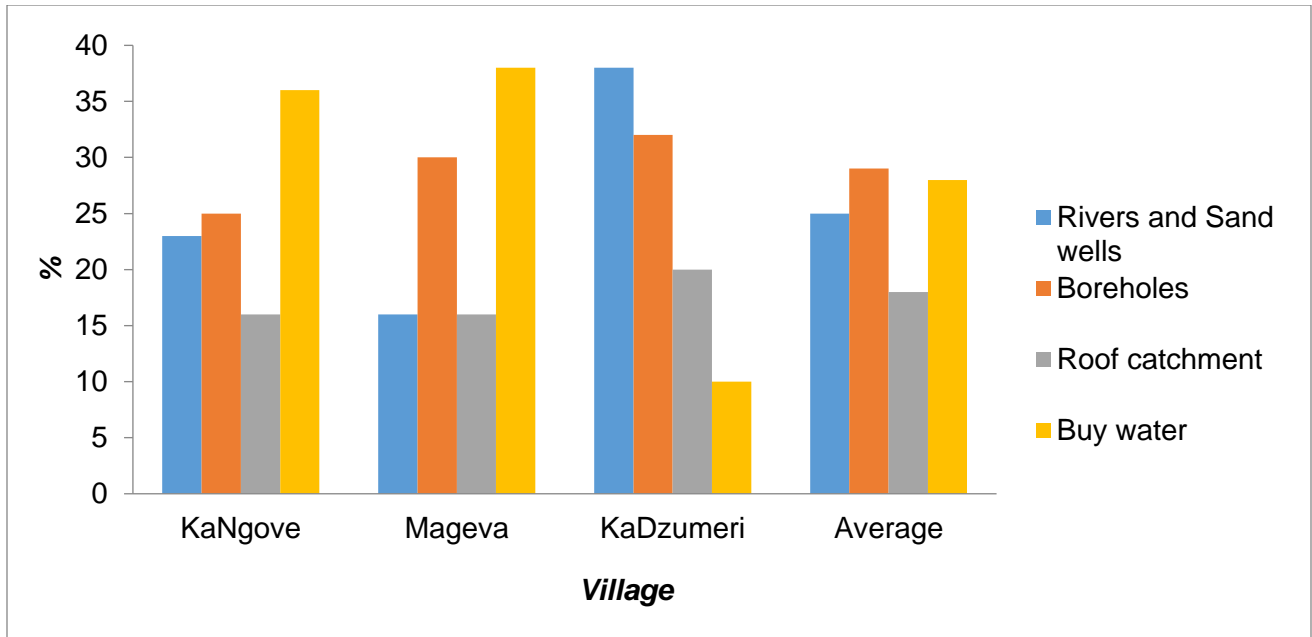
The study found that in KaNgove and Mageva villages, respondents adapted to water shortages through buying water due to a lack of municipal water from the boreholes constructed as a means for the communities to cope with water shortages. It was also found that these boreholes would go for 2 or 5 months without being operational, thus leaving the communities stranded with the only option to accessing water being to buy from water vendors or using rivers.

The findings of the study clearly show that within the three villages, households were not only reliant on boreholes during periods when water was easily accessible but also during periods of water scarcity. This can be attributed to the fact that other sources of water dry up in times of droughts which may have been escalated by climate variability. The failure of the municipality to provide the community with water that is accessible throughout the seasons is also an important

factor. The study found that in KaDzumeri, community members drilled a communal borehole as a way of addressing water scarcity (Figure 6.3) due to the unfunctional nature of municipal boreholes. In Mageva the respondents also dug their own boreholes, but this required substantial amounts of money which could only be afforded by those in employment, again indicating the importance of income levels in coping with water shortages.

Those with high and uninterrupted income are also able to buy water during scarcity. It appears buying water is a widespread coping mechanism as reported on communities in Sekhukhune District of Limpopo ([www.enca.com](http://www.enca.com)). It was also found in this study that respondents with low income levels also dug sand wells as a way of accessing clean water from ephemeral rivers. In a related study, Chipeta (2009) found that communities would dig their own boreholes and also sell water to those without boreholes as a way of coping with water scarcity.

Respondents in the income brackets of R1000 to R5000; R5000 to R10000; R10000 to R15000 and above R15000 (Figure 5.6) were better adapted than those in income brackets of less than R1000 to cope with water shortages as they were able to buy water. Even when using river water, they could afford to buy water and household bleach (*jik*) to purify the water or buy electricity/firewood to use in boiling the water. Respondents in the income bracket of less than R1000 and those with no income were less able to cope with water shortages as they could not afford to buy water, bleach or afford electricity/firewood to treat the water. They depend more on untreated river water thus increasing their chances of being affected by water-borne diseases.



**FIGURE 6. 1** HOUSEHOLDS MAIN WATER SOURCE DURING WATER SHORTAGE (WHEN THERE IS NO WATER IN THE MUNICIPAL PIPELINES OR BOREHOLES). SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY 2018.



A

B

**FIGURE 6. 2** ELEVATED BOREHOLE STORAGE TANK IN MAGEVA VILLAGE (A) AND GROUND LEVEL BOREHOLE STORAGE TANK IN KADZUMERI (B). SOURCE: FIELD SURVEY 2018.



A

B

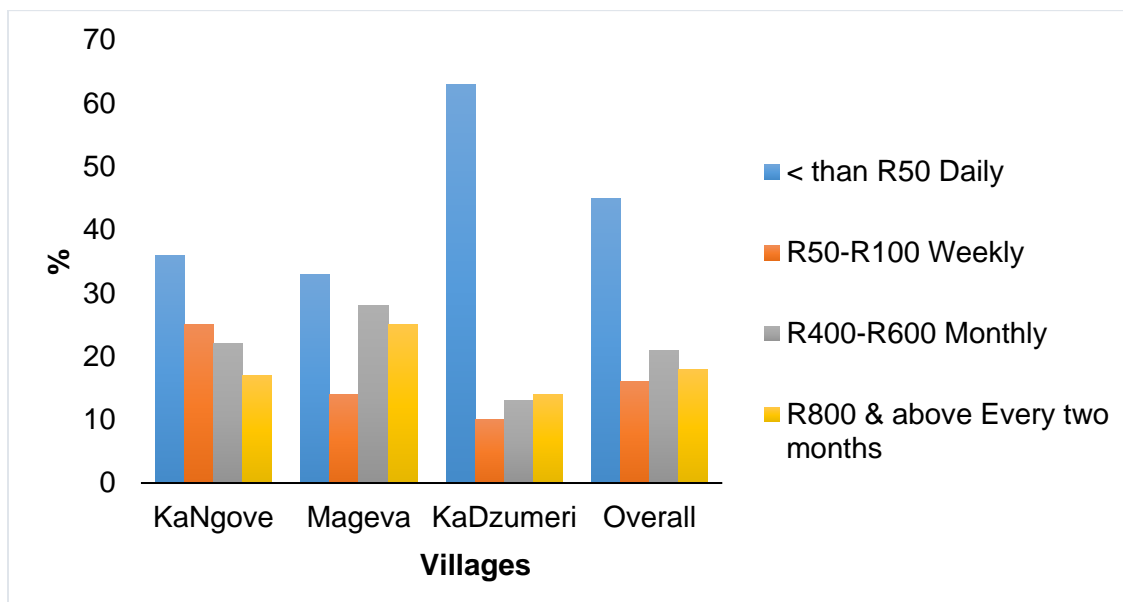
**FIGURE 6. 3** COMMUNITY BOREHOLE CONSTRUCTED BY LOCAL VILLAGERS IN KADZUMERI (A-B).

*SOURCE: FIELD SURVEY 2018.*

The findings of this study showed that buying water ranked second as one of the coping mechanisms taken by households to address water shortages (Figure 6.1). However, unlike boreholes this is not only short-term but also expensive for most families. This study found that about 45% of respondents indicated that they buy water at less than R50 per water container daily, 16% buy water between R50-R100 per drum weekly, 21% buy water between R400-R600 per water tank monthly, while 18% buy water at R800 and above per tank, every two months (Figure 6.4).

In KaNgove, 36% of respondents buy water at less than R50 per water container daily, 25% buy water between R50-R100 per drum on a weekly basis, 22% buy water between R400-R500 per water tank monthly, while 17% buy water between R800 and above per water tank after every two months (Figure 5.6). In Mageva, 33% of respondents buy water at less than R50 per water container after two days, 14% buy water between R50-R100 per drum weekly; 28% buy water between R400-R600 per water tank monthly, while 25% buy water between R800 and above per water tank after two months (Figure 5.6). In KaDzumeri, most of the respondents (62%) buy water at less than R50 per water container weekly, 10% buy water between R50-R100 per water drum after two to three weeks, 13% buy water between R400-R600 per water tank monthly, with 14% buying water between R800 and above per water tank after two months (Figure 5.6).

The findings of this study therefore reveal that within the three study villages, households were spending a sizeable amount from their income purchase water to cope with water scarcity. According to the findings of this study on income levels, households (35%) had a monthly average income of between R1000 to R5000 (Figure 5.6), suggesting that households spent most or half of their income on water. It is argued here that buying water is not a sustainable coping mechanism as it digs into households' livelihoods.



**FIGURE 6. 4** WATER COST INCURRED BY HOUSEHOLDS IN BUYING WATER DURING PERIODS OF WATER SCARCITY WITHIN THE THREE STUDY VILLAGES. SAMPLE SIZE (N=112). SOURCE: FIELD SURVEY 2018.

Other coping mechanisms included respondents buying water tanks (88.9%) (2000-5000 litres), drums (60-90 Litres) and containers (20-25 Litres) that were used for storing water during times when boreholes have broken down. Others resorted to reducing water usage (12.1%) and water re-usage. These findings coincide with those of Ngima (2015) in a study in Githurai Ward (Kenya) who found that households engaged in buying storage containers for storing water to use when required. Similarly Chipeta (2009) in a study in Blantyre city (Malawi) found that most households stored water in large containers for use when there was no water supply. This implies that water storage in containers is a common coping strategy among households as it complements purchasing water. Field observations revealed shortcomings with some of the strategies. For example, it was found that water stored in drums that were not fully covered due to lack of lids, which could lead to contamination during storage and waterborne infections (Figure 6.5).

Direct observation in the field revealed that nearly all households had facilities for harvesting rainwater from rooftops. However, it was done on a small scale (collecting water into drums, containers and buckets only), hence undermining its importance as a long-term coping strategy (Figure 6.6). The other important consideration is that the dry season is long in this region, thus rendering water harvesting an ineffective solution. Figure 6.7 shows a river flowing with water after a heavy rainfall event and how seven days later it had quickly dried out. This is an indication of the challenges experienced with accessing rain and river water for the households and the need for large scale water harvesting to trap the rain water that otherwise dries up along the river channel.



A

B

**FIGURE 6. 5** WATER STORED IN BUCKETS (A) AND A WATER STORAGE DRUM WRAPPED WITH A DUSTBIN PLASTIC BAG (B) IN A HOUSEHOLD IN KANGOVE. *SOURCE: FIELD SURVEY MARCH 2018.*



A

B

**FIGURE 6. 6** RAINWATER HARVESTING TECHNIQUES USED IN HOUSEHOLDS WITHIN THE STUDY VILLAGES TO ADDRESS WATER SHORTAGES (A-B). *SOURCE: FIELD SURVEY 2018.*



A

B

**FIGURE 6. 7** MOLOKOTSI RIVER WITH WATER FLOWING AFTER HEAVY RAINFALL (16 MARCH 2018) (A) AND DRY (B) AFTER SEVEN DAYS (24 MARCH 2018). *SOURCE: FIELD SURVEY MARCH 2018.*

### 6.3. Institutional Coping Strategies to Water shortages

#### 6.3.1. Primary schools and clinics

The study found that as a coping strategy, the five primary schools and two clinics located within the three study villages in Greater-Giyani Local Municipality, drilled boreholes to tap underground water to help them deal with challenges of water access. It was determined in Chapter 5 that the municipality was not providing any form of water supply to these critical public institutions resulting in them constructing their own boreholes (Figure 6.8). It was also found that every primary school within the study villages was practising rainwater harvesting during rainy days as a way of augmenting the groundwater supply (Figure 6.9). The study also found that within the two clinics in the study villages, water meant to be used for drinking by patients and nurses from the boreholes was further purified to ensure that any pathogens that could cause waterborne diseases were eliminated (Figure 6.10).



A

B

C

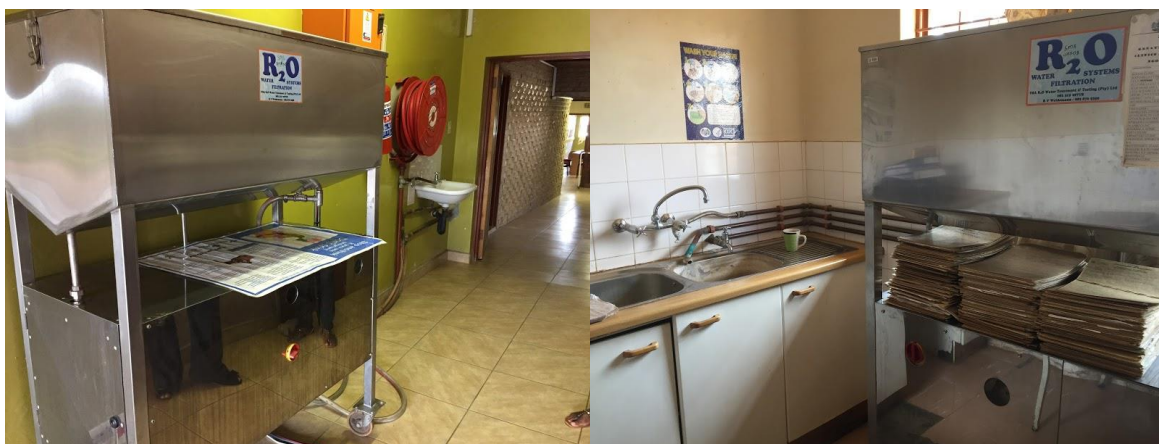
**FIGURE 6. 8** BOREHOLE SYSTEM IN NGOVE VAHLAVE PRIMARY IN KANGOVE VILLAGE. FROM UNDERGROUND (A) TO THE STORAGE TANK (B), AND TO THE TAP (C). SOURCE: FIELD SURVEY MARCH 2018.



A

B

**FIGURE 6. 9** TWO RAINWATER STORAGE TANKS (A-B) IN MK KHAMBANI PRIMARY SCHOOL IN KANGOVE VILLAGE. *SOURCE: FIELD SURVEY MARCH 2018.*



A

B

**FIGURE 6. 10** WATER PURIFICATION SYSTEMS IN DZUMERI HEALTH CENTER (A) AND NGOVE CLINIC (B) WITHIN THE GREATER-GIYANI LOCAL MUNICIPALITY. *SOURCE: FIELD SURVEY MARCH 2018.*

### 6.3.2. Extent of municipal interventions in water supply

The study sought to establish whether the municipality had put in place some interventions to help address the perpetual problem of water shortage in the three study villages. It was found that the municipality dug boreholes in KaDzumeri and KaNgove villages to ensure that the villagers had access to water (Figure 6.11). However, the problem arose when the borehole pumps were damaged and it took months for them to be fixed or replaced. Nearly all respondents (99%) indicated that municipal interventions were of very poor quality. Municipal officials from environmental services also detailed that Ngove village depend solely on boreholes which pumps water at least once per week. The officials also revealed that there were central water taps erected for villagers but sometimes communities can spend a month without running water.

The environmental services officials stated that the district has developed a climate change strategy which outline types of crops which are resistant to high temperatures and drought conditions. The Department of Agriculture has also set aside a relief budget to assist farmers during drought periods. From the interviews with municipal officials it was reported that the municipality has a disaster unit which manages a disaster relief grant. However, this was a surprise to heads of households as they indicated that they had never received any assistance from the municipality with relief.

In Mageva village the study found that the municipal water pipes would be dry for days and no announcements or arrangements would be made by the municipality to ensure that the villagers have access to water. It was also found that it was only during funerals that the municipality would provide the affected households with water delivered by trucks. This was also acknowledged by the municipal official that they supplied water through water carts to breaved families. At other times this facility was unavailable, even during periods of extreme water shortage.



A

B

**FIGURE 6. 11** MUNICIPAL BOREHOLES IN KANGOVE (A) AND KADZUMERI (B) VILLAGES. *SOURCE: FIELD SURVEY MARCH 2018.*

The study also found that primary schools and clinics were not receiving any municipal assistance for water services. Hence, they depend heavily on their own boreholes and rainwater harvesting techniques to ensure that they are well adapted to water scarcity. This was supported by the municipal officials who indicated that there are boreholes in schools and clinics, hence no need to provide them with water. This brings in the question as to who is responsible for the provision of water to these government institutions. The constitution clearly spells out that access to water is a human right and by an act of parliament the government undertook to provide water to everyone including community institutions. However, it has established that although there are limited municipal interventions, they are inadequate and even discriminatory especially towards government institutions.

### **6.3.3. Interventions by Non-Governmental Organizations**

The study did not find any evidence of interventions by non-governmental organizations, but in KaDzumeri village, a farmer had constructed a borehole for his farm and had given permission to the people to collect water from it (Figure 6.12).



**FIGURE 6. 12** PRIVATELY CONSTRUCTED BOREHOLE IN KADZUMERI. *SOURCE: FIELD SURVEY MARCH 2018.*

#### **6.4. Summary**

This chapter addressed the research question on how households and public institutions cope with water scarcity within the three study villages of KaNgove, Mageva and KaDzumeri in the Greater-Giyani Local Municipality. It was found that households, primary schools and clinics were mainly depending on groundwater (boreholes) and also practising rainwater harvesting during the rainy season. The study did not find any evidence of non-governmental interventions to ensure clinics and primary schools have adequate access to water. The few municipal interventions found were largely inadequate.

## CHAPTER 7

### CONCLUSIONS AND RECOMMENDATIONS

#### 7.1 Introduction

The primary aim of this study was to understand the nature and extent of water supply challenges affecting rural communities in Greater Giyani Local Municipality. The study also sought to learn how households, schools and clinics are living (coping) with water scarcity and supply challenges. The main focus was on three rural communities of KaNgove, Mageva and KaDzumeri which were identified by the Department of Water and Sanitation as needing urgent assistance since dams in the area were failing to sustain the communities with adequate water (Department of Water and Sanitation, 2014). The study also brought in the climate dimension and its impact on availability of surface water resources in the study area.

This chapter presents the summary of key findings, mostly, from chapters 4 to 6. It also offers recommendations for future studies and for practice.

#### 7.2 Synthesis of key findings

##### 7.2.1 Major sources of water and water supply challenges

The study found that communities in Greater-Giyani used various sources of water. The main water sources were boreholes which were supplemented by rivers, dams and water vendors. The main problem was a lack of a water reticulation system and generally low dam levels as this a low rainfall area. It was found that primary schools and clinics also depend on boreholes as the primary water source. Within school yards and health facilities there was no running water from the municipal pipelines such that boreholes became the main supply. It was also found that some school boreholes were located at a distance from the school yard due to low underground water within the school yards. This highlighted the extent to which the water problem stretches within the study area.

Water shortages within KaDzumeri, KaNgove and Mageva were due to the municipality failing to provide adequate water to the communities through pipelines. However, in areas where there were municipal boreholes, poor maintenance of the boreholes and vandalism were the leading causes of water shortages. Poor maintenance of the water treatment plant also contributed to the communities lacking access to clean water for drinking and cooking. It was also found that

variations in climate were an additional stressor to water supply resulting in limited water available in dams and reservoirs.

### **7.2.2 Effects of climate variability on water availability**

It was necessary to have an analysis of the availability of surface water resources in the area through rainfall, temperature and hydrological data. The area is located in the northeastern interior of South Africa receiving most of its rainfall during the austral summer (December to February). It is generally semi arid, with high variability at seasonal and interannual timescales. Droughts are regular in this area whilst flood events are infrequent but mostly due to remnants of tropical cyclones entering the Limpopo River valley from Mozambique. Dam levels in the area were found to be generally low but highly sensitive to climate variability. The rising trend of temperatures particularly in the recent years is worrying as it might enhance evaporation from water bodies and reduce soil moisture for cropping.

### **7.2.3 Coping with water shortages**

The study found that poor access to water had varying impacts on rural communities and public institutions within the Greater-Giyani Local Municipality. The major consequences of not regularly having access to water daily was the lack of water for cooking, bathing and washing. It was further found that most of the rural communities have since stopped practising irrigation of crops due to the shortage of water over the Greater-Giyani Local Municipality. Due to scarcity of water, communities had to spend more money on buying water instead of prioritizing other basic necessities, such as children's education and health care.

Most households in the Greater-Giyani Municipality devised various methods as coping mechanisms as a result of shortages of water. It was found that in the absence of piped water supply from the municipality, the main coping strategy were boreholes. The sustainability and yields of groundwater requires investigation. It was also found that some households sometimes bought water from vendors as a way to cope with water shortages, while those who could not afford to buy depended on river water for survival and also rainwater harvesting during rainy days in summer. Those dependent on river water and rainwater were more vulnerable and less able to cope with water shortages.

The study revealed that those employed were better positioned to adapt or cope with water shortages as it some households to drill their own boreholes and buy water, while also able to afford other basic necessities such as food, school fees and clothing. It was reported that rural

communities in Sekhukhune District in Limpopo were also resorting to buying water from neighbors with boreholes ([www.enca.com](http://www.enca.com)). This is despite the government having impounded a large dam (De Hoop Dam) nearby. There is no infrastructure to supply water from the dam to the villages.

## **7.3 Recommendations and future work**

### **7.3.1 Recommendations for practice**

The municipality is the key institution that is tasked with water provision to communities in the Greater-Giyani Municipality. A key recommendation from this study is for the municipality and/or government to urgently allocate resources for the impounding of water reticulation infrastructure not just in the study area but also in many other rural villages in Limpopo that are affected by similar water shortages. Even communal taps would be a good starting point. Water pipelines are often used to transport water from regions of higher rainfall to semi arid regions for hundreds of kilometers. As the study has shown that the local dams have limited capacity, such a pipeline could be an option to transport water from the large Nandoni Dam in the neighboring Thulamela Municipality.

While pipelines may be a long term measure, in the short term the municipality can drill boreholes in communities without water, fix and ensure proper maintenance of existing boreholes. Proper and regular management and maintenance of pipeline infrastructure from the available dams is necessary. The dissertation findings also recommend that the municipality provide water tankers to the communities which have no access to water - Hlomela, Muyexe, Nkomo, Ngove, Mageva and Dzumeri villages.

It is also recommended to create community outreach and awareness programs on how communities can save water as a way to address water scarcity in the area including e.g. conservation agriculture. The study further recommends that all government institutions practise rainwater harvesting as a way to ensure sustainable use of water even though it's a seasonal remedy. One institution that the study fully recommends to practice rainwater harvesting, is the fire station whose lack of water can create a serious problem during periods of fire hazards.

The study further recommends that the Greater-Giyani local municipality open a complaint center that will provide 24-hour emergency and essential services contact points for the public. This center will be responsible for day-to-day emergency responses by municipality personnel to public complaints related to water and other disasters. The Department of Agriculture can assist the

local communities with alternative cropping methods as most of the villagers have abandoned their farming practices which was their main primary source of livelihoods.

Communities are affected differently by water shortages and, as such, their methods of dealing with water shortages vary. Whilst certain coping strategies were expensive and unsustainable such as buying water, communities may be sensitized and educated on long term and more sustainable strategies such as conservation of water, water harvesting among others.

Communities can also practice water reuse and greywater as a means to conserve water. To avoid water related health problems, rural communities in the study area must disinfect water collected from the rivers before use e.g. by boiling the water.

### **7.3.2 Recommendations for future studies**

Water security is a dynamic and complex issue. Below are some of the research questions that have arisen from this study and may be considered for future studies: -

- a) What are the future consequences of over reliance on groundwater for Greater-Giyani Local Municipality?
- b) What is the quality level of the water being harvested from hand dug wells in rivers in KaDzumeri?
- c) What could be the cause for lack of groundwater in some parts of the Greater-Giyani Local Municipality?
- d) How can underground water exploitation be monitored and regulated?
- e) What are the future implications of climate variability on surface and groundwater resources in the study area?
- f) What are the socio-economic impacts of water shortages on resource-poor rural communities?

### **7.4 Conclusion**

It has been established in this study that the water challenges are huge in rural communities of Greater Giyani Local Municipality. Households and public institutions in the area struggle daily with accessing water as municipal boreholes and pipelines are not sufficient in providing sufficient water for the whole community. The communities are commended for managing to “live with” water shortages through a number of coping mechanisms. However, a growing population, rising air temperatures, a variable climate and projected climate change may impact on water problems

even more. Rural livelihoods may suffer as a result and hence the need for appropriate disaster risk reduction measures.

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## APPENDICES

### APPENDIX A

My name is Mmbadi Elelwani, a postgraduate student at the Department of Geography and Geo-Information Sciences, University of Venda (UNIVEN). I am conducting a research study on ***Water security under a changing climate in rural Limpopo: a case study of the Greater-Giyani Local Municipality, South Africa***. This study seeks to investigate the potential impacts and extent to which the rural communities of KaDzumeri, KaNgove and Mageva in the Greater-Giyani Local Municipality adapt to water scarcity and water supply challenges in a changing climate and a growing population. Your patience and time in answering the questions is highly appreciated. Your responses will be treated with the outmost confidentiality.

#### HOUSEHOLD QUESTIONNAIRE:

Date.....

No.....

Village/Location/Sub-location.....

#### SECTION 1

##### A. Demographic Information and socio-economic characteristics

##### 1. Sex

Male	1	
Female	2	

##### 2. Age

Under 20	1	
20-30	2	
21-40	3	
41-50	4	
51 and above	5	

3. Marital Status

Single	1	
Married	2	
Divorced/Separated	3	
Widowed	4	

4. Are you the head of the household?

Yes	1	
No	2	

5. Total number of people in household?

Between 1-3	1	
Between 4-6	2	
7 and above	3	
Alone	4	

6. How long have you lived in this area?

Less than a year	1	
Between 1-4 years	2	
Between 5-8 years	3	
Between 9-12	4	
13 and over	5	

7. Were you born in this area?

Yes	1	
No	2	

8. If No, where did you migrate from?

From within the Mopani District	1	
From within Limpopo	2	
From other parts of South Africa	3	

Indigenous to the area	4	
Other (Specify)	5	

9. Reasons for migrating?

.....

10. Highest Educational Level

No Formal Schooling	1	
Creche/Pre-school	2	
Primary school	3	
Secondary school	4	
Tertiary school	5	

11. Employment status

Unemployed	1	
Self-employed	2	
Employed	3	

12. Main Occupation

Farmers	1	
Fisher	2	
Civil servant	3	
Private sector	4	
Trade\commercial	5	
Self-employed	6	
Other- specify	7	

13. What is the main source of your household income?

None	1	
Child support grant	2	
Allowance from relatives	3	
Salary (formal)	4	

Wage (contract)	5	
Pension	6	
Disability benefit income	7	
Other (specify)	8	

Specify\_\_\_\_\_

14. Choose the range of your monthly income.

None	1	
R100-R500	2	
R500-R1000	3	
R1001-R5000	4	
R5001-R10000	5	
R100001-R15000	6	
R15000+	7	

15. How many people are earning income in this household?

None is working	1	
One member	2	
Two members	3	
Three members	4	
Four members	5	
More than four members	6	

16. Current Source of income for the household head?

None	1	
Child support grant	2	
Allowance from relatives	3	
Salary (formal)	4	
Wage (contract)	5	
Pension	6	
Disability benefit income	7	

Other (specify)	8	
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Specify \_\_\_\_\_

17. What is the average expenditure per month?

Less than R1 000. 00	1	
Between R1 000.00 and R5 000.00	2	
Between R5 000.00 and R10 000.00	3	
Between R10 000.00 and R15 000.00	4	
Above R15 000.00	5	
Other (Specify)	6	

Specify \_\_\_\_\_

**B. The main water sources in the study area.**

1. How many liters of water do you consume in a day in your household?

Below 25 lts	1	
26-45 lts	2	
46-65 lts	3	
Above 65 lts	4	

2. What do you mainly use the water for? (Tick the one(s) applicable to you)

Drinking	1	
Washing	2	
Irrigation	3	
cooking	4	
Bathing	5	
Other (specify)	6	

Specify \_\_\_\_\_

3. What is the main source of drinking water for members of your household? (Tick the one applicable to you)

Tap water	1	
Borehole	2	
River	3	
Dam	4	
Water Vendors	5	
Other (specify)	6	

4. Are there days when water is not available?

Yes	1	
No	2	

5. If yes, how frequently do you have access to clean water?

After 2 days	1	
After 3 days	2	
3-4 days	3	
5-6 days	4	
Weekly	5	
A fortnight	6	
Monthly	7	
everyday	8	

Specify \_\_\_\_\_

6. Where is that water source located?

Inside household	1	
Within the village boundary	2	
Another neighboring village	3	
Other (specify)	4	

Specify \_\_\_\_\_

7. Do you have to travel to collect water or you have the water in the yard?

Yes	1	
No	2	

8. If yes, how long do you think is the distance?

Less than 1Km	1	
1.1Km-2Km	2	
2.1Km-3Km	3	
3.1Km-4Km	4	
4.1Km and above	5	

9. How long does it take to go there, get water, and come back?

Less than 10 minutes	1	
Between 10 – 30 minutes	2	
Between 30-50 minutes	3	
1 hour	4	
1h30 minutes	5	
2 hours	6	
2h30 minutes	7	
3 hours and above	8	

10. Who usually goes to this source to collect the water for your household?

Man	1	
Women	2	
Girl child	3	
Boy child	4	
Household	5	
Other (specify)	6	

Specify \_\_\_\_\_

11. who have to search for water in case of shortage?

Man	1	
Women	2	
Girl child	3	
Boy child	4	
Household	5	
Other (specify)	6	

Is this cultural or economic? Yes/No

Specify \_\_\_\_\_

12. Do you do anything to the water to make it safer to drink?

Yes	1	
No	2	

Specify if No, \_\_\_\_\_

13. If yes, what do you usually do to make the water safer to drink?

Boil the water	1	
Treat the water with chemicals	2	
Distilling water with a solar still	3	
Other (specify)	4	

Specify \_\_\_\_\_

14. What container do you fetch water in?

Bucket	1	
Water container (e.g. 5 gallon)	2	
Drum	3	
Other (specify)	4	

Specify \_\_\_\_\_

15. What do you use to carry the water?

Head	1	
Wheelbarrow	2	
Car	3	
Cart (donkey, horse etc)	4	
Other (specify)	5	

Specify \_\_\_\_\_

16. Where do you store water?

Tanks	1	
Drum	2	
Water containers	3	
Other (specify)	4	

Specify \_\_\_\_\_

**C. Factors affecting sustainable water distribution and supply**

1. Have you ever experienced water supply challenges in this area?

Yes	1	
No	2	

2. If yes, for how long were this supply challenges experienced?

Hours	1	
Days	2	
Months	3	
Years	4	

3. What do you think are the major causes of unsustainable water supply in this area?

Lack of rain	1	
Municipality	2	
Changes in climate	3	
Rapid population growth	4	
Depleted water towers	5	
Other	6	

Specify \_\_\_\_\_

**D. Climate variability effects on Water Availability and Water Access.**

1. What are the significant changes that you have observed in your community over the last 20 years?

Unpredictable rains	1	
Prolonged Droughts	2	
Very hot seasons	3	
Very wet seasons	4	
Other (specify)	5	

Specify \_\_\_\_\_

2. What is the main impact of these changes on the local community?

Flooding	1	
Reduced water sources	2	
Crop failure	3	
Disease outbreaks	4	
Other (specify)	5	

Specify \_\_\_\_\_

3. If you have selected reduced water sources above, what are the main sources of water for domestic use?

Rivers	1	
Shallow wells	2	
Borehole	3	
Sand dams	4	
Roof catchment	5	
Other (specify)	6	

Specify \_\_\_\_\_

4. What do you think are the effects of climate variability on water resources in your area?

Drought	1	
Increased evaporation	2	
Changes in water levels	3	
Reduced rainfall amount	4	
Increased flooding	5	
Other (specify)	6	

Specify \_\_\_\_\_

5. How do you cope with these changes?

Store water		
Use water harvesting technique		
Minimise use of water to essential use		
Look for water from distant areas		
Something else		

6. What is the distance to the nearest water source?

Less than 1 Km	1	
1-3 Km	2	

4-5 Km	3	
Over 5 Km	4	

7. Has the distance changed from the past 10 years?

Yes	1	
No	2	

8. If yes, what are the impacts of the increased distance?

Increased distance	1	
High cost of water	2	
Quality and quantity reduced	3	
Other (specify)	4	

Specify \_\_\_\_\_

### E. Socio-Economic Impact of Water Shortages

1. How have you been affected by water shortages from past 10 years?

Less water for domestic use	1	
Less water for livestock	2	
Less water for business	3	
Less water for gardening	4	
Increased expenditure on health	5	
Loss of income	6	
Overexploitation by private service providers	7	
Other (specify)	8	

Specify \_\_\_\_\_

### F. Coping Strategies to Climate Change Challenges

1. What steps do you take when there is water shortage?

Rooftop catchment	1	
Sand dams	2	
Use river water	3	
Dug boreholes	4	
Other (specify)	5	

Specify \_\_\_\_\_

2. Where do you get water from during periods of scarcity?

Tap	1	
River	2	
Borehole	3	
Dam	4	
Buy water	5	
Other (specify)		

Specify \_\_\_\_\_

3. Do you buy water when there is no supply?

Yes	1	
No	2	

4. If yes, how much does it usually cost depending on the type of water container?

Less than R50 per water container	1	
Between R50 -R100 per drum	2	
Between R400 – R600 per Tank	3	
R800 and above (specify)	4	

5. Are there any adjustments that you have made within your household as a way to address water scarcity? If yes, what are they?

Reduced water usage	1	
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Construction of water harvesting schemes	2	
Implement soil conservation schemes	3	
Practice monoculture	4	
Water reuse	5	
Other (specify)	6	

Specify \_\_\_\_\_

6. How long has it been while using the above measures?

Between 0-1 years	1	
Between 2-4 years	2	
Between 4-5 years	3	
More than 5 years	4	

7. Which other methods do you use to adapt to water supply problems?

Rooftop catchment	1	
Sand dams	2	
Use river water	3	
Dug boreholes	4	
Other (specify)	5	

### **G. Municipality Intervention**

1. What is the nature of water supply services in your area?

Excellent	1	
Good	2	
Poor	3	

2. Does the municipality announce before there is water cut off?

Strongly agree	1	
Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

3. Are the available water structures maintained well?

Strongly agree	1	
Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

4. In cases where there is no water available in the community, does the municipality provide the community with water?

Strongly agree	1	
Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

**THANK YOU FOR YOUR TIME!**

## APPENDIX B

My name is Mmbadi Elelwani, a postgraduate student at the Department of Geography and Geo-Information Sciences, University of Venda (UNIVEN). I am conducting a research study on ***Water security under a changing climate in rural Limpopo: a case study of the Greater-Giyani Local Municipality, South Africa***. This study seeks to investigate the potential impacts and extent to which the rural communities of KaDzumeri, KaNgove and Mageva in the Greater-Giyani Local Municipality adapt to water scarcity and water supply challenges in a changing climate and a growing population. Your patience and time in answering the questions is highly appreciated. Your responses will be treated with the outmost confidentiality.

### Primary School Questionnaire:

Date.....

No.....

Village/Location/Sub-location.....

#### A. Major sources of water at Primary schools within area of study.

1. How many years have the school been operational?

Less than 1 year	1	
Between 1 - 2 years	2	
Between 2- 4 years	3	
4 and above	4	

2. Over the course of the school operational period, has the enrolment number increased or decreased?

Increased	1	
Decreased	2	

3. If increased, by what margins has it increased?

From 500-1000	1	
From 1001-2000	2	
From 2001-3000	3	
By more than 3001	4	

4. If decreased, by what margins has it decreased?

From 1000-500	1	
From 2000-1000	2	
From 3000-2000	3	
Below 500	4	

5. What is the total number of learners at your school?

1000-2000 Learners	1	
2001-3000 Learners	2	
3001-4000 Learners	3	
4001 and above	4	

6. What are the main water source used at your school?

Tap water	1	
Borehole	2	
River	3	
Dam	4	
Water Vendors	5	
Other (specify)	6	

7. Do you have water shortages at your school?

Yes	1	
No (specify)	2	

Specify \_\_\_\_\_

8. If yes, how frequently do you have access to clean water at the school?

After 2 days	1	
After 3 days	2	
3-4 days	3	
5-6 days	4	
Weekly	5	
A fortnight	6	
Monthly	7	
Everyday	8	

Specify \_\_\_\_\_

9. Where is the water source located?

Inside school yard	1	
Within the village boundary	2	
Another neighboring village	3	
Other (specify)	4	

10. Do you do anything to the water to make it safer to drink?

Yes	1	
No	2	

Specify if No, \_\_\_\_\_

11. If Yes, what do you usually do to make the water safer to drink?

Boil the water	1	
Treat the water with chemicals	2	
Distilling water with a solar still	3	
Other (specify)	4	

**B. Factors affecting sustainable distribution of water at Primary schools.**

1. What do you think are the major causes of unsustainable water supply at your school?

Lack of rain	1	
Municipality	2	
Changes in climate (Increased heat/high evaporation rates)	3	
Increased enrolment rate	4	
Depleted water towers	5	
Other (specify)	6	

Specify \_\_\_\_\_

**C. Effects of climate variability on Water Availability and Water Access at Primary schools**

1. What are the significant changes that you have observed since you have been at the school over the period of the school's existence?

Unpredictable rains	1	
Prolonged Droughts	2	
Very hot seasons	3	
Very wet seasons	4	
Other (specify)	5	

Specify \_\_\_\_\_

2. What are the main impacts of the changes you have observed?

Flooding	1	
Reduced water sources	2	
Crop failure	3	

Disease outbreaks	4	
Other (specify)	5	

Specify \_\_\_\_\_

3. What do think are the effects of climate variability on water resources in your area?

Drought	1	
Increased evaporation	2	
Changes in water levels	3	
Reduced rainfall amount	4	
Increased flooding	5	
Other (specify)	6	

Specify \_\_\_\_\_

4. What is the distance to the nearest water source?

Less than 1 Km	1	
1-3 Km	2	
4-5 Km	3	
Over 5 Km	4	

5. Has the distance changed?

Yes	1	
No	2	

6. If Yes, what are the impacts of the increased distance?

Increased distance	1	
High cost of water	2	
Quality and quantity reduced	3	
Other (specify)	4	

#### **D. Socio-Economic Impact of Water Shortages**

1. How is the school being affected by water shortages?

Less water for drinking	1	
Less water for cooking	2	
Less water for gardening	3	
Overexploitation by private service providers	4	
Other (specify)	5	

Specify \_\_\_\_\_

#### **E. Coping Strategies to Climate variability Challenges**

1. What steps do you take when there is water shortage?

Rooftop catchment	1	
Sand dams	2	
Use river water	3	
Dug boreholes	4	
Other (specify)	5	

2. Where do you get water from during periods of scarcity?

Tap	1	
River	2	
Borehole	3	
Dam	4	
Buy water	5	
Other (specify)	6	

Specify \_\_\_\_\_

3. Do you buy water when there is no supply?

Yes	1	
No	2	

4. If yes, how much does it usually cost depending on the type of water container?

Less than R50 per water container	1	
Between R50 -R100 per drum	2	
Between R400 – R600 per Tank	3	
R800 and above (specify)	4	

5. Are there any adjustments that you have made within your household as a way to address water scarcity? If yes, what are they?

Reduced water usage	1	
Construction of water harvesting schemes	2	
Implement soil conservation schemes	3	
Practice monoculture	4	
Water reuse	5	
Other (specify)	6	

Specify \_\_\_\_\_

6. How long has it been while using the above measures?

Between 0-1 years	1	
Between 2-4 years	2	
Between 4-5 years	3	
More than 5 years	4	

7. Which other methods do you use to adapt to water supply problems?

Rooftop catchment	1	
Sand dams	2	
Use river water	3	

Dug boreholes	4	
Other (specify)	5	

Specify \_\_\_\_\_

### F. Municipality Intervention

1. What is the nature of water supply services in your school?

Excellent	1	
Good	2	
Poor	3	

2. Does the municipality announce before there is water cut off?

Strongly agree	1	
Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

3. Are the available water structures maintained well?

Strongly agree	1	
Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

4. In cases where there is no water available in the community, does the municipality provide the school with water?

Strongly agree	1	
----------------	---	--

Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

**THANK YOU FOR YOUR TIME!**

## APPENDIX C

My name is Mmbadi Elelwani, a postgraduate student at the Department of Geography and Geo-Information Sciences, University of Venda (UNIVEN). I am conducting a research study on ***Water security under a changing climate in rural Limpopo: a case study of the Greater-Giyani Local Municipality, South Africa***. This study seeks to investigate the potential impacts and extent to which the rural communities of KaDzumeri, KaNgove and Mageva in the Greater-Giyani Local Municipality adapt to water scarcity and water supply challenges in a changing climate and a growing population. Your patience and time in answering the questions is highly appreciated. Your responses will be treated with the outmost confidentiality.

### HEALTH FACILITIES QUESTIONNAIRE:

Date.....

No.....

Village/Location/Sub-location.....

#### A. Major sources of water at health centres within area of study.

1. Do you experience water shortages at your health centre?

Yes	1	
No (specify)	2	

Specify\_\_\_\_\_

2. If yes, for how long do you experience these water shortages?

Hours	1	
Days	2	
Months	3	
Years	4	

3. What is the main water source used at your health centre?

Tap water	1	
Borehole	2	
River	3	
Dam	4	
Water Vendors	5	
Other (specify)	6	

Specify \_\_\_\_\_

4. Where is the water source located?

Inside clinic yard	1	
Within the village boundary	2	
Another neighboring village	3	
Other (specify)	4	

Specify \_\_\_\_\_

5. Do you do anything to the water to make it safer to drink?

Yes	1	
No	2	

Specify if No, \_\_\_\_\_

6. If Yes, what do you usually do to make the water safer to drink?

Boil the water	1	
Treat the water with chemicals	2	
Distilling water with a solar still	3	
Other (specify)	4	

**Factors affecting sustainable distribution of water at health centre.**

1. What do you think are the major causes of unsustainable water supply in the area?

Lack of rain	1	
Municipality	2	
Changes in climate	3	
Increased enrolment rate	4	
Depleted water towers	5	
Other (specify)	6	

Specify \_\_\_\_\_

**Effects of Climate variability on Water Availability and Water Access at health centre**

1. What are the significant changes that you have observed since you have been in the area as a health officer?

Unpredictable rains	1	
Prolonged Droughts	2	
Very hot seasons	3	
Very wet seasons	4	
Others (specify)	5	

Specify \_\_\_\_\_

2. What are the main impacts of the changes you have observed?

Flooding	1	
Reduced water sources	2	
Crop failure	3	
Disease outbreaks	4	
No change	5	
Others (specify)	6	

Specify \_\_\_\_\_

3. What do you think are the effects of changing climate on water resources in your area?

Drought	1	
Increased evaporation	2	
Changes in water levels	3	
Reduced rainfall amount	4	
Increased flooding	5	
Other (specify)	6	

Specify \_\_\_\_\_

4. What is the distance to the nearest water source?

Less than 1 Km	1	
1-3 Km	2	
4-5 Km	3	
Over 5 Km	4	

### **Socio-Economic Impact of Water Shortages for clinics**

5. How is the health centre being affected by water shortages?

Less water for drinking	1	
Less water for cooking	2	
Less water for gardening	3	
Overexploitation by private service providers	4	
Other (specify)	5	

Specify \_\_\_\_\_

6. Has the ever been a case reported about a patient that suffered from any of these diseases?

Cholera	1	
---------	---	--

Diarrhoea	2	
Malaria	3	
Other (specify)	4	

Specify \_\_\_\_\_

7. Which is the class that suffers more from these diseases?

Specify \_\_\_\_\_

### **Coping Strategies to Climate Change Challenges**

1. What steps do you take when there is water shortage?

Rooftop catchment	1	
Sand dams	2	
Use river water	3	
Dug boreholes	4	
Other	5	

2. Where do you get water from if there is no water?

Tap	1	
River	2	
Borehole	3	
Dam	4	
Buy water	5	
Other (specify)		

Specify \_\_\_\_\_

3. Do you buy water when there is no supply?

Yes	1	
No	2	

4. If yes, how much does it usually cost depending on the type of water container?

Less than R50 per water container	1	
Between R50 -R100 per drum	2	
Between R400 – R600 per Tank	3	
R800 and above (specify)	4	

5. Are there any adjustments that have been made in the health centre as a way to address water scarcity? If yes, what are they?

Reduced water usage	1	
Construction of water harvesting schemes	2	
Implement soil conservation schemes	3	
Practice monoculture	4	
Water reuse	5	
Other (specify)	6	

Specify \_\_\_\_\_

6. How long has it been while using the above measures?

Between 0-1 years	1	
Between 2-4 years	2	
Between 4-5 years	3	
More than 5 years	4	

7. Which other methods do you use to adapt to water supply problems?

Rooftop catchment	1	
Sand dams	2	
Use river water	3	
Dug boreholes	4	
Other	5	

Specify \_\_\_\_\_

### Municipality Intervention

1. What is the nature of water supply services in your health centre?

Excellent	1	
Good	2	
Poor	3	

2. Does the municipality announce before there is water cut off?

Strongly agree	1	
Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

3. Are the available water structures maintained well?

Strongly agree	1	
Agree	2	
Neutral	3	
Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

4. In cases where there is no water available in the community, does the municipality provide the health centre with water?

Strongly agree	1	
Agree	2	
Neutral	3	

Disagree	4	
Strongly disagree	5	

Comments \_\_\_\_\_

**THANK YOU FOR YOUR TIME!**

## APPENDIX D



University of Venda

My name is Mmbadi Elelwani, a postgraduate student at the Department of Geography and Geo-Information Sciences, University of Venda (UNIVEN). I am conducting a research study on ***Water security under a changing climate in rural Limpopo: a case study of the Greater-Giyani Local Municipality, South Africa***. This study seeks to investigate the potential impacts and extent to which the rural communities of KaDzumeri, KaNgove and Mageva in the Greater-Giyani Local Municipality adapt to water scarcity and water supply challenges in a changing climate and a growing population. Your patience and time in answering the questions is highly appreciated. Your responses will be treated with the outmost confidentiality.

### Dam operators

**Full name** : .....

**Title** : .....

**Position** : .....

### 1. General information

<b>Gender</b>	Male <input type="checkbox"/> Femal <input type="checkbox"/>
<b>Age group</b>	<18 <input type="checkbox"/> 21- 30 <input type="checkbox"/> 31-40 <input type="checkbox"/> 41-50 <input type="checkbox"/> 51-69 <input type="checkbox"/> 70 and above <input type="checkbox"/>
<b>Occupation</b>	

<b>Educational Level</b>	<b>Mark with an X</b>
Did not go to school	
Primary School	
Secondary School	
Undergraduate Degree	
Postgraduate Degree	

1. Please provide your job description.

.....

2. How long have you been working as a dam operator?

.....

3. Mention the recent drought events, the year and their related impacts on middle letaba/msami dam.

.....

4. In your opinion, how badly was your dam levels affected in terms of the water availability?

.....  
.....

5. Who is responsible for water services delivery in Greater Giyani Local Municipality?

.....

6. Are the responsible worker(s) doing enough to make sure that water is always available to all areas?

.....

7. Does the municipality provide sufficient support in water supply to the villages?

.....

8. What are the monitoring measures for the authorities who are responsible for the provision of water services?

.....

9. What type of water services does the municipality provide to the communities of KaDzumeri, Mageva and KaHomu village?

.....

10. How often does these municipality supply water to the villagers, primary schools and Clinics?

.....

.....

11. What are the main problems the municipality faced in different villages of Greater Giyani in terms of water supply?

.....

12. How are these problems addressed?

.....

.....

13. What would you recommend should be done to reduce water supply problems?

14. Do you think there are ways of promoting water conservation in this area?

15. What would be your view about your community and drought?

Any further comments?

## APPENDIX E



My name is Mmbadi Elelwani, a postgraduate student at the Department of Geography and Geo-Information Sciences, University of Venda (UNIVEN). I am conducting a research study on ***Water security under a changing climate in rural Limpopo: a case study of the Greater-Giyani Local Municipality, South Africa***. This study seeks to investigate the potential impacts and extent to which the rural communities of KaDzumeri, KaNgove and Mageva in the Greater-Giyani Local Municipality adapt to water scarcity and water supply challenges in a changing climate and a growing population. Your patience and time in answering the questions is highly appreciated. Your responses will be treated with the outmost confidentiality.

### Mopani Disaster Management Centre

**Full name** : .....

**Title** : .....

**Position** : .....

1. Mention the recent drought events, the year and their related impacts.

.....  
.....

2. In your opinion, how badly was these communities affected in terms of the socio-economic and environmental aspects? (Mageva, Ngove and Dzumeri)

.....  
.....

3. Do you think that in these community people are vulnerable to drought? Please explain.

.....  
.....  
4. Who is responsible for water services delivery in Greater Giyani Local Municipality?

.....  
5. Are the responsible worker(s) doing enough to make sure that water is always available to all areas?

.....  
6. Does the municipality provide sufficient support in water supply to the villages?

.....  
7. What are the monitoring measures for the authorities who are responsible for the provision of water services?

.....  
8. What type of water services does the municipality provide to the communities of KaDzumeri, Mageva and KaHomu village?

.....  
9. How often does these municipality supply water to the villagers, primary schools and Clinics?

10. What should be done to improve water supply in these villages, primary schools and Clinics?

11. What are the main problems the municipality faced in different villages of Greater Giyani in terms of water supply?

12. How are these problems addressed?

13. How does climate change affect the availability of water and the households, schools and health facilities ability to access it? Please explain.

14. What role do the village authorities play in addressing these problems?

15. Is there anything that the municipality officials of councilors should do in order to reduce or eliminate the problem of poor water supply?

.....

16. How have water shortages affected the communities?

.....  
.....

17. Are there any disease outbreaks that have been reported related to water shortages?

.....

18. Are the key stakeholders such as the government, farmers and community doing enough to address water supply problems?

.....

19. What would you recommend should be done to reduce water supply problems?

.....

20. Do you think there are ways of promoting water conservation in this area?

.....

21. What would be your view about your community and drought?

.....

Any further comments?

## APPENDIX F



My name is Mmbadi Elelwani, a postgraduate student at the Department of Geography and Geo-Information Sciences, University of Venda (UNIVEN). I am conducting a research study on ***Water security under a changing climate in rural Limpopo: a case study of the Greater-Giyani Local Municipality, South Africa***. This study seeks to investigate the potential impacts and extent to which the rural communities of KaDzumeri, KaNgove and Mageva in the Greater-Giyani Local Municipality adapt to water scarcity and water supply challenges in a changing climate and a growing population. Your patience and time in answering the questions is highly appreciated. Your responses will be treated with the outmost confidentiality.

### Health Facilities Representatives

**Questionnaire for collecting information on understanding of climate change, its impact and existing climate change adaptation strategies for municipalities: Health Facilities Representatives**

**Interviewer** : .....

**Date of interview** : .....

**Purpose of interview** : The purpose of the questionnaire is to obtain information on interviewee's understanding of climate change, its impact and existing climate change adaptation strategies within the Greater-Giyani Local municipality for households, schools and health facilities. This will assist in hydrological modelling of climate change impacts and developing

practical adaptation strategies for municipal/domestic water uses in Greater-Giyani Local Municipality.

## 2. General information

<b>Gender</b>	Male <input type="checkbox"/> Female <input type="checkbox"/>
<b>Age group</b>	<18 <input type="checkbox"/> 21- 30 <input type="checkbox"/> 31-40 <input type="checkbox"/> 41-50 <input type="checkbox"/> 51-69 <input type="checkbox"/> 70 and above <input type="checkbox"/>
<b>Occupation</b>	

<b>Educational Level</b>	<b>Mark with an X</b>
Did not go to school	
Primary School	
Secondary School	
Undergraduate Degree	
Postgraduate Degree	

## 2. Water supply for clinics in Greater Giyani Local Municipality (area within KaNgove, Mageva and KaDzumeri side)

2.1 Please provide us with the list of clinics within Mageva, KaNgove and KaDzumeri villages?

.....

2.2 Has the number of patients visiting the clinics increased over the past 10 years and by what margins?

.....

.....  
.....

2.3 What are the main sources of water supply of each of the clinics mentioned in question 2.1?

.....  
.....  
.....  
.....

2.4 How often is the municipality able to meet the water demand for each of these clinics?

.....

2.5 If there are periods where they fail to meet that demand, what are the likely causes?

.....  
.....  
.....  
.....

2.7 How do clinics deal with water shortages, particularly during dry periods?

.....  
.....  
.....  
.....

### **3. Climate change, its impact and existing climate change adaptation strategies**

3.1 What is your understanding of the term “climate change”?

.....

3.2. Climate change has now become a reality. How is it impacting on the clinics water supply?

.....

.....

.....

.....

.....

.....

.....

.....

3.3. Do you think that the impacts are going to be worse or better in the future?

Worse

Better

3.4. What is (are) the reason(s) for the answer you provided in question 3.4?

.....

.....

.....

.....

3.5. Do you have strategies for adapting to climate change impacts?

Yes

No

3.6. If yes are they working effectively?

Yes

No

3.7 What is (are) the reason(s) for the answer you provided in question 3.6?

.....

.....

.....  
.....

3.8 Have you documented the adaptation strategies that you are currently using?

Yes

No

If yes, please provide us with the document.

3.9 How often do you revise/update these strategies?

.....

4.0. Has there ever been some cases reported about patients that suffered from any waterborne diseases and how many?

.....

.

4.1. Which is the class that suffers more from these diseases?

.....

**THE END. THANK YOU FOR YOUR PARTICIPATION.**

## APPENDIX G



My name is Mmbadi Elelwani, a postgraduate student at the Department of Geography and Geo-Information Sciences, University of Venda (UNIVEN). I am conducting a research study on ***Water security under a changing climate in rural Limpopo: a case study of the Greater-Giyani Local Municipality, South Africa***. This study seeks to investigate the potential impacts and extent to which the rural communities of KaDzumeri, KaNgove and Mageva in the Greater-Giyani Local Municipality adapt to water scarcity and water supply challenges in a changing climate and a growing population. Your patience and time in answering the questions is highly appreciated. Your responses will be treated with the outmost confidentiality.

### Schools Representatives

**Questionnaire for collecting information on understanding of climate change, its impact and existing climate change adaptation strategies for municipalities:  
Schools Representatives**

**Interviewer** : .....

**Date of interview** : .....

**Purpose of interview** : The purpose of the questionnaire is to obtain information on interviewee's understanding of climate change, its impact and existing climate change

adaptation strategies within the Greater-Giyani Local municipality for households, schools and health facilities. This will assist in hydrological modelling of climate change impacts and developing practical adaptation strategies for municipal/domestic water uses in Greater-Giyani Local Municipality.

### 3. General information

<b>Gender</b>	Male <input type="checkbox"/> Female <input type="checkbox"/>
<b>Age group</b>	<18 <input type="checkbox"/> 21- 30 <input type="checkbox"/> 31-40 <input type="checkbox"/> 41-50 <input type="checkbox"/> 51-69 <input type="checkbox"/> 70 and above <input type="checkbox"/>
<b>Occupation</b>	

<b>Educational Level</b>	<b>Mark with an X</b>
Did not go to school	
Primary School	
Secondary School	
Undergraduate Degree	
Postgraduate Degree	

## 2. Water supply for primary schools in Greater Giyani Local Municipality (area within KaNgove, Mageva and KaDzumeri side)

2.6 Please provide us with the list of Primary schools within Mageva, KaNgove and KaDzumeri villages?

.....  
2.7 Has the number of leaners at primary schools increased over the past 10 years and by what margins?

.....  
.....

2.8 What are the main sources of water supply of each of the Primary schools mentioned in question 2.1?

.....  
.....

2.9 How often is the municipality able to meet the water demand for each of these schools?

.....

2.10 If there are periods where they fail to meet that demand, water are the likely causes?

.....  
.....

2.7 How do primary schools deal with water shortages, particularly during dry periods?

.....  
.....

### **3. Climate change, its impact and existing climate change adaptation strategies**

3.1 What is your understanding of the term “climate change”?

.....

3.2. Climate change has now become a reality. How is it impacting on school's water supply?

.....  
.....

3.3. Do you think that the impacts are going to be worse or better in the future?

Worse

Better

3.4. What is (are) the reason(s) for the answer you provided in question 3.4?

.....  
.....

3.5. Do you have strategies for adapting to climate change impacts?

Yes

No

3.6. If yes are they working effectively?

Yes

No

3.7 What is (are) the reason(s) for the answer you provided in question 3.6?

.....  
.....

3.8 Have you documented the adaptation strategies that you are currently using?

Yes

No

If yes, please provide us with the document.

3.9 How often do you revise/update these strategies?

.....

4.0 Has there ever been a case reported about learners that suffered from any of waterborne diseases such as malaria, diarrhea and cholera?

.....

4.1 Which is the class that suffers more from these diseases?

.....

***THE END. THANK YOU FOR YOUR PARTICIPATION.***

## APPENDIX H

### Letter of Permission

University of Venda  
Private bag x5050  
Thohoyandou 0950, Limpopo  
South Africa

The Municipal Manger  
Mopani District Municipality

17 April 2018

Dear Sir/Madam

#### **Re: Seeking permission to conduct a study**

I am a masters student at the University of Venda. In order to complete my degree (MENVSC), I am expected to conduct a research project of my choice.

As it is being observed that the rate of climate change has been on the rise at an alarming rate. It is therefore important to shade the light on the strategies that households and institutions such as schools and clinics are adapting to water shortages as the climate continues to change. Within this area. In that regard I have decided to conduct a study which disclose: the methods that are being employed by households and institutions in addressing water shortages. A case study of the Greater-Giyani Local Municipality. The data will be collected through questionnaires were the recorded data will be kept confidential.

In that regards, I therefore as for permission to use the households in your area. I am of the hope that the findings of this study will, assist in adapting to water shortages as the climate continue to change and this will assist the future generations in surviving with the limited water resources.

Thank you for your cooperation and assistance

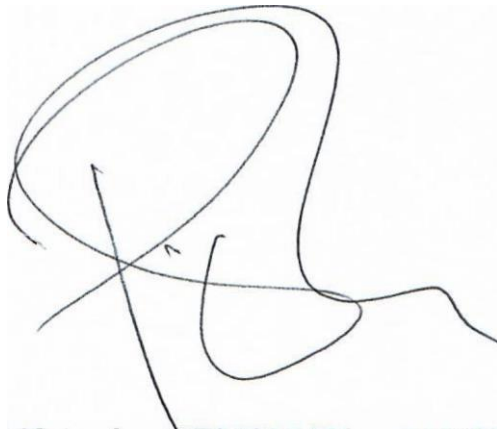
Warm Regards

## APPENDIX I

### English Proof Reading and Editing Report

**15 October, 2018**

This is to certify that I, **Dr P Kaburise**, have proofread the research report titled - **Water Security Under A Changing Climate In Rural Limpopo: A Case Study Of The Greater-Giyani Local Municipality, South Africa** - by ELELWANI MMBADI (student number: (11620886)). I have indicated some amendments which the student has undertaken to effect, before the final document is submitted.



**Dr P Kaburise: 0794927451 / 0711138079)**

**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 J

RESEARCH AND INNOVATION  
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:

**Mr E Mmbadi**

Student No:

**11620886**

PROJECT TITLE: **Water security under a changing climate in rural Limpopo: A case study of the Greater-Giyani Local Municipality, South Africa.**

PROJECT NO: **SES/18/GGIS/08/2508**

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr H Chikore	University of Venda	Supervisor
Dr F Okaka	Mol University	Co - Supervisor
Ms KH Nelshisaulu	University of Venda	Co - Supervisor
Mr E Mmbadi	University of Venda	Investigator - Student

ISSUED BY:

**UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE**

Date Considered: August 2018

Decision by Ethical Clearance Committee Granted

Signature of Chairperson of the Committee: \_\_\_\_\_

Name of the Chairperson of the Committee: Senior Prof. G.E. Ekosse



University of Venda

PRIVATE BAG X5050, THOHYANDOU, 0950, LIMPOPO PROVINCE, SOUTH AFRICA  
TELEPHONE: (015) 962 8504/8013 FAX: (015) 962 8000

"A quality driven financially sustainable, rural-based Comprehensive University"

UNIVERSITY OF VENDA DIRECTOR RESEARCH AND INNOVATION 2018 -09- 11 Private Bag X5050 Thohoyandou 0950
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