Evaluating water supply to selected villages in the Greater Giyani Municipality

By

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DECLARATION

I, Selane Lebogang Salome, hereby declare that the dissertation for the fulfilment of a Masters of Earth Science (Hydrology and Water Resources) degree at the University of Venda, hereby submitted by me, has not previously been submitted for a degree at this or any other university, and that it is my work in design and execution and that all reference material contained therein were duly acknowledged.

Signature: ______________________ Date: 17/01/2022

ABSTRACT

The Greater Giyani Municipality (GGM) is one of the South African municipalities that is experiencing challenges in providing water to the Giyani Community. In 2010 the Department of Water and Sanitation (DWS) initiated the Nandoni-Nsami bulk infrastructure project to remedy the challenge of water supply to the GGM. However, the project has been delayed since its inception and currently sits at 54% of completion. Thus, the study endeavours to evaluate water supply in the selected villages in GGM. The 25 selected villages for this study are direct beneficiaries from the incomplete Nandoni-Nsami bulk infrastructure project. Primary data was collected through a questionnaire survey, key informant interviews and site observation in the study area. The study used convenience sampling to collect data from households and purposive sampling at GGM. Secondary data was collected from municipal and government publications (i.e. Department of Water and Sanitation documents) as well as scientific journals. GGM uses both improved and unimproved sources due to unreliable water supply. The range of water supply sources varies from government boreholes, bulk water (in-house connections and communal taps), truck water tankers, river, household boreholes as well as water vendors. Based on the free basic water policy, water demand data for the selected villages is 3 230 600 litres per day while the total water supplied to 16 153 households across all 25 villages in Giyani is 1 796 676 litres per day. This is below the estimated water demand for domestic use as per the free basic water policy which shows that on average these communities are receiving much less water than required for their daily use. The sources of water supply at GGM are not meeting the water demand due to climatic factors, population growth, inadequate resources, and poor infrastructure. The Water Supply and Demand Balance Index showed that the study area is experiencing over 90% of some level of water shortage with only 8% experiencing slight to no water shortage. This study therefore proposes strategies to meet the water demand in the study area, which include water conservation, demand management, groundwater development, truck water tankers and water supply innovations.

Keywords: Domestic use, Free basic water policy, Sources of water supply, Water demand, Water supply.

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DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
GGM	Greater Giyani Municipality
IDP	Integrated Development Plan
MDM	Mopani District Municipality
NGO	Non-Governmental Organisation
NWRS	National Water Resource Strategy
RDP	Reconstruction Development Plan
RWH	Rain Water Harvesting
SA	South Africa
SDBI	Supply and Demand Balance Index
UNICEF	United Nations International Children's Emergency Fund
WCM	Water Conservation Management
WDM	Water Demand Management
WHO	World Health Organisation
WSA	Water Service Authority
WSP	Water Service Provider

CHAPTER 1: INTRODUCTION

1. Background of the study

Compared to the rest of the world, Africa has the lowest water supply coverage with only 62% of populations having access to an improved water supply (WHO and UNICEF, 2014). The majority of those without access to proper water supply are in rural areas and are more susceptible to poverty and disease which is responsible for the death of thousands of people every year especially East Asia and sub-Saharan Africa (Lee and Schwab, 2005). Population growth has resulted in increased water demand and has been responsible for a decrease in groundwater levels and surface water supplies are increasingly contaminated (Edokpayi *et al.,* 2017). Water supply and sanitation challenges in developing countries are expected to increase due to population growth and climate change (Molobela and Sinha, 2011).

Furthermore, Molobela and Sinha (2011) stated that shortage of water is anticipated to become an ever-increasing issue in future because of an increment in greenhouse gasses which will have a major impact on water resources. The lack of adequate precipitation and soil moisture leads to drought conditions which result in scarce water resources (Baatjies, 2014). About 6 million South Africans do not have access to a reliable source of safe drinking water, while 13 million do not have access to adequate sanitation (Manase *et al*., 2009). This was further supported by Mdanisi (2010) who stated that basic services to all citizens are still a challenge in South Africa, with an estimated 14 million people still without adequate water supply.

Statistics SA (2016) reported that 83.5% of households have access to piped water. The Department of Water and Sanitation (DWS) is the custodian of all water resources, and its responsibility is to protect, preserve and conserve water resources (Mdanisi, 2010). Municipalities are responsible for water supply to communities; however, they have been faced with challenges to supply clean water for domestic use due to infrastructure backlog particularly in rural areas (Sithole, 2019). Ageing infrastructure is worsened by poor operations and maintenance at municipal level, which was identified as a major source of water problems (Mema, 2010). The Mopani District Municipality was well provided with bulk water supply infrastructure (Mdanisi, 2010), although the Mopani District Municipality Integrated Development Plan (MDM, IDP) (2019/2020) stated that there is a challenge of water supply due to shortage of pipeline reticulation within the villages. Regardless of ageing infrastructure, DWA (2014) highlighted other factors that interrupt water supply in Giyani which are illegal connection and water infrastructure vandalism. To address the above challenges the National Treasury administered funding for water projects. Municipal infrastructure design standard must meet water requirements of free basic water supply of 6000 litres per household per month (25 l/p/d). DWS appointed Lepelle Northern Water as an implementing agent for the MDM revitalisation programme which includes various water treatment works, wastewater treatment works, boreholes and pipelines (Rikhotso, 2020). Areas of Giyani are spatially scattered resulting in difficulty and expensive processes to provide water supply pipelines (Mdanisi, 2010).

The aim of the study is to evaluate water supply to selected villages in the Greater Giyani Municipality. Greater Giyani Municipality IDP (2019/2020) reported that main sources of water supply are community standpipes above and at a distance of over 200 m, boreholes, springs, rain tanks, dams, rivers, pipes inside yards and water vendors. The Government of South Africa that has a way of ensuring that services are received by those who are unable to afford them, assigned municipalities to supply free basic water of 6000 litres per household per month (25 l/p/d). Many rural areas are faced with severe water supply shortages and areas such as Giyani are at risk of disease outbreaks as a result of using unclean water from rivers and hand-dug boreholes.

Giyani communities were assured that the supply of water would improve because municipality planned to transfer water from Nandoni to Nsami dam to address scarcity of water (Tshikomolo, 2012). The study will evaluate water supply by calculating water demand and supply at the villages. Water service development is driven by demand emphasised in the White Paper on Water Supply and Sanitation Policy (Mmbadi, 2019). The GGM piped water inside dwellings is at 13,4% (Statistics SA, 2011), the percentage indicates that the municipality must invest in a water reticulation system in the long term and more boreholes and tankers in the short term to meet water demands of the people. A study by Tshikomolo (2012) stated that lack of data on domestic consumption makes household water demand difficult to be computed. Furthermore, water used in places without meter connection and broken meters makes it difficult to have accurate data.

2. Statement of problems

Rural areas rely mostly on water obtained directly from streams or boreholes at a distance more than 200 m from their households (Kulinkina *et al.,* 2020). Villages in GGM have inadequate infrastructure for water supply, due to ageing infrastructure and a lack of capacity to distribute water to all households within communities (Malatjie, 2016). The study area selected 25 villages which are among the villages that are supposed to benefit from the Nandoni-Nsami bulk water project and have water-supply shortages. The government initiated Nandoni-Nsami bulk infrastructure project in 2010, this was because Nsami Dam and its treatment waterworks capacity were at 28 ml which was insufficient to meet the water demands of GGM (DWA, 2009).

This project is part of projects the DWS commissioned to supply services that will provide 6000 litres per household per month and within 200 m of a household (Daries, 2011). The Limpopo State of the Province reported (2020) that Nandoni-Nsami water pipeline project was at 54% of physical progress. In the meantime, selected villages supposed to benefit from the project, have no access to potable drinking water. According to the GGM IDP (2019/2020) the municipality has remedial plans whilst waiting for completion of the project; villages use boreholes where there is an acute shortage of water supply. The villages of GGM according to the Free Basic Water Supply Policy of National Government (2000) are guaranteed the provision of free basic water of 6000 litres per household per month (25 l/p/d) to maintain life.

The free basic water (25 l/p/d) is required for drinking, cooking, dish washing, house washing, clothes washing, personal hygiene and sanitation (Zadeh *et al.*, 2014). According to Baartjies (2014), there is still no formal water supply system within the selected villages, hence, the need for this study. At municipalities there is a lack of water demand and conservation management, meaning efficiency and effective use of water is not improved (Gleick, 2003). Furthermore, the aim of water demand management is to conserve water by influencing demand (Russell and Fielding 2010).

3. Motivation and significance of the study

According to Section 27 of the Constitution of the Republic of South Africa (Act 108 of 1996), “everyone has the right to clean and safe drinking water and dignified sanitation services”. The government ensured that services are received even by those who are unable to afford them by assigning municipalities the responsibility of supplying free basic water of at least 6000 litres per household per month which is 25 litres per person per day (Mothetha *et al*., 2013). The study was conducted in the Greater Giyani Municipality, where water services are supplied by the Mopani District Municipality (Water Services Authority) and further responsible for the maintenance of the bulk water services infrastructure.

Greater Giyani Municipality was declared a disaster area by means of Notice 315 of 2009 in term of section 41(1) of the Disaster Management Act 57 of 2007 published in the Government Gazette of 09/09/2010. Nandoni-Nsami bulk infrastructure project was initiated to assist with water supply at Giyani as it was declared a disaster area. There are selected villages in the GGM that have been denied access to adequate water since the Nandoni-Nsami Bulk Water project is not yet completed, the communities are at risk of disease outbreak because of using hand-dug boreholes and the river (Mmbadi, 2019). Water service development is driven by demand emphasised in the White Paper on Water Supply and Sanitation policy (Mmbadi, 2019).

DWA (2014) gave Lepelle Northern Water the responsibility to ensure adequate water supply in the GGM to address water supply shortage. Data collected will demonstrate whether the design standard for the GGM water supply meets the target of 6000 litres per household per month (25 l/p/d). The municipality will have the water demand data of villages, which becomes a valuable asset for planning and management of water resources within the GGM. Kanyoka *et al.* (2008) indicated that domestic water use research projects are common. Therefore, the study will form part of the other studies conducted in Giyani regarding water supply shortage, and the government will ensure that free basic water supply becomes a reality to the people of Giyani.

4. Objectives

4.1 Main objective

The main objective of this study is to evaluate the water supply to the 25 selected villages in the GGM.

4.2 Specific objectives

- To determine the extent of water sources in the selected villages of the study area.
- To determine water demand in each of the selected village supposed to benefit from the Nandoni-Nsami bulk infrastructure project.
- To estimate water supply in the respective villages of the study area.
- To recommend water supply strategy to rural communities.

4.3 Research questions

- What are the current sources of water supply at GGM?
- Does the GGM provide water to meet the needs of households?
- How many litres of water are supplied in each household per day?
- What water supply strategies can be applied by Greater Giyani Municipality to ensure equitable access and sustainability?

5. The study area

Greater Giyani Municipality (GGM) falls within the Mopani District Municipality (MDM) with another four locals municipalities: Greater Tzaneen, Greater Letaba, Ba-Phalaborwa and Maruleng as shown in Figure 1.1. Giyani is 472 m above sea level and located at 23.32° S 30.72° E. The municipality covers approximately 2967, 27 km² areas with only one semi-urban area, Giyani. The municipality has a population of 256 127 with a total number of households of 70,537. The areas of study are namely N'wamatatane, Basani, Maxabele, KaDzingidzingi, Shimange, N'wa Mankena, KaMapayeni, KaGaula, Daniel Rababelela, Bode, Mbatlo, KaNwadzekudzeku, KaMatsotsosela, KaXitlakati, KaMaswanganyi, Vuhlehli, Sekhiming, KaKheyi, KaMakoxa, Mlhava Willem, Mbaula, KaSiandana, Gonono, Northhapton, Muyexe villages (Figure 1.1). They are part of the selected villages that are supposed to benefit from Nandoni-Nsami bulk water project. Statistics SA (2011) reported that the villages had 0 to 5% piped water inside dwellings.

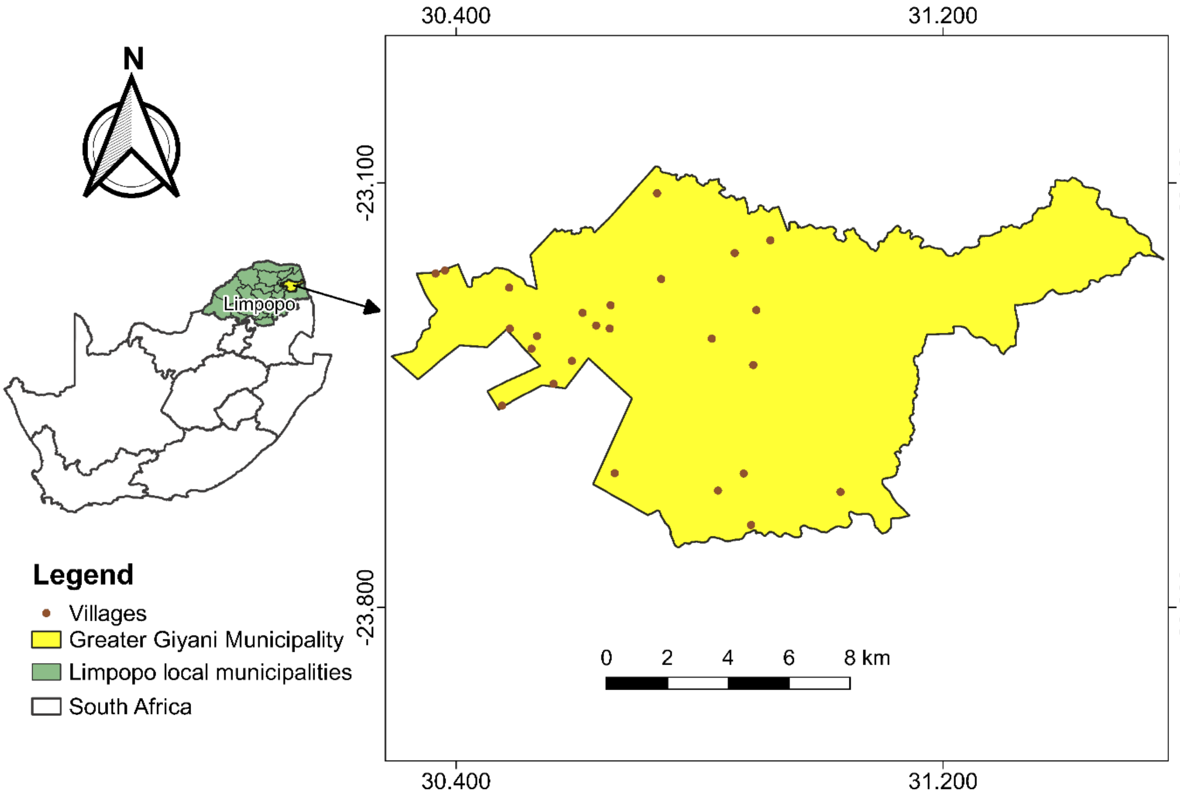

Figure 1.1: Location of the selected villages in GGM

During public participation the above villages reported water shortage (GGM IDP, 2019/2020). It has 10 traditional authority areas comprising of approximately 93 villages and seven townships. The municipality has 31 wards grouped into five clusters in which the population of each ward exceeds 5000 people. Rural communities are situated far apart, which makes infrastructure development expensive. According to statistics SA (2011) Greater Giyani Municipality is dominated by a rural area at 87.4%. The area is characterised by low rainfall and with very hot summers (Mmbadi, 2019). Rainwater harvesting is practised during summer by most households in the municipality (Mmbadi, 2019). Shortage of surface water because of low rainfall has a direct impact on development which results in the use of groundwater in the GGM. Whilst the GGM uses groundwater and surface water from Letaba Dam getting water from Middle Letaba River, Koedoes River, Brandboontjies River, and small streams, the second is the Nsami Dam which gets water from the Nsami River (Mmbadi, 2019). Mopani District Municipality is a water service authority which has executive authority to provide water services within the area of jurisdiction (IDP, 2019/2020). Whilst Greater Giyani Municipality is a water service provider, expected to initiate and implement interventions and measures aimed at efficiency of water use (Bila, 2013). Khwashaba (2018) stated that residents at GGM provide basic services for themselves like fetching water from the rivers and drilling their own boreholes. The common safe water resources at GGM are bulk and borehole water (Tshikolomo *et al.,* 2012). The water infrastructure in Limpopo identified consists of reservoirs, reticulation networks, street-taps, and boreholes pumps (Mmbadi, 2019).

CHAPTER 2: LITERATURE REVIEW

2.1 Chapter overview

When the apartheid administration was abolished in 1994, South Africans did not have access to a formal water supply, while currently the country has achieved high rates of access to safe drinking water and sanitation (Baatjies, 2014). Since 2004, SA and Netherlands shared knowledge in the field of the decentralization of water management, political and strategic aspects of water management (Lebese, 2017). The DWS has been assigned by the government with ensuring that the country's water resources are protected, managed, used, developed, conserved, and controlled in a sustainable manner for the benefit of all people and the environment. (Botha, 2020). However, improving access to water supply and sanitation fail to reach a substantial proportion of world's population (Makhari, 2016). The absence of systematic data on water demand and use is one of the major problems in managing water resources (Lebese, 2017). Huang and Yin (2017) stated that for development and execution of national water resources, an important analysis that can be used is called water supply and- demand balance index. Giyani villagers continue to suffer from lack of water resources regardless of investment by national government.

About R114 million was allocated for Nandoni to Nsami pipeline construction of 49 km bulk potable water pipeline (MDM IDP, 2019/2020). Shortage of pipeline reticulation within rural areas is the reason why water supply is below Reconstruction and Development Programme (RDP) level (MDM IDP, 2019/2020). People are forced to use unsafe water for drinking and other domestic purposes, because of a water scarcity problem facing people around the world (WHO and UNICEF 2010). The chapter will give an overview of water supply, considering that SA had a Millennium Development Goal target of halving the proportion of people without access to an improved water source by 2015. Furthermore, this chapter will indicate the state of water supply infrastructure and whether the presence of water supply infrastructure guarantees that people will have access to safe water noting that technologies do not always work. Mnisi (2011) noted that households with piped water network on the edge of villages and on higher ground find that water does not reach them due low pressure to reach higher ground. The study was informed by scholars who emphasised that data need to be generated to provide a basis for designing an implementation plan to manage and sustain future water use in rural unmetered areas. Lebese (2017) stated that data on domestic water consumption is often expensive to produce and time consuming to collect. (NOTE: data is used in the singular as it is a collective word)

2.2 State of water resources in South Africa's water supply

Water supply refers to services that provide water for households, public institutions or any economic activities and involves a series of activities from abstraction of raw water at sources to delivery of treated water to consumers and from consumer back to a water source (Makhari, 2016). The author further stated that n developing countries, the management of water supplies are undertaken by government parastatals that have the dual objectives of delivering a social service while generating revenue to offset cost. Mopani District Municipality is a water service authority which has executive authority to provide water services within its area of jurisdiction (IDP, 2019/2020).

According to Sithole (2019), Lepelle Northern Water is an implementing agency and bulk water supplier that provides bulk water supply to MDM and this service is not to yield a profit but to cover costs. Water supply schemes namely surface and groundwater are commissioned to supply water in rural area (Hay *et al.,* 2012). A lack of stable water supply systems in villages results in rural people using multi-sources of water (Omarova *et al.,* 2019). The ability to deliver water varies on groundwater or run-off river flow for water supply schemes in rural areas which become vulnerable during drought (Loubser *et al*., 2021).

Municipalities fail to provide potable water to their consumers due to both human and technical factors, for example retaining and training adequately skilled people to run a water treatment plant is difficult for rural municipalities (Van Koppen *et al.,* 2020). At operational level skills development and capacity building for technical staff is required, further emphasised that the following local intervention options are required to alleviate shortage in water supply and to allow for the required upgrades in the level of water services namely (Hay *et al*., 2012):

- Implementation of water conservation and water demand management measures to reduce losses and wastage.

- Upgrading of existing infrastructure to increase yield or assurance of supply.
- Groundwater development.
- Water re-use.
- Small-scale surface water development.
- Water trading.
- Desalination of seawater.
- Rainwater harvesting.

Sithole (2019) stated that DWS have a funding gap of R333 billion for infrastructure refurbishment, rehabilitation, and development. Although there is a gap Mmbadi (2019) stated that the DWS constructed 794 dams with 31 billion m^3 storage capacity to improve water supply. SA will need a 90 million Rand investment to balance demand and supply by refurbishing, upgrading, and developing new infrastructure (Reddick and Kruger, 2019). Mnisi (2011) stated that in the US infrastructure failure is caused by water problems and deteriorated infrastructure systems, increasing risk of leaks, blockages and malfunctions. Masindi and Dunker (2016) stated that groundwater and surface water development is necessary because many rural settlements still lack adequate water supplies to meet their basic needs. Noting that, South Africa still does not have an adequate water supply despite all processes being in place, rural areas resort to unsafe drinking water (Mothetha *et al*., 2013). To ensure access to water government must build tap systems, pipes and other infrastructure that will deliver reliable water (Omarova *et al*., 2019). Failed water supply infrastructure mostly causes inadequate water supply in most parts of SA not water scarcity (Loubser *et al*., 2021). The engineering approach to water development requires a direct method of computing water demand and feasibility and design studies are used for detailed planning of rural water supply schemes (Lebese, 2017).

A study by Van Schalkwyk (1996) stated that inadequate water supply situations are caused by an inappropriate choice of water supply technology, low levels of community involvement, development, poor maintenance, an insufficient supply of water, inadequate provision of water abstraction points, lack of wind and prolonged drought. Regardless of these challenges, the SA government has made significant improvements concerning water service provision, but rural areas and townships still depend on untreated water from rivers and other sources (Amis *et al*., 2018). Kativhu

(2016) stated that participation by the community should be encouraged to achieve a sustainable water supply by attending meetings, expressing demand for water sources, providing free labour and selecting appropriate technology. According to Thwala (2010) communities must be involved in all phases of designing, implementing, maintaining, supervising, and evaluating new water supply and sanitation systems.

2.4 Free basic water supply policy (2000)

The Republic of South Africa (RSA) has a policy of providing free basic water. Outlined in 1997 National Water Services Act (RSA, 1997) and National Water Act of 1998 (RSA, 1998) which aim to provide the "right of access to basic water supply" and a "basic" supply means 25 litres per person per day, easily reached within 200 m of the household. The policy's goal is to provide all impoverished homes with a basic water supply (25 l/p/d) at no expense to them. Municipalities across South Africa should strive to achieve this responsibility of supplying free basic water services to all communities (Mmola, 2012). The cost at municipalities has increased and there is no profit because of the free basic water being supplied which is not generating any revenue (Scheihing *et al.,* 2020). The DWS provides funding to municipalities for construction of new infrastructure and the rehabilitation of existing water and sanitation infrastructure, which is prioritising on 27 of the poorest districts municipalities, of which the MDM is part (Sithole, 2019).

Municipalities are provided with annual grant from government to ensure service delivery (Mothetha *et al.,* 2013). Including, managing, and repairing breakdowns of public water schemes (Van Koppen *et al.,* 2020). Municipalities with a high number of indigent households depend on that government grant to ensure free basic water (Muller, 2008). Borehole systems offer the community free water (van Koppen *et al.,* 2020). Mukheibir and Sparks (2003) stated that groundwater is an essential source of water, particularly in rural areas. Households with piped water are provided with 6000 litres per household per month of free basic water whilst communities with acute shortages of water are using boreholes for water supply (Muller, 2008). Communities need more water than basic water, therefore communities must pay for incremental capital development cost as well (MacDonald and Calow, 2009).

2.5 Sources of water supply

The guidelines for human settlement planning and design state that sources of water for human settlement can be obtained from springs, wells and boreholes, rainwater, surface water, bulk supply pipelines and a combination of these. Netshipale (2016), stated that water should be supplied in a reliable manner sufficient for daily household demand for domestic use including personal hygiene availability, therefore water must be potable (health-related quality), obtained with appropriate technology (taps) and be at an accessible, reasonable distance from households. Domestic water uses in rural areas comprise indoor use such as drinking, cooking, cleaning, laundry, bathing and outdoor livestock watering, gardening, and yard cleaning (Lebese, 2017). People rely on some form of water sources for basic domestic use, which it may be yielded in sufficient, insufficient, unclean manner and may require people to walk hours to fetch water from sources (Webster, 2000). In rural areas Geere and Cortobius (2017), stated that 50% or the population still must fetch water from sources outside their yards. It is further elaborated by Mnisi (2011) that people in rural areas fetch water from rivers, springs, wells, and boreholes and this has been factored into their daily chores. Due to unstable water supply systems stated above, rural areas use multi-sources, for instance tap water for drinking, wells for hygiene and rainwater for gardens (Omarova *et al*., 2019).

South Africa is not the only African country where people travel a long distance to get water, but also spend a lot of time and money doing so (WHO, 2004). Households without access to potable pipe water, fetch water from numerous sources such as rivers, springs, communal taps and boreholes and store it in tank at home which in turn can lead to compromised water quality (Loubser *et al.,* 2021). The majority of rural areas in Limpopo province use groundwater as the main source of domestic water supply (Mmbadi, 2019). Furthermore, this accounts for 70% of local household water supply (Toit *et al.,* 2012). Municipalities appear to be reliant on surface water for water supply, and many water projects are failing because of this reliance on a single source. (Masindi and Dunker, 2016). Water use can be augmented by different water sources such as groundwater (springs, wells, and boreholes), rainwater and stormwater harvesting (DWA, 1997) to ensure basic water needs. Greater Giyani Municipality's main sources of water supply are community standpipes above ground and at distances over 200 m, boreholes, springs, rain tanks, dams, rivers, pipes inside yards and water vendors (IDP, 2019). The following are GGM households according to main sources of water for drinking shown in Table 2.1.

Table 2.1: GGM households according to main sources of water (Source: Statistics SA, 2016)

Source of water	Number of households
Piped (tap) water inside dwellings/houses	7232
Piped (tap) water inside yard	23 702
Piped water on community stands	11751
Boreholes	10807
Rainwater tanks in yard	19
Neighbours' taps	3791
Public/communal taps	7298
Water tanker	2721
Flowing water stream/river	2547
Wells	0
Springs	0
Others	608

2.5.1 Groundwater

South Africa is composed of hard rock formations that do not contain large aquifers that are available nationwide which makes groundwater not to be abundant (Lachassagne, 2001). Hydrogeological properties of underlying aquifers vary in quality and quantity (Toit *et al.,* 2012). Geology, degree of fracture and topography govern the occurrence of groundwater, whilst in lowlands mainly rift valley areas groundwater availability is relatively high (Lebese, 2017). When groundwater abstraction exceeds average recharge aquifer storage is depleted, and groundwater tables are lowered. Groundwater is taken into consideration and regarded as secure due to the fact a whole lot of geological and ecological features are present which include the delivery of a dissolved count underground, rock weathering and diagenesis, formation of mineral deposits, assisting water purification and vitamins' transportation methods and growing abstraction (Mnisi, 2011). Groundwater becomes complicated and costly to withdraw when it is limited over a depth of 800 m below the ground (Mnisi, 2011).

Groundwater is economically much cheaper than surface water because it does not need construction of reservoirs or long pipelines and at point of demand is available at a little cost (Baatjies, 2014). Groundwater can be viably, and cost effectively developed as alternative bulk water sources or conjunctive with surface water (Toit *et al*., 2012). Pietersen (2006) reported that groundwater when managed properly is a reliable source and low in cost comparable with surface water resources (Pietersen, 2006). According to Netshipale (2016) the use of private boreholes in households as sources of water create health risks due to underground water which is contaminated. Management and monitoring of groundwater supply schemes are not carried out properly because it is not possible to derive total yield or usage (Hay *et al*., 2012). Globally in rural areas in arid and semi-arid regions groundwater resources are a major source of water for household use (Lebese, 2017).

The National Water Act no 36 of 1998 Schedule 1 allows groundwater for domestic use without a licence (Reddick and Kruger, 2019). (Lachassagne *et al*., 2001) stated that in rural areas and many arid areas in South Africa groundwater is extensively used although it is limited by the geology of the country much of which is hard rock and large porous aquifers occur only in a few areas. During droughts boreholes run dry which results in drilling and developing additional boreholes (Hay *et al.,* 2012). Groundwater is protected from surface contamination and abstraction can be maintained during short periods of droughts which makes it advantageous for rural water supply (Mackintosh and Colvin, 2003). Boreholes are used as a short-term plan, but communities dismantle or break pumps and the reason municipalities view them as unreliable sources of water supply (Hay *et al.,* 2012). Groundwater is preferable to surface water in rural areas because it may be easily developed closer to homes, has acceptable quality with less contamination, is less expensive to produce, and is more reliable (Campbell *et al*., 2002). There is a perception that groundwater provides freshwater, however, groundwater is vulnerable to a variety of threats including overuse and contamination (Mnisi, 2011). Other researchers have confirmed the previous findings, stating that towns use groundwater for bulk domestic water delivery on a regular basis (Hay *et al.,* 2012). Rural areas in South Africa use boreholes and these are mostly privately owned (Potgieter *et al.,* 2006) whilst other communities purchase water from private borehole owners (Kariuki and Schwartz, 2005). Borehole owners incur significant cost, and that is the reason water is sold at a cost varying from

R1 to R5 per container (van Koppen *et al.,* 2020). Municipalities are using groundwater in the form of boreholes regularly especially during drought, but with a notion that groundwater is not a sustainable resource for bulk domestic supply (Mthethwa 2018).

Contrary to public perceptions groundwater is viewed as not being a sustainable resource for bulk domestic supply and cannot be managed properly (Hay *et al.,* 2012). Limited attention has been given to groundwater as an important resource in SA (Hay *et al.,* 2012). Municipalities face challenges as borehole transformers are frequently stolen or there are low yields not sufficient to meet water demand (Malima, 2020). Lebese (2017) stated that groundwater as an alternative source of water supply, requires protection and monitoring for sustainable use at household local level in unmetered rural areas. According to the researcher, regarding the above protection and monitoring municipalities in rural areas must put an appropriate plan in place that manages abstraction and use. The GGM IDP (2020) stated that borehole pump machines and transformers are stolen at a high rate and boreholes are vandalised, therefore measures must be adopted namely awareness campaigns, enforcement of criminal law procedures, repairs, and maintenance of infrastructure and monthly reviews.

Municipalities fail to pay electricity bills in time therefore pumps are closed, and community members organise diesel for themselves due to the failures of municipalities (Van Koppen *et al.,* 2020). According to GGM IDP (2019/2020) boreholes augment supply in communities where there is an acute shortage of water, paying for diesel and electricity used for pumping water is the responsibility of the municipality. The DWA (1994) calculated that groundwater provided 5400 million cubic metres of water per year. Although when underground water is overused, it will lead them to either run dry or be highly stretched (DWA, 2015). MDM IDP (2019/2020) stated that for areas without water the municipality will rehabilitate and drill new boreholes and the budget for 2020/2021 was R100 000 000.

2.5.2 Private In-House Connections

This source of water is piped water which is directly connected into the houses of consumers (Allen *et al.,* 2006). According to Ukoli-Onodipe (2003) private connections are metered or non-metered which record the volume of water consumed and all levels of consumption are charged at a flat rate for non-metered systems. Less water is wasted, if proper management is in place such as meter systems to help account for water loss (Muller, 2020). Potable piped water ensures that residents have suitable and repeated access to a clean drinking water supply. Developing countries balance water scarcity and demand by implementing intermittent water supply meaning water is supplied for less than 24 hours in a day for in-house connected customers to a water distribution system (Loubser *et al*., 2021). In S A water supply duration is reported to be 24 hours. Mnisi (2011) stated that community members connect taps in their yards. Tezera (2011) confirmed that private in-house connections are classified as improved water sources according to WHO and UNICEF assessment. Strategic Framework for Water Services (2003) defined basic household water supply as either 25 litres per person per day or 6 000 litres per household per month (Sithole, 2019). Mdanisi (2010) stated that villages in Giyani use taps installed by the homeland government although taps installed in each yard have been dry since 2006.

2.5.3 Public Standpipes

This service refers to when water is fetched from a pipe some distance away from houses and put in storage in containers (Ukoli-Onodipe, 2003). Municipal water treatment plants distribute water to standpipes (Singh, 2009). Tezera (2011) stated that public standpipes are classified as improved water sources according to WHO and UNICEF assessment. Public standpipes are common in rural areas where there are no household connections, therefore, water is provided through communal standpipes within 200 meters of households (Sithole, 2019). South Africa uses public standpipes mostly in rural areas despite the renewed focus on providing safe water for all by government (Haarthoff and Rietveld, 2009). The daily limit of 25 litres is not usually met from community taps (Ralo, *et al.,* 2000). This source of water according to Ukoli-Onodipe (2003), is not convenient since during transportation and storage water is exposed to contamination. Storage and collection containers are made of polyethylene which serves as a source of nutrients for the growth of bacteria which adhere to the container's surface (Singh, 2009). Hippo water rollers used to collect and store 90 litres of water from standpipes have been introduced in some parts of the country (Haarthoff and Rietveld, 2009). Households in rural areas store water in containers of about 20 litres, 200-litres drums or JoJo tanks, most have JoJo tanks of

2500 and 5000 litres (Van Koppen *et al.,* 2020). Mnisi (2011) stated that water is not supplied for longer periods in communal standpipes. Although Haarthoff and Rietveld (2009) stated that DWA published design guidelines for public standpipes in 2004 namely that standpipes should be a maximum walking distance of 200 m from home, a maximum of 25 households or 100 people should be served by a standpipe, the flow rate should not be less than 10 litres/minute, the tap should be high enough for the container to fit underneath, and so forth. Singh (2009) stated that the above design guidelines are not adhered to because a single standpipe serves several hundred people whilst others travel more than 200m from households.

2.5.4 Water points (rivers and lakes)

Surface water bodies carry a very small quantity of fresh water such as lakes and rivers (Mnisi, 2011). Surface water quality and quantity depends on a combination of climatic and geological factors (Baatjies, 2014). Freshwater flowing through rivers and lakes are being polluted by humans. WHO and UNICEF assessment classified water points (rivers and lakes) as unimproved water sources (Tezera, 2011). Communities that draw water from unhygienic sources are at high risk of contracting diseases (Mdanisi, 2010). Rural communities largely rely on river and stream water as a source of water for domestic use, because often municipal water is supplied periodically sometimes during the early hours of the morning (Twort et al.*,* 2000). According to Makhari (2016) people are exposed to a range of waterborne diseases because of fetching water from rivers.

2.5.5 Truck water tanks

Truck water tankers are large tankers attached to a vehicle and filled with treated water from treatment works (Singh, 2009). Tezera (2011) stated that mobile community water tanks are classified as unimproved water sources according to WHO and UNICEF. Singh (2009) stated that this source of water is for community members without standpipes, water is collected to storage containers directly from tanker via a tap. The above water source, according to Singh (2009) is susceptible to contamination during collection, transportation, or storage. Truck water enables the DWS to monitor water use as an immediate water relief system which saves lives.

2.5.6 Rainwater harvesting

The other source of drinking water is and for other household activities is rainwater and is classified as an improved water source according to WHO and UNICEF assessment (Tezera, 2011). A significant number of debris and dirt accumulates on first water runoff from roof, therefore first runoff water must be discarded (Masindi and Dunker, 2016). During the rainy season, which is mid-June to Mid-September, (state where this is -ED) runoff from roofs is collected and stored and is perceived to be the cleanest water (Tezera, 2011). Rainwater depends on two factors the type of roof which is supposed to be an iron roof since it is cleaner and healthier to drink and the rainy season which makes it a conditional source (Tezera, 2011).

2.6 Water supply technologies and innovations

They are a wide range of technological and non-technological innovations to address water challenges, innovators are encouraged to develop water innovations that will help address the following water challenges (Amis *et al*., 2018). Water supply problems due to water schemes being out of order through technological failure, regular breakdown of engines, the capacity of reticulation systems becoming insufficient to supply the whole villages and dams that run dry during the dry season in rural areas (Mnisi, 2011). WHO and UNICEF (2000), assessment assumed that certain types of technologies are safer or more adequate than others therefore used water supply technologies are used as indicators of improved or non- improved water supply and sanitation. Thus, water supply technologies considered to be improved and those considered to be non- improved shown in Table 2.2.

Table 2.2: Water supply technologies (Source: WHO and UNICEF, 2000)

Improved Technologies **Water Supply**	**Not Improved Technologies** **Water Supply**
Household connections	Unprotected well service
Public standpipe connection	Unprotected spring
Borehole pour	Vendor-provided water
Protected dug well	Bottled water
Protected spring	Tanker truck provision of water
Rainwater harvesting	

There are innovations which try to address water challenges especially for rural areas namely VulAmanz and Hippo Roller. VulAmanz is a perfect home-water treatment technology that has the potential to provide safe drinking water for communities who have no access to consumption of water and Hippo Roller is a bucket that stores 90 litres of water at once, which improves people's access to water sources and reduces the workload of having to carry buckets (Amis *et al.,* 2018). Many parts of SA experience minimum water-quality standards and challenges are factored by inadequate infrastructure and insufficient budget (Mdanisi, 2010). The challenges of potable water provision in rural areas are caused by difficult topographies, very broad population distribution, lack of skills to operate and maintain water treatment systems, logistical difficulties and lack of funding (Amis *et al.,* 2018).

2.7 Estimating total water supply

According to Statistics SA (2019) 3.1% of households still fetch water from rivers, streams, stagnant water, pools, dams, wells, and springs. Domestic water use is needed for drinking, cooking, house cleaning, clothes washing, personal hygiene, gardening, and sanitation (DWAF, 1997). Consumption varies from household to household and people collect and store water in containers from communal boreholes and streams (Omarova *et al.,* 2019). Residents of the GGM provide their own basic services themselves, selected villages supply water for their household in containers for consumption. The capacity of households to store water, determines the amount of water collected (Tshikolomo *et al.,* 2012). Mulovhedzi (2016) stated that assuming a daily need of 25 litres per person, DWS has determined that the minimum amount of water needed to meet the basic needs of an eight-person household is 6000 litres per household per month. Accurate data on water consumption is difficult to obtain as households do not measure water consumption (Tshikolomo *et al.,* 2012). Meter readings provide water-supply data for households, institutions, and so forth in the absence of meter readings many studies employed the use of questionnaires and field observations to collect data (Mothapo, 2020).

Khwashaba (2018) stated that residents at the GGM provide basic services for themselves like fetching water from the rivers and drilling their own boreholes and through site observations and questionnaire surveys water supply information will be obtained to estimate water supply in the respective villages. Households procure containers of 25 litres, drums 200 litres and JoJo tanks of 2200 or 2500 litres to store water for continuous supply of water (Van Koppen *et al.,* 2020). The study will accept estimations of quantities of water supplied as provided by respondents. Containers vary in capacity from 20 to 25 litres and water is stored in JOJO tanks of different capacities depending on household choice. Therefore, Equation(s) 1 and 2 are used to compute the average water supply and total water supply of the village, respectively.

$$Average\ water\ supply = \frac{total\ water\ supply}{sampled\ households} \qquad 1$$

$$Total\ \text{water supply} = average\ water\ supply \times\ households \qquad 2$$

2.8 Water supply challenges in South Africa

Water supply has been constrained even through it is everywhere in terms of availability, whilst water management continues to be a challenge faced by the world (Biswas, 2004). Although water challenges vary by region within a country, it is further evidence that water challenges are neither uniform nor constant or consistent over time from season to season, and year to year. The world's water management challenges are limited physical resources, chronic rainfall deficits, rapid population growth and economic stagnation (Biswas, 2004). South Africa’s service delivery in rural areas has always lagged behind that of urban areas due to several factors such as of being a remote and geographically spread-out population which makes the development and maintenance of infrastructure, as well as the provision of services such as water supply, costly and difficult to maintain (Nkuna, 2019). The above finding is supported by Mnisi (2011) who stated that water provisioning is costly and difficult to maintain in remote and geographically spread-out communities in SA located on hillsides, and which have unplanned layouts (Mnisi, 2011). Diarrhoea is responsible for 1.8 million deaths worldwide each year, 90% of them are children under the age of five (Kosek *et al.,* 2003).

Hence, the provision of adequate services reduces death caused by diarrheal disease by an average of 65%. Water shortages lead residents to use poor-quality water for drinking (Mnisi, 2011). This leads to water and sanitation-related diseases for example, diarrhoea which is amongst the top ten causes of death while loss of time due to inconvenient water supply is also significant (Manase, 2009). Without access to safe water supplies and sanitation, people are at higher risk and good health is compromised. People who rely on water from rivers and streams in the GGM face serious health problems such as littering of garbage and water pollution from sewage overflows (IDP, 2019/2020). In South Africa, rural women were found to spend more than four hours a day collecting fuel and water (Morna, 2000).

Women are assigned duty of collecting and transporting water in many rural areas because they are the prime water users at household level. Women and girls collect water from water sources that are hours apart each day which is an excuse for girls not being able to attend school. (Rosen and Vincent, 1999). According to Urgaya (2020), water supply planning, implementation and management must ensure women's involvement. Improved access to water supply benefits communities, through the reduction of diseases and the improvement of women's lives. Government needs a coordinated robust and holistic approach to respond to challenges of water supply to rural communities due to the extent of demand for basic water supply (Sithole, 2019). Water Demand Management Programmes and other comprehensive strategic interventions in many rural communities in South Africa are hindered by a lack of political support (Shikwambane, 2017). Schweitzer (2009) states development of the provision of sustainable water services for a rural area is a most important, difficult, and neglected sphere. Molobela and Sinha (2011), emphasised that these challenges dictate a critical need to properly manage and conserve water resources. South Africa developed a clear policy for municipal infrastructure grant guiding the use, funding allocations, programming systems, setting structure and procedures from national to local level (Atkinson,2007). Furthermore, finance allocated to the water and sanitation sector for municipalities is extremely low (Briscoe and Garn, 1995). Mopani District Municipalities are unable to provide water in most of its towns due to the inadequate water resources, ageing infrastructure, limited capacity in municipalities, non-payment for water services and poor planning (Loubser *et al.,* 2021). Hoffman and Nkadimeng (2016), further stated that water supply challenges are caused by financial constraints and the limited capacity of existing infrastructures. The infrastructures are designed to serve a limited population and due to increased water demand linked to population growth, are stretched beyond the design capacity

(Loubser *et al,* 2021). The above researcher further noted that water supply infrastructures in rural areas do not meet water demands.

2.8.1 Climate change

The water scarcity problem is exacerbated by high levels of climate unpredictability, necessitating significant storage to ensure supplies during dry periods (Muller, 2008). In many parts of the world the effect of climate change and climate variability such as drought have negative impact on water supply (Lebese, 2017). The study area is characterised by low rainfall of between 200 and 400 ml per annum and with a very hot summer (Mmbadi, 2019). The low rainfall pattern in areas results in the gradual dropping of dam levels (Maake and Holtzhausen 2015). Evaporation rate affects the amount of water available to replenish groundwater and depends on temperature and relative humidity (Molobela and Sinha, 2011).

SA was severely affected by the El Nino drought during 2015/2016, adverse effects are still experienced which did not only affect agricultural activities, but also rural domestic water use and demand (Lebese, 2017). Furthermore, it was stated that the magnitude and timing of drought is directly affected by changes in the total amount of precipitation, its frequency and intensity. Increased groundwater depletion is expected during shorter period combinations, while more severe rainfall is combined with increased evapotranspiration and irrigation. (Molobela and Sinha, 2011). Low rainfall patterns in areas result in a gradual drop in dam levels (Maake and Holtzhausen 2015). Climate change can be controlled with the help of new technologies and satellites that signal change.

2.8.2 Water infrastructure

Hoffman and Nkadimeng (2016) revealed that water supply challenges are related to inadequate planning and investment in water infrastructure development. Municipal assets management and maintenance plans for water infrastructure are urgently needed because existing infrastructures have deteriorated and need urgent maintenance and upgrades (Hoffman and Nkadimeng, 2016). Major water infrastructures run through rural areas without supplying those areas (Masindi and Duncker, 2016). Van Schalkwyk (1996) stated that revenue generated from paying for water ensures sustainability of water supply infrastructure. Although, municipalities collect almost no revenue from rural residents, even if the amount of service offered is only a yard connection because of this, the service is extremely reliant on government funding to stay afloat. The Department of Water and Sanitation inherited about 600 rural water supply schemes from the apartheid government, whilst schemes were run down, poorly managed and desperately in need of repairs and upgrading (Gombert, 2003).

Shikwambane (2017) stated that national government allocates a smaller budget to local government regarding water supply to the rural communities, which is why it fails to meet the daily water needs of the rural population and maintain the existing water infrastructure. Poorer municipalities are in densely populated, deep rural areas characterized by an accumulation of service provision (Luwaga, 2003). Infrastructure development and maintenance and ensuring the availability of services such as water supply, are expensive and difficult to sustain in remote and geographically dispersed areas. Residents throughout the country do not want to pay a flat rate for water services because of the unequal distribution of water, which has led to intermitted functioning of schemes (Vairavamoorthy et al., 2008). The latter study noted that water infrastructures at the MDM mostly were installed 30 years ago, pipelines have deteriorated. Refurbishment and proper maintenance of existing infrastructure is a solution which is best and cost effective (Hay *et al.,* 2012). Although Van Koppen *et al*. (2020) stated that functionality of water infrastructure implemented at rural areas in Limpopo province standing at 14% is fully functional, 15% is sub-functional and 71% is dysfunctional.

2.8.3 Population growth

Many parts of South Africa are already experiencing water scarcity, which is expected to worsen in the future as the country's population grows; similar forecasts apply to most other Southern African countries (Iny, 2017). Rapid urbanization and population increase will result in severe water scarcity as well as having a significant influence on the natural environment (Kumar *et al*., 2020). By 2025, a third of the population in developing countries is expected to be affected by water scarcity (Amarasinghe, 2014). Tzanakakis, *et al*. (2020) stated that more than half of the world's population live in cities now, especially in densely populated cities; by 2050, more than two-thirds of the population will live in cities.

The availability of water becomes stretched as the population and per capita consumption grow putting more pressure on the supply (Totsuka, *et al* (2004). Water supply sources constructed 20 to 30 years ago is the reason that population outnumbers the available sources, and the systems are ineffective (Malima, 2020). Larger populations will need greater amounts of water, but ecosystems' ability to supply more consistent and cleaner supplies will be harmed (Amarasinghe, 2014). It is necessary to develop technological tools and new approaches to identify and address the challenges posed by population growth (Tzanakakis *et al.,* 2020). Malima (2020) emphasised that meeting the water needs of growing populations all stakeholders should invest in systems that have more water supply options.

2.8.4 Water quality

Water quality protection is a major challenge for South African water policy (Mukheibir and Sparks, 2003). Edokpayi *et al.* (2017) stated that natural processes and anthropogenic activities affect water quality. Therefore, water treatment systems must be protected against biological and chemical contamination by the water sector (WHO, 2008). A lack of access to adequate water supply and poor sanitation leading to exposure to pathogens through water faeces, toxins, and water collection and storage pathways, affects people's health (Edokpayi *et al.,* 2018). The dams receive water directly from nearby rivers and then undergo the treatment process although the water is polluted with various forms of pollution caused by human activities. (Bouwer, 2000). There was emphasis on the fact that surface water resources should be treated efficiently not to pose health risk to users (Edokpayi *et al*., 2017). In addition, unsafe sanitation and ineffective water treatment technologies in existing facilities pose significant risks to many. (WHO, 2018). South Africa’s poor state of wastewater treatment facilities raised concern over the levels of sewer pollution in the country’s freshwater resources (Edokpayi *et al*., 2020).

In 2008 the DWS designed the Blue and Green Drop certification programmes for drinking water and wastewater management and improvement in SA municipalities (Naidoo *et al*., 2016). Mothetha *et al.* (2013) stated that the quality and reliability of all water services are threatened by deterioration in the infrastructure. Edokpayi *et al.* (2018) stated that for their daily supply, many South African communities still rely on untreated or improperly treated water from surface resources such as rivers and lakes. Water pollution reduction will efficiently increase water supply, which raises the safety margin for preserving water supplies during droughts (Anderson, 2003).

In many parts of South Africa, communities draw water from untreated or undertreated surface resources such as rivers and lakes that should be protected from pollution (Edokpayi *et al*., 2017). Water collected from the following unimproved sources such as wells, ponds, springs, lakes, rivers, and rainwater harvesting which are consumed without any form of treatment pose a major public health risk (Edokpayi *et al.,* 2018). Rankoana (2021) stated that rainwater harvesting was a source of water in 2016 at Richmond (Northern Cape Province of South Africa) due to lack of potable water. Poor water quality has exacerbated protests in Hammaskraal, Edokpayi *et al.* (2020) reported that municipalities supplied residents with water of high turbidity which was not fit for drinking and had a bad odour and taste. Further in Modimolle residents protested due to poorly treated drinking water.

2.9 Water resource management

Water resources in South Africa for many years were managed efficiently and effectively and the approach to managing water resources system has been by means of the same methodologies and techniques that have worked well (Seago, 2016). Water supply management must be considered to ensure provisioning of adequate amounts of water and of good quality to communities (Kativhu, 2016). The interventions should be to increase supply and reduce demand namely in groundwater development, wastewater treatment, increased conservation and demand management efforts (Mthethwa, 2018). SA is world's driest nation due to low annual rainfall and it cannot waste its water therefore water demand management approaches have been developed by municipalities (Baatjies, 2014). Accurate estimation of population growth is important for water supply planning, design, and development (Van Schalkwyk, 1996). Inadequate service and inequitable water distribution result from inaccurate estimation that led to deficiency in basic design information (Van Zyl *et al*., 2007).

Lebese (2017) argued that information on water requests and utilisation must be created, and an expository system applied that will help in planning usage arrangements for country unmetered ranges to supply a basis for maintainable utilisation, administration, and the administration of such waters. The potential source of water should be evaluated, and contemplation be given to the amount of water accessible to meet display and future needs as well as quality of water when planning water supply for a range (Cosgrove and Louck, 2015). There are approaches in South Africa developed by the DWA for managing water resources namely pitman rainfall-runoff model, water resources yield model and water resource planning model which are regarded as standard modelling tools (Seago, 2016).

Paying for water must be implemented to reduce water demand, discourage waste, irresponsible water use, limit water losses and promote awareness of the scarcity of water (Van Schalkwyk, 1996). Water needs to be restricted in future because of climatic conditions and increased demand for water resources through population growth, urbanisation, and economic growth (Baatjies, 2014). (WHO, 2014) stated that by 2030 all people in South Africa must have access to safe water from an improved source. South Africa assigned local government, which is the sphere of government closest to the people, the responsibility of water service delivery (Oelofse, 2010). The DWA (2017), gazetted the standards and standard for levels of water supply administration which were based on standards of widespread get to, human mobility, client support, benefit measures, change, and esteem for cash (Shikwambane, 2017). For the provision of water to people, there are four levels of service; (1) Bulk services: a source of potable water to be provided to people that is metered in all circumstances, (2) the minimum level of service: people access 25 -50 L /p /d at low to medium pressure, and use of more than 25 L /p /d is paid for, (3) the middle level of service: people access and pay for 51 -90 L /p /d at medium pressure, and (4) the full level of service: people access and pay for more than 90 L.

Lastly, the level for which there is no service or provision takes place people have access to water from insecure or unimproved sources. The people with no service category access unsafe and poor-quality water from rivers, springs and small dams/catchment areas which are usually far from dwellings and furthermore they do not use water treatment or purification methods to ensure water is safe for drinking. (Masindi and Duncker, 2016) stated that the DWS fund projects the provisioning of water from tankers, boreholes, standpipes, and pipelines and the refurbishment of water treatment works. The values of water supply and demand balance index states that SDBI > 1, means that total supply of water is more than total demand and therefore the GGM has no shortage of water.

If 0.9 < SDBI < 1, it means that total water supply is smaller than total demand and therefore the region has a slight shortage of water; this may affect production, which needs a large amount of water. If 0.6 < SDBI < 0.9 it means that total water supply is smaller than total demand and therefore the region has a moderate shortage of water; in this case, domestic life may be affected much more. If SDBI < 0.5 it means that total water supply is only half of total demand and therefore the region has an acute shortage of water. According to the IDP (2019) the GGM has communities with acute shortage of water supply therefore they use boreholes to augment supply (Mmbadi, 2019).

2.9.1 Water demand management

Lebese (2017) stated that water required by users to satisfy their need is called water demand. Therefore, for this study the water demand is the minimum water to be made available to the villages by the municipality in compliance with the government policy basic water needs (25 l/p/d). Free basic water supply is the provision of at least the basic volume of water for indigent households, a minimum of 25 litres of potable water per person per day as prescribed by the Minister responsible for water supply (Muller, 2008). When required, the Minister in charge of water supply has the power to impose water restrictions, but no less than 25 litres per person per day. South African government does not have sufficient water supply systems to cope with demands (Mnisi, 2011). Water demands need to be considered in planning and design of bulk water works (Van Schalkwyk, 1996). There is a need to focus on increasing water supply together with reducing water demand (Jacobs-Mata *el at*., 2018.

The government plans to adopt the global demand of 50 l/p/d because water demand in SA is below minimum international standards (Lebese, 2017). A study based in the USA by Gleick (1996) estimated that a person requires 50 l/p/d, which is more developed with infrastructure and a very different socio-economic/political environment than SA (Jacobs-Mata *et al.,* 2018). A strategy to deal with water requests for human needs proposed, five litres for drinking, 20 litres for sanitation, 15 litres for showering and 10 litres for nourishment planning and was acknowledged by the World Bank (Lebese, 2017). South African suburban families use 300 litres per person per month, which is much higher than 6 000 litres per month prescribed by the South African legislation (Jacobs-Mata *et al.*, 2018). Van Schalkwyk (1996) stated that for traditional dwellings for domestic activities water demand is 15 litres per person per day and categorised as follows (see Table 2.3).

Table 2.3: Water demand for traditional dwellings (Source: Van Schalkwyk, 1996)

Domestic activities	**Water demand (litres per person per day)**
Drinking	2
Cooking	1
Dish washing	2
House cleaning	1
Clothes washing	2
Bathing	7
Total water demand	15

Water demand is reduced by having to pay for water used, it discourages waste and irresponsible water use, limits water losses and promotes an awareness of the scarce resource (Van Schalkwyk, 1996). MDM IDP (2019/2020) stated that over usage of water was observed amounting to more than 150 l/p/d in towns and villages. The 6000 litres per household per month (200 litres per household per day) to meet the basic needs for a household of eight people (25 litres per person per day) is used as a demand constant value for calculating water demand in line with the Free Basic Water Policy of National Government to guarantee the provision of free basic water to maintain life, sustenance, cleanliness, health, and sanitation. Water demand is obtained by multiplying the basic water needs of 6 000 litres per household per month, household of eight people for daily use is 200 litres per household per day which is standard with the number of households in each village as shown in Equation 3.

$$Water\ demand = number\ of\ households \times Per\ capita\ water\ demand \quad 3$$

2.9.2 Standpipe prepaid metering

Maintaining a stable water supply is a key concern for municipalities. Most rural municipalities get their water from communal standpipes (Heymans, *et al*., 2014). It is vital to charge for water consumption in order to recoup the costs of maintaining this costly infrastructure. There is a system that municipalities can use for water management, prepaid standpipes. Each household purchases a prepaid card to store purchased water credits. The user plugs the card into a prepaid standpipe to collect water, and when water is provided, the amount on the token decreases (Kastner, *et al.,* 2005). This method assures that each home is exclusively accountable for the water it consumes and that all users pay. The prepayment water meters are set up to deliver the free basic 6 kl in advance, as well as the option to purchase additional water credits. The prepayment system complies with SABS 1529-9 criteria and is powered by replaceable batteries with a 3-year lifespan (Kastner, *et al.,* 2005). Water metering is a water supply management technology which quantifies water tariffs, detects leakages, water demand is monitored and water supply planning (Hanjahanja *et al.,* 2018). Prepaid standpipes system promotes water conservation and reduces wastage, raises awareness of consumption, and incentivizes customers to close taps and repair leaks on their properties (Malunga, 2017). The municipalities can generate monthly consumption data from the prepaid standpipes (Iipinge, 2016). The prepaid metering project was rejected in SA in the Phiri area which falls under Johannesburg Water, because residents felt that there was an impingement on their right to access the 6kl/h/m water as provided for in their constitution (Hanjahanja *et al.,* 2018).

2.10 Water supply strategies

Different strategies are adopted by different countries to try to cope with water insecurity. Coping strategies are ways people use to be able to cope with water supply shortages for instance, buying water from unsafe sources such as agricultural wells which were not assessed for quality and. re-use of the same water for several tasks like water used to boil vegetables re-used to wash dishes and washing of floors re-used to flush the toilet. In addition, toilets are not flushed frequently, washing less regularly and using a bucket or jug to limit the water used instead of showering. A washing machine is not used instead clothes are hand washed in a bucket. There are no gardens at all in dryer areas or only rain-fed crops are grown. Strategies include fetching and boiling water from shallow wells and sometimes water is filtered through a cloth to remove visible debris during the rainy season. Swaziland communities sell livestock to buy water from private borehole owners and practice roof rainwater harvesting. Where water supply systems fail, people have drums and tanks which are filled when water is available to meet water needs when the system fails, and rainwater is another source that is harvested and stored in tanks (Mnisi, 2011).

Furthermore, they use their own hard-earned money and social grant money to hire vehicles to fetch water for them in other villages and fill the drums. To ensure sufficient water is made available for sustainable socio-economic development, there must be a shift from infrastructure development projects to a more integrated approach where there are both demand side and supply side management interventions (Seago, 2016). The DWS (2019) has a National Water Resource Strategy (NWRS) which sets out vision and strategic action for effective water management and focuses on water conservation and management (Enqvist and Ziervogel, 2019).

2.10.1 Water pricing strategy

Masindi and Duncker (2016) stated that water pricing as a form of progressive block tariffs was introduced to policy framework in South Africa as a cost-recovery measure through a White Paper (1994) on Water Policy. A three-tier rising block domestic tariff was proposed, comprising a life-line tariff for consumption of less than 25 litres a day, a normal tariff based on average historic costs for consumption between 25 litres and 250 litres a day, and a marginal tariff based on long-run marginal costs for consumption of more than 250 litres a day (Makhari, 2016). Raw water pricing strategy ensures equitable and appropriate raw water tariffs that will enable sustainable operation and management of raw water infrastructure and will fund catchment management funding/financing models for water resources infrastructure establishment of an economic regulator for the entire water value chain.

2.10.2 National Groundwater Strategy

The National Groundwater Strategy for groundwater is a strategic resource in many parts of South Africa, especially in rural areas (Masindi and Duncker, 2016). It also plays an important role in the supply of water to small towns and villages in drier parts of the country. Groundwater currently reflects only 9% use and is underused, undervalued and not well managed. With about 3 500 million m^3 of groundwater estimated to be available for further development, much scope exists to exploit the potential of groundwater as a freshwater source. The need for groundwater data and information continues to increase to assist in planning to provide water to people, monitoring, drought relief and climate change. Groundwater, despite its relatively small contribution to bulk water supply, represents an important and strategic water resource in South Africa, since its services between 52% and 82% of community water-supply schemes in the Eastern Cape, Limpopo, Northern Cape, Northwest, and KwaZulu-Natal.

2.10.3 Re-use Strategy

Muller (2020) stated that with its Re-use Strategy the DWS has developed a water re-use strategy to encourage informed decisions regarding water re-use. Re-use may be increased significantly with return flows in coastal cities, where it might otherwise drain into a sea. At 14%, water re-use is already a serious component of the water mix, albeit mostly indirectly. Direct re-use, especially in coastal areas, must be further encouraged. Municipalities must consider water reuse for future facilities (Hay *et al*, 2012). Rural areas practice water re-use of water used for bathing or laundry that is employed for irrigating trees, flowers, lawns and vegetables or cleaning floors or washing cars.

2.10.4 Rainwater harvesting

Lebek and Krueger (2021) stated that the Department is formulating a Rainwater Harvesting (RWH) Strategy to deal with the effects of temperature change. Global climate change poses significant social, economic and environmental risks, especially in developing countries. Several municipalities now use roof rainwater tanks for domestic purposes. These are particularly effective when utilised in conjunction with other water options. Rainwater harvesting gives people in border areas where reticulation has not yet been implemented access to water. The programme targets rural communities through the installation of tanks and awareness campaigns. The rainwater harvesting guidelines have been in process since 2018/19.

2.10.5 Desalination strategy

Masindi and Duncker (2016) stated that the Department has developed a supporting desalination strategy, which also includes desalination as a technology for treating water aside from seawater for water re-use. Desalination of seawater could potentially provide limitless resources of freshwater. The DWS will ensure that desalination is taken into account as an option for meeting future water requirements, particularly in coastal cities where there's sufficient electricity for desalination. There is also scope for increasing desalination, which is currently providing only 1% of the country's water needs. Inland measures are in place to desalinate acid mine water and brackish water resources, while coastal areas have a chance to desalinate seawater.

2.11 Chapter summary

The chapter found that water supply in SA is the responsibility of municipalities assigned by the DWS, although the water authority is failing to provide the free basic water of at least 6000 litres per household per month. The failure of municipalities to supply water leads to villages in the GGM using multiple sources which pose health risks and are unreliable. Groundwater is regarded as the main source of water supply in most rural areas in SA. The sources of water supply in rural areas are groundwater, public standpipes, in-house connections, water points (rivers and streams), truck water tankers and rainwater harvesting. Rural areas without in-house connections store water in containers of 25 litres, 200 litres drums and JoJo tanks of 2200 litres or 2500 litres. Water supply challenges in SA are due to climatic factors, population growth, poor infrastructure development and maintenance, limited capacity in municipalities, non-payment of water services and poor planning. Water authorities should implement water supply strategies and manage the scarce resource.

CHAPTER 3: MATERIALS AND METHODS

3.1 Chapter overview

This chapter presents detailed information regarding data requirements, sourcing, collection, and the methodologies applied to analyse the different datasets. The subject matter for this study is to evaluate water supply to selected villages in the GGM, methods that were used to collect the required data are site observation, questionnaire surveys and key informant interviews. Data from secondary sources (i.e., government repositories, NGO reports and scientific journal papers) were also collected.

3.2 Data requirements, sources, and collection

The data required for this study includes households' data per village, water supplied per household, water supply source(s), type of container used to collect water, litres of water collected per trip and frequency of collection were obtained through site observation and questionnaire survey (see Appendix A). Household data was obtained from Statistics SA (2011). Data on water supply strategies was obtained from secondary sources including government repositories, NGO reports and scientific journal papers.

3.3 Target population and sampling procedure

3.3.1 Target Population

The target population for this study were households from the 25 selected villages that are supposed to be the beneficiaries of the Nandoni-Nsami pipeline project, according to the Director of Water and Sanitation within Greater Giyani Municipality. The households that were targeted for this study were from selected villages (i.e.) Basani, Maxabele, KaDzingidzingi, Shimange, N'wa Mankena, KaMapayeni, KaGaula, Daniel Rababelela, Bode, Mbatlo, KaNwadzekudzeku, KaMatsotsosela, KaXitlakati, KaMaswanganyi, Vuhlehli, Sekhiming, KaKheyi, KaMakoxa, Mlhava Willem, Mbaula, KaSiandana, Gonono, Dingamazi, Muyexe and N'wamatatane

3.3.2 Sampling method

Convenience and purposive sampling methods were employed for the questionnaire survey. Convenience sampling was selected because respondents from the target population that meets the practical criteria like age, being easily accessible, available at a given time and willingness to participate will be part of study (Etikan *et al.,* 2016). These were considered because, during the day the majority of community members are at work, an unwillingness to participate as communities have complained about water supply shortage for several years and households are headed by children due to migration of parents/guardian for employment to city or death. Therefore, data was collected from households that were conveniently available to participate in the study. Purposive sampling is based on the knowledge of population sampled (Tongco, 2007). The study used purposive sampling which collected data from the GGM satellite manager, who is responsible for water supply. Purposive sampling was used to select key informant interviews so that they could provide detailed information on water supply sources.

3.3.3 Sampling size

Table 3.1 shows the number of households per village and the total sample size. According to Statistics South Africa (2016), GGM has a population of 256 127 and 70 477 households. The study selected 25 of the 55 villages which were supposed to benefit from Nandoni-Nsami bulk water project, to-date the villages have no access to water for domestic use as stated in the GGM IDP (2019-2020). The sample size was calculated using raosoft (http://www.raosoft.com/samplesize.html). Therefore, this study's sample size for selected villages is at 99% confidence level and a margin of error of 5% and is 638. The research sampled 26 households per village to cater for non-responses possibilities, which increased by 12 to 650 households.

Table 3.1: Number of households per village and sample size

No.	Village name	Number of Households	No.	Village name	Number of Households
1	N'wamatatane	179	14	KaXitlakati	518
2	Basani	577	15	KaMaswanganyi	561
3	Maxabele	491	16	Vuhlehli	443
4	KaDzingidzingi	847	17	Sekhiming	485
5	Shimange	574	18	KaKheyi	382

6	N'wa Mankena	820	19	KaMakoxa	1077
7	KaMapayeni	952	20	Mlhava Willem	316
8	KaGaula	641	21	Mbaula	705
9	Daniel Rababelela	461	22	KaSiandana	1473
10	Bode	510	23	Gonono	292
11	Mbatlo	495	24	Dingamazi	1366
12	KaNwadzekudzeku	874	25	Muyexe	826
13	KaMatsotsosela	288		Total	**16153**

3.4 Data analysis

3.4.1 Estimating total water supply

The capacity of households to store water, determines the amount of water they collected (Tshikolomo *et al*., 2012). It is difficult to have accurate figures of quantities of water used, because households are unmetered (Tshikolomo *et al*., 2012). Therefore, estimated water supply was obtained through data collected during site observation and questionnaire survey. The study accepted the estimation of the quantities of water supplied as provided by respondents. Containers varied from 25 litres, 2200 litres, 2500 litres JOJO tanks depending on households. To estimate the average water supply, Equations 1 and 2 (please see Chapter 2 subsection 2.7) was used.

3.4.2 Determining water demand in the study area

The DWA (1992) stated that 6000 litres per household per month is minimum water to be made available per household in terms of government policy for a household of eight people assuming the need for 25 litres per person per day. This study estimated the water demand of each of the selected villages. The 6000 litres per household per month was divided by 30 days, equalling 200 litres per household per day. The 200 litres per household per day was used as a demand constant value for all villages in line with the Free Basic Water Policy of National Government to guarantee provision of free basic water to maintain life, for sustenance, cleanliness, health, and sanitation. In this study, water demand was calculated using Equation 3 (please see Chapter 2 subsection 2.9.1).

3.4.3 Water supply and demand balance index analysis

Water supply and demand balance index (SDBI) was used to analyse water supply and demand of selected villages considered in this study. Analysis will measure the ability of the GGM to provide water to meet the needs of the population (Huang and Yin, 2017). Values of water supply and demand balance index were determined by the total water supply and water demand at selected villages. The SDBI was obtained using Equation 4 and Table 3.2 shows the corresponding SDBI to a supply demand category.

$$\text{Supply and Demand Balance Index (SDBI)} = \frac{\text{Total Water supply (TSW)}}{\text{Total Water Demand (TWD)}} \qquad 4$$

Table 3.2: Values of water supply and demand balance index (Source: Huang and Yin, 2017).

Type	**Extreme**	**Acute**	**Moderate**	**Slight**	**No shortage**
SDBI	0 - 0.3	0.3 - 0.6	0.6 - 0.9	0.9- 1	>1

3.5 Formulation of the proposed water supply strategy for Villages in the GGM

Figure 3.1 shows the methodological framework to be used in the development of the proposed water supply strategy for villages in the GGM. Methodological framework is a user's tool to guide through a process using stages or a step-by-step approach (McMeekin *et al*., 2020). The first stage is to obtain the population data for selected villages, source(s) of water supply to be able to observe water usage. The researcher will be able to calculate water demand and water supply for analysing the water supply and demand balance index. The above calculations will assist to identifying water supply strategies applicable to GGM.

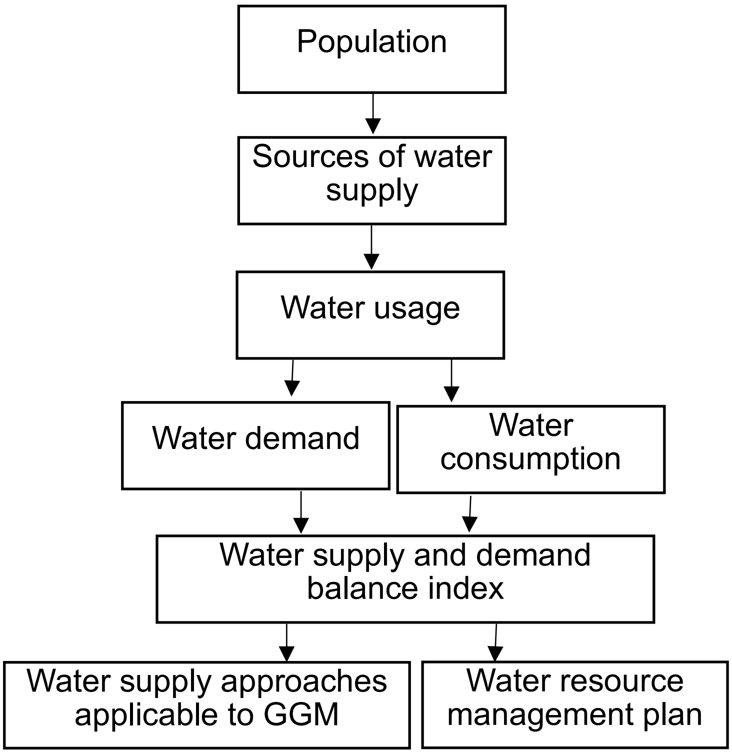

Figure 3. 1: Proposed water supply strategy methodological framework

3.6 Chapter summary

This chapter discussed the methodological approach of the dissertation. Primary data was collected by means of site observation, questionnaire survey and key informant interviews while secondary data was derived from literature (government repositories, NGO reports and scientific journal papers). The study was conducted at the GGM, and all twenty-five (25) villages were sampled. In terms of sampling convenience, the purposive sampling method were used. The following chapter analyses and discusses the collected data.

CHAPTER 4: WATER SUPPLY TO THE 25 VILLAGES OF THE GGM

4 Chapter overview

This chapter presents the findings on the state of water supply to the 25 villages of the GGM. Although in 2010 the Nandoni-Nsami water project was initiated as a solution to this problem, media and other anecdotal evidence asserts that the situation has not improved. Rural areas in Limpopo province according to Van Koppen *et al.* (2020) stated that implemented water infrastructure functionality stands at 14% fully functional, 15% sub-functional and 71% dysfunctional. Over three million South Africans who live in rural areas still lack access to basic water supply (Lebek *et al.,* 2021). The researcher ensured that the respondents understood the purpose of the study because others thought the researcher was bringing water to them. The researcher clarified to the respondents that the study was for academic purposes although she hoped that the relevant authority would refer to the study.

The headman from Mbatlo did not want to take part in the study indicating that they have participated in many studies regarding water, but changes have not taken place, reply to questions on how many litres they used for domestic activities, the respondents indicated that the question was difficult for them to answer due the scarcity of water in their villages. Therefore, guided by the formulated objectives, the study aimed at evaluating the water supply in 25 selected villages under GGM. The respondents were conveniently sampled across all villages and the questionnaires were distributed personally from door to door. Apart from the household questionnaire, there was also a structured interview administered to the GGM official as a key informant about the sources of water supply within the municipality. This was done to effect comparison between the municipality and the households with respect to the sources of water supply in the villages.

4.1 Sources of water supply

Table 4.1 shows sources of water supply findings obtained through the questionnaire survey to the households in selected villages of the GGM. Information gathered from the GGM official indicated that the municipality has three main sources of water supply (borehole water supplied through communal taps, bulk water through in-house connection and communal taps, and truck water tanker). This result concurs with information provided by households although some community members also indicated that they get water from nearby rivers, private boreholes, and a water vendor. Khwashaba (2018) in a study emphasised that residents at the GGM provide basic services for themselves such as fetching water from the rivers and drilling their own boreholes. Statistics SA (2017) noted that rural households still rely on unimproved water sources at 24% like rainwater harvesting, surface water bodies, bottled water, or tanker trucks, meaning the GGM forms part of the percentage as stated. Study findings as shown in Table 4.1 indicate that both the municipality and households agreed that government boreholes were the main source of water supply.

As outlined in the GGM IDP (2020), boreholes augment water supply in villages with acute water shortage in the municipality. The findings on government boreholes indicated that 84% households out of 96% in the municipality agreed with the presence of government boreholes as the major source of water supply in the GGM. The municipal bulk water supply source does not reach all the 25 villages according to household data, 44% households indicated that there is no bulk water supply, although the municipality indicated that bulk water from the water treatment plant is distributed to standpipes or in-yard pipes to all villages within the municipality.

Table 4.1: Water supply sources in GGM villages

	Sources of water supply									
	Government Borehole		Private borehole		Water tanker		Bulk water		Other (Specify)	
Villages	**Municipality**	**Households**	**Municipality**	**Households**	**Municipality**	**Households**	**Municipality**	**Households**	**Municipality**	**Households**
N'wamatatane					✓		✓	✓		
Basani	✓	✓		✓	✓	✓	✓			
Maxabele	✓	✓			✓		✓	✓		
KaDzingidzingi	✓	✓		✓	✓		✓			✓
Shimange	✓	✓		✓	✓		✓			
N'wa Mankena	✓	✓		✓	✓		✓			
KaMapayeni	✓				✓		✓	✓		
KaGaula	✓	✓			✓		✓			✓
Daniel Rababelela	✓	✓		✓	✓					
Bode	✓	✓		✓	✓		✓			✓
Dingamazi	✓	✓		✓	✓	✓	✓			
KaNwadzekudzeku	✓	✓			✓					✓
KaMatsotsosela	✓	✓			✓		✓	✓		
KaXitlakati	✓				✓		✓	✓		
KaMaswanganyi	✓	✓		✓	✓		✓			✓
Vuhlehli	✓	✓			✓		✓	✓		
Sekhiming	✓	✓		✓	✓				✓	
KaKheyi	✓	✓		✓	✓		✓	✓		✓
KaMakoxa	✓				✓		✓	✓		
Mlhava Willem	✓	✓			✓		✓	✓		
Mbaula	✓	✓			✓		✓	✓		
KaSiandana	✓	✓			✓		✓			✓
Gonono	✓	✓		✓	✓		✓			
Mbatlo	✓	✓		✓	✓		✓			
Muyexe	✓	✓		✓	✓		✓	✓		

During a field survey, broken and dry taps were observed whilst in other villages, the municipality implemented intermitted water supply but only at Xitlakati village water supply is uninterrupted. Water supply at Xitlakati village is from Nondweni water treatment works at Ba-Phalaborwa municipality. Although Mnisi (2011) reported that bulk water is not received for an extended duration of time, in some villages households tend to illegally connect taps in their yard to the municipal distribution system. Illegal connections are one of the issues that have been highlighted as affecting water supply in rural areas, having an impact on the pressure of water in the distribution system. According to Mokgobu (2017) some piped water is lost along the way, not allowing the reservoir to fill up.

Lebek *et al.* (2021) further emphasised that some residents had installed taps in their yards and connected them to the pipe system that supplies water to the public standpipes. Whilst the municipality considers such yard taps to be illegal since they divert water from public standpipes, and which is diverted from pipes to yard connections before it reaches the public standpipe. Communities in the selected villages in the study area are using unimproved sources of water supply such as rivers and the truck water tanker according to WHO (2006) the sources are classified as unimproved sources of water supply (Lebek *et al.,* 2021). Domestic water uses in rural households for those without access to formal municipal services depend on rivers, streams, and springs (Lebek *et al.,* 2021). Although the municipality has indicated that they deploy truck water tankers to communities experiencing water shortages, 23 of the 25 villages indicated that this measure of immediate relief does not reach their households.

Netshipale (2016) stated that at the start of a tankering programme municipality must monitor their drivers. Given the fact that Giyani constitute predominantly of indigent households (84%), it is a challenge to find that only 10 of its villages has municipal bulk water supply. There are some households who acquired other sources to complement unreliable water supply from municipal sources. This implies that while government through its municipalities has a mandate to ensure adequate basic water supply to its citizens, this is not the case for the GGM. The rest of the villages use water from other sources such as rivers, vendors, and own boreholes. This study also found that water supply sources in GGM are determined by socio-economic and geographical factors. Most households who used rivers, truck water tankers and communal borehole water were those in deep remote villages while vendors and private borehole water supplies could only be accessed by the elite households who reside in villages just outside the Giyani business centre and were capable financially. This further shows the uneven distribution of wealth in the municipality. The study also found that proximity to the town correlates positively with municipal bulk water supply, the closer the villages are to the town, the more access they would have to the municipal bulk water supply. For instance, KaMakoxa and Kamapayeni villages are close to Giyani business centre had bulk water supply (in-house connection) relative to villages far from the business centre. The majority of the villages in the study area do not receive water every day as there is a water supply schedule for both bulk and borehole water. According to the municipality, such a schedule is necessitated because of low dam levels and borehole yields.

4.1.1 Government borehole

Figures 4.1 (a – c) shows a municipal borehole that pumps water to a reservoir which supplies water to villages through communal standpipes. A study conducted by Lebek *et al*. (2021) indicated that standpipe water is groundwater-fed, where groundwater is pumped from boreholes to reservoirs and from there to the standpipes. The researcher found that groundwater is the main source of water supply in the selected villages. This agrees with the study findings by Mmbadi (2019) which found that Limpopo province uses groundwater as the main source of domestic water supply. Boreholes are a common source of water supply whilst overuse of groundwater, according to DWA (2015), will cause it to run dry or be overstretched. Lebek *et al*. (2021) stated that to meet the rising water demand of the growing rural communities, municipalities regularly over pump boreholes resulting to the collapse of boreholes, depletion of aquifers and then new boreholes must be drilled at much deeper levels (up to 200 metres).

Figure 4.1: Borehole water supply in the study area, (a) Municipal borehole (b) Reservoir storage and (c) JoJo tanks storage

To ensure a constant water supply to communities from boreholes during power cuts, the municipality resorted to the use of solar energy for pumping on all the boreholes. The GGM IDP (2020) stated that electricity used for pumping water from boreholes for community water supply is the responsibility of municipality. At Ga-Moela Sekhukhune District according to Van Koppen et al. (2020) members organised themselves to buy diesel due to municipal failure to procure diesel for dumping water from boreholes. During a field survey as shown in Figure 4.2, this study found that some households at KaGaula are incurring the costs of pumping water for domestic use. Whilst at Mbaula village community members contributed funds to drill their community borehole to complement the unstable municipal water supply. The community contributed money to drill the borehole and thus through the tribal council's office, the headman is responsible for management of the borehole. The finding above at Mbaula village concurs with the findings that access to water in South African (rural areas) still relies on citizens own initiatives and infrastructure to access water (Van Koppen *et al.,* 2020). Du Plessis (2020) emphasises that water-related issues are more likely to be managed communally as a collective group in rural areas. Furthermore, it is emphasised by Hofstetter *et al.* (2020) that access to water in many rural areas relied on villagers' own initiative and infrastructure since water services are often not available therefore households invest in storage capacity.

Figure 4.2: KaGaula village electrification fee Figure 4.3: Mbaula village funded boreholes

Villages such as Kakheyi, Dingamazi, KaNwadzekudzeku, KaMatsotsosela, Vuhlehli and KaKheyi use schedules due to low yield. In this respect and in line with the findings regarding water supply, community members had an agreement that each household collect a certain amount of 25 litres containers per day depending on the schedule. In KaNwadzekudzeku and Mlhava Willem, boreholes and communal taps are fenced and closely monitored by community members to avoid vandalism and to manage water resources. In other instances, these infrastructures were found inside the yard of community members which is a way of managing and monitoring groundwater supply schemes. Municipal water infrastructures are vandalised in SA which is a widespread challenge (Lebek *et al.,* 2021). There are several malfunctioning boreholes due to vandalism, theft, and low yield in villages like Maswanganyi and Nwadzekudzeku. This finding concurs with the assertion made by CMD and GGM IDP (2020) that municipalities in Limpopo province share similar borehole challenges; borehole infrastructure frequently being stolen and there are low yields at times. Hence, the infrastructure must be protected.

4.1.2 Private boreholes

In SA, groundwater for domestic use is permitted without a licence, however, such boreholes should be registered with the DWS. Private boreholes were found to be inside households that were financially stable. Such households offer assistance to other community members who have water supply challenges at an average price of R1.50 per 25 litre container. The charge is as a result of the expenses incurred by the borehole owner from the drilling to the operation of the borehole (Van Koppen *et al.,* 2020). Households with private boreholes store water in JoJo tanks, like the storage from the municipal boreholes. Due to socio-economic factors, this study found that private boreholes are not common in villages further from the Giyani town and that villages closer mostly made use of private boreholes. In villages such as Kakheyi and Matsotsosela, private boreholes have run dry. This may be because of improper geotechnical surveys and results in financial losses to homeowners.

4.1.3 Bulk water supply

The World Health Organisation (WHO) considers bulk water (in-house connections) a safe and convenient source of water. This study found that bulk water shortages were due to low water levels in dams that supply water to Giyani. Muller *et al.* (2009) stated that dams run dry due to inadequate rainfall. Bulk water supply is provided by Giyani, Middle Letaba, Papowe, Nondweni Water Works, and the latter belongs to Ba-Phalaborwa Municipality. The supply of water from Giyani Water Works is scheduled according to days or weeks while that from Ba-Phalaborwa Municipality is accessed every day. Xitlakati is the only GGM village that receives water from Nondweni Water Works. As shown in Figure 4.3, Xitlakati households had adequate water for domestic use and other purposes such gardening. Makosha Village is next to Nsami Dam, households located at lower elevation have access to bulk water supply whilst those located at higher ground do not receive bulk supply due to low pressure to reach the higher ground and illegal connections have been noted to interrupt water supply. Water stored in reservoirs for subsequent distribution is severely compromised due to illegal connections and deteriorated municipal pipelines (Maake and Holtzhausen, 2015).

Figure 4.4:Bulk water supply in KaXitlakati village

Mdanisi (2010) states that villages at Giyani use taps installed by the homeland government. It was observed in this study that most of the in-house taps had rust and were dry, an indication that it was long since they received water. As stated in Hay *et al.* (2012), the water infrastructure at Giyani has deteriorated and needs refurbishment and proper maintenance.

4.1.4 Communal taps

In the villages where there are in-house connections, it was observed that standpipes are common. DWA (2004) published a design guideline for public standpipes namely that standpipes should be a maximum walking distance of 200 m from homes, a maximum of 25 households or 100 people should be served by a standpipe, flow rate should not be less than 10 litres/minute, taps should be high enough for a container to fit underneath, and so forth. In this study the DWA guidelines were not adhered except at KaXitlakati and KaMapayeni, for example, it was found that a single standpipe served a community of more than 100 people and other community members travelled more than 200 m from their homes to fetch water from the communal taps. It was observed that water distributed to communal taps was from municipal boreholes. Pertaining to water collection, the field survey found that mostly women are responsible for water collection. These findings agree with a study by Morna (2000), which found that rural women spend over four hours daily collecting and transporting water. Women and children spend many hours each day collecting water from distant sources, sometimes they experience long queuing times (Baguma *et al*., 2010).

4.1.5 Water tankers

Truck water tankers are large tankers attached to a vehicle and filled with treated water from treatment works (Singh, 2009). The DWS views truck water tanker as an immediate water supply relief system which can save lives. The GGM uses a water truck with 14 000 litres capacity to supply water with a standard rule that each household is supplied with 200 litres per week. The researcher found that 14 000 litres is supplied to 70 households because each household is supplied 200 litres per week as the standard rule of the municipality. Water supply using truck water tankers is inadequate to meet the basic household demand (Palanca-Tan, 2020). Only households without any other source of water were allowed access to tanker truck water supply. There are 22 villages which have no access to truck water supply contrary to the findings from municipality. The household respondents indicated that during special events such as funerals, when requested the truck water is accessible to communities. The GGM is not executing the DWS remedial plan because the truck water tanker is not always used as an immediate water relief plan.

4.1.6 Vendor water supply

Several households in KaDzingidzingi, Bode, KaMaswanganyi and KaSiandana villages supplemented their municipal bulk water supply by purchasing water from Blue Waters. Blue Waters fetches water from Giyani Water Treatment Plant. However, this was a privilege to only those who can afford it and reside near the Giyani CBD. A company was identified that supplies water at a rate of R250.00 for 2500 litres and

R220.00 for 2200 litres. This led to high demand of JoJo tanks for water storage and as a result, community members initiated stokvels to purchase JoJo tanks for each household. The findings of Van Koppen *et al. (*2020) correspond with the findings observed by the researcher that JoJo tanks at the study area are used for storage and not for rainwater harvesting, and are constructed near the road or in a distant field. However, Loubser *et al.* (2021) urged that water stored in home tanks for a long period in turn may lead to compromised water quality. The period that water is stored, how well and how often storage containers are washed, and hand contact with drinking water are all factors that influence the level of bacterial contamination in storage containers (Lebek *et al.,* 2021).

4.1.7 River water

Communities that draw water from unhygienic sources such as open water bodies are at high risk of contracting water-borne diseases (Mdanisi, 2010). Villages such as the KaNwadzekudzeku and KaKheyi, draw water directly from rivers as a source of domestic water supply. Lebek *et al.* (2021) emphasised that domestic water uses in rural households for those without access to formal municipal services depend on rivers, streams, and springs. This is because municipal water delivery to these villages is periodical. The households indicated that they boil the water before use as a way of treatment. However, IDP (2019/2020) stated that people who depend on water from rivers and streams in GGM face serious health problems of water pollution due to littering and overflow of sewage into the rivers from urbanised areas. Giyani is characterised by low rainfall between 200 and 400 mm per annum and with very hot summers (Mmbadi, 2019). Hence, if the rivers are dry these households will be left without a source of water supply for an extended period. The researcher observed dry streams which Lebek *et al.* (2021) linked to dry streams in winter and drought that was experienced between 2014 and 2017.

4.1.8 Rainwater harvesting

Rainwater harvesting is practised during summer by most households, although Maake and Holtzhausen (2015) stated Giyani is characterised by low rainfall pattern. The National Government implemented a rainwater harvesting strategy at Muyexe village which saw the procurement and installation of 5250- litre JoJo tanks to each household for rainwater harvesting. The strategy failed because it is a conditional source that depends on the rainy season. Community members indicated that the installation of the tanks did not curb the water challenge in the village.

4.2 Water demand at GGM villages

Table 4.2 shows the total water demand for each of the selected villages in the study area. The study found that the total water demand of the 25 selected villages in the GGM is just over 3 million litres per day.

Table 4.2: Basic water demand in GGM villages

	Villages	**Number of Households**	**Basic Water Supply (l/h/d)**	**Total water demand (l/h/d)**
1	N'wamatatane	179	200	35 800
2	Basani	577	200	115 400
3	Maxabele	491	200	98 200
4	KaDzingidzingi	847	200	169 400
5	Shimange	574	200	114 800
6	N'wa Mankena	820	200	164 000
7	KaMapayeni	952	200	190 400
8	KaGaula	641	200	128 200
9	Daniel Rababelela	461	200	92 200
10	Bode	510	200	102 000
11	Dingamazi	1366	200	273 200
12	KaNwadzekudzeku	874	200	174 800
13	KaMatsotsosela	288	200	57 600
14	KaXitlakati	518	200	103 600
15	KaMaswanganyi	561	200	112 200
16	Vuhlehli	443	200	88 600
17	Sekhiming	485	200	97 000
18	KaKheyi	382	200	76 400
19	KaMakoxa	1077	200	215 400
20	Mlhava Willem	316	200	63 200
21	Mbaula	705	200	141 000
22	KaSiandana	1473	200	294 600
23	Gonono	292	200	58 400
24	Mbatlo	495	200	99 000
25	Muyexe	826	200	165200
	Total			**3 230 600**

South Africa has a policy of providing free basic water. Outlined in 1997 National Water Services Act (RSA, 1997) and National Water Act of 1998 (RSA, 1998) which aims "right of access to basic water supply" and a "basic" supply means 25 litres per person per day, easily accessible within 200 m of the household. In this study, water demand for each village was determined using the free basic water supply policy. That is, 6000 litres per household per month for a household of eight (8) people which translates to 200 litres per household per day. About 80% of household in villages around Giyani are dominated by indigent households, implying that it is the responsibility of the GGM to provide free basic water to meet the needs of the households. Although the ministry responsible for water supply has the power to impose water restrictions, however, this should be not less than 200 litres per household per day (DWS, 2017) in a rural set-up of a household with eight people.

4.3 Water supply at GGM villages

Table 4.3 shows that the basic water supply in Giyani is 1 796 676 litres per household per day which is less what the daily demand of 3 230 600 litres per household per day. This implies that water supply shortage in Giyani is approximately 44.4%. Furthermore, the results in Table 4.3 indicate that of the 25 sampled village communities, only two (KaMapayeni and KaXitlakati) had their basic water demand met through the Giyani bulk water supply infrastructure. Through the information gathered from the questionnaire survey, this study estimated water supply in GGM villages per day. The study utilised estimated quantities of water supplied as provided by the respondents.

Although Tshikolomo *et al*. (2012) argues that it is difficult to have accurate figures of water quantities used because most households are unmetered, DWAF's (1994) assumption can still be applicable that households with private boreholes and in-house connections from different water works meet the basic need supply of 200 litres per household per day. A study by Lebek *et al.* (2021) suggested that in the absence of data on water volumes used in a home with yard tap during their observation led to a suggestion that the water volume used by a yard exceeds the free basic water volume of 25 litres per person per day. Households procure containers 25 litres, drums 200 litres and JoJo tanks of 2200 or 2500 litres to store water for continuous supply of water (Van Koppen *et al.,* 2020). At the study area water collection containers varied from 25 litres, 2200 litres, and 2500 litres JoJo tanks. The capacity of households to store water, determines the amount of water collected (Tshikolomo *et al*., 2012).

Although at the study area the amount of water collected is determined by the rules endorsed by the community.

Table 4.3: Water supply in GGM villages

	Villages	**Number of Households**	**Average water supply (l/h/d)**	**Total water supply (l/h/d)**
1	N'wamatatane	179	75	13 425
2	Basani	577	125	72 125
3	Maxabele	491	114	55 974
4	KaDzingidzingi	847	108	91 476
5	Shimange	574	138	79 212
6	N'wa Mankena	820	83	68 060
7	KaMapayeni	952	246	227 550
8	KaGaula	641	70	44 870
9	Daniel Rababelela	461	75	34 575
10	Bode	510	77	39 270
11	Dingamazi	1366	75	102 450
12	KaNwadzekudzeku	874	125	109 250
13	KaMatsotsosela	288	116	33 696
14	KaXitlakati	518	200	103 600
15	KaMaswanganyi	561	77	43 197
16	Vuhlehli	443	140	62 020
17	Sekhiming	485	75	36 375
18	KaKheyi	382	125	47 750
19	KaMakoxa	1077	165	177 705
20	Mlhava Willem	316	118	37 288
21	Mbaula	705	148	104 340
22	KaSiandana	1473	107	107 529
23	Gonono	292	77	20 732
24	Mbatlo	495	75	37 125
25	Muyexe	826	57	47 082
	Total			**1 796 676**

A study by Kanyoka *et al.* (2008) conducted at Sekororo-Letsoalo in Limpopo Province stated that for domestic purposes the quantity of water used ranged from 75 to 200 litres per household per day. The respondents emphasised that due to water supply shortages each household was permitted three 25 litres containers per day which is 75 litres per household per day due to low borehole yield. Furthermore, those who procured water from vendors stored water in JoJo tanks and supplied themselves with the procured water for a month meaning 2500 litres used 83 litres per household per day and 22000 litres used 73 litres per household per day. The study found that most

GGM households have their own sources of basic water supply either as the main source or complimentary to the erratic supply from the municipal sources. Water storage in containers of 25 litres, JoJo tanks of 2500, 5000 or 10 000 litres is regarded as self-supply (Van Koppen *et al.,* 2020). Moreover, they provide water storage facilities such as JoJo tanks for themselves.

4.4 Water supply and demand balance index

To determine the water supply and demand balance index (SDBI), data on water supply and demand was used. SDBI that is less than one (1) means that there is a surplus of water supply. The SDBI measured the GGM's ability to provide water to meet the basic needs of the households (Huang and Yin, 2017). The above findings Table 4.1 on sources of water supply indicated that borehole water is the main source of water supply except KaMakoxa, KaMapayeni, Xitlakati and N'wamatatane villages. Figure 4.5 shows the SDBI for the 25 samples villages in the study area. The SDBI ranges from the lowest 0.3 to a high of 1.2. From the study findings, Muyexe village has extreme water shortage (0.3), Tapela (2012) stated that access to water is below the free basic water policy at Muyexe village.

As outlined above Muyexe village has a major water supply challenge (Billa, 2013). GGM IDP (2020) reported that boreholes are used to supply water in villages with acute shortage of water in the municipality. Figure 4.4 indicate that 4 % of the villages have extreme, 48 % of the villages have acute, and 24 % acute-moderate water shortage which concurs with findings presented in Table 4.1 which showed that borehole water is used as the main source of water supply. Water supply shortage is as follows: according to SBDI moderate water supply shortage is 16 per cent, slight to no shortage is 4 per cent and no shortage is 4 per cent. KaMapayeni and KaXitlakati showed that the villages have adequate water supply to meet water demand.

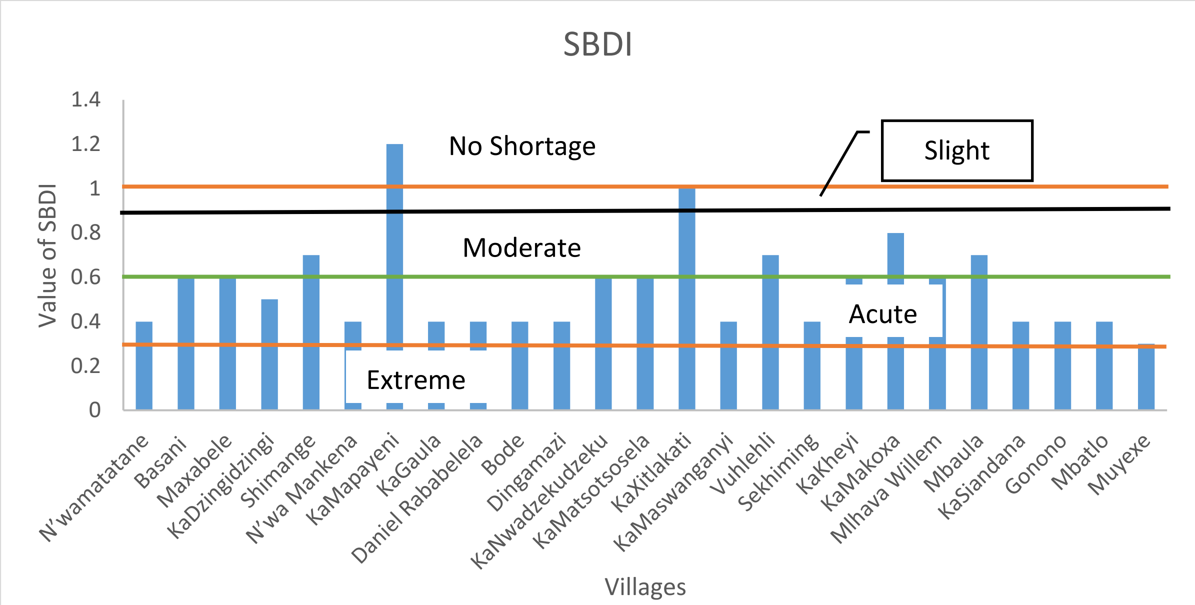

Figure 4.5: The water supply and demand balance index for the 25 sampled villages in the GGM

4.5 Factors affecting the water demand and supply at GGM

4.5.1 Climate

Giyani experiences long standing dry seasons and very hot summers; therefore, it is characterised by erratic rainfall patterns and extremely low water tables. The study found that these climate factors have intensified water supply shortages in Giyani. Most boreholes and rivers run dry during summer while the water level in dams drops. In terms of bulk water supply, a village which was found to have a perfect basic water supply as indicated by SDBI got water from Nondweni Water Works which falls under Ba-Phalaborwa Municipality while villages getting water from Giyani Water Works experienced severe shortages due low water levels in dams.

4.5.2 Proximity to water sources

The study found that in some villages the walking distance to the communal taps exceeded the 200 metres maximum official distance designed for the location of the standpipe from the parameters of the community. Some households hired scotch carts to carry their water buckets while some utilised wheelbarrows. In addition, the study found that water demand at each standpipe exceeded the official supply terms of 25 households/100 individuals per standpipe with a flow of 10 litres per minute. It was found that in some communities a single standpipe supplied over 100 individuals, and this automatically implies that the flow rate was distorted. Apart from communal taps, households who depended on river water supply also had distance challenges. They too used donkey carts to fetch water from the river. Household members spend a lot of precious time fetching water from distant sources, especially women and children. There is no clear distinction between water source and intended use, as most households rely on unimproved water sources as well as other alternatives to supplement their domestic water needs.

4.5.3 Proximity to the CBD

This study found that the current distribution of water from municipal sources, indicated that the supply of bulk water is uneven and biased towards the villages that are close to Giyani business centre. Remote villages use rivers as their main alternative because the tanker truck does not supply water daily and there are stringent restrictions attached to tank truck water supply. It was noted that the tanker truck does not supply water unless there is a need such as funeral gathering and the service does not extend to all remote villages. This reflects inadequate and inconsistent water supply distribution among peri-urban and rural water, hence the surge in water demand conflicts in Giyani.

4.6 Socio-Economic Factors

Molobela and Sinha (2011) emphasised that those who are deprived the benefit of water in SA are poor people, due to lack of technological assets to access water leading them to drink water from unimproved water sources against excessive labour or cash costs. The findings of this dissertation indicate that households who used vendor supplied water to supplement erratic supply from municipal sources were financially stable and close to the vendors. Most vendors operated near the CBD. Vendor-supplied water required finances not only to purchase water but also to purchase bulk water storage containers of at least 2200 litres such as ‘JoJo tanks. Likewise, own boreholes could only be afforded by financially stable households. Drilling a borehole and setting up the infrastructure is expensive for indigent households.

4.7 Chapter summary

The chapter dealt with sources of water supply at 25 villages under the GGM. The villages use mixed sources of water supply due to an unreliable supply namely government and private boreholes, bulk water supply from treatment plants, truck water, vendor, and stream/river. Households supply water for themselves by drilling their own boreholes or buying water from private boreholes and vendors because municipal sources of water supply (Table 4.1) are not reliable due to low yield, vandalism, and low dam levels. The GGM is experiencing the following levels of water shortage: 4% extreme, 44% acute, 24% acute to moderate, 16% moderate, 4% slight to no shortage and 4% no water supply shortage. This therefore indicates that the policy of providing free basic water is not a reality to the villages at GGM except in KaMapayeni and KaXitlakati villages. The expected water demand for the 25 villages is 3 230 600 litres per month.

CHAPTER 5: PROPOSED WATER SUPPLY STRATEGY TO RURAL COMMUNITIES IN GREATR GIYANI MUNICIPALITY

5.1 Chapter overview

Recommendations are made to satisfy water demand. The municipality has a high number of indigent households that depend on government grants to ensure free basic water. Significant improvements concerning water service provision has been made in SA but rural areas in Giyani still depend on unreliable sources.

5.2 Current status of water supply in the GGM

Government boreholes, bulk water, vendor water, truck water tanker, private boreholes, and streams are sources of water supply in the GGM. The above sources of water supply are unreliable, which is why communities use numerous alternative sources. The government has invested in the drilling of boreholes and is the dominant source of water supply. Bulk water supply is a source of water supply which is insufficient due to low dam levels, and which is of good quality and accessible through pipelines inside yards or communal taps. Nandoni-Nsami bulk infrastructure project will ensure water supply at the GGM by augmenting the Nsami Dam which is currently at a low level.

Truck water tankers owned by the municipality as a source of water supply with 14 000 litres capacity serve 70 households in accordance with the municipal regulations once a week. Individuals at the GGM who can afford them have drilled boreholes by commercial businesses at a cost of R20 000.00 and above. Residents next to Giyani business centre supplement their water supply by purchasing water from vendors. The company supplies water at a rate of R250.00 for 2 500 litres and R220.00 for 2 200-litre JoJo tanks. Because of the arid circumstances in Giyani, stream water is scarce and rainwater harvesting is not a safe water source. Due to water supply issues, the population has turned to this source, which has the potential to produce a health crisis. The water supply strategy must supply 3 230 600 litres to meet the total water demand in GGM if the supply exceeds demand therefore paying for water must be applied to generate revenue and conserve water.

5.3 Proposed water supply strategy

The DWS has entrusted the WSA and WSP to ensure that everyone in the country, including poor households who cannot afford a water supply, has access to at least a basic supply (defined as 25 litres per person per day) free of charge. The GGM is having challenges of supplying communities with at least basic level of service mentioned above. Therefore, the water supply strategy below is formulated in terms of the free basic water policy, wherein the GGM is obliged to provide at least 6000 litres of water to each household for free and promoting WD/WCM to ensure effective and efficient use of water.

5.3.1 Water conservation and demand management

The GGM must create a directorate for water demand and conservation management to develop a strategy, the purpose of which is for efficient and effective use of water by institutions and consumers in the GGM. SA needs to focus on neglected demand as the focus was on supply both in the medium and long term, while demand management encouraged efficient use of water, including training, voluntary compliance, pricing policy, legal restrictions on water use, water rationing or imposition of water saving standards by technology (Mukheibir and Sparks, 2003). Re-use of treated wastewater is seen as a water demand management or water conservation option that can improve water use efficiency within an existing water supply (Smakhtin *et al*., 2001).

The city of Cape Town has developed or implemented WC/WDM strategies. In 2007 a strategy was approved which targeted water savings of approximately 90 million m3/a by 2016/17 whilst many municipalities have no strategies developed to address water losses and to reduce water requirements (Muller, 2020). Smakhtin *et al.* (2001) agreed that to achieve real water savings implementation of water demand management is a solution to the water shortage experienced in SA considering the construction delays experienced for new water infrastructure. The Municipality must install monitoring devices in the form of prepaid water meters both bulk and borehole water at each household and prepaid standpipes at communal taps and allocate free basic water 6000 litres per household per month with an option to purchase additional water credits or conserve water. The municipality will generate water supply data, and this data and monitoring devices will assist the municipality in the following:

- Designing an implementation plan for the effective use of water
- Water demand management
- Generating monthly consumption data from the prepaid standpipes and in-house meters promoting water conservation and reducing wastage, raise awareness of consumption, and incentives customers to close taps and repair leaks on their properties
- Water re-use

To overcome the looming water scarcity in SA water re-use is an essential strategy in both rural and urban environment (Naidoo *et al.,* 2016). Smakhtin *et al*. (2001) argued that South Africa's water re-use efficiency is poor when compared to other countries. Van Niekerk and Schneider (2013) stated that, it is estimated that up to 14% of South Africa's water is used mainly through wastewater return to rivers, where it is discharged for indirect re-use downstream. Mmbadi (2019) further recommended that communities in Giyani must practise water re-use to conserve water. According to Van Koppen *et al.* (2020) t water used for washing, bathing, and laundry can be reused to irrigate trees, flowers, lawns, and sometimes vegetables, and to clean floors and for construction purposes. Whilst there is a view that water re-use can harm plants and regards used water as dirty. Smakhtin *et al.* (2001) stated that over 20% of drinking water demand are fulfilled from wastewater treated in Windhoek, Namibia, in accordance with drinking water regulations.

Scheihing *et al. (*2020) emphasised that paying for water will improve community and municipal relations and promotes water conservation. Whilst Mukheibir and Sparks, (2003) indicated that consumption can be reduced through pricing mechanisms to achieve the goal of sustainable use, demand reduction, efficient allocation, and equitable allocation. Households that are identified as indigent easily exceed the free basic water supply of 6000 litres per household via public taps by constantly running taps, unreported leakages, and vandalism of public infrastructure but if there was personal responsibility of paying for water at public taps using the prepaid standpipe meter can reduce wastage of drinking water (Scheihing *et al.,* 2020).

5.3.2 Upgrading of existing infrastructure to assure water supply

Government requires to prioritise Giyani in its water infrastructure development projects especially the Nandoni-Nsami bulk infrastructure grant because SA's water resource comprises 77% surface water. During the 1980s, the need for community involvement in the planning and implementation of rural water supply projects became increasingly evident (MacDonald and Calow, 2009). In rural areas like Giyani, groundwater and surface water development still does not deliver enough water to meet their basic water needs. Increasing water coverage in Giyani by expanding existing and developing new water supply sources as well as storage facilities can serve a considerable number of households. To ensure access to water, government must build tap systems, pipes and other infrastructure that will deliver reliable water. Communities must be involved in all phases of designing, implementing, maintaining, supervising, and evaluating new water supply and sanitation systems.

The GGM must involve end users and play a role in monitoring and approving payments from consultants and contractors to ensure that these private service providers have enhanced accountability to end users. The GGM villages need to take part on decisions made by the municipality regarding water supply, villages must know what their money is used for. Community and municipal relations are improved by paying for water strategy (Scheihing *et al.,* 2020). Lastly, government projects must be strictly audited to minimise misuse of limited financial resources allocated by national government and community participation should be the forerunner for community-based projects.

5.3.3 Groundwater development

The municipality must drill more boreholes at the GGM where there is high yield and supplement villages with low yields because the Groundwater Resource Information Project (GRIP) recently undertaken by DWA in the Eastern Cape confirmed the importance of groundwater for rural water supply (Hay *et al.*, 2012). Although groundwater is not considered a sustainable resource for large domestic supplies and cannot be properly managed, groundwater is regularly used for most of the GGM and municipalities must treat the water to meet the needs of the population. The DWS promotes groundwater resources because it considers it as being a reliable and feasible option (Enqvist and Ziervogel, 2019). Therefore, GGM aquifers and groundwater programmes must be effectively managed according to best practice guidelines and groundwater management frameworks (Liggett and Talwar, 2009). The community needs to remember that improving groundwater is far more imperative, particularly in rural areas, than building huge, widespread dams to reach vast, sparsely populated villages (Hay *et al.,* 2012).

Muller (2008) emphasised that institutions must not allow groundwater extraction to exceed the rate that it can be replenished as the above resource must be protected. The protection of the infrastructure by the municipality can start by rolling out education and awareness campaigns to the respective communities. Furthermore, the municipality should work closely with law enforcement for to curb the cases of vandalism of groundwater as it is the main source of water supply at the GGM. There should be an awareness campaign, criminal law enforcement, repair, and maintenance programmes. Awareness campaigns will educate members about the negative impact of illegal connections on water supply services which affect the pressure of water in the pipelines.

5.3.4 Truck water tanker

The municipality must continue with the programme of tank installation in each household like at Muyexe village and allocate trucks of 14000 litres to provide water for other domestic uses except drinking and cooking. Van Schalkwyk (1996) stated that at traditional dwellings water demand for domestic activities is 15 litres per person per day. Therefore, the truck water tanker must supply water to meet water demand for dish washing, house cleaning, clothes washing and bathing which is 12 litres per person per day in a household of eight, which is 96 litres per household. The DWS is financially assisting poor households with rainwater storage tanks and related works in rural areas (Edokpayi *et al*., 2017). The storage tanks can be used for water storage from the truck water tanker instead. The storage tanks installed will supplement water supply, reduce problems such as water salinity, time and energy taken off to fetch and is less risky compared to river/streams (Baguma *et al*., 2010). To avoid the build-up of natural matter within the tank and to guarantee that the water delivered is secure to drink, water in a tanker should be chlorinated (WHO, 2013). Whilst Wildman (2013) stated that surface water needs to undergo pre-treatment (coagulation/flocculation or filtering) because the water is too turbid for water it to be chlorinated unlike borehole water which is good quality and easily chlorinated. According to WHO (2013), truck water tanker drivers are unreliable and untrustworthy, the municipality must have good planning and oversight through regular monitoring and record checks to ensure smooth operations. Omarova *et al.* (2019) stated that WHO (2013) emphasised that each tanker can make six trips each day, and UNICEF (2019) agreed with the findings.

Because trunk water will enable the GGM to monitor water use and meet the water demand which is a form of immediate water relief which can save lives. Therefore, Table 5.1 indicates how many litres of truck water is required for the villages with acute to extreme water shortage to meet the water demand. The municipality must at least fill 2 592- litre JoJo tanks in each household on a biweekly basis to ensure constant water availability to the community for domestic activities. The municipality can partner with water vendors and pay the services offered by water vendors to villages because the free basic water policy is not adhered to when pensioners pay for water supply. Therefore, the municipality must seek donations from stakeholders to purchase truck water tankers and prioritise villages experiencing acute and extreme water shortages.

Table 5.1: Truck water tanker

	Villages	**Number of Households**	**SBDI**	**Minimum amount of water plus the 10% losses**	**Monthly Trips**	**Trips per month considering 6 rotation per day**
1	N'wamatatane	179	Acute	463 968	33	5
2	KaDzingidzingi	847	Acute	2 915 424	157	26
3	N'wa Mankena	820	Acute	2 125 440	152	25
4	KaGaula	641	Acute	1 661 472	119	19
5	Daniel Rababelela	461	Acute	1 194 912	85	14
6	Bode	510	Acute	1 321 920	94	15
7	Dingamazi	1366	Acute	3 540 672	253	42
8	KaMatsotsosela	288	Acute	746 496	53	09
9	KaMaswanganyi	561	Acute	1 454 112	104	17
10	Sekhiming	485	Acute	1 257 120	90	15
11	KaSiandana	1473	Acute	3 818 061	273	46
12	Gonono	292	Acute	756 864	54	09
13	Mbatlo	495	Acute	1 283 040	92	15
14	Muyexe	826	Extreme	2 140 992	153	26

5.3.5 Water supply Innovations

To relieve the burden of collecting water in rural communities, hippo rollers were developed in SA. In 2011, the telecommunication company Vodacom donated 150 hippo rollers to Muyexe village. Due to the difficult topography within GGM's water provisioning system, the municipality must purchase hippo roller containers that can hold 90 litres of water at a time. This will improve access to water and reduce the burden of carrying buckets. To monitor and regulate service provisioning, the GGM must ensure that municipalities comply with legislative and regulatory standards for levels of water supply services which are based on principles of universal access and human dignity user participation, service standards, redress, and value for money.

5.4 Chapter summary

The GGM is assigned to supply free basic water of 6000 litres per household per month (25 l/p/d) therefore the estimated water demand for the 25 villages is 3 230 600 litres per household per day. The proposed strategy to meet the water demand are as follows:

- Water conservation and demand management
- Upgrading of existing infrastructure
- Groundwater development
- Truck water tankers
- Water supply innovations

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Inadequate water supply, deteriorating access to basic quality, quantity and unequal water supply distribution systems have become a norm with Giyani residents for more than a decade. Considering this problem, this study was conducted to evaluate water supply in all twenty-five villages under the GGM. The water crisis in Giyani can be alleviated by means of the completion of the Nandoni-Nsami bulk infrastructure project instead of the short-term solution of municipal boreholes and truck water tankers, which do not meet the water demand of the villages and creates health risks for residents. The Ba-Phalaborwa Municipality currently is assisting the GGM with water supply at Xitlakati village and has been meeting the village's water demand since Giyani is dry. This research found that municipal sources of water supply at the GGM are government borehole (water supplied through communal taps), bulk water (in-house connection and communal taps), and truck water tankers. However, due to erratic supply from municipal sources, households had alternative water supply sources which include river, own boreholes, and vendors. Khwashaba (2018) stated the above findings that due to erratic supply from municipal sources residents provide basic services for themselves

This study found that the GGM comprised predominantly of indigent households. Thus, it is the responsibility of the GGM to supply free basic water of at least 200 litres per household of eight individuals per day. With a total of 16 153 households across all 25 villages in Giyani, the study found that the minimum basic water demand is 3 230 600 litres per day. On the supply side, the average water supplied across all villages was 111.64 litres per household per day. This is roughly half less than the basic water demand. To be precisely, this study found that the total water supplied for 16 153 households across all 25 villages in Giyani is 1 796 676 litres per day. This is the total water supply from both municipality and households' alternative sources. The design standard for the GGM water supply does not meet the water demand of the villages which is 3 230 600 but currently according to the study is 1 796 676. GGM's ability to provide water to meet the population demand is half of the total demand acute water shortage 0.5 according to SBDI. The findings reveal that municipal water supply sources are seriously overwhelmed mainly due to climate factors, inadequate resources and in some cases poor infrastructure. GGM villages use multiple sources of water supply which are unreliable and depend largely on socio-economic factors and geographical location. Government has made major efforts to provide water supply for all at Giyani in the past decade, but progress was not as expected. Therefore, Giyani's residents are infringed of their right to access adequate quality free basic water from improved water sources for their livelihood. Bulk water supply from Giyani Water Works was restricted and scheduled according to days.

Hence, the households had to source water from alternative sources to account for the days when bulk water will not be supplied. In addition, water supplied through tanker trucks was limited to 14 000 litres per week with a standard rule that each household gets 200 litres per week. Government attempted to provide JoJo tanks for water harvesting, however, the strategy hardly materialised due to erratic rainfall patterns in Giyani. The study also found that municipalities used solar panels to power government boreholes where there was no electricity supply. These boreholes could work only on a sunny day.

6.2 Recommendations

6.2.1 Recommendations for practice

The GGM's sources of water supply need to be improved, it is a decade that the 25 villages have been without stable water supply, and current sources of water supply are unreliable, inaccessible, poor quality and unaffordable. This recommendation also applies to other municipalities elsewhere in the country. The recommendations below can ensure access to water supply for domestic use:

- National government, communities and other water stakeholders must work together to put pressure on current water infrastructure development projects especially the Nandoni-Nsami Bulk Infrastructure Project, must review its auditing and accounting strategy.
- The Municipality must create a water demand management directorate to ensure that bulk water infrastructure development is planned in accordance because water demand data assists designers during implementation planning of water infrastructure development.

- The GGM is a dry region; groundwater needs to be protected and monitored for sustainable use. The Municipality must consider drilling boreholes as a short-term plan, not to curb water supply challenges.
- The Municipality must cooperate with the community and law enforcement to ensure that water infrastructures are protected. Those who engage in illegal activities such as illegal connection, vandalism, and theft must face legal action.
- Water re-use strategy using the same water for several tasks like water used to boil vegetables re-used to wash dishes and washing of floors, washing bathing or laundry be used for irrigation of trees, flowers lawns and vegetables or cleaning floors or washing cars.
- Monitoring and regulating service provisioning, GGM must ensure that municipalities comply with legislative and regulatory standards for levels of water supply services which are based on principles of universal access and human dignity, user participation, service standards, redress and value for money.

6.2.2 Recommendations for future studies

This study addressed various issues about the on-going discussion about the water problems in Giyani. Among other issues, the available sources of water supply in Giyani villages (both municipal and alternative sources), basic water demand and supply in each village, the quality of water infrastructure currently in use by the GGM and the effort required to access water supply from both municipal and alternative sources. The following are some research questions that have developed because of this work and should be considered:

1. What are other sources of water supply can be used in SA's rural areas?
2. Are villagers willing to pay for water supply in the GGM?
3. What disease outbreaks have occurred in rural areas due to unimproved sources of water supply?

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APPENDIX A: CONSENT FORM

Name of the Researcher	**Lebogang Salome Selane**
Title of the study	**Evaluating water supply to selected villages in the Greater Giyani Municipality**

Dear Participant

You are hereby requested to give your consent to participate in the study. If you are willing, kindly complete the form below.

Kindly note that the information provided will be treated with confidentiality and used for the study purposes only. Therefore, you will not be named in any written work arising from the study. Should you require further clarity, you are free to discuss your concerns with the researcher.

I---------------------------------- give my consent to participate in the study titled; **Evaluating water supply to selected villages in the Greater Giyani Municipality.** I am aware that my participation in the study is voluntary and that I am free to withdraw my participation at any time.

Signature___________________

Date__________________________

APPENDIX B: QUESTIONNAIRE SURVEY TO VILLAGES

Instructions to respondents:

- There are no correct or incorrect answers to the items in this questionnaire.
- Complete the questionnaire as honestly as possible. The first response that comes to mind is usually the most valid response.
- Only one response per item is permitted.
- Note that your responses will make a valuable contribution to our understanding of the current sources of water supply at Greater Giyani Municipality.
- Please answer all the questions
- Completing the survey will take approximately 15 minutes
- The researcher and respondents will adhere to COVID-19 regulations namely.
    - Compulsory wearing of mask.
    - Washing hands with an alcohol-based hand sanitiser before and after survey.
    - Clean and disinfect pencils and surfaces before the survey.
    - Request the respondents that we must avoid touching our eyes, nose and masks during the survey.
    - Avoiding close contact with the respondents.

Section A: Demographic Information

	1. Gender	
1	Male	
2	Female	
	2. **Age Category**	
1	21-29 years	
2	30-39 years	
3	40-49 years	
4	50-59 years	
5	+ 60 years	
	3. **Position occupying in the village**	
1	Ward councillors	

2	Traditional leader	
3	Water committee member	
4	Leader of organisational parties	
5	Government official	
	4. **How long have you been living at Giyani?**	
1	0-3 years	
2	4-6 years	
3	7-10 years	
4	11-15 years	
5	16-20 years	
6	More than 21 years	

SECTION B

1. What are the sources of water supply in the village?

Improved Water Supply sources		Unimproved Water Supply sources	
Household connections		Unprotected well Service	
Public standpipe connection		Unprotected spring	
Borehole pour		Vendor-provided water	
Protected dug well		Bottled water	
Protected spring		Tanker truck provision of water	
Rainwater harvesting			

1.1. If, you don't have household connection how many litres do you collect per trip?

10L	
20L	
25L	
Others	

1.2 How many trips to you make per day?

01	
03	
05	
Others	

1.3 How many litres do you use for the following domestic activities?

Drinking	
Cooking	
House washing	
Personal hygiene	
Others	

2 How many are communal standpipes are in the village?

01	
02	
03	
04	
05	
More than 5	

2.2 Do you receive water every day from the taps?

Yes	
No	

2.3 If no, on which day of the week do you receive water?

Monday	
Tuesday	
Wednesday	
Thursday	
Friday	
Saturday	
Sunday	

2.4 What distance do community members travel to fetch water?

Less than 200 m	

200 m	
More than 200 m	

2.5 Who is responsible to fetch water?

Men	
Women	
Girl child	
Boy child	

2.6 The taps in the village are installed by?

Homeland government	
Democratic government	

3 What type of boreholes are in the village?

Private boreholes	
Government boreholes	

3.2 What is the state of the government boreholes in the village?

Functional d	
Not functional	

3.3 Do community members buy water from private boreholes?

Yes	
No	

If yes, how much does a container cost?

Less than R2.00	
R2.00	
More than R2.00	

4 Do municipality provide truck water from the treatment plant?

Yes	
No	

4.2 If yes, how many days in a week?

Once a week	
Twice a week	
Every day in a week	

5 Do you fetch water from the riverbank?

Yes	
No	

5.2 If yes, what do you use to treat the water before use?

Boil the water	
Use bleach	
None of the above	

5.3 Has the village previously experienced any outbreak of waterborne diseases?

Yes	
No	

5.4 If yes, what type of waterborne?

Diarrhoea	
Cholera	
Typhoid fever	
All the above	

APPENDIX C: QUESTIONNAIRE SURVEY TO MUNICIPALITY

Instructions to respondents:

- There are no correct or incorrect answers to the items in this questionnaire.
- Complete the questionnaire as honestly as possible. The first response that comes to mind is usually the most valid response.
- Only one response per item is permitted.
- Note that your responses will make a valuable contribution to our understanding of the current sources of water supply at Greater Giyani Municipality.
- Please answer all the questions
- Completing the survey will take approximately +-15 minutes
- The researcher and respondents will adhere to COVID-19 regulation namely.
    - Compulsory wearing of mask.
    - Washing hands with an alcohol-based hand sanitizer before and after survey.
    - Clean and disinfect pencils and surfaces before the survey.
    - Request the respondents that we must avoid touching our eyes, nose and mask during the survey.
    - Avoiding close contact with the respondents.

Section A: Demographic Information

	5. Gender	
1	Male	
2	Female	
	6. **Age Category**	
1	21-29 years	
2	30-39 years	
3	40-49 years	
4	50-59 years	
5	+ 60 years	
	7. **Position occupying in the village**	

1	Ward councillors	
2	Traditional leader	
3	Water committee member	
4	Leader of organisational parties	
5	Government official	
	8. How long have you been living at Giyani?	
1	0-3 years	
2	4-6 years	
3	7-10 years	
4	11-15 years	
5	16-20 years	
6	More than 21 years	

SECTION B

1. What are the sources of water supply in the village?

Improved Water Supply sources		Unimproved Water Supply sources	
Household connections		Unprotected well Service	
Public standpipe connection		Unprotected spring	
Borehole pour		Vendor-provided water	
Protected dug well		Bottled water	
Protected spring		Tanker truck provision of water	
Rainwater harvesting			

ETHICS APPROVAL CERTIFICATE

RESEARCH AND INNOVATION
OFFICE OF THE DIRECTOR

NAME OF RESEARCHER/INVESTIGATOR:

Mrs LS Monareng

STUDENT NO:
11562872

PROJECT TITLE: **Evaluating water supply to selected villages in the Greater Giyani Municipality.**

ETHICAL CLEARENCE NO: SES/21/HWR/09/1509

SUPERVISORS/ CO-RESEARCHERS/ CO-INVESTIGATORS

NAME	INSTITUTION & DEPARTMENT	ROLE
Dr FI Mathivha	University of Venda	Supervisor
Dr OS Durowoju	University of Venda	Co - Supervisor
Mrs LS Monareng	University of Venda	Investigator – Student

Type: Masters Research
Risk: Straightforward research without ethical problems (Category 1)
Approval Period: September 2021 – September 2023

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

General Conditions

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

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

ISSUED BY:
UNIVERSITY OF VENDA, RESEARCH ETHICS COMMITTEE
Date Considered: August 2021

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

Signature:

UNIVERSITY OF VENDA
OFFICE OF THE DIRECTOR
RESEARCH AND INNOVATION
2021 -09- 20
Private Bag X5050
Thohoyandou 0950

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