

**AN EVALUATION OF COMMUNITY PERCEPTIONS ON THE GREATER LETABA
RIVER AS A SOURCE FOR SUSTAINABLE LIVELIHOODS FOR THE COMMUNITY
OF MARIVENI, LIMPOPO PROVINCE**

by

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2025

DECLARATION

I, Mmamare Alice Lekganyane, declare that the dissertation titled; *An Evaluation of Community Perceptions on the Greater Letaba River as a Source for Sustainable Livelihoods for the Community of Mariveni, Limpopo Province*: hereby submitted to the University of Limpopo for the degree of Master of Science in Geography has not previously been submitted by me for a degree at this or any other university; that it is my own work in design and in execution; and that all materials contained herein have been duly acknowledged and fully cited.

LEKGANYANE MA

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Gratitude to the man above, God Almighty, God of Mount Zion. He who planned this path for me and made sure that I walked on it. I will eternally be grateful for what he has done for me.

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Abstract

The perceptions of the community towards rivers as a source of livelihood are quite crucial not only for the derived socio-economic livelihoods but also for the effective management of rivers as perception is central to how the local people perceive the river in terms of water quality, water quantity, and related land use changes. Moreover, it is important to promote their sustainability to ensure that they continue to provide social, environmental, and economic benefits to the communities. This study aimed to evaluate how Mariveni community members view the Greater Letaba River as a source of sustainable livelihoods. To collect data, a mixed-method approach was used involving a survey questionnaire which was administered to 98 households that were sampled randomly. Observation as a data collection technique was supplemented to note aspects such as activities around the rivers and other aspects that the respondents did not mention during the surveys. The senses of sight hearing, taste, and smell were used to determine water quality and water quantity. Almost 80% of the respondents indicated that they rely on the river as a resource. Nonetheless, many respondents indicated that the water quantity was reduced due to a decrease in rainfall and farm irrigation among others. The water quality was reported to be poor, and this was said to have been caused by the dumping of garbage in the river, farming activities, disposal of waste such as diapers, waste from animals, chemicals from farming activities, and sewage pipes draining into the river. Perceptions differed with the majority being those who indicated that there was no change. The respondents indicated that there was an increase in the frequency with which they visited clinics due to people becoming ill more regularly due to poor water quality. Fishing was no longer feasible which led to reduced related business and food security. There was also a reduction in recreational activities such as swimming. People had to travel to those households that sank boreholes to buy water at a high price and this also had an impact on the time spent with their families. Those who had gardens along the river could not irrigate which also hurt the recreational activities. The conclusion is that the community values the Greater Letaba River as a source of their livelihood. The recommendations include raising awareness through local structures such as the councilor through the Integrated Development Plan (IDP) for

recognition of the importance of the Greater Letaba as a valuable resource. The sinking of boreholes and dam construction were also some of the interventions recommended by the community but also but the researcher.

Keywords: *Mariveni community, sustainable development, water scarcity, water quality, climate change, livelihood, water pollution, perceptions.*

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LIST OF ABBREVIATIONS

AMD	Acid Mine Drainage
AUC	African Union Commission
AR	Assessment Reports
BC	Brundtland Commission
CMA	Catchment Management Agency
CO ₂	Carbon Dioxide
COCHSTA	Cooperative Governance, Human Settlement and Traditional Affairs
DEAT	Department of Environmental Affairs and Tourism
DEA	Department of Environmental Affairs
DWS	Department of Water Sanitation
DWAF	Department of Water Affairs and Forestry
ES	Ecosystem Services
ESKOM	Electricity Supply Commission
FET	Further Education and Training
GW	Greywater Water
GSDP	Gross State Domestic Product
GDP	Gross Domestic Product
HQ	Hazard Quotient
P	Phosphorus
IWRM	Integrated Water Resources Management
IPCC	Intergovernmental Panel on Climate Change
IDP	Integrated Development Plan
LULC	Land Use Land Change

LUC	Land Use Change
MDG's	Millennium Development Goals
NSAS	Nubian Sandstone Aquifer System
NW & SMP	National Water and Sanitation Master Plan
OECD	Organisation for Economic Cooperation and Development
RISDP	Regional Indicative Strategic Development Plan
RCP	Representative Concentration Pathway
SASOL	South African Coal and Oil Company
SAHRC	South African Human Rights Commission
SDG's	Sustainable Development Goals
SLA	Sustainable Livelihoods Approach
SL	Sustainable Livelihoods
SADC	Southern African Development Community
TVET	Technical Vocational Education and Training
TREC	Turfloop Research Ethics Committee
UN	United Nations
UNGA	United Nations General Assembly
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNCED	United Nations Conference on Environment and Development
WRC	Water Research Commission
WEFGR	World Economic Forum's Global Risks
WCED	World Commission on Environment and Development
WMA	Water Management Areas
WWAP	World Water evaluation Programme

WHO	World Health Organisation
WCC	World Council of Churches
WCDRR	World Conference for Disaster Risk Reduction

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Land and water are fundamental resources to generate food and represent two of the most essential resources for mankind (Hussain *et al.*, 2019). Water is not only essential to life and to thriving communities, but it brings value to land (Rugland, 2021). However, the sustainability of the farming system, food, income, and employment are severely threatened by the deterioration of land and water resources. Sustainability focuses on the ability of people to safely co-exist on earth over a long time (Dibaba *et al.*, 2020).

According to Zhang *et al.*, (2015) changes in land use have a direct impact on ecosystem services (ESs). The term "land use" describes how humans intentionally use land to accomplish goals that are at least somewhat impacted by the natural resources the land provides. Since land is a finite resource and is used by everyone, some laws and regulations protect and ensure it is used safely and fairly. Diverse land uses provide varying types of ecosystem services. For instance, forests can produce timber and store carbon, while croplands provide food and pasture, and water resources are essential for providing water and regulating water levels (Zhang *et al.*, 2015). Furthermore, other categories include land use for purposes such as residential, recreational, commercial, industrial and transportation (Kent, 2022). The loss and degradation of ESs directly threaten regional and global eco-safety and have substantial influence on human well-being (Msofe *et al.*, 2018; de Castro *et al.*, 2021). Population expansion and economic development exert increasing demands on the supply of ecosystem services, resulting in a variety of environmental effects. To accomplish sustainable land use management, it is imperative to comprehend Land Use Change (LUC) processes to maximise the efficiency of land resource use and mitigate any adverse landscape effects that may arise from LUC (Msofe *et al.*, 2018).

Water quality is defined as a measure of water use for different purposes such as domestic, industrial, agricultural and recreational. Water quality plays a central role in all aspects of living organisms on the earth, attracting the attention of a broad range of scientists, researchers, and water resource managers (Camara *et al.*, 2019). Understanding how land use affects water quality is essential to ensuring human well-

being. People's land production and living activities have a profound impact on the material input process of surface, river, and lake ecosystems. In the meantime, the landscape pattern of land use will also affect the surface runoff, biological cycle, and geochemical cycle process, so that pollutants entering rivers and lakes have significant impact on water quality. Healthy water quality is essential for sustainable agricultural production, human health, and ecological habitat stability (Cheng *et al.*, 2022). The spatial distribution of water quality reflects the process of social and economic activities and determines the surface hydrothermal and mass balance. Its change directly affects the biogeochemical cycle and alters the water, energy, and carbon cycles of land and atmosphere, leading to climate change (Cheng *et al.*, 2022).

This study is grounded on the human environment interaction theory by Hammond and others developed in 1995 (Iglis, 2008). The author (Iglis, 2008) further expands the "human-environment" phrase that it refers to the historical and current interactions between people and their built and natural surroundings, as well as the corpus of literature on these topics that looks at place attachments, ecological orientation, and nature values (Iglis, 2008).

Human activity has an impact on the environment, as seen by Hammond's model. Although this model encompasses all human activity, knowledge of the interrelated components of the model enhances comprehension of potential consequences for diverse behaviors in the surrounding context. Behaviour often resonates from people's attitudes and perceptions (Akintunde, 2017). The environment has served as a home for both humans and several other species; nevertheless, due to human greed, people have developed strategies for survival and adaptation. However, the fact remains that environmental health is inextricably related to the health of the global economy and population (Lynam, *et al.*, 2012; Akintunde, 2017).

Perception is the process of attaining awareness or understanding of sensory information. Since the world embraces everything, these are countless stimuli arriving at the sensory organs simultaneously and waiting to be processed. However, it cannot be perceived that all the information is available to us, because in doing so we would

experience information overload and disorder. Therefore, we perceive only part of the information from the environment through a selective process (Qiong, 2017). It builds a person's cognitive structure upon which reasoning, decision making, and behaviour are based (Lynam, *et al.*, 2012). Attitude, on the other hand, is one of the main properties of the human psyche, which expresses a reaction within the interaction with the surroundings and may include cognition (thought), affect (emotion) and behavioural predispositions (Gaiseanu *et al.*, 2020).

1.2 Problem statement

There has been a persistent decline in water quality throughout history, mostly in the 20th century, with increasing complexity and cumulative consequences for human health. Numerous regions throughout the world experience reduced water supplies due to pollution, which makes human populations more vulnerable. The loss of biodiversity, the increase in treatment costs, or the effect on human health can all be used to explain the economic effects of declining water quality (Tundisi *et al.*, 2015).

Rivers are a source for sustainable livelihoods in that they supply water for domestic rural and urban use, agriculture, industries, and tourism activities and maintain aquatic life. The Department of Water and Sanitation has reviewed the reconfiguration of the nine to six Water Management Areas (WMAs). The proposal is to establish six Catchment Management Agencies (CMAs) nationally (NWRS-3, 2021). The Limpopo, Inkomati, Pongola/Maputo, and orange river systems cover an estimated 60% of the country's surface area and have a 40% average river flow (DEA, 2011). The Greater Letaba River, which is a tributary of the Limpopo River System, falls within the Olifants River Basin (WMA). The sub-catchment drains a surface area of about 13,670 km². The Great Letaba River is a perennial river contributing over 50% of the downstream flow of the Olifants River into the Kruger National Park (KNP) (Kekana *et al.*, 2022).

The Greater Letaba River as a natural resource is important for agricultural purposes (both subsistence and commercial) which boost the local economy including that of Mariveni village thereby alleviating rural poverty. Mariveni is one of the villages located along the Greater Letaba River. Several studies have been conducted on the Greater Letaba River with an emphasis on water quality and LUC issues. Literature sources

show that perceptions of people on this river as a source of sustainable livelihoods have never been undertaken anywhere in the Greater Tzaneen Municipality and specifically at Mariveni village (Greater Tzaneen Municipality SDP, 2017). Evaluating the perceptions of the community of Mariveni on the Greater Letaba River as a source for sustainable livelihoods is therefore what this study intends to achieve.

1.3 Aim, objectives and research questions of the study

1.3.1 Aim of the study

The aim of the study is to evaluate how Mariveni community members view the Greater Letaba River as a source of sustainable livelihoods.

1.3.2 Objectives of the study

The objectives of the study are to.

- i. assess community of Mariveni's source of livelihoods emanating from the Greater Letaba River.
- ii. establish the changes in the water quality and quantity of the Greater Letaba River as perceived by the community in Mariveni village.
- iii. determine the possible impacts that the change in the Greater Letaba River has on the socio-economic value of the community of Mariveni village.
- iv. assess the mitigation strategies on the sustenance of the Greater Letaba River by the local authorities as a source of sustainable livelihoods.

1.3.3 Research questions

- i. What are the community members' sources of livelihoods emanating from the Greater Letaba River?
- ii. What are the possible factors that affect water quality and quantity of the Greater Letaba River?
- iii. How has the water quality and quantity in the Greater Letaba River affected the socio-economic status of the community of Mariveni village?
- iv. Which mitigation strategies have been implemented by the authorities in Mariveni village to ensure that the Greater Letaba River is sustained as a source of sustainable livelihoods?

1.4 Scientific contribution

The study is beneficial in that it emphasises the socio-economic impacts of the Greater Letaba River on the community of Mariveni. South Africa is a semi-arid country with water shortage at the forefront of the country's crisis therefore; factors which affect the river negatively are also highlighted in the study. This serves as an awareness guide for the community members of Mariveni to take care of their natural resources for future generations. The study findings also contribute towards the body of science by providing empirical evidence, which will inform the development of appropriate interventions. Furthermore, the study is expected to highlight and increase awareness on current water constraints experienced in the study area. In addition, insight into current and future areas of infrastructural and service improvement and augmentation will be provided. Finally, the study will also provide knowledge on the possible water management strategies that can be implemented to conserve the river as a natural resource in the Greater Tzaneen Local Municipality.

1.5 Ethical consideration

The University of Limpopo Turfloop Research Ethics Committee (TREC) provided ethical clearance because the study involved human participation (see addendum B). In addition, the researcher also sought authorisation from the Greater Tzaneen Local Municipality, Traditional Authority and Ward Councillor to conduct research. To ensure the respondents' privacy and confidentiality, those who wished to remain anonymous were treated as such. During data collection, the researcher ensured that participants' willingness to participate in the study was taken into consideration to maintain standard of care and dignity. In addition, home language is a person's pride therefore, the researcher ensured that participants who saw it fit to use their home language when responding to questions were free to do so. The researcher together with field assistants wore proper attire during data collection and walked in pairs to eliminate risks. The researcher complied with research principles, considerations, and guidelines to avoid data fabrication, forgery and plagiarism.

1.6 Limitations of the study

The study was conducted at Mariveni Village which is an area wherein Tsonga is the dominant language. Language barrier presented to be a hindrance during data collection. Therefore, an interpreter was employed to assist in translation. Again, time was an issue during data collection because of distance leading to the sample size being modified to address the issue. More field workers were therefore engaged in assisting with data collection.

1.7 The study area

The study was conducted at Mariveni village. The focus of the study was the Greater Letaba River. The river passes Mariveni village on the northern side (refer to figure 1 below). The village is situated in the Greater Tzaneen Local Municipality, and it is 38,9km from Tzaneen town. The geographical location is 23⁰89'03"S and 30⁰34'89E (STATS SA, 2010; DWS, 2018). The municipality is one of the five local municipalities in Mopani District Municipality, others being Greater Letaba, Greater Giyani, Ba-Phalaborwa and Maruleng (COGTA IDP, 2020). Greater Tzaneen Local Municipality is divided into four clusters namely, Bulamahlo, Lesedi, Relela and Runnymede. Mariveni is one of the villages in Lesedi cluster (Greater Tzaneen Municipality SDP, 2017). The municipality has a range of natural resources such as Mopani trees and serves as a host to diverse tourism attractions.

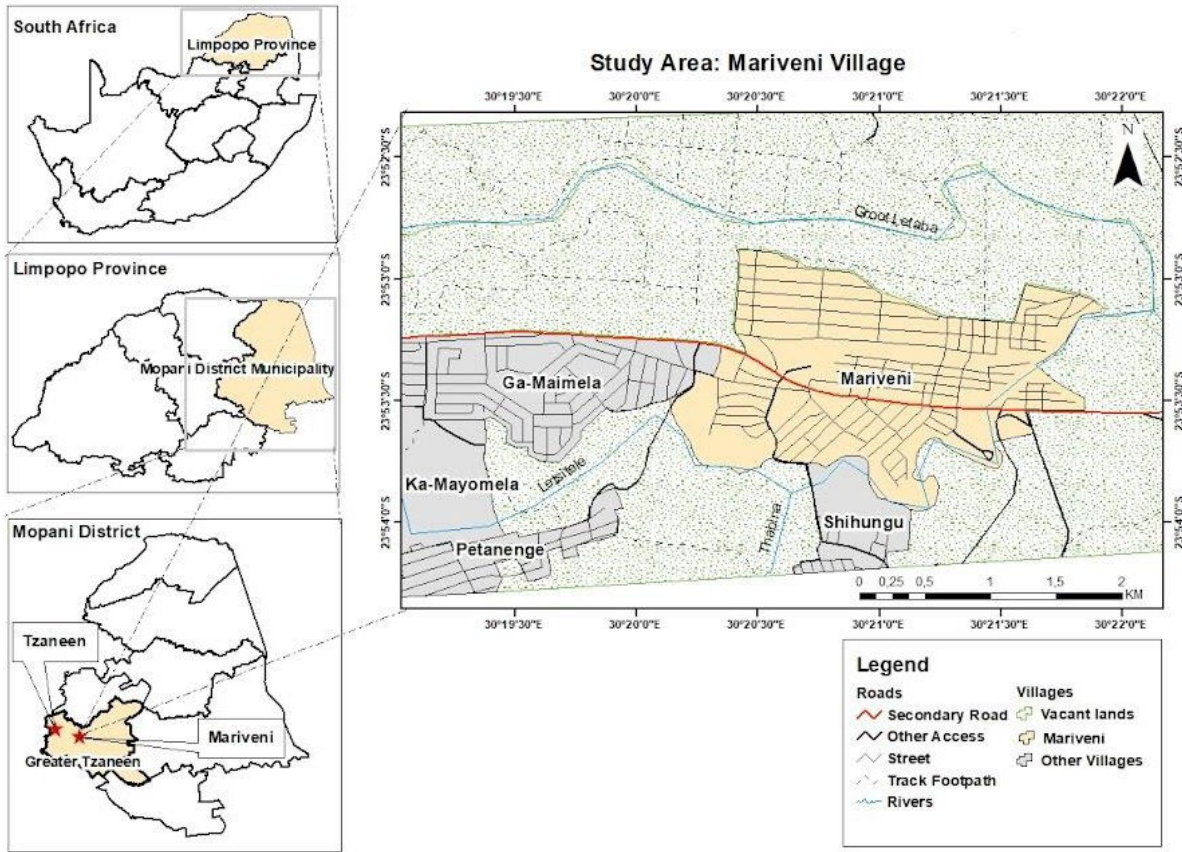


Figure 1:Map of Mariveni village(Mashao., 2021).

1.8 Organisation of the study

Chapter one gives a thorough explanation of the background, problem statement, the aim, objectives, and research questions of the study. This chapter also includes scientific contribution, ethical consideration, limitation of the study, the study area and a summary of the study. **Chapter two**, on the other hand, provides a broad literature review from past research about land use land change and water resources which includes quality and quantity, A conceptual framework of the study is also included in this chapter. **Chapter three** describes the methodology used to collect and analyse data for the study. It is divided into the research design, research sampling and data collection and analysis methods. **Chapter four** presents the results of the analysed data in detail and discuss them from a perspective of information obtained from research documents and other sources of literature. **Chapter five** provides for the conclusions that were drawn from the research as a whole. The chapter ends with the suggested

recommendations. A list of all references from sources used in the study is included at the end of the dissertation while the relevant addenda are attached at the end of the document.

1.9 Summary of chapter

This chapter provided a brief background into human interaction with the natural environment with specific focus on land use, land change and water resources. The problem statement together with the aim, objectives and research questions of the study are included in this chapter. Description of the study area, limitations of the research as well as the scientific contribution and the ethical considerations are also part of this chapter. Lastly, the layout of chapters is included.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews previous studies on water as a resource for sustainable livelihoods as well as land use land change issues. The following resources were reviewed: policy papers, books, dissertations, government documents, conference proceedings, and scholarly-refereed journals. This chapter provides a background context for the study, and it is divided into the following subsections: Land Use Land change, water as a source for livelihoods, sources of water, strategies to augment water supply, sustainability, water quality and quantity in South Africa, legislative frameworks, case studies and conceptual framework of the study.

2.2 Land use Land change (LULC)

Msofe *et al.*, (2018), states that land encompasses all elements of the biosphere, both above and below the surface. Land also includes the types of soil and terrain, the surface hydrology (including shallow lakes, rivers, marshes, and swamps). Furthermore, it includes the near-surface sedimentary layers and the corresponding groundwater reserves, the populations of plants and animals, the patterns of human settlement, and the physical consequences of past and present human activity. Land cover refers to the physical characteristics of the land surface, such as croplands, mountains, or forests. It also includes the amount and kind of surface water, and soil components (Msofe *et al.*, 2018;de Jong *et al.*, 2021).

Scenarios of LULC play a vital role in exploring future developments and policy options for climate change, biodiversity, food security, ecosystem service and sustainable development. There are around 15 billion hectares of land worldwide. Around 2% of this area is covered by cities and infrastructures (Bringezu *et al.*, 2014). The number of people living in cities worldwide has grown significantly, from 751 million in 1950 to 4.2 billion in 2018. The UN projects that by the year 2050 there will be 9.7 billion people on the planet from the current estimated 7.7 billion. Furthermore, urbanisation may result in an extra 2.5 billion people living in urban areas globally with 90% of this increase occurring in Asia and Africa(Dawson, 2018; Profiroiu *et al.*, 2020; Uhunamure *et al.*, 2021).

Population and economic development are the most important determinants for food demand. Population growth and changes in consumption patterns put unprecedented pressure on global natural resources (Stehfest *et al.*, 2019). High population growth pushes down per-capita consumption due to higher food prices resulting from an increased pressure on land and production which often leads to reduction in crop yields and limitations of farmland production and increasing the risks to food security (Stehfest *et al.*, 2019; Spinoni *et al.*, 2021). Raising understanding of the connections between population, environment, and development on a worldwide scale is a significant challenge. Thus, it is imperative that people become more aware of the effects of the world's expanding population and excessive consumption to protect the environment (Ganivet, 2019).

2.3. Water as a resource

Water is an essential and irreplaceable component of life, a critical source for ensuring adequate food supply, serve as a habitat supporting an ecosystem and it is of services for water-based ecosystems. It is critical for human society development (Panel José *et al.*, 2018; Hellberg, 2019; Nyam *et al.*, 2020). Water resources are typically limited, dispersed unevenly throughout the world, and extremely susceptible to climate change. The total water resources available in the world are estimated to be in the order of 46,000 km³/year, including 36,000 km³/year of surface water and 10,000 km³/year of groundwater. The United States of America has the largest share of the world's total freshwater resources with 45%, followed by Asia with 28%, Europe with 15.5% and Africa with 9% (Gaye *et al.*, 2018).

2.3.1. Sources of water

Surface water and groundwater are examples of water sources (Drinan *et al.*, 2013). The main components of water resource management in South Africa include return-flow management, water storage, abstraction, and watershed and river systems (Nyam *et al.*, 2020).

2.3.1.1. Groundwater

Groundwater is a source for the earth's surface natural springs and fountains stored in aquifers beneath the earth's crust (Drinan *et al.*, 2013). It is a key supply of freshwater

for the global population. Groundwater is used for domestic, agricultural, and industrial purposes, among other things. It supplies about 97% of the world's accessible freshwater. Globally, about half of the irrigation water used for agriculture is derived from groundwater and supplies drinking water to around a third of the global populace. In dry and semi-arid locations with little precipitation and surface water, groundwater is a particularly valuable resource. When other sources are insufficient, it becomes an essential buffer resource (Jakeman *et al.*, 2016; Galanakis *et al.*, 2019; Peiyue Li *et al.*, 2020).

About 90% of water used in countries like Saudi Arabia, Austria, Denmark, Belgium, and Denmark comes from aquifers. Additionally in Northern Europe and Japan groundwater is primarily used for home and industrial uses (Jakeman *et al.*, 2016). The Nubian Sandstone Aquifer System (NSAS) is the world's largest fossil water aquifer system. It covers an estimated area of 2.6 million km², including parts of Sudan, Chad, Libya, and most of Egypt. The System is made up of three major sub-basins: Kufra, Dakhla, and the N. Sudan Platform. NSAS is crucial since it is the only viable source of water for future development plans in northeastern Africa's arid regions. In the southwestern part of Egypt, the Sharq El Owainat or East Oweinat development project uses central pivot irrigation to mine the fossil water for extensive agricultural development. Crops include wheat and potatoes (California institute of technology, 2021). Egypt and Libya, faced with overpopulation issues and a need to create additional agricultural fields to sustain their growing populations, established plans to develop and utilize the aquifer over the previous three decades. As a result, the NSAS is heavily exploited in these countries for agricultural and drinking water purposes (Mohamed *et al.*, 2022). Jakeman *et al.*, (2016) echoes the same sentiment as Mohammed and other authors that large aquifers that are essential to agriculture are in danger due to overexploitation, especially in Mexico, China, Iran, Saudi Arabia, India, Pakistan, and the United States.

The total groundwater storage estimated based on globally accepted methods for South Africa is about 17400 km³. Not all this groundwater storage is available for abstraction as it varies spatially (Abiye, 2023). The National Water and Sanitation Master Plan

(2018) states that the present use of groundwater is estimated at between 3 000 and 4 000 million m³/a. The Northern Cape and the western section of the Northwest Province, which are dominated by the Kalahari sediments underlined by Karoo sedimentary rocks, contain the largest groundwater storage in South Africa, often due to the confined nature of the aquifers (Nkosi *et al*, 2021; Abiye, 2023). According to the Department of Water and Sanitation (DWS), (2022), more than 50% of available groundwater is being utilised in five Water Management Areas (WMAs) across the country, with the highest utilisation happening in Limpopo.

It is extensively used for various economic and domestic activities all over the country (Abiye, 2023). An article by groundwater division, (2014/15) agrees with Abiye that groundwater is an important source used primarily for irrigation as agriculture is vital in South Africa; groundwater also supplies more than 300 towns and smaller communities with water. The DWS acknowledges groundwater as a national asset and an integral part of South Africa's water resource which has helped to reduce the backlog for domestic water supply in different parts of the country. Abiye, (2023) states that groundwater plays a paramount role in sustaining streamflow, lakes, wetlands and aquatic ecosystems during dry periods; for example, during the recent drought in the Western Cape in 2017/18, industry sought to develop alternative water sources to ensure continuity of supply, and to alleviate pressure on the City of Cape Town's supply network. Two businesses that were able to successfully develop groundwater resources are Distell and Peninsula Beverages. In doing so they were able to improve their water security and support the greater community in avoiding the "Day Zero" scenario (Electromagnetic loop for aquifer surveys, City of Cape Town, 2021).

The natural groundwater flow is impacted when groundwater abstraction surpasses recharging over prolonged periods of time and over wide areas. This can have detrimental effects on streams, wetlands, and ecosystems that depend on groundwater (Wada *et al.*, 2010). Major groundwater aquifers in South Africa cannot be utilised due to contamination which occurs when manmade products such as petrol, oil and other harmful substances get into groundwater supplies and cause it to become unsafe and unfit for human use. This is more evident in the eastern and north-eastern parts of the

country and the Western Cape. Deteriorating groundwater quality may have severe health impacts on health and livelihoods in communities using polluted groundwater without treatment (Nkosi *et al.*, 2021; DWS, 2022). Groundwater provides a lifeline that needs to be focused on for further utilisation to advance the sustainable development of South Africa (Abiye, 2023).

2.3.1.2 Surface water

According to Drinan *et al.*, (2013), common sources of surface water include lakes, rivers, and spring or precipitation water that have been directed into reservoirs for surface water storage. The nation's rivers flow approximately 49 200 million m³/a (DWS, 2014/15). Given the nation's entire annual runoff of over 49 000 million m³/a, there is a consistent surface water supply yield of 98% on almost 10 200 million m³/a. The northeastern section of the country is home to most the country's major water source regions, with 8% of the geographical area contributing 50% of the average annual runoff (NW&SMP, 2018). More than 4395 dams are officially recognised in South Africa, of which 794 are classified as major dams. Dam storage accounts for almost two-thirds of average yearly runoff (Masindi *et al.*, 2016).

Currently, the nation boasts more than 120 river systems; of these, 82% are under threat, 44% are critically endangered, 27% are endangered, 11% are vulnerable, and 18% are least threatened (Nyam *et al.*, 2020). South Africa is mostly dependent on surface water supplies for agricultural, industrial, and urban needs. The Integrated Vaal River System provides water to the whole of Gauteng province, the South African Coal and Oil Company (SASOL) Petro-chemical industry, and the South Africa Electricity Public Utility (ESKOM) power facilities in Mpumalanga. Operating rules assist in the efficient management of the water supply system, and are critical during drought situations, also to trigger water restrictions when required (NW & SMP, 2018). The Department of Water and Sanitation (DWS) developed operating rules for several large water supply systems in South Africa, such as the Integrated Vaal River System, the Mngeni Water Supply System, the Orange River System, the Algoa System, the Amatole System, the Western Cape System and the Groot Letaba System, as well as rules for several stand-alone schemes (NW & SMP, 2018).

2.3.2 Water as a source for livelihoods

As far as sustainable development goes, water is regarded as the most important resource. It is crucial not just for economic growth, industry, and agriculture, but also for the environment's most vital element, nature protection and human health because of its profound effects (Chartzoulakis *et al.*, 2015).

2.3.2.1 Water in the agricultural sector

In almost every area of agriculture, water is a vital input that determines the final harvest. If plants are not properly irrigated, even the best fertilizers and seeds will not work to their maximum capacity (Dhawan, 2017). Over the course of the previous century, the amount of land under irrigation worldwide has expanded more than six times, from about 40 million hectares in 1900 to more than 260 million hectares. Nowadays, the 18% of cropland that receives irrigation provides 40% of the food consumed worldwide. The irrigation infrastructure is made up of a system of canals that connect rivers, groundwater, well-based systems, tanks, and other goods that collect rainfall for use in agriculture (Chartzoulakis *et al.*, 2015).

Utilising water resources sustainably will surely be essential as the food production system gets ready to satisfy the demands of a growing population (Cook *et al.*, 2009). With respect to global agricultural production, India is ranked second. In 2013, agriculture and related industries, including forestry and fisheries, employed 50% of the labour force and generated 13.7% of the GDP (Gross Domestic Product). About two-thirds of India's crops still rely on the monsoon, with 39 million hectares watered by groundwater and 22 million hectares by irrigation canals (Dhawan, 2017). China has seen a sharp increase in soybean imports over the past 20 years because of the nation's rising meat consumption. It is projected that by 2024, the combined soybean production of Brazil, Argentina, and the United States of America will not be enough to supply China's demand due to present trends (Ganivet, 2019).

Nhemachena *et al.*, (2018) states that initiatives from the African Union Commission (AUC), which support the Sustainable Development Goals (SDGs) and other national development programmes of member states, recognise the agricultural sector's contribution to economic development and sustainable livelihoods on a continental and

worldwide scale. Furthermore, the region's fulfilment of sustainable development goals at the Southern African Development Community (SADC) level depends heavily on the agriculture sector's strategic priority and cross-cutting environmental and sustainable development difficulties. Food security and trans-boundary natural resources were identified as special regional projects in the 2015–2020 revised Regional Indicative Strategic Development Plan (RISDP). Over 60% of people in the SADC area rely on the agricultural sector for their primary source of income (both directly and indirectly), which suggests that the sector's performance has a big impact on food security, poverty alleviation, and economic growth. Furthermore, the agriculture industry makes up 17% on average of the region's GDP, and when the middle-income countries are taken out of the equation, that proportion rises to almost 28% (Nhemachena *et al.*, 2018).

According to United Nations (2019) forecasts, South Africa's population will reach 68 million by 2035 and 75 million by 2050. Although agriculture is important for food production, population growth ultimately puts more pressure on demand for food production which in turn affects water supply. Agricultural irrigation accounts for approximately 62% of the total annual water volume available from both surface and groundwater sources (Ayisi *et al.*, 2021). Therefore, water is vital source for agricultural development. Agriculture, forestry, and fisheries are some of the primary economic sectors which contribute to roughly 12.2% GDP growth (DWS, 2019/2020).

2.3.2.2. Water in the mining sector

According Härkisaari *et al.*, (2017) mining has played a crucial role in human endeavor for thousands of years, providing raw resources for enhancing safety and standard of living as well as constructing the modern industrial society. For many centuries, the extraction of iron, gold, silver, copper, tin, lead, diamonds, and coal has been one of the most significant mining activities in our history. With 33.5% of global mineral production, China is the world's largest producer of mineral raw materials (apart from petroleum and natural gas). The United States of America is second with 12.0%, Australia with 7.9%, Russia with 7.1%, India with 6.4%, South Africa with 4.7%, Indonesia with 4.0%, Brazil with 2.1%, and Canada with 2.0% (Härkisaari *et al.*, 2017).

One of the major cornerstones of the South African economy is the mining industry. The Witwatersrand Gold Mining Basin is the world's largest gold mining basin which spans over 1,600 km². Abiye (2023), states that an estimated 8% of groundwater sustains the mining sector. Furthermore, a significant concentration of coal mining activity is concentrated in Emalahleni, Mpumalanga Province. Along the primary water source catchment, there are twenty-four operational coal mines in the country (Kamunda *et al.*, 2016; Mhlongo *et al.*, 2017). The coal industry is South Africa's third-largest water consumer (Donnenfeld, 2018). In the mining industry, water is often consumed for cooling purposes (Oberle, *et al.*, 2019). To avoid any health problems, the watershed region needs to have its water quality monitored and purified with diligence and effectiveness (Mhlongo *et al.*, 2017).

2.3.2.3. Water in the tourism sector

Tourism is recognised as a catalyst for socio-economic development in both industrialised and developing nations. The industry produces valuable foreign exchange, creates jobs, and aids in the development of infrastructure and the reduction of poverty (Venugopalan, 2021). Water as a resource is vital to the travel and tourism sector. It is crucial for both recreational activities and fundamental human requirements, and it is also one of the main factors keeping the industry viable (Ribas *et al.*, 2017). Recreational travel includes activities such as social visits, cultural excursions, religious journeys, family vacations, sporting events, and medical visits. Hotels, swimming pools, golf courses amongst others forms part of water-based tourism. Participating in such recreational pursuits has the potential improve a person's physical and mental health due to its calming effect on the body and mind, the alleviation of stress, and the provision of an enjoyable life (Zhu, 2023). Most highly developed western nations, like France, Switzerland, and Austria, have built up a sizable portion of their social and economic welfare from tourism-related revenue. Tourism generates almost 10% of the world's GDP and employs over one in ten people worldwide (Geethika *et al.*, 2015).

Fauzi *et al.*, (2024) mention that Indonesia is renowned as a premier rural tourism destination, showcasing breathtaking and pristine rural scenery, vibrant traditions, and a

distinctive rural lifestyle. The expansion of rural tourism in Indonesia is significant, as the number of tourist villages was projected to reach 4,732 by 2023. These villages provide avenues for sustainable local economic growth. They play a role in generating employment, empowering communities, and fostering an entrepreneurial mindset among local inhabitants. One area with significant rural tourism potential is the Kedung Ombo reservoir area in Central Java Province. This vast reservoir is the largest in Southeast Asia and presents opportunities for water tourism, culinary tourism, nature tourism, and agro-tourism. Various community groups have established tourist attractions within and around the reservoir, offering a range of experiences (Fauzi *et al.*, 2024).

Dube *et al.*, (2020) state that one of the fastest-growing industries is tourism, with economic growth rates that exceed national rates, contributing to global economic development. Several nations have expressed a wish to use tourism as a means of accomplishing their Sustainable Development Goals (SDG). To improve their sustainable performance, stakeholders in the tourist sector in Africa and beyond have begun to adopt the SDGs framework, with varying degrees of success and difficulty (Dube *et al.*, 2020). Before the arrival of Covid-19, South Africa was ranked the top tourism destination in sub-Saharan Africa. According to the World Travel and Tourism Council, the 2018 contribution of the tourism sector in South Africa directly accounted for 2.8% of GDP, which amounts to R139 billion. The indirect contribution of the tourism sector to the country's GDP in 2018 stood at an even higher 8.2%, according to the Department of Tourism (Stats SA, 2018; Dube *et al.*, 2020). In addition, the tourism sector direct employment accounted for 4.2% of total employment in the South African economy in 2018, while tourism's indirect contribution to total employment stood at 9.2% for 2018 (Dube *et al.*, 2020).

The uMngeni area receives the highest proportion of visitors to KwaZulu-Natal. Various tourism attractions rely on natural resources in the uMngeni catchment area, especially water-based natural capital. The region is a hub for water sports, including the Midmar Mile and the Dusi Canoe Marathon (also known as the 'Dusi'). The Dusi marathon is an annual three-day paddling race held along the uMsunduzi and uMngeni rivers between

Pietermaritzburg and Durban. The race is the largest canoeing event on the African continent attracting between 1 500 and 2 000 paddlers each year. In 2017, the event generated an estimated direct economic impact in the region of R4 million and an indirect economic impact of up to R9 million (The Water Wheel September/October 2020). Loskop Dam is located about 32 km south of Groblersdal in Mpumalanga, in the upper catchment of the Olifants River. The dam is a freshwater angling hot spot and popular tourist attraction. The dam is surrounded by the 25 000 ha Loskop Dam Nature Reserve. Loskop Dam and associated activities like fishing competitions, water sports and lodges play an essential role in the economy of the area (The Water Wheel September/October 2020).

2.4 Strategies to augment water supply

A significant shortage of water has resulted from rising worldwide population growth, climate change, greater irrigation, and economic development, particularly in arid and semi-arid countries. The possible global impact of the water problem has been recognised by the World Forum as a global danger. Globally, there has been a growing demand for freshwater. These problems had necessitated the development of several techniques to increase water. One of the main strategies for addressing water scarcity is integrated water resources management (Galanakis *et al.*, 2019).

2.4.1 Stormwater or rainwater harvesting

There is a need to reduce reliance on conventional surface water schemes and seek alternative sources of water supply to avert a future water crisis. Within urban areas, municipalities must find ways to adapt to, and mitigate the threats from, water insecurity. Stormwater harvesting (SWH) is one alternative water resource that could supplement traditional urban water supplies (Fisher-Jeffes, *et al.*, 2016; NW&SMP, 2018).

According to Fisher-Jeffes *et al.*, (2016), the Atlantis Water Resource Management Scheme (AWRMS) has been in operation since 1979. An important design aspect of this SWH system was the use of the town of Atlantis as a significant component of the catchment. The town was planned with separate residential and industrial areas, which allowed for the separation of high- and low-quality wastewater effluent. Stormwater and

higher quality treated municipal effluent are used to recharge an unconfined aquifer for later extraction and use. Low-quality water is disposed through recharge near the coast in such a way as to create a hydraulic barrier between the cleaner groundwater and the seawater.

The Department of Water and Sanitation (DWS) backs a nationwide initiative to collect rainwater, with a significant emphasis on helping rural households build above- and below-ground rainwater storage tanks for food gardens and other uses. Roof rainwater tanks are becoming common in many communities for residential usage, and they work especially well when combined with other water supply alternatives. Although the exact number of cubic millimeters that rainwater harvesting can generate annually is still unknown, it is a quick-to-implement solution (South Africa Yearbook, 2014/15).

2.4.2 Desalination strategy

Galanakis *et al.*, (2019), reports that an estimated 70% of the planet is made up of oceans, with freshwater making up only 2% of the total. Many elements of the planet have been impacted by climate change. Storm surge, sea level rise, and flooding are all caused by the hydrological cycle, which is clearly impacted. To address the problems related to water scarcity, desalination of brackish or saltwater has emerged as a competitive technological and financial option. Among the different alternative solutions for solving the issues of water scarcity, desalination is only implemented as a last resort when conventional freshwater resources have been stretched to the limit. Desalination is considered as a drought-proof water source, since it does not depend on river flows, reservoir levels, or climate change.

Dhakal *et al.*, (2022), states that large-scale seawater desalination began in the 1960's using thermal distillation processes such as multi-stage flash (MSF) and multi-effect distillation (MED). The membrane-based technology reverse osmosis (RO) was introduced into the market in the 1970s, mainly to treat brackish water. Since the 1980s, advances in membrane technology and materials have made it possible to use RO technology for seawater applications. As a result of this advancement, since 1999, membrane-based technologies, including RO, electrodialysis (ED), and nanofiltration

(NF), have become the most dominant technologies for water desalination. Based on the available data, RO is currently the most applied technology, not only for seawater desalination, but also for drinking water and industrial water production. At present, the Middle East is the largest market for desalination, but there are also large-scale desalination programmes in Australia, Algeria, the USA and Spain (The Water Wheel, 2011). Countries such as Afghanistan, Eritrea, Ethiopia, Niger, Nigeria, Pakistan, Somalia, Sudan, and Tanzania have already installed seawater and/or brackish water desalination plants. The user category in most of these countries that have already installed desalination plants is mainly for municipal water and industrial water use (Dhakal *et al.*, 2022).

Desalination of brackish groundwater has been in operation for decades in various small towns and settlements in the Northern Cape and along the coast, sometimes for emergency supply during droughts. The coastal town of Bushmans River Mouth in the Eastern Cape is also being served by a seawater desalination plant for more than 20 years. During the devastating drought of 2009-2011 in the Southern Cape, several small desalination plants were established at coastal towns, i.e. Sedgefield, Knysna, Plettenberg Bay and Mossel Bay, the latter being the largest plant at 15 Ml/day (NW&SMP, 2018). The plant at Mossel Bay has been mothballed since its completion as an emergency scheme in 2011, as its water has not been required since then (NW&SMPM, 2018). Reverse osmosis, which is the most used desalination technology in South Africa, works by forcing seawater through many layers of a specialised membrane under high pressure, leaving the salt concentrate on one side of the membrane and desalinated water on the other (The Water Wheel, 2011).

Desalination is a costly process because it is often chemically, energetically and operationally intensive and focused on large systems. Therefore, it requires a considerable infusion of capital, engineering expertise, and Infrastructure. Despite all these facts, desalination is gaining a market to meet the demand of freshwater shortage worldwide (Galanakis *et al.*, 2019; Dhakal *et al.*, 2022).

2.4.3 Water re-use

The indirect re-use of water at present is estimated to already account for about 14% of all available water. Water is re-used indirectly on a large scale in in-land areas, such as in Gauteng in the Vaal and Crocodile-West catchments, as the return flows from the wastewater plants forms part of a down-stream raw water abstraction from the same river. The water re-use schemes in Beaufort-West (direct re-use) and George (indirect re-use), which were also built because of the 2009-2011 drought, are operating full time and supply good quality water to the inhabitants. The Department of Water and Sanitation developed a National Strategy for Water Re-use (NSWR) in 2011. The intent of the water re-use strategy is to encourage wise decisions relating to water re-use at different scales and levels (NW&SMP, 2018). The performance of existing wastewater treatment plants in terms of meeting discharge standards and reliability is critical to the successful integration of water reuse into reconciliation strategies and into water supply systems in SA (NW&SMP, 2018).

Greywater (GW) is less polluted domestic water, excluding that from toilets. This water can serve as an essential resource for consumption. Global regulations have mandated greywater recycling. Greywater is divided into two groups: light greywater and dark greywater. Dark GW comes from the kitchen, and light GW comes from washbasins and bathrooms (Galanakis *et al.*, 2019).

2.5 Water quality and quantity in South Africa

Water is essential for life; it drives socioeconomic development and supports healthy ecosystems. Without access to reliable sources of water, the economy will suffer. South Africa is a water-scarce country, one of the thirty driest countries in the world with an average annual rainfall of approximately 460 mm, less than half the world average (CSIR, 2021). Water quality is a major concern worldwide, according to reports. Water quality issues plague both emerging and developed countries. According to the World Bank Report, water pollution jeopardises nearly all agreed-upon SDG's to stop environmental degradation, poverty, and suffering by 2030 (DWS, 2019/2020).

2.5.1 Impacts of poor water quality and quantity on agriculture

According to the DWAF (2002) report, Inorganic Chemical Water Quality of Surface Water Resources in SA, the composition of mineral salts is the primary indicator of the state of water quality in South Africa. Natural soil erosion and the washout of naturally occurring salts in the soil are the two main sources of mineral salts; human settlements and activities also contribute to this process (National Climate Change Response White Paper, 2011). The agriculture sector's performance is anticipated to be significantly impacted by climate change, which will have a negative impact on the accomplishment of food and nutrition security. Southern Africa's agricultural systems were found to be susceptible to the effects of climate change, according to the Fourth and Fifth Assessment Reports (AR4 and AR5), which were published with a medium degree of confidence.

Due to the widespread effects of the El Niño Southern Oscillation (ENSO)-induced drought in 2015–16, over 40 million people, or 14% of the Southern African Development Community population, experienced food insecurity. Lots of animals perished because of the drought, and 5.1 million tonnes less corn were produced overall (National Climate Change Response White Paper, 2011). Falling dam water levels have resulted in energy insecurity in several nations whose electricity is generated by hydropower. Based on empirical data, the SADC agricultural productivity would be greatly impacted by anticipated climate change (National Climate Change Response White Paper, 2011).

Based on available data, climate change will cause a 50% decline in agricultural production in the region by 2080. Except for South Africa and Zambia, the region already experiences shortages for the main primary crops, so this is concerning. A decline of any kind would exacerbate the food and nutrition insecurity in the region. According to the United Nations Development Program (UNDP), unfavorable environmental variables like water scarcity, climate change, and land degradation may cause food costs to rise by 30 to 50% in the upcoming decades. The greatest effected will be low-income populations because these increases have an impact on their health (Naidoo *et al.*, 2018).

2.5.2 Climate change on water quality and quantity

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 by several states working together. The IPCC defines climate change as the state of the climate that can be identified statistically by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (Dagbegnon *et al.*, 2016). As a result, the 1992 United Nations Conference on Environment and Development saw the introduction of the United Nations Framework Convention on Climate Change (UNFCCC). Reaching stabilisation of greenhouse gas concentrations in the atmosphere at a level that would preclude dangerous anthropogenic interaction with the climate system is the UNFCCC's declared goal. August 1997 saw the ratification of the UNFCCC by the South African government. It was quickly realised that the UNFCCC's promises were insufficient to achieve its main goal, and as a result, the Kyoto Protocol was adopted in 1997 following extensive international negotiation. The government of South Africa joined the Kyoto Protocol in July 2002 (DEAT, 2004).

According to data from the IPCC, the earth's surface temperature has risen during the past 150 years. There was a 0.35⁰C increase between 1910 and the 1940s and a 0.55⁰C increase between the 1970s and the present. The IPCC came to the conclusion that these patterns are probably caused by human-caused global warming, which also affects natural climate variables (Smith, 2013).

The Fifth Assessment Report of the IPCC states that in South Africa, the near-surface mean temperature is predicted to be between 1.5 ⁰C along the coast and roughly 3⁰ C inland for the period 2081–2100, as opposed to the reference period 1986–2005. In terms of precipitation changes in both direction and magnitude, RCP 8.5⁰C predicts a 3–6 ⁰C warming in the interior of South Africa by 2081–2100, compared to the 1986–2005 baseline (Ayisi *et al.*, 2021). However, this warming is tentative. Furthermore, from 1960 to 2003, the average annual temperature of South Africa increased by around 0.13⁰C per decade, with seasonal variations, according to assessments of climate data from 26 meteorological stations throughout the country (Rankoana, 2020).

The IPCC AR5 states that this temperature rise exacerbates reduced river flows, lower water levels in wetlands and lakes, and higher concentrations of hazardous substances in water resources. The functioning of aquatic ecosystem is also impacted which lowers biodiversity. Moreover, less dissolved oxygen causes quicker evaporation rates, which change water reservoirs, unbalance nutrients, and increase the frequency of algal blooms (Edokpayi *et al.*, 2021; Ayisi *et al.*, 2021). In dry and semi-arid regions of the world, groundwater recharge is declining, apart from areas where significant precipitation and flooding are major sources of recharge. The climatic change susceptibility of the South African aquifers suggests that while those underground stress now are unlikely to fail, those that are not will be vulnerable to it during specific future seasons. There were differences between -0.6 and 33.5 mm/a in the recharge and groundwater level changes (NW&SMP, 2018; Edokpayi *et al.*, 2021).

The use of groundwater resources has increased, especially in urban areas, because of reduced yearly rainfall and the unpredictability of surface water resources. In Southern Africa, urban households have turned to drilling wells because their domestic taps typically run dry. Additionally, some groundwater naturally contains fluoride and arsenic, elements that can have negative health effects on humans (Naidoo *et al.*, 2018; Edokpayi *et al.*, 2021). South Africa has identified climate change as a major concern because of the serious damage it poses on the nation's food security, biodiversity, ecosystem services, and water resources (Ayisi *et al.*, 2021). The multifaceted nature of climate change impacts necessitates the implementation of cross-sectoral mitigation and adaptation strategies (Naidoo *et al.*, 2018).

2.5.3 Water pollution

High-quality water resources are necessary for both ecological integrity and economic growth. The main causes of the deterioration of South Africa's water quality are industrial activities coupled with a general decline in operation, agricultural runoff, improper management of wastewater treatment infrastructure, and household waste both liquid and solid that is disposed of in river systems, polluting those (Gqomfa *et al.*, 2022). Water pollution is any alteration to the physical, chemical, or biological characteristics of water that has an adverse effect on living organisms, according to the

World Health Organisation (WHO) (1997). Most of the time, a variety of human activities like farming, mining, urban and industrial development, and leisure lead to pollution. It modifies the possible uses of natural waterways and drastically degrades their quality amount (Musingafi *et al.*, 2014).

Research indicates that South Africa generates around 450 million tons of garbage each year, with the mining sector accounting for 70% of this amount (Musingafi *et al.*, 2014). A significant proportion of the approximately 1,150 wastewater treatment works (WWTW) and 44% of the 962 WWTW are in poor or critical condition and require immediate restoration, according to the National Water and Sanitation Master Plan (2018). The economy and public health are significantly impacted by inadequate water and wastewater treatment.

The vast majority of South Africans are rural residents who depend mostly on unimproved water sources, such as streams, rivers, and exposed springs and waterways. According to Musingafi *et al.* (2014), many communities are now extremely vulnerable to upstream effluent discharges as well as changes in upstream land-use patterns and water-abstraction patterns due to their direct reliance on natural water sources. Because people in rural regions depend on dirty water for drinking, irrigation, and other household uses. Turton (2016) further emphasised that there is a large geographic distribution of direct contact with this water. The primary source of waste and water pollution is mining activity, which results in the uncontrolled release of contaminated water known as acid mine drainage. Toxic heavy metals like uranium from mine workings and residual deposits, together with dissolved salts, are typically present in the acidic water (Musingafi *et al.*, 2014).

Heavy metals linked to acid mine drainage and microcystin are present in the food produced in these gardens because the communities utilise tainted water for irrigation. Acid mine drainage affects aquatic ecosystems, soil quality, and the permeability of heavy metals into the environment, in addition to being linked to surface and groundwater contamination (Turton, 2016). At 10,000–18,000 micrograms per litre, South African river levels, however, are far higher than the WHO safety thresholds. According to studies, the amount of microcystin in South Africa's tap water is far lower,

roughly 10 micrograms per litre. These levels are still ten times more dangerous than the WHO safety standards amount (Musingafi *et al.*, 2014).

Contamination of water is the source of many waterborne illnesses, including cholera, diarrhoea, and dysentery (Musingafi *et al.*, 2014). Five million deaths a year are attributed to waterborne illnesses, most of them being children. Nearly every year, there are numerous and severe cases of deadly cyanobacterial poisoning in South African reservoirs. Although no human fatalities have been reported in South Africa yet, these poisonings have solely resulted in the deaths of domestic animals, cattle, and wildlife. Chronic long-term exposure to low concentrations of cyanotoxins in drinking and household water is a health risk to humans in South Africa (Ashton *et al.*, 2008). Necrotoxins result in cellular necrosis, or the death of living tissue. These poisons typically have a slow-acting effect and do not always cause death. Usually, they result in severe localised tissue injury (Turton, 2016). Water and food-borne illnesses, such as cholera and diarrhoea, as well as vector-borne illnesses like dengue fever and malaria are already on the rise in the SADC region (Naidoo *et al.*, 2018).

According to the South African Human Rights report (2014), the United Nations Development Program (UNDP) estimates that illnesses brought on by a lack of access to clean water or a poor quality of water cause 443 million school days to be missed annually (Turton, 2016). Furthermore, illnesses related to inadequate hygiene, poor sanitation, and contaminated water claim the lives of 115 Africans every hour. More children die from poor sanitation and safe drinking water than from HIV/AIDS, malaria, and measles combined. Diarrhoea is the second greatest cause of death for children in underdeveloped nations, and this contamination is a major source of it as well as other serious illnesses like cholera (Turton, 2016).

Sewage discharge is a complicated mixture of bacteria, viruses, and concentrated nutrients, among many other things. Pathogens like cryptosporidium, which can cause diarrhoea or a chronic cough in the respiratory system, are also present in the effluent. It includes more than 100 known viruses, such as the adenovirus that causes colds, the rotavirus that puts kids under five years old at risk for diarrhoea, and the coxsackievirus that typically affects youngsters and causes the mumps, aseptic meningitis, and hand,

foot, and mouth disease(Turton, 2016). There is evidence linking insulin-dependent diabetes to a higher risk of heart disease, pancreatitis, and liver damage in a more hazardous subtype that also affects the impoverished (Turton, 2016).

According to the 2018 National Water and Sanitation Master Plan report, there has been a persistent deterioration of water supplies. All nine of South Africa's water management areas saw a decline in river health between 1999 and 2011. During that time, the number of tributaries with poor ecological conditions has expanded and many of the nation's rivers have been pushed beyond the point of recovery. The volume and quality of the water in major rivers are greatly dependent on healthy tributaries. According to estimates, South Africa has lost more than half of its wetlands, and of the 3.2 million hectares (less than 5% of its total land area) that remain, a third are already in bad condition, making it difficult for them to regulate water flow and purify water (NW&SMP,2018).

Freshwater conservation is a global concern, with phosphorus (P) and nitrogen (N) frequently acting as limiting variables affecting water quality because of eutrophication (Savic *et al.*, 2022). To counteract the detrimental effects of water eutrophication, which cause toxic algal blooms to proliferate and seriously damage aquatic ecosystems, phosphate removal has become essential. Throughout the world, phosphate-based fertilizers are widely used to boost food production in regions that otherwise couldn't support significant agricultural expansion. Given the quantity of phosphate that is applied to soils, it is not surprising that a large portion of the phosphate that plants do not need to use leaches out of the soil and builds up in rivers. An additional factor aggravating the accumulation problem is phosphates from industrial and municipal effluent. Water with higher phosphate concentrations can support the growth of hazardous plants and algae more quickly, which can produce an excess of toxic algal blooms and seriously damage aquatic ecosystems globally by eutrophicating them (Hassan *et al.*, 2020).

Additionally, the burning of biomass, ground water pollution, atmospheric deposition loads from burning fossil fuels, runoff from burned and nitrogen-saturated grasslands and forests, and biomass burning all contribute to the worsening of eutrophic conditions

(de Villiers et al., 2007). According to a recent study, burning fossil fuels releases methane emissions that are increased and equal to 18–33% of the annual emissions of carbon dioxide (CO₂) (Hassan *et al.*, 2020).

The average phosphorus concentration in South Africa's natural water resources (as orthophosphate) is projected to be 0.73 mg/liter, whereas freshwater pollution (as Chemical Oxygen Demand) is predicted to be 4.74 ton/km³(DWS Annual report, 2017/18). These numbers show that freshwater resources in South Africa are overly enriched and categorised as moderately to extremely eutrophic. There are a lot of algae in several South African reservoirs. These bodies of water may have water with odd tastes and colours. Sometimes, algae can create poisons that are harmful to people's health (DWS Annual report, 2017/18).

The accumulation of metabolic products (such as hydrogen sulphide in deep waters), turbidity or discoloration of the water (which results in low or poor light penetration), a decline in the water's taste, a depletion of dissolved oxygen, and an increased prevalence of cyanobacterial bloom-forming species are the usual indicators of eutrophication (Ashton *et al.*, 2008). Turton (2016), states that cyanobacteria have the capacity to burst their cells when they encounter water. River water contains dissolved inorganic nitrogen and phosphorus from both natural and man-made sources. When there is no pollution, the nutrients in river water are mostly a balance between the biological productivity in the system and the production of dissolved species that come from the chemical weathering of phosphorus- and nitrogen-containing geological deposits in the catchment (Ashton *et al.*, 2008).

Overabundance of nutrients upset the delicate balance between different plant species, causing the destruction of aquatic plant communities, which serve as a variety of animal species' food sources, homes, and breeding grounds. Elevated nutrient levels can also be poisonous to aquatic species and harmful to human health. Fish and invertebrates are killed by it because of oxygen being depleted during the breakdown of the extra organic matter that is created (StatsSA, 2017). River nutrient levels have an impact on the health of the aquatic bodies they feed, including wetlands, estuaries, groundwater,

and surface freshwater reservoirs (de Villiers *et al.*, 2007). More than two-thirds of the average yearly stream flow in South Africa is retained in the country's reservoirs compared to rivers that are moving, the water in these dams, which frequently have vast surface areas, evaporates more quickly. Global warming raises salinity levels (Ashton *et al.*, 2008).

Water with a high Total Dissolved Solids (TDS) concentration is carried by the rivers that drain the country's arid interior regions, mostly due to high sulphate and chloride concentrations (Stats SA, 2017). This indicates that the water is tasteless and corrosive, which frequently degrades the quality of the water. In addition to physiological consequences, dissolved minerals, gases, and organic elements can also result in issues with colour, taste, and odour (Drinan *et al.*, 2013). It is quite costly to stabilise the salt content of water to restore its quality (StatsSA, 2017).

Fearfully, the Vaal River, which provides water to Gauteng, the home of 45% of South Africa's population and the source of 60% of the nation's GDP, is under danger due to growing salinity levels (Turton, 2016; StatsSA, 2017). In the Grootdraai and Vaal dams, soluble compounds and salts were discovered, according to a 2012 Department of Water Affairs research. When combined tailings dams, dumps used to hold mining waste with 400 kilotonnes of uranium pass by them, this tributary gets contaminated (Turton, 2016; StatsSA, 2017). Exposure to cyanobacterial toxins may cause mild morbidities, including skin rashes, earache, and irritation of the eyes and upper respiratory and gastrointestinal tracts (Ashton *et al.*, 2008).

2.7 Sustainable Development Goals

2.7.1. Social goals

SDG 1 significantly broadens the scope and increases the ambition of Millennium Development Goal 1. By 2030, it aims to totally abolish extreme poverty. Additionally, SDG 2 enhances and broadens MDG 1. The objective enables the global community to move beyond its initial aims and incorporate the tracking of aspects related to sustainable agriculture, higher agricultural productivity, and nutrition. As a result, in addition to focusing on outcome-level assessments, SDG 2 also attempts to analyse and assess the structural reasons of food insecurity. This process of monitoring helps to

find solutions that could result in improvements at the outcome level (Sustainable Development Goals: Country Report, 2019).

2.7.2 Economic goals

The social and economic goals established by the former MDG targets and, more recently, the SDG targets require far more work than South Africa has done, notwithstanding the country's significant progress in closing the enormous gaps left by decades of poverty, inequality, and unemployment (Stats SA, 2017). Recognising the specific progress made to date, fixing pertinent flaws, and building on lessons learned in pursuit of the previous set of targets are crucial for ensuring a successful transition from the MDGs to the SDGs and addressing how these targets relate to South Africa's own development strategies. Most of the MDGs and the SDGs pertaining to the economy are connected. The elimination of poverty (MDG 1), environmental sustainability (MDG 7), and macroeconomic and socioeconomic progress (a global partnership agenda) are the three main focuses of SDG 8 (MDG 8)(Sustainable Development Goals: Country Report, 2019).

2.7.3. Environmental goals

As a specific improvement on MDG 7, which is to promote environmental sustainability, SDG 6 was established. The world's growing concern over the quantity and quality of water resources is the cornerstone of SDG 6, as it is necessary not just to meet sanitation and water supply requirements but also to facilitate urbanisation and economic growth (Renata *et al.*, 2018). The understanding that excessive pollution is having an adverse effect on the water quality of resources and linked ecosystems, as well as the degradation of ecosystems related to water, gave rise to SDG 6 (UN Environment, 2018).

Interestingly, SDG 6 goes beyond MDG Target 7c's primary focus of water supply and sanitation to offer a thematically larger, more comprehensive, and context-specific framework for water. The expansion focuses attention on challenges connected to water quality, demand management and efficiency in water use, protection of ecosystems associated to water, and local and transboundary Implementation of Integrated Water Resources Management (IWRM)(Sustainable Development Goals: Country Report,

2019)..Considering the nation's limited water resources, the larger scope of SDG 6 requires the use of more diversified and inclusive approaches backed by research, development, and innovation to fulfill the 2030 targets. Thus, South Africa needs to think carefully about how to give impoverished communities safe, water-smart, and sustainable sanitation facilities by 2030. With South Africa being a water-scarce country and water scarcity expected to worsen due to climatic unpredictability, the current waterborne sanitation infrastructure system is unsustainable (Sustainable Development Goals: Country Report, 2019).

Moving on to SDG 13, MDG 7, "Ensure environmental sustainability," was the MDG most closely related to catastrophe risk reduction and climate change. Disaster risk reduction and sustainable development are intertwined since none can be achieved without the other. Disasters impede social progress and economic prosperity. At the 3rd UN World Conference for Disaster Risk Reduction (WCDRR) in March 2015 in Sendai, Japan, the UN Member States agreed the Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework), which was the first agreement on the post–2015 development agenda(Sustainable Development Goals: Country Report, 2019).The framework is a non-binding, 15-year agreement that acknowledges that, while the state has main responsibility for lowering the risk of disaster, other stakeholders such as local government and the commercial sector also share accountability. The Framework recognises that disasters seriously obstruct the path towards sustainable development, with many of them being made worse by climate change and occurring more frequently and intensely. It recognises and underscores the significance of catastrophe risk reduction in relation to climate change and sustainable development, and vice versa. (Sustainable Development Goals: Country report, 2019).

2.8 The Sustainable Livelihood Approach (SLA)

Enhancing comprehension of impoverished households' livelihoods can be achieved through the sustainable livelihoods approach (SLA) (Krantz, 2001). And according to Kamaruddin *et al*, (2014), the SLA is a multifaceted, integrative, and logical strategy to ending poverty in contrast to other strategies. To address other crucial aspects of poverty, such as vulnerability and social exclusion, the idea of Sustainable Livelihoods

(SL) aims to go beyond traditional definitions and approaches to this problem. The need for more focus on the different processes and circumstances that either improve or limit the ability of the impoverished to support themselves in an environmentally, socially, and economically sustainable way is now widely acknowledged (Kamaruddin *et al.*, 2014).

The Brundtland Commission on Environment and Development first proposed the idea of sustainable livelihoods as a means of integrating socioeconomic and ecological factors into a cohesive framework that was relevant to policy. The United Nations Conference on Environment and Development (UNCED) in 1992 extended the idea, particularly considering Agenda 21, and promoted the realisation of sustainable livelihoods as a general objective for the eradication of poverty. It also reaffirmed that policies addressing development, sustainable resource management, and poverty eradication could all be addressed concurrently by means of sustainable livelihoods (Krantz, 2001). The external influence of one livelihood on other livelihoods, which has an impact on regional and global resources, is referred to as environmental sustainability (Krantz, 2001; Majale, 2002).

According to Nyam *et al.*, (2020) the way communities perceive and engage with the environment, particularly when it comes to water resource management, they are influenced by social drivers. These drivers impact freshwater resources both directly and indirectly through the demands and uses of water. Urbanisation, health, poverty, inequality, education, and population increase are some of the most significant social forces. From 58.07 million in 2019 to 64.2 million in 2030, that is the expected population growth in South Africa. 6.13 million more people are involved in this. Due to the requirement to satisfy the expanding population, food production must increase at the current rate, which will put additional strain on water supplies. Over the same time frame, there will be 42.86 million youth in the world, up from 38.18 million. Raising people's educational levels may have a favourable impact on their health, which may boost their productivity. Reduced vulnerability to risk may improve poor people's proclivity to engage in previously unproven and more productive economic pursuits, and so on (International Futures 2019) (Nyam *et al.*, 2020). There is no standardised

approach to implementing the SLA concept. The key difference is that the SLA does not necessarily aim to address all aspects of the poor's lives, but rather to use a holistic viewpoint in livelihood analysis to identify those difficulties of topic areas (Krantz, 2001).

2.9 Legislative framework

South Africa's status as a water-scarce country is reflected in the legislative framework governing water. This framework has prioritised water scarcity and effective management of national resources, as well as the need to address historical imbalances and promote justice and equity in the availability and use of water resources.

2.9.1. The South African Constitution

The first of the ideals listed in the Constitution's basic provisions is human dignity, the achievement of equality and the advancement of human rights and freedoms, which are the principles upon which the state is based (NW&SMP, 2018). Sections 24 and 27 of the Constitution states that everyone has the right to access to sufficient water, an environment that is not harmful to health and well-being and to have the environment that is protected for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation, promote conservation and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development (NW&SMP, 2018). According to Algotsson *et al.*, (2009) the constitution further clarifies the need for an intergovernmental and participatory approach to managing water resources and sanitation services. This includes the clarification of the roles and functions, powers and authority of the different spheres of government and the institutions in delivering on this constitutional mandate.

2.9.2. The National Water Act 1998 (Act No 36 of 1998)

The National Water Act (NWA) in Section 2 (a) (e) (h) affirms the role of the state to protect natural resources. Section (2) mandates the National government to ensure that water is protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner, for the benefit of all persons and in accordance with

its constitutional mandate. The NWA provides the legal framework for the management of water resources, which includes the allocation of water for beneficial use and the redistribution of water (Algotsson *et al.*, 2009). Furthermore, it also identifies the need to establish suitable institutions to achieve its purpose. In addition, it provides for the development of a regularly reviewed National Water Resource Strategy and the requirement of each Catchment Management Agency (CMA) to develop a catchment management strategy for the water resources within its jurisdiction. The CMA is responsible for water resources management while the Water Services Authorities (WSA)'s responsibility is on agricultural water use, individual and industrial water use (Herrfahrdt-Pähle, 2010).

2.9.3. The Water Services Act 1997 (Act No 108 of 1997)

The Water Services Act prescribes the legislative duty of municipalities as water service authorities to supply water and sanitation according to national norms and standards. In addition, it regulates Water Boards as important water service providers. It acknowledges that although municipalities have authority to administer water supply services and sanitation services, all government spheres are required to work towards this object, within the limits of physical and financial feasibility (NW&SMP, 2018).

2.9.4. The Water Research Act 1971 (Act No 34 of 1971)

The Water Research Act established the Water Research Commission and the Water Research Fund to promote water related research and the use of water for agricultural purposes, industrial purposes, or urban purposes (DWS, 2017/18).

2.9.5. The National Environmental Management: Biodiversity Act 10 of 2004

According to the (2017/18) Department of Water and Sanitation report, the National Environmental Management Biodiversity Act advocates for the protection of ecosystems. 52(2); the objectives of this Act under Section 52(2) (*i*) are to provide for the management and conservation of biological diversity within the Republic and of the components of such biological diversity. Section 52 further states in subsection 1 (a) (b) that the Minister and an MEC for environmental affairs in a province may, by notice in the *Gazette*, publish a national or a provincial list of ecosystems that are threatened and

in need of protection. Section (2) of the act lists the following categories of ecosystems which need to be protected in terms of subsection (1):

(a) Critically endangered ecosystems, being ecosystems that have undergone severe degradation of ecological structure, function or composition because of human intervention and are subject to an extremely high irreversible risk transformation.

(b) Endangered ecosystems, being ecosystems that have undergone degradation of ecological structure, function or composition because of human intervention, although they are not critically endangered ecosystems.

(c) Vulnerable ecosystems, being ecosystems that have a high risk of undergoing significant degradation of ecological structure, function or composition because of human intervention, although they are not critically endangered ecosystems or endangered ecosystems; and

(d) Protected ecosystems, being ecosystems that are of high conservation value or of high national or provincial importance, although they are not listed in terms of paragraphs (a), (b) or (c). Section 54 also states that an organ of state that must prepare an environmental implementation or environmental management plan in terms of Chapter 3 of the National Environmental Management Act, and a municipality that must adopt an integrated development plan in terms of the Local Government: Municipal Systems Act, 2000 (Act No. 32 of 2000), must consider the need for the protection of listed ecosystem(DWS, 2017/18).

2.9.6. The National Environmental Management Act no. 107 of 1998 as amended by the National Environmental Management Amendment Act, No. 62 of 2008

According to the (2017/18) Department of Water and Sanitation report, this act ct has set out principles in section 3 and 4. Section 3 states that development must be socially, environmentally, and economically sustainable. Section 4 continues to state that (a) sustainable development requires the consideration of all relevant factors including that;

(i) the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied.

(ii) pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied.

- (iii) the disturbance of landscapes and sites that constitute the nation's cultural heritage is avoided, or where it cannot be altogether avoided, is minimised and remedied;
- (iv) waste is avoided, or where it cannot be altogether avoided, minimised and re-used or recycled where possible and otherwise disposed of in a responsible manner.
- (v) the use and exploitation of non-renewable natural resources is responsible and equitable and takes into account the consequences of the depletion of the resource.
- (vi) the development, use, and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised;
- (vii) a risk-averse and cautious approach is applied, which considers the limits of current knowledge about the consequences of decisions and actions; and
- (viii) negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied (DWS, 2017/18).

2.10 Case studies

2.10.1 Global cases

For sustainable land resource management in emerging nations, an understanding of the dynamics of land use land change is essential. One of the main contributing factors to variations in Earth's temperature and overall ecosystem is LULC. Comprehending the correlation between LULC and its propelling factors is among the essential components of the surroundings (Msofe *et al*, 2018). The integration of the urban system and its consequences on the socio-economic circumstances of the community are impacted by the growth of the central city region into suburban areas. Global urban sustainability has become a major concern because of the fast-increasing urbanisation and industrialization. A common conception of sustainability is an effort to strike a balance between conflicting social, environmental, and economic concerns (Surya *et al.*, 2021).

South Asia must provide food for about 25% of the world's population although making up less than 5% of the planet's land area. Many South Asian nations have implemented measures to incentivize farmers to boost food production to achieve food self-sufficiency. These measures include minimum pricing for rice and wheat and subsidies

for energy, irrigation, and fertilizers. Because of these incentives, farmers have been disinclined to use water and energy resources efficiently, which has led to an alarming pace of drop in groundwater levels. The energy and water prices of today are frequently too low to influence behaviour. The irony is that food security is ultimately put in jeopardy by cheaply supplying electricity and water for agriculture (Simpson *et al.*, 2019).

In India, the fishing industry is crucial to the country's population's ability to support itself. The Brahmaputra and Barak River systems are two of the largest in the world and have abundant fishing resources. About 60 million people rely solely on fishing for their livelihood, while an estimated 12 million people fish directly. Over 2% of the economy's Gross State Domestic Product (GSDP) comes from the fishing sector (Kachari *et al.*, 2015). The inland fisheries, which provide employment for 15% of the world's workforce, are especially significant to the rural poor. In addition to being a significant source of foreign exchange earnings, it is acknowledged as a potent source of revenue and employment creation because it fosters the expansion of several ancillary sectors and provides affordable, wholesome food. The right farming system approaches combined with sustainable resource utilisation will boost fish output and create job possibilities (Kachari *et al.*, 2015).

According to (Hassan *et al.*, (2020) here is a broad usage of phosphate-based fertilizers that boost food production in regions that could not support significant agricultural growth. The predominant type of phosphorus needed by plants is called inorganic phosphate, and it is the elevated concentration of this substance that causes dangerous cyanobacterial algal blooms and oxygen-deficient zones known as "hypoxic" zones, which in turn increases methane emissions and degrades the overall water quality. In the US, phosphate levels in the rivers and streams increased to about 40% which put water bodies at risk. The yearly anticipated overall economic cost of mitigating eutrophication in the United States is around \$2.2 billion. Phosphorous contents in eutrophic lakes range from 1.2 mg/L to 2.99 mg/L. By 2050 and 2100, respectively,

these figures are predicted to rise by a factor of 1.37–3.10 and 2.17–4.91.4 (Hassan *et al.*, 2020).

2.10.2 Regional case studies

The State of the River Nile Basin report (2012), states that the lack of environmental sanitation throughout the Nile basin causes bacterial pollution and nutrient enrichment in the Nile region. Large portions of the Nile system, especially those with low population densities, continue to have adequate quality, although sections near urban centres are mostly affected by localised heavy pollution. In remote areas, groundwater also naturally contains large concentrations of dissolved minerals. Widespread soil erosion occurs in the Nile's headwater zones. The Eastern Nile sub-basin, which accounts for 97% of the total sediment load, has exceptionally large sediment outputs. The storage capacity of reservoirs in Egypt and Sudan is rapidly lost due to sediment capture. Since the Nile River's limited flows are already completely used for domestic, industrial, agricultural, and environmental reasons, water demand is gradually increasing because of population expansion and the development of wealthy nations (State of the River Nile Basin report, 2012).

Most land resources in the neighbouring hydro-system Danube-Tisza-Danube (HS DTD) in Serbia 75% are utilised for farming, and they have very fertile soil (chernozems, meadow black soils)(Savic *et al.*, 2022).Furthermore, Adjacent to the canal network are a multitude of industrial enterprises and around 80 distinct urban zones with inhabitants. For the northern region of Serbia, the multifunctional HS DTD is vitally important economically. This hydro-system's primary applications are drainage, wastewater intake and transfer, inland navigation, flood control and protection, irrigation for agriculture and industries, and aqua farming. The catchment region is covered by the system to the tune of 1.1 million hectares (ha). Concerns about nutrients and eutrophication in lakes, whether man-made or not, as well as other water courses (such as rivers and drainage canal networks), are prevalent in Serbia and neighbouring areas with comparable agro-ecological characteristics, particularly in lowlands that are mostly used for agriculture, like Vojvodina (Surya *et al.*, 2021).

2.10.3 National/Local case studies

One of South Africa's principal river systems is the Olifants River. Water is supplied for household, commercial, and agricultural uses (Bediako, 2019). According to Marr *et al.*, (2022) the Olifants River generates approximately 40% of the flow of the lower Limpopo River and provides water to support the rapid socio-economic development of the Gaza Province in Mozambique and the Mpumalanga and Limpopo provinces in South Africa. In addition, the Olifants River watershed has seen a sharp rise in agricultural and urban growth in recent decades. Water for commercially significant intensive agricultural regions is also provided by irrigation projects, such as those along the lower Olifants from the Abel Erasmus Pass to Oxford Bridge and between the Loskop and Flag Boshielo dams. In addition, the Olifants River catchment encompasses more than 50% of South Africa's most important conservation area, the Kruger National Park, as well as mining and industrial operations (such as those at eMalahleni, Middelburg, eastern Bushveld Igneous Complex, and Phalaborwa Industrial Complex)(Rasifudi, 2019).

The Olifants River System is regarded one of the most degraded river systems in South Africa because of the numerous agricultural, industrial, and mining operations in the basin (Rasifudi, 2019). The river and its tributaries are claimed to be contaminated with heavy metals and inorganic nutrients including sulphates and nitrates from agricultural fields, mine drainage, and wastewater treatment plants. The Blyde and Steelpoort rivers are significant tributaries of the Olifants. The Blyde is noted for its consistent flow and high-water quality, and it primarily serves agricultural and home needs (Rasifudi, 2019).

Anthropogenic activities in the catchment area, particularly mining (e.g., ferrochrome and platinum), agriculture, and human settlements, have had an impact on the Steelpoort river. The increased activity in the catchments has resulted in the release of contaminants, particularly heavy metals, into the rivers (Bediako, 2019). Pollution in the Olifants River has resulted in a reduction in the number of Nile crocodiles, which are keystone species for the river, and this appears to be an ongoing process because no remedy to increase their survival in these waters has been found (Rasifudi, 2019).

The Mhlathuze River is one of the main rivers in the region, flowing from the Babanago highlands to Empangeni and Richards Bay before emptying into the Indian Ocean. The river is part of the Mhlathuze Catchment, which is centered on the two large towns of Empangeni and Richards Bay, both of which are located 160 km north of Durban. Richards Bay is home to a variety of industries, including aluminium smelters, fertilizer facilities, and iron, titanium, and zircon mining. It also features Africa's largest coal export plant. Land is used for commercial forest plantations such as wattle, pine, and eucalyptus, as well as agricultural land for crops such as sugar cane, citrus, vegetables, maize, and other grains and grassland is utilised for cattle grazing. Due to the presence of vast industries, heavy metal pollution was discovered to be widespread in the region(Elumalai *et al.*, 2017).

CHAPTER 3: METHODOLOGY AND ANALYTICAL PROCEDURE

3.1 Introduction

This chapter discusses the methods used to collect and analyse data collected for this study. It commences with the research design, the sampling procedures, the data collection methods and lastly, analysis and presentation of data.

3.2 Research design

The researcher used a mixed method approach which included both qualitative and quantitative approaches for data collection and analysis. The purpose of using a mixed method approach was to enable the researcher to integrate analytically and conceptually the quantitative and the qualitative data. Qualitative research is in-depth research that uses a range of techniques to grasp why people think, feel, react, and behave in the way that they do (Talbot, 2015). Quantitative research produces numerical data by quantifying attitudes, opinions, and patterns (DeFranzo, 2020). Below is a table that demonstrates the process as followed from the beginning to the end of the data collection, analysis and discussion process.

Phase	Procedure	Product
Phase 1: Leadership engagement	Approach community leadership	Permission
Phase 1: Data collection	Sampling	Sample size
Phase 2: Data collection	Individual semi-interview survey (98)	Interview transcript
Phase 2: Data analysis	Framework analysis	Descriptive statistics
		Themes
Integration of phase 1&2	Interpretation of survey data	Discussion of results

3.3. Sampling procedures

Sampling is a method of selecting a sample from the population (Pandey *et al*, 2015). For this study, the researcher used a local settlement map. The researcher randomly selected 100 households on the map before visiting the marked the number of households. However, it was from only 98 of these households where the researcher was able to gather data with the two having been said to be away.

3.3.1 Sampling frame

The sampling frame was 6 055 households in Mariveni village (Stats SA, 2010).

3.3.2. Sampling size

Since Mariveni village has a high number of households, the sample size was calculated using a 0.01 margin of error.

The sample size was calculated using the following formula by Yamane (1967):

$$n = \frac{N}{1 + N(e)^2}$$

Where n = Sample size

N = Population size

e = Margin of error, which is 0.1

Therefore, $n = 6\ 055 / (1 + 6\ 055 (0.1)^2)$

$$= 6\ 055 / 1 + 6\ 055 \times 0.01$$

$$= 6\ 055 / 61, 5$$

Therefore, n=98

The sample size was therefore 98 households.

3.3.3. Sampling method

A simple random sampling method was used in this study because it is free from biasness and from personal error. Ninety-eight (98) households were randomly selected for data collection. After data had been collected from 98 households, 10 households

were selected from this sample for an in-depth interview. The purpose of in-depth interviews is not to test hypotheses, but to get a perspective of other people's experiences and a gist of what they make of those experiences (Seidman, 1991).

3.4. Data collection methods

Data collection is a systematic process of gathering observations or measurements. Whether one is performing research for business, governmental or academic purposes, data collection allows the researcher to gain first-hand knowledge and original insights into the research problem (Bhandari, 2020).

3.4.1 Secondary data

The researcher also used secondary data and these included journals, books, newspapers, government reports, case studies, research papers as well as the internet to gather information relating to water issues to support the study findings. One of the reasons these were used was to ensure that relevant information published in both academic and literature is sourced since water issues are published not only in journals but also in various government newspapers which are at district and local levels. These came in handy in terms of either endorsing or refuting the information provided by the respondents.

3.4.2 Primary data

3.4.2.1 Survey questionnaires

In this study, 98 questionnaires were administered to household heads or their closest deputies to acquire primary data. The questionnaire constituted open and close-ended questions. The researcher used survey questionnaires which were divided into six sections. The first section captured the demographic information of the respondents, and the second section collected data on the economic activities of the broader community as observed by the respondent. The third section gathered information on the drivers of land use changes and the associated underlying causes. The fourth section focused on community's perception of the Greater Letaba River as a source of livelihood for the Mariveni community. In terms of water quality perception, three senses were used (smell (waste), taste (saltiness), and sight (turbidity) according to what the community of Mariveni village (objective ii) indicated they experienced. The perceived

socio-economic value of the community of Mariveni village (objective iii) in relation to the river was also captured. The fifth section focused on mitigation and adaptation measures put in place by various stakeholders such as the local community, traditional authorities, and local businesses (objective v).

3.4.2.2. Field observation

Field observation was conducted on the status of the Greater Letaba. This enabled the researcher to directly observe the community members' attitudes towards the river. Furthermore, this tool enabled the researcher to explore how community members of the Mariveni village view the Greater Letaba River as a resource (objective i). The instrument also identified changes in water quantity (capacity level) and quality (smell, taste, and turbidity) as observed by the community of Mariveni village (objective ii). Lastly, the tool assessed the possible impacts that the changes in the river have on the socio-economic value of the community of Mariveni village (objective iii). This was useful information in terms of either endorsing or refuting the information provided by the respondents. Guiding the observation as a data collection technique were the objectives indicated in the first row. This ensured that relevant data/information was collected throughout the study (Table 1).

Table 1: Objectives, instrument used, and the type of information collected.

Objectives	Instrument used	The type of information
i) Explore how community members of Mariveni village view the Greater Letaba River as a resource	Field observation. Questionnaire.	Definitions; Community views of the river as a resource.
ii) Identify changes in water quantity and quality according to the community of Mariveni village.	Field observation. Questionnaire.	Changes in the water quality (smell, taste and turbidity) changes in the river capacity level.

iii) Assess the possible impacts the river has on the socio-economic value of the community of Mariveni village.	Field observation. Questionnaire.	Waterborne illnesses are related to changes in water quality. Local economy with respect to agriculture and tourism activities.
iv) Assess the river mitigation strategies by local authorities.	Questionnaire.	Organogram. National and Provincial water departments' strategies. Water management initiatives. Awareness campaigns.

3.5. Data analysis and presentation

The researcher used SPSS Statistics 27 (2019) software to capture collected data. Data was then cleaned it to eliminate discrepancies during analysis phase. After cleaning, various statistical analysis wasrun to analyse quantitative data. Histograms, Pie charts and Tables were used to present analysed data (See Table 2). On the other hand, unlike numerical data, for the qualitative data the researcher, captured it using NVIVO 12 (2018) software and produced themes through creating nodes and subsequently all related information was used as quotations or responses as evidence to demonstrate the community perception, views and suggestions regarding the water issues.

Table 2: Data analysis and presentation

Objectives	Instrument used	Data analysis method	Data presentation method
i) Explore how Mariveni village community members' view the	Field observation. Questionnaire.	Descriptive statistics, Narrative analysis method	Use of statistical graphics (bar graphs and pie charts) and

<p>Greater Letaba River as a resource.</p>			<p>tables</p> <p>Presented thematically in paragraphs</p>
<p>ii) Identify changes in water quantity and quality according to the community of Mariveni village</p>	<p>Field observation.</p> <p>Questionnaire.</p>	<p>Descriptive statistics</p> <p>Narrative analysis method</p>	<p>Use of statistical graphics (bar graphs and pie charts) and tables</p> <p>Presented thematically in paragraphs</p>
<p>iii) Assess possible impacts that the change in the river has on the socio-economic value of the community of Mariveni village</p>	<p>Field observation.</p> <p>Questionnaire.</p>	<p>Descriptive statistics</p> <p>Narrative analysis method</p>	<p>Use of statistical graphics (bar graphs and pie charts) and tables</p> <p>Presented thematically in paragraphs</p>

iv) Assess mitigation strategies on the sustenance of the Greater Letaba River by the local authorities	Questionnaire.	Descriptive statistics	Use of statistical graphics (bar graphs and pie charts) and tables
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3.6 Summary of chapter

This chapter described the sampling procedure which was followed sampling 98 households in the community using random sampling. The methods used which were both qualitative and quantitative with the later capturing the numerical data while the former captured the data in the form of response. Observation was also used which enabled the researcher to note the natural environment and activities around the dam such as gardens. SPSS was used to analyse the data using graphs as presented in the next chapter which covers the results and discussion.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Introduction

This study explores the perception of Mariveni community members on the importance of the Greater Letaba River as a source of sustainable livelihood. The chapter presents data analysis and interpretation of the information acquired from the respondents in Mariveni Village. It further incorporates the observation made to validate the information acquired from the respondents concerning the research. The focal point of this section is to highlight the land use tenure system in the area, the perception of land use change versus reality as based on satellite information, sources of livelihood, the perception of water quality and quantity, and possible mitigation strategies as suggested by community members. The information has been presented using tables, graphs, and photos starting with socio-economic information which gives a background of the community.

4.2 Socio-economic information

In the socio-economic characteristics, the structured questionnaire probed the following information, gender, age, marital status, educational level, employment status, occupation, and monthly incomes of the respondents.

4.2.1 Age of the respondents

Age can be defined as the time interval between a given day, month, and year of birth or as the biggest completed unit of solar time, such as years for adults and children, or months, weeks, days, hours, or minutes for newborns under a year old, as applicable (StatsSA, 2017). The outcomes from the survey questions demonstrate that the distribution of the respondents age was grouped into six categories starting from =>25; 26-35; 36-45; 46-55; 56-65 to >65 age classes.

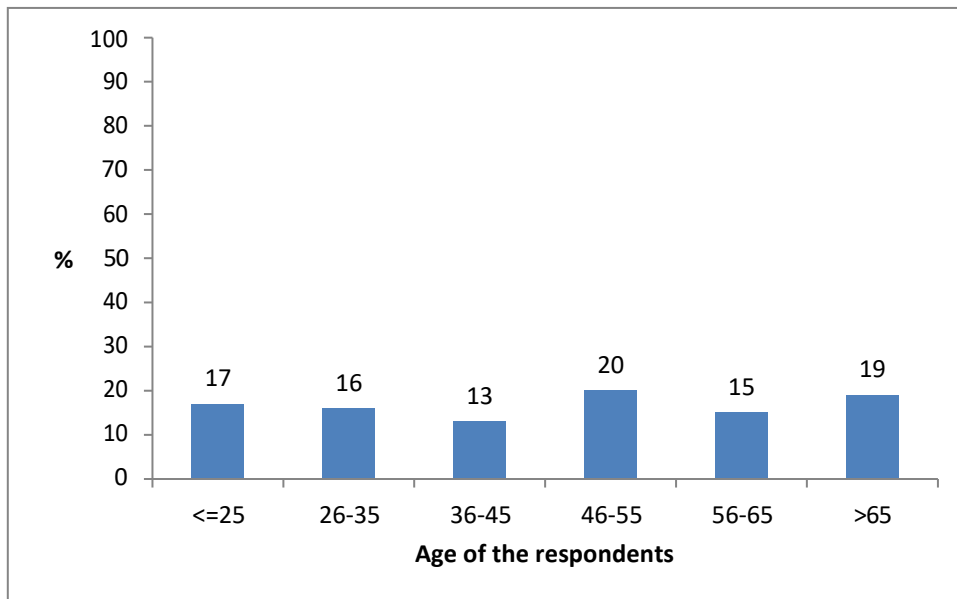


Figure 1: Age of the respondents (%).

The study showed that 17% of the respondents were aged 25 years and below, 16% were aged between 26 and 35 years, while 13% of the respondents were aged between 36 and 45 years. Furthermore, 20% of the respondents were aged 46 to 55 years, whereas 15% were aged 56 to 65 years. Lastly, 19% of the respondents were aged 65 and above. The difference across the age classes was noted predominantly with a difference of 1%. This demonstrates that there is a balanced representation of the population in the community, and this can be explained by various factors. Those from the age brackets of 46-56 to >65 age class are in the retiring age because, from 55 years of age, employees are allowed to take an early pension while 60 years is regarded as a normal retirement age for many people. This means that those who would have been away working in towns might have come back from urban areas to the community. Respondents in the age classes from <25 to 35 years of age are youth who are also out of the community having gone to seek better opportunities somewhere else.

4.2.2 Education

According to Statistics South Africa (2007), one's educational level is determined by the greatest grade earned in school or the highest post-school certification attained. The Constitution's Section 29 (1) emphasises that every South African citizen has a right to

basic education as well as further education. The government's obligation to guarantee that every South African has access to education is recognised under the Constitution. Nortje (2017), states that education has long been seen as a key determinant of a country's economic well-being. Furthermore, education is a key factor in reducing unemployment in developing countries, which in turn will lead to economic growth because it promotes innovation and transmission of new knowledge.

On the other hand, in emerging nations like South Africa, illiteracy is one of the obstacles that can impede the advancement of social, economic, technological, and educational sectors. The reason for enquiring about the educational level of the respondents was to check whether the community members had a better understanding of environmental issues pertaining to land cover and water resources with a particular interest in sustainability. Furthermore, it was to determine whether they were able to relay and understand information on the socio-economic impact of the river but also their proposed mitigation measures that could be implemented to address the environmental problem while sustaining their livelihoods.

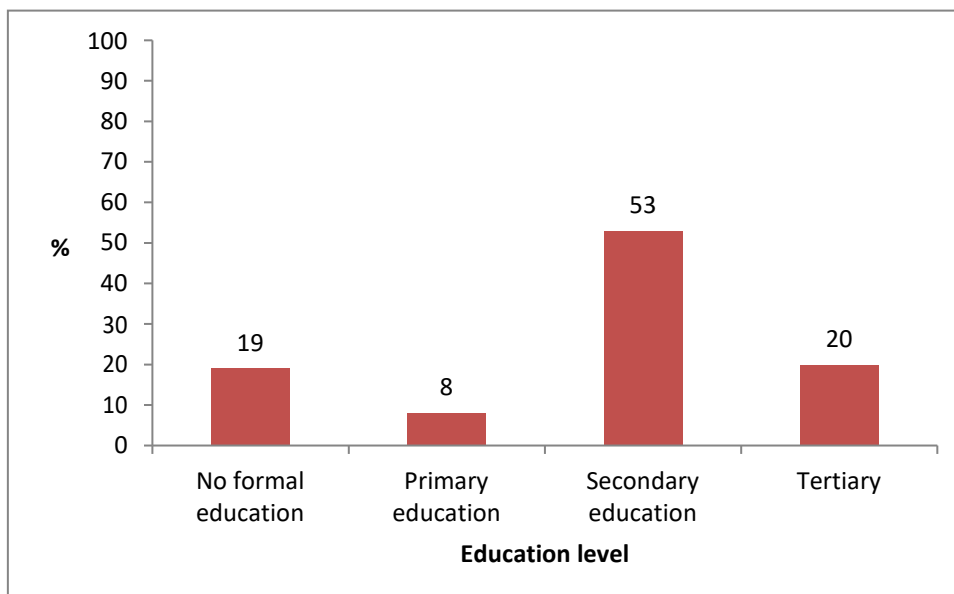


Figure 2: Educational level of the respondents (%)

Figure 3 above showed that many respondents (53%) had attended secondary school, followed by those who had gone to tertiary level at 20%. Those who had no formal

education were the second lowest at 19% with those who only went up to primary school being at 8%. This means that the community of Mariveni consisted of various categories of people, i.e. those who cannot read or write and those who have a lower level of education and the educated. The fact that those who were educated constituted 20% and represented the second most percentage of respondents implies that there are relatively many people who are educated in the community. This may be accounted for by the community's location which is closer to Tzaneen town and Polokwane city which have colleges and a university (University of Limpopo). For instance, around these towns, there are many Technical Vocational Education and Training (TVET) colleges both private and public such as Letaba Further Education and Training (FET).

4.2.3 Employment status

The Organisation for Economic Cooperation and Development (OECD, 2003), states that an individual's job status pertains to their contractual arrangement with other individuals or organisations and their current state of being employed. Figure 4 indicates that 50% of the respondents who took part in the study were unemployed contrary to more than 20% who were employed, followed by 20% of pensioners. This suggests that this large number of unemployed community members sustain themselves through odd jobs and self-employment. The remaining 10% are learners.

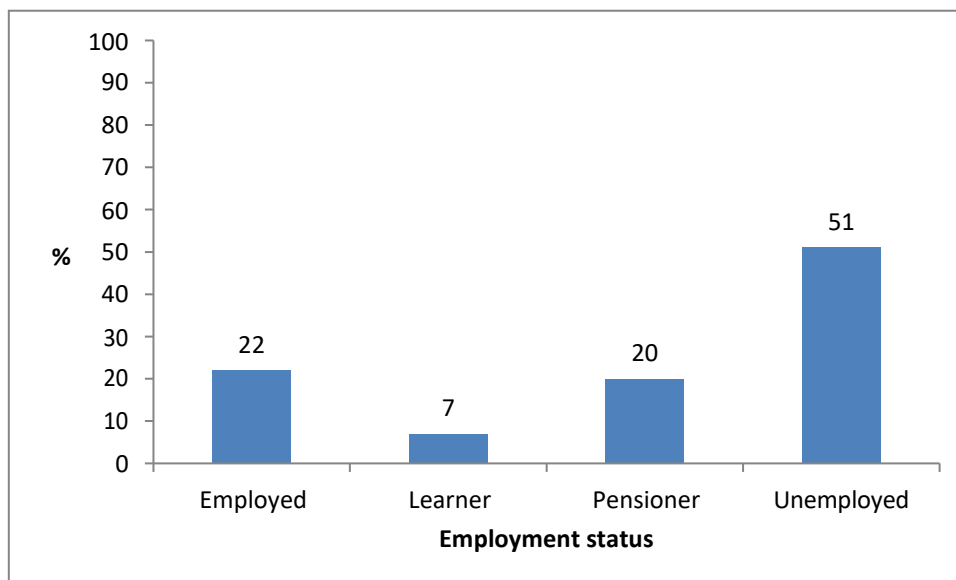


Figure 3: Employment status of the respondents (%)

South African unemployment is structural in nature and continues to be a source of worry (Tabarrok, 2010). The labour market remains at the core of South Africa's socio-economic challenges. In 1994, the narrow unemployment rate was 20%, rising to 26.7% in 2000 and falling to 22.5% by 2007. By 2017, however, the unemployment rate had risen to 27.7%, the highest level so far in the current decade (Stats SA, 2017). Current political uncertainty and poor economic growth are predicted to drive the narrow unemployment rate even further, towards 30% in the coming years. Unemployment is very high in rural South Africa, due to a lack of economic opportunities in the former apartheid homelands (Francis *et al.*, 2019). Less employment opportunities are a clear indication that there is a scarcity of jobs in South Africa even in areas around towns and farms. One would expect a high number of employments given many farms around the study area but also the nearby towns of Modjadjiskloof and Tzaneen to even those who were not educated as they would work as laborers.

4.2.4 Gender of Respondents

The World Health Organisation (2016), defines gender as the socially created traits that distinguish men and women, including roles, conventions, and interactions within and between male and female groups. Figure 5 below shows the composition of females and males in Mariveni. Out of a total number of interviewed respondents, 61% were female and 39% were male.

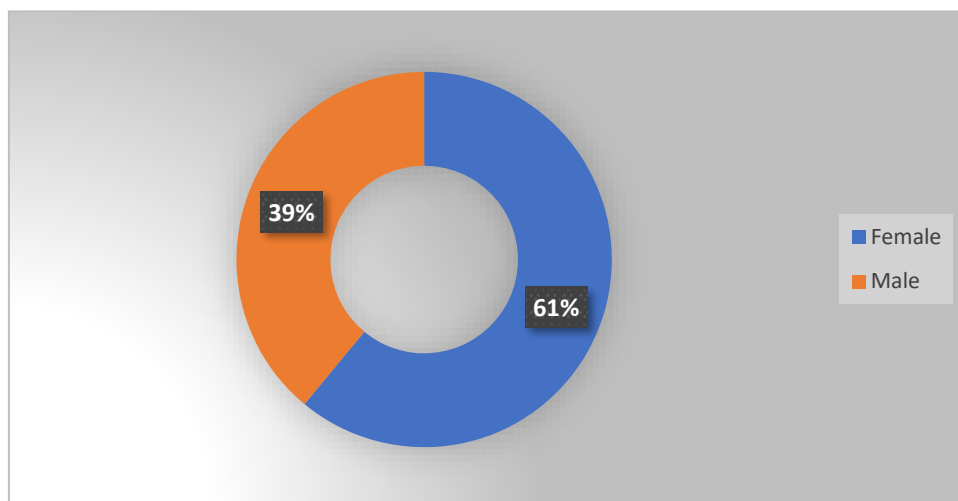


Figure 4: The gender of respondents (%)

Although men do dominate the community, the widespread consensus is that there are more women than men. This suggests that even in Mariveni, this is the case (Montshwe, 2006). Still, there were more men observed in the Free State Province (StatsSA, 2017). One reason to have more females than men in the rural areas is that men are generally the ones who provide for the families and thus look for job opportunities in urban areas leaving their wives and kids at home.

4.2.5. Period residing in the community

Figure 6 indicates the period over which respondents have been residing in Mariveni village. The Figure shows that there were many respondents (82%) who stayed in the area with the rest of the respondents having stayed there over the period of less than 20 years.

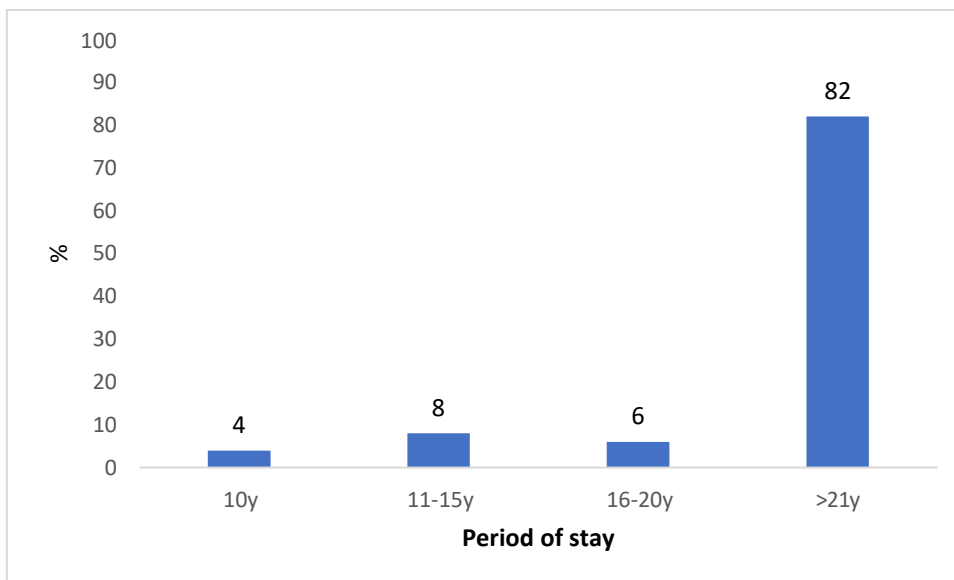


Figure 5: Period of stay (%)

The fact that many had stayed there for more than 21 years and above demonstrates that the community consists of older people but also that many of the respondents have been residing there for many years indicating a low out migration.

4.2.6. Main economic activities

Economic activities provide economic or financial gain by creating commodities or services. Economic consideration is crucial in these activities since human's desire to

satisfy their biological necessities such as food, housing etc. Economic activities are carried out for monetary reasons. Economic activity provides the basis for social economic advancement in addition to fulfilling individual needs. Social development is linked to the economic activity carried out there (Cook, 2019).

South Africa has the most diversified, industrialized economy in Africa. It also has one of the top five-highest GDPs per capita in sub-Saharan Africa and is one of very few upper-middle-income countries in the region. As noted earlier, however, income distribution is highly unequal. South Africa is a top producer of mined raw and processed commodities (e.g., platinum, steel, gold, diamonds, and coal). Other major industries include automobile, chemical, textile, and food manufacturing. These sectors, part of an overall industrial base that contributed just under 26% of GDP in 2017, are important sources of jobs. There is also well-developed tourism, financial, energy, legal, communications, and transport sectors, which are part of an overall services sector that contributed nearly 62% of GDP in 2017. South Africa is also a famed wine producer and exports diverse agricultural products, but only about 10% of its land is arable and agriculture makes up less than 3% of GDP (Cook, 2019).

Subsistence agriculture is mainly prevalent in Sub-Saharan Africa, Southeast Asia, and sections of South and Central America. A farmer who practices subsistence farming raises almost all their crops and cattle for their use and leaves little to no excess for trade or sale. Primitive agricultural societies across the globe engaged in subsistence farming. Ninety-eight percent (98%) of the respondents indicated that they practiced agriculture as a form of economic activity while only 2% said that they practiced tourism.

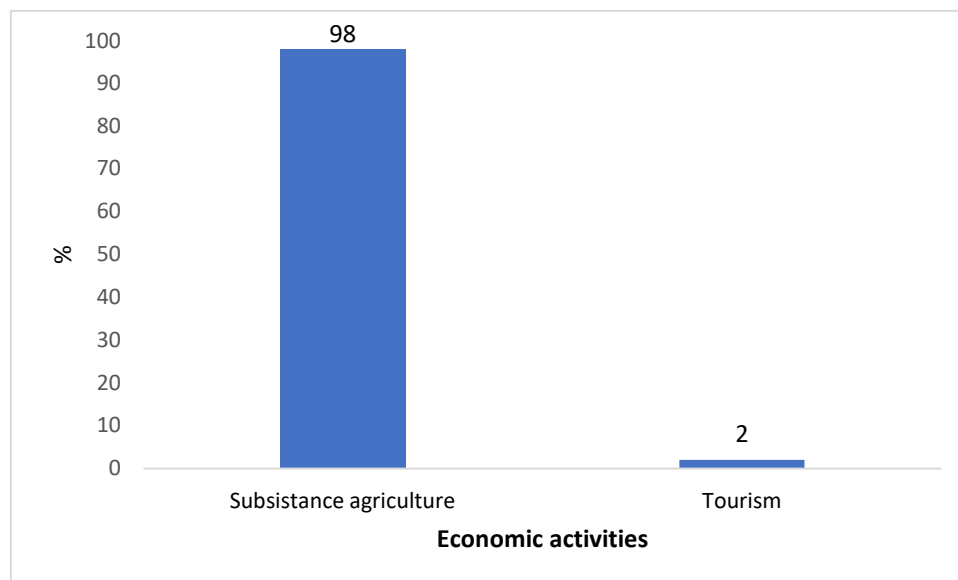


Figure 6: Economic activities (%)

With many people having been unemployed as indicated above it means the majority are relying on agriculture as a source to sustain their livelihoods. However, given the fact that females are the majority, it means they are the ones who were involved as is widely the case in the literature. According to Sambo, (2014), most agricultural activities in South Africa's rural areas are performed by female farmers. This is because a large proportion of men have moved to metropolitan areas in search of better-paying jobs.

4.2.7. Land tenure system.

According to Kasimbazi, (2017), land tenure refers to a relationship between persons or groups and land. "Land" refers to additional natural resources like trees and water. A system of rules or an institution created by society to control behaviour is known as land tenure. The allocation of land ownership rights within a community is determined by tenure regulations. They outline the duties and limitations associated with the use, control, and transfer of land rights (Hull *et al.*, 2019). In simple terms, land tenure systems determine who can use what resources for how long, and under what conditions. Private land ownership refers to land that is owned privately by an individual, married couple, or other entities. For instance, in a neighborhood, certain trees, residential areas, and agricultural areas may belong exclusively to specific families.

Other members of the community can be excluded from using these resources without the consent of those who hold the rights.

A right of commons that may exist inside a community, where each member has the freedom to use the holdings of the group independently, is referred to as communal land ownership. For instance, grazing cattle on a communal pasture and taking resources from a river may be rights shared by community members. All the respondents acknowledged that the land was communal and not private. An important difference between open access and communal systems is that under communal systems non-members of the community are excluded from using the common areas. However, generally under communal land tenure resource access becomes open access because there are no specific rights assigned to anyone and as a result, everyone is included, or no-one can be excluded. The land tenure system is the dominant one in Mariveni.

4.3 Perceptions of the community of Mariveni

Perception is a mental image and physical experience comprehended in the context of an idea or awareness, whereas attitude is a psychological state respecting a statement or a circumstance (Teachman *et al.*, 2008). According to Qiong, (2017), perception diversity exists not only because words or expressions are sometimes individually unique, but also because they are circumstance-bound. It is assumed in social psychology that an individual's personal evaluations are more informative of the person's attitude than what she/he claims to do. The attitude of environmental concern originates from the individual's concept of himself and from the degree of self-perception as a fundamental part of the natural environment (Raman, 2016). Perception is important on how to see the resources. In case of Mariveni, the perception of the Greater Letaba River as a source of sustainable livelihoods is very crucial as the community highly depends on this river.

4.3.1 Comparison of Perceptions on land use change and satellite image information

Many respondents (54.6%) were of the view that there was no change in the Greater Letaba River, followed by (36.7%) of those who said that the river capacity has decreased. The least (8.9%) were of the view that the river has increased in capacity. However, remote sensing information indicated that there was an increase in the size of the river which shows that people’s perceptions can either align or misalign with reality. Further examples can be observed in the cases of ecosystems such as grasslands and natural forests.

Results shown in Table 3 also revealed what the perceptions of the respondents on land use change per category were not only for Letaba River but for the whole Letaba catchment. The participants perceived that cultivated and built-up areas experienced an increase whilst there was no change in the rest.

Table 3: Comparison between community perceptions of Land use change and remote sensing information (presented in %)

Letaba Catchment	Land use type	Increase	Decrease	No change	Satellite Images
	Cultivated lands	70 %	11%	18%	Decrease (0.14%)
	Built up areas	78.9%	3.3%	17.8%	Increase (2.84%)
	Plantations	11.1%	44.4%	74.4%	Increased (1.56%)
	Letaba river	8.9%	36.7%	54.6%	Increase (1.11%)
	Bare surfaces	5.6%	25.6%	68.9%	Increased (1.56%)
	Grasslands	11.1%	26.7%	62.2%	
	Natural forests	22.2%	31.1%	66.7%	

Most of the perceived changes were misaligned with changes observed through satellite imagery except for the built-up area. The lack of correspondence between the community's perceptions of different land use types and satellite images indicates that people's perception can be misaligned to reality. On the other hand, the correspondence, or the alignment between the community's perceptions between built-up areas and satellite images shows that at times perceptions can be correct. One reason why there is a correspondence between built-up areas and the satellite images is that built-up areas are residential places, malls, or any human development areas. These are conspicuous making it easy for people to observe them when they develop when compared to other land uses such as rivers. For instance, an increase or decrease in the river can be observed through the volume of water flowing, meaning people are likely to link low water volume/level to a decrease in a river size (width) and an increase in the volume of water to an increase in the river size. All this is misleading because according to Mengen *et al.*, (2020), the river size measurement (width) is measured using the highest point of the bank that is reached by the water from both sides of the river. This is too scientific not only for ordinary people such as those in the study area but also for educated people in other fields that are far apart from environmental studies and geography.

4.3.2 Perception of the Land Use Drivers

The development of land use land change usually relies on the two broader groups of man-made agents, namely, proximate drivers and underlying causes. The proximate drivers explain the direct action of humans on local land covers and include expansion of agriculture, population growth, unsustainable exploitation of forest resources, and infrastructure development. Indirect forces are economic, institutional, technological, cultural, and demographic changes that accelerate the effect of proximate drivers on natural resource use (Betru *et al.*, 2019). Drivers of land use change were almost the two that are mentioned by the authors as indicated in Table 4.

Table 4: Perceptions of respondents on Land use change drivers (%)

Letaba Catchment			
Driver of land use	Least important	Important	Most important
Natural resource extraction/harvesting	27.8%	8.9%	63.3%
Timber harvesting	67.8%	8.9%	23.3%
New residential areas	25.6%	21.1%	53.3%
Farm abandonment	-	-	-
Agricultural expansion	20.0%	16.7%	63.3%
Increase in livestock numbers	-	-	-
Infrastructure development	54.1%	24.4%	21.1%
Poverty	23.3%	18.9%	57.8%
Lack of financial resources	32.2%	22.2%	45.6%
Population growth	10.0%	10.0%	80.0%
Lack of law enforcement	44.4%	25.0%	30%
Land use policies	45.6%	30%	24.4%
Demand for wood products	-	-	-
Lack of environmental awareness	-	-	-

The increase in the number of community members and extraction of resources such as fuel wood harvesting were some of the most common activities mentioned by 80% and 63% respectively. Agricultural expansion also received the same % to that of resource harvesting. These factors are interrelated because when the population increases there will be an increase in the demand for fuel wood extraction like land for agricultural land particularly in such areas where the majority primarily use electricity for lighting and fuel wood for cooking due to lack of affordability. The fact that there are gardens around the river is evidence that agriculture is important for their livelihoods. As will be seen under the water quality subsection, the availability of farms around the river was referred to as one of the factors that have contributed to the change in the river. With a lack of

employment, it is logical that more and more people can resort to farming for livelihoods.

Related findings exist in Ethiopia where Betru *et al.*, (2019), found that population growth was one of the drivers of the change in land use in Ethiopia with high demand for agricultural land resulting from it contributing to the deterioration and depletion of forest resources of the country.

4.4 Source of Livelihoods

Water sustains all people's livelihoods through water-intensive agriculture and industrial operations, consumption, sanitation, and environmental services (Seckler & Amarasinghe, 2000). Water resources are vital for ecosystem function and the well-being of human societies (Kalogiannidis *et al.*, 2023). The importance was also demonstrated in this study with 78% of the respondents indicating that they relied on the river as a source of domestic use (water for drinking, washing, and irrigation) contrary to 22% of the respondents who said they did not rely on the river. Those who did not use river water used other sources of water such as underground water as there were people who sunk boreholes.

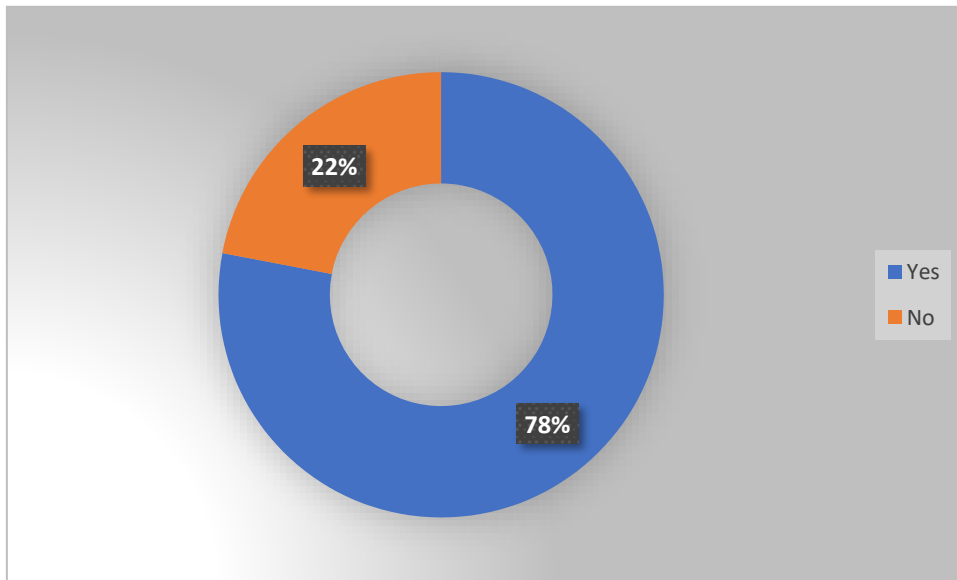


Figure 7: Reliance on Letaba River (%)

One of the activities for which the community of Mariveni used river water was irrigating gardens as indicated by Respondents 4 and 20: *“We have been using this river to irrigate our crops such as cabbage and spinach. However, for the past few years, there has been a reduction in the water flow which affects our productivity.”* This indicates that the river is used to produce crops which they sell to earn livelihoods and with the scarcity of jobs, this means that the river is creating agricultural enterprises. The use of river water for commercial is common even in South Africa but has caused challenges regarding the volume that the river can supply. This leads to the drying out of rivers, which suggests that even in this area there should be policies that should determine the capacity of the river concerning irrigation of smallholder farmers. This is particularly so as one of the Respondents (30) indicated that there are more and more people farming alongside the riverbed: *“Many people are finding it hard to find employment, they plant crops alongside the riverbed to be able to provide for their families”.*

4.5 Changes in water quality

Water quality is defined conceptually as the physical, chemical, and biological properties of water supply that affect how suitable it is for a given application, such as how effectively the user's needs are met by the quality of the water (FAO, 1994). The quality of water is determined by its acceptability for human consumption, recreational activities, and its ability to support aquatic life and other wildlife (Neary, 2002). According to WHO (2006), water used for residential or personal use needs to be safe and devoid of chemicals, radioactive materials, and microorganisms that could endanger people's health. Water quality is generally acceptable, however, due to the country's geology, the natural quality of groundwater in the far western regions and rivers in the southern and western coastal regions are poor (Thompson, 2006).

As with the rest of Africa, agricultural land, and urban land are generally considered to be key contributors to water quality changes in watersheds in South Africa. Human behaviors associated with urbanisation (e.g., increased industrialisation and housing development) can affect the water quality of regional surface water bodies (Cheng, *et al.*, 2022). The quantity and quality of water sources are expected to deteriorate further to the point where they seriously impede future socio-economic development. The

deterioration of surface water quality has become a global environmental problem (Camara *et al.*, 2019). Most respondents 52% believed that water quality had changed while 48% did not believe that water quality had changed.

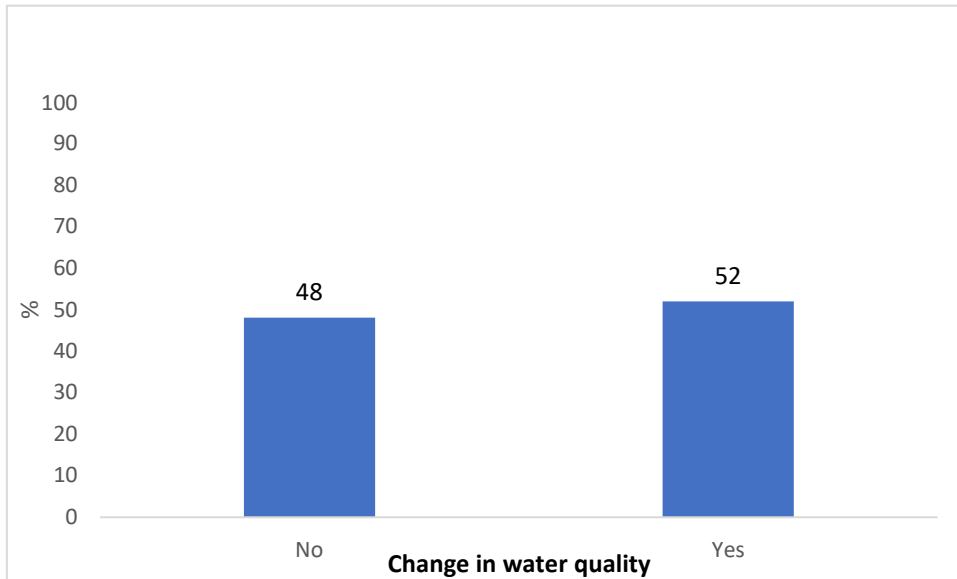


Figure 8: Changes in water quality (%)

The water quality in the study area was poor as identified through three senses, smell, taste, and colour by the respondents: *“The taste of water is bad, and it does not smell nice”* (Respondent 19). According to Respondent 83, the water was not clean and looked brownish in colour. *“Sometimes the water smells and is not clean in colour and looks brownish”*.

Many of those who observed change 21% said that it was through a colour change, followed by those whose observation was through a combination of colour, smell, and taste 9% while those who observed a change through colour and smell were at 8% like those who observed a change through smell only (Figure 10). The least were those whose observation came through taste 6%.

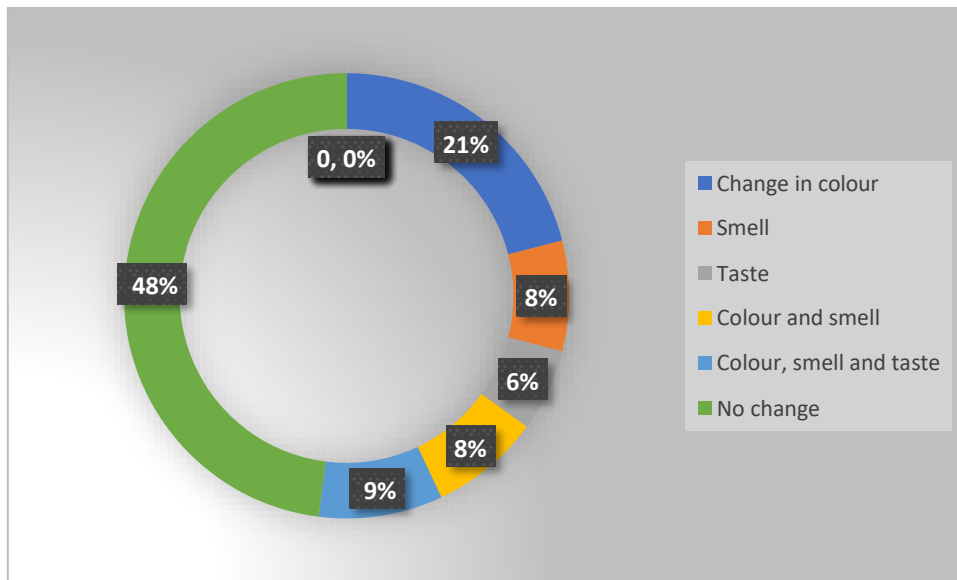


Figure 9: Characteristics used to assess water quality change (%).

The observation above indicates that different people observe change differently. Below are the common causes that the respondents felt led to the change in water quality are specified below:

- Farming activities
- Disposal of waste such as diapers
- Waste from animals
- People throwing garbage.
- Lack of water purification
- Chemicals from farming activities
- Sewage pipes draining into the river.
- Waste from domestic animals

4.6. Changes in water quantity

The earth's surface water bodies have undergone significant alterations due to both global climate change and increased human activity. The production of agriculture and industry has been significantly impacted by these changes in surface water bodies (Zhou *et al.*, 2017). Water quantity is defined as the overall yield and timing of water from a watershed, as determined by peak flow and total yield over a certain time. Most of the respondents 66% indicated that there was a change in the water quantity of the

river while 24% of the respondents did not believe that the water quantity changed (Figure 11).

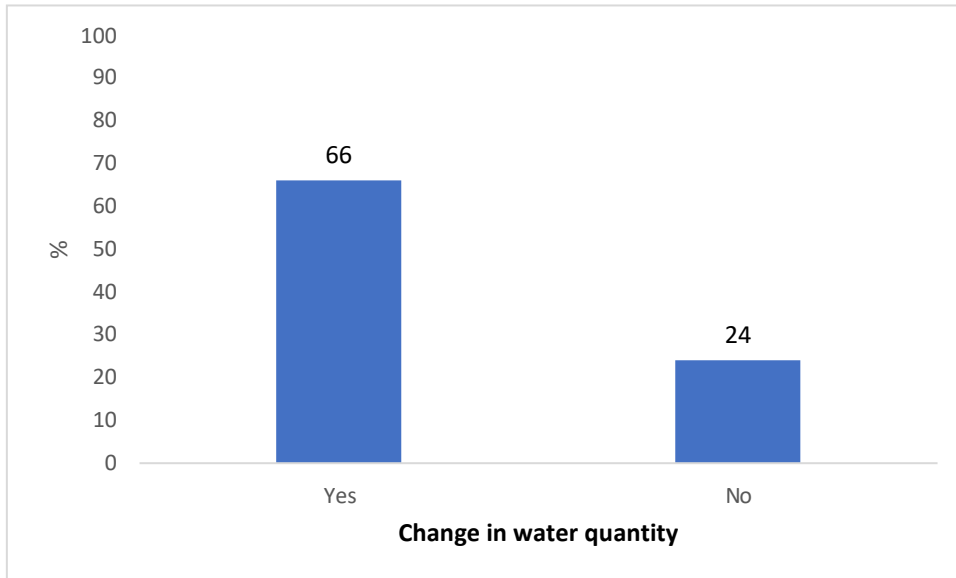


Figure 10: Changes in water quantity (%)

In terms of the cause of water quantity, many respondents, 29%, felt that the absence of rain was the main cause (Figure 12). These were followed by those who indicated that the change was through irrigation of the nearby farms and dumping of waste, both at 19%. Five percent (5%) of the respondents indicated rainfall as the cause for poor water quality with 4% indicating other factors. Those who thought that there was no change were at 24%.

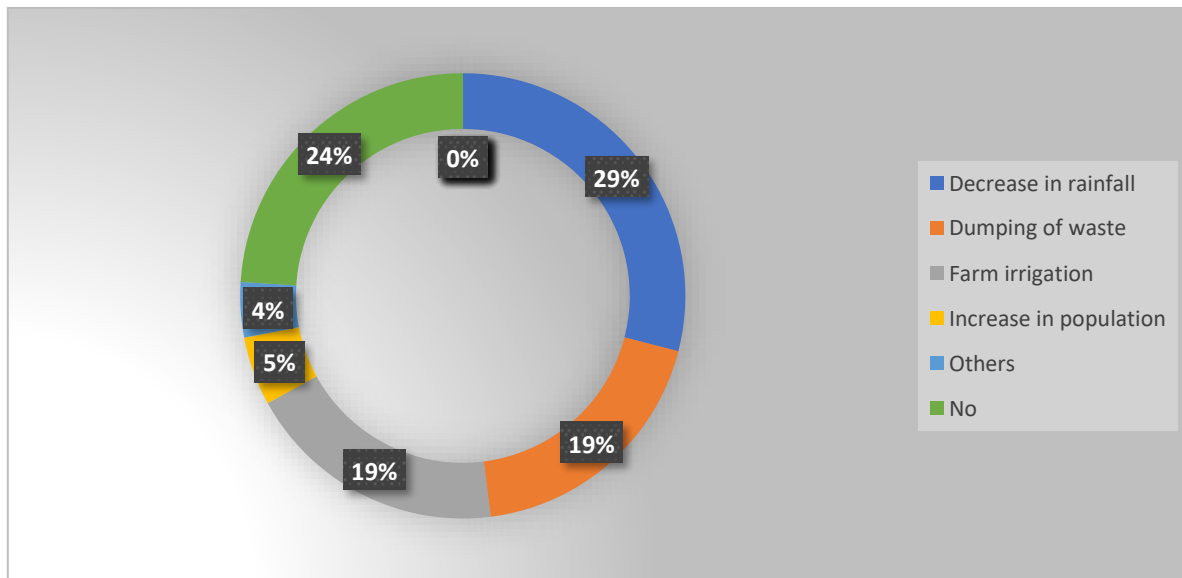


Figure 11: Causes of water quantity change (%)

The evidence presented above is consistent with a study conducted by Kourgialas *et al.* (2017), which found that during the past few decades, there has been a major stress on the environment, particularly on water resources, leading to water-related issues in many parts of the world. The use of agrochemicals, herbicides, animal manure, and other agricultural practices continuously deteriorates the surface and underground resources, and industrial wastes, in addition to tourism and urban activities. Groundwater pollution can affect human health due to its influence on the food supply chain. When crops are irrigated using wastewater containing persistent toxins and groundwater tainted by heavy metals, hazardous substances can accumulate in cereals and vegetables, endangering human health (Peiyue *et al.*, 2021).

4.7 Impact of change on water quality and quantity on the socio-economic status of the community of Mariveni

In several river basins, including the Limpopo basin in Southern Africa, the Ganges basin in India, and the Murray-Darling basin in Australia, the season of low water availability is when water demand is highest. The consumers of water resources themselves are the direct victims of overuse; during droughts, they increasingly experience water shortages that endanger the livelihoods of entire communities by reducing harvests and costing farmers money. Water shortages are becoming a greater problem for businesses whose activities depend on it. Additional consequences

encompassed declines in biodiversity, reduced flows impeding navigation, land subsidence, and salinisation of soils and groundwater reserves (Mesfin *et al.*, 2017). Some of the respondents indicated that the change in water quality has negatively affected their socio-economic status: Respondent 2 said, *“It caused illness and raised the cost of getting treatment”*. Below are the common responses regarding water quality changes.

- Reduced water for irrigation in the past years affected productivity resulting in some people no longer growing any crops.
- Increase in health hazards
- Fishing was no longer feasible which led to reduced related business and food security.
- Reduced recreational activities such as swimming.
- Limited family time as people travel to fetch water from far places in the community where they drilled boreholes.

From the above, it is evident that the river was central to community's socio-economic well-being. As such the change in water quantity meant that this would negatively affect the irrigation of the crops around the farms thus impacting their livelihoods. This was pointed out by Respondent 93: *“Reduced water quantity has affected backyard gardening which has increased the cost of living as we have to buy more food instead of growing our own”*. Similarly, this is what Respondent 10 mentioned: *“We have lost sources of income because we cannot irrigate our vegetables and fruits anymore due to lack of sufficient water. We use buckets to irrigate our crops. When water is less it means, we must go to deep areas which is risky because there are crocodiles*. This means that people must look for money to buy food to survive which puts economic pressure on their lives. With the unemployment rate being so high as has been demonstrated already it means lack of water places an extra economic burden on the people's lives. Additionally, this demonstrates that their lives are in danger as they are more vulnerable to being caught by crocodiles.

Another interesting finding was on the impact on health and wellbeing of the community members with one respondent indicating that they had to spend more money on

treatment than before due to the frequency with which health hazards were experienced. *“It increased illness and cost expenditure for getting treatment”*. Water that is highly contaminated with micro-organisms such as intestinal bacteria, viruses, and protozoa is dangerous to the health of residents/inhabitants who encounter such irrigation water. Such water is dangerous to the health of people who use the river and its environment for recreation. This information is supported by Barnes and Taylor (2003) in their study. However, as not everyone was relying on the river those who got boreholes were not affected as indicated by Respondent 11: *“I never bought water because I have a borehole”*. However, as the number of such people was small i.e less than, 20%, it means that very few community members have drilled boreholes. Therefore, the effect of river water quantity change is felt by more people in the community.

4.8 Cooperation between traditional authority and government

For better management of water resources at all levels, international, regional, and community levels, there should be a need for cooperation between all stakeholders. These institutions include both governmental and commercial entities that must create, operate, and sustainably maintain water systems and services. New partnerships are required between government and traditional authorities for effective local administration together with civil society to create cooperative management arrangements that benefit both the population and the environment (Tantoh *et al.*, 2020). As demonstrated by the figure 13 below, the study revealed that 93% of the respondents said that there was a lack of cooperation between the government and traditional authorities.

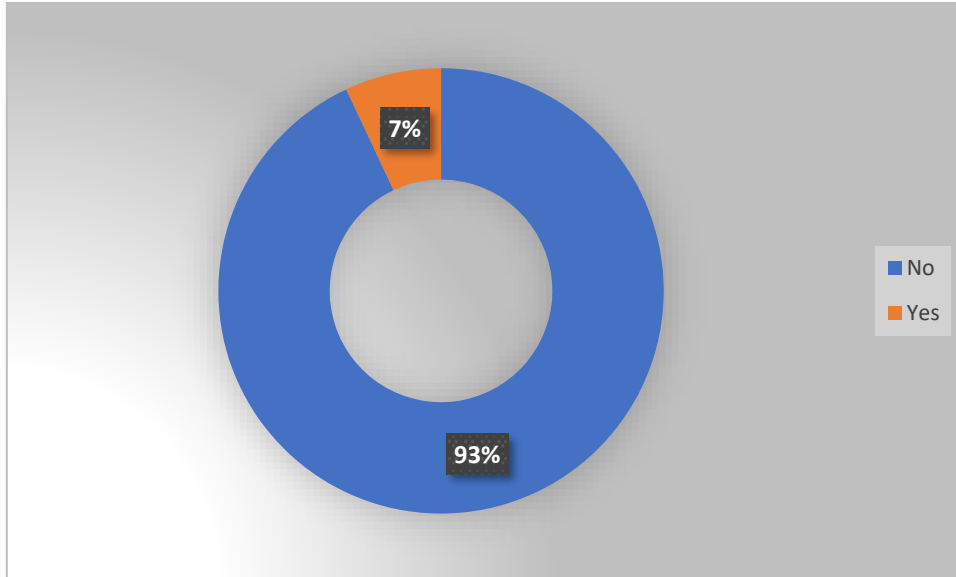


Figure 12: Perceived Cooperation between Traditional Authority and Government (%)

Lack of cooperation can largely be blamed for most of the water quality and quantity problems because most of the indicated causes of a change in water quality and quantity reveal a lack of management measures and support and rules enforcement in place. For instance, littering, old water pumps, and farm irrigation are causes that can be addressed or mitigated by an effective water government system.

4.9. Mitigation strategies addressing water quality and quantity.

On the question of whether the identified water quality and quantity problems could be resolved, many respondents 87% felt that they could be resolved while 13% of the respondents were of the view that the problems could not be resolved.

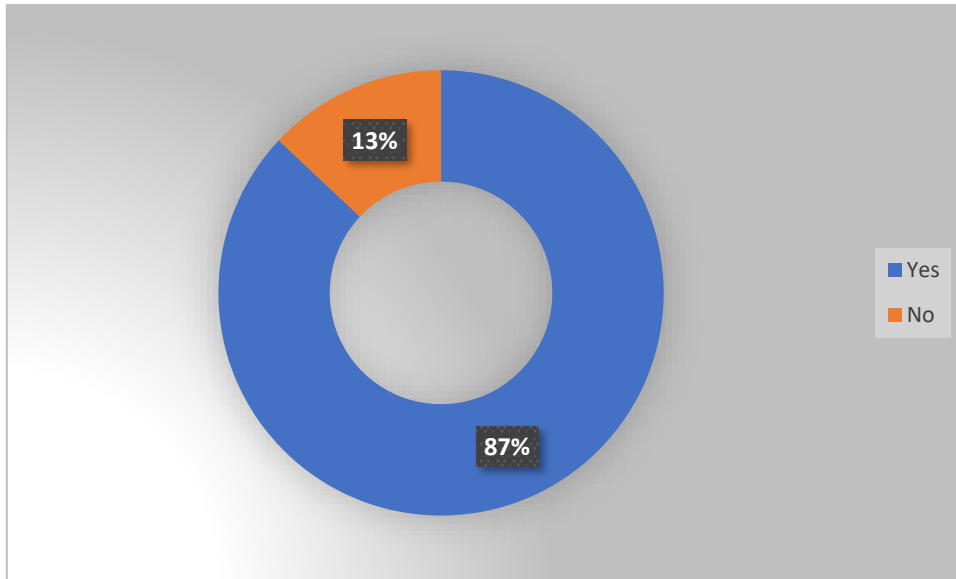


Figure 13: Views on whether water quality and quantity strategies can work (%).

The respondents suggested various mitigation strategies that can be implemented. Respondent 79 suggested this: *“Government has to organize with the local municipality to try and supply the community with water. There should be cooperation between the councilor and the local chiefs because if they do not work together people are the ones who suffer. For instance, the water pump is old, and we need a new one, but the government does not buy it for us”*. Respondent 40 suggested that a dam should be created to conserve water which he was of the view that this should be important given the challenge of climate change: *“Dams must be built to store water because with climate change, we are seeing less frequency of rainfall. So, a dam will be important in this context because when heavy rains occur you never know when it will occur unlike in the previous years when we were sure that it would rain”*.

4.9.1 Sinking of boreholes

For community development and catastrophe preparedness, drilling water boreholes can be crucial (Ateya, 2023). People suffer from a lack of water and inadequate infrastructure in many developing-nation areas. Boreholes can help with these issues by offering a nearby supply of clean water for cooking, drinking, washing, and other household needs. However, a geohydrologist would be required to determine the amount of underground water resource available as well as its capacity as this is key to determining the sustainability utilisation of underground water use. If this is not done,

over time the water will be depleted, especially if there is overutilisation of the water. For instance, the depletion of water resources over the past three decades has been reported by Singh (2009) to be an environmental problem in many countries such as India where about 40% of the country's total cultivated land is irrigated through both surface and underground water. As a result, they have put in place a policy that promotes sustainable use of water resources and cooperation among stakeholders (Singh 2009). For those who did not indicate they relied on the river, one of their reasons was that they had sunk boreholes, and these were among 22% of respondents. On the other hand, those who did not have to buy from those with boreholes, especially for drinking, could use the river water for washing and bathing.

4.9.2 Water Management Awareness

Communities can initiate the implementation of effective strategies for water management by raising awareness and providing education about sustainable and efficient water management practices. By doing so, sustainable livelihoods may be created, and the ecological environment can be enhanced. Respondent 4: *“Our people need to be taught how to efficiently use water, especially for irrigation because you find them not caring much about water usage as long as they produce at the end of the day”*. This implies that the government must teach local people how to use water sparingly. Water management education, which includes all these components, has the potential to increase an individual's and household's knowledge of how our natural resources are being abused and how to avoid this from happening in the future.

4.10. Summary of chapter

The chapter presented and discussed the results of the study. These ranged from socio-economic information of the study area which included the age of the respondents, gender, period of stay and the employment status. Key aspects presented and discussed are the perceptions that the respondents had around the role of the river which were found to be a source of water for various used such watering gardens. The majority were of the view that the river size did not which contrary to satellite image which indicated that it changed on the other hand built-up areas were said to have been increase which was supported by the satellite image. Various activities were indicated to

have been negatively affecting the quality of the river such as agricultural activities upstream and dumping of waste. Sinking of borehole was indicated to be one key recommendation to address water shortage especially by those who did not afford to sink one on their plot but it is advised that assessment should be done regarding the availability and sustainability of underground should government use them as an intervention to ensure that it does not waste resource as underground water can easily get depleted in areas where there is less availability.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In this last chapter, the lessons learnt were integrated, the findings to the study objectives aligned and conclusions drawn from all the key findings in this study. These related to water quality and quantity of the Greater Letaba River, Land Use Land Cover issues as well as the perceptions of the community of Mariveni on the river as a source of sustainable livelihoods. The findings have significance not only for the Greater Tzaneen Local Municipality, but also for other regions dealing with the critical issues of water resource use. The purpose of this chapter was to give a complete overview of the study's contributions, highlighting the way forward for sustainable and equitable water access, quality and quantity for all communities in the study area and beyond.

The chapter presents the study's results, structured to address its objectives:

- i. assess community of Mariveni's source of livelihoods emanating from the Greater Letaba River.
- ii. establish the changes in the water quality and quantity of the Greater Letaba River as perceived by the community in Mariveni village.
- iii. determine the possible impacts that the change in the river has on the socio-economic value of the community of Mariveni village.
- iv. the mitigation strategies on the sustenance of the Greater Letaba River by the local authorities as a source of sustainable livelihoods.

Lastly, the chapter presents a summary and conclusions drawn from the findings of the study. This is followed by recommendations for future improvement.

5.2 Summary and conclusions drawn from the study

Mariveni community consists of youth, middle-aged, and elderly individuals with the latter being the majority. It has been indicated that the youth are at institutions of learning and/or work in urban areas. The study has discovered that many people, stayed there for more than 21 years and females are the dominant gender. The level of education is high with the majority having attended school at least until secondary level.

The study also detected that the unemployment rate, as in many other areas in the country, was high.

The results on the water quality revealed that many people in the study area believed that water quality and quantity have changed, and the changes have affected their well-being socially and economically. From a social perspective, people indicated that they had their time spent with their families reduced and had fewer recreational activities which included swimming and fishing. Economically, they have to spend money by buying water from those who invested in boreholes with the continuous increase in the amount of water. In addition, they also indicated that they visited clinics more frequently which also shows the negative health related effects caused by the change in water quality which has resulted in the eruption of water-borne illnesses.

While the majority had said that the river size did not change, the satellite images indicated that it did, which shows that perception can be aligned and misaligned with reality. Nonetheless there is enough evidence that the amount of water has decreased overtime which affects people' livelihoods. The main aim of the study was to evaluate Mariveni community's perception of the greater Letaba River as a source of sustainable livelihoods. The results of the research indicated that the river was an important source of livelihood. Almost 80% of the respondents indicated that they relied on the river for economic and social activities. They used the river for various purposes including washing, drinking, and bathing. In terms of livelihoods, they drew water from the river to irrigate the gardens that they established alongside the river from where they sold the products to the community thereby getting an income.

The results also indicated that water quality was observed to have changed by many respondents and the causes for the change included chemicals from farms and dumping of household waste. Similarly, there were people who felt that the water quantity had changed. The change in water quality and quantity was said to have influenced activities that took place in the area to improve on the livelihoods of the community. Reduction in the level of production was indicated to be one of the key economic impacts with respondents indicating that this affected their livelihoods. The change in water quality meant that people had to consult medical doctors more

frequently due to the associated water-borne diseases. The results also demonstrated that perceptions can sometimes not be aligned to reality. The majority of the respondents had indicated that there was no change in the size of the river which was not true as it had changed as proved by the remote sensing information (Mengen *et al.*, 2020).

5.3 Recommendations

The results from the study will be useful to the Greater Tzaneen Municipality in policy and decision-making. The study therefore recommends the following.

- The local councilor should raise the need to have boreholes through the local IDP and their implementation needs to be preceded by an assessment of how many boreholes are required so that an adequate number is implemented.
- As a temporary measure, the municipality should provide water by using water tankers in the areas to reduce the costs incurred through buying from those who sunk boreholes.
- The government should provide waste bins for garbage dumps as this was also indicated to be one of the contributing factors to a change in water quantity. However, awareness in this regard will be required to ensure that bins are used because studies have demonstrated that putting bins around an area does not necessarily mean that people will not litter.
- The government and research institutes should make awareness and training workshops about possible water conservation techniques that are applicable in the study area.
- Future research is required that can scientifically investigate the severity of water quality problems as studies done around that area indicate that there is a water quality problem due to chemicals used in farms. Such results should be shared with community members for their information especially since there were those who did not believe that the water quality has changed.
- The government should support small businesses and enterprises in the community to create jobs so that there is less pressure on the river.

- More research studies should be conducted on the perception with an increased data collection period as perceptions change depending on socio-economic factors which they themselves change.
- NO which will serve as barriers that stop or restricts the flow of water or underground streams. Reservoirs created by dams not only suppress floods but also provide water for activities such as irrigation, human consumption, industrial use, aquaculture, and navigability.

5.4 Conclusion and synthesis of the dissertation

The study has uncovered critical aspects of water quality and quantity changes in the Greater Letaba River resulting from Land Use Land Cover changes which emanate mainly from anthropogenic activities. The assessed community of Mariveni is aware and are experiencing the challenges that come with these changes. These have therefore informed a range of adaptation responses to limit the impacts of these challenges. Water pollution and reduction in water quantity in the river emerged as a formidable adversary, which has resulted in the depletion of the value of water in the river as a sustainable livelihood. It has been realised that it is not just natural phenomena such as climate change that presents obstacles but also operational issues like aging infrastructure and financial constraints that play their part in limiting communities' access to water as a source of sustainable livelihoods.

One of the issues that can be concluded upon is that it is always the vulnerable rural communities such as that of Mariveni that bear the heaviest burden when resources are degraded. Yet, within these challenges lies the opportunity for change. The recommendations paint a path forward, including exploring prospects such as giving attention to rural areas infrastructure, raising awareness in ways that resonate with local communities especially with regards to preserving water as a vital resource, and exploring new, community-led approaches to water management. These strategies, combined with technological innovations and a focus on health and water quality, can help to overcome these hurdles.

Furthermore, follow-up studies that can assess whether the recommendations have been implemented might be required especially as there may be more natural phenomena such as drought and floods that may further affect the quality and quantity of water in the Greater Tzaneen Local Municipality (and Mariveni village in particular) due to climate change. Such a study may also include an assessment of the extent to which farming activities uphill are contributing to the change in water quality. The study concludes by advising that other interested parties should invest some of their time and money in investigating the viability of other clusters within the Greater Tzaneen Local Municipality and the Mopani Distric Municipality at large.

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APPENDIX 1: QUESTIONNAIRE

QUESTIONNAIRE

Research title: Socio-economic drivers of land-use/land-cover change in GLC, the effects on the river as a source of livelihoods, along with the mitigation and adaptation strategies

Respondent:

This questionnaire seeks to collect data on land use and land cover changes, their drivers, impacts and mitigation and adaptation strategies. It is expected to generate and provide helpful information for policy makers and development practitioners about socio economic drivers of land use and land cover change. Therefore, your inputs as a stakeholder to fill this questionnaire is highly appreciated and information provided will be treated with confidentiality. Your right to participate or not is also respected.

1. KEY INFORMANT CHARACTERISTICS						
a) Age of respondent	<=25	26-35	36-45	46-55	56-65	>65
b) Gender	Male			Female		
c) Highest level of your education?	No formal Education			Primary Education		
	Secondary Education			Tertiary Education		
	Other					
d) What is your Occupation						
e) Which position do you hold in your community						
e) What are your responsibilities with regards to this position?						

f) How long have you lived in this community?	10 yrs	10-15 yrs	16-20 yrs	>20yrs
g) If less than 10 years, where were you staying before?	In a different village but same municipality			
	In a different municipality			
	In a different province			
	In a different country			
h) What was the reason for this migration	Farming			
	Marriage			
	Employment			

	Others (Specify	
2. CONOMIC ACTIVITIES IN THE AREAS		
E		
a) What do the majority of people in the community/region/district do for a living?		
b) What are the main economic activities in the community/region/district?	Agriculture	
	Employment	
	Own businesses	
c) Land tenure system in the area and proportions	Type	Proportion
	Communal	

	Commercial	
	Municipal land	
	Other	

d) What are the different proportion areas related to different land uses in the region/district	Cultivated Lands	Bare Surfaces
	Built up areas	Grasslands
	Plantations	Natural forests
	Water bodies	Shrublands
	Wetlands	

3. DRIVERS OF LANDUSE CHANGES IN THE AREAS

a) Which land uses of the community/region have undergone notable change – increase or decrease?		Increase	Decrease	No Change
	Cultivated Lands			
	Built up areas			
	Plantations			
	Water bodies			
	Wetlands			
	Bare Surfaces			
	Grasslands			
	Natural forests			
	Shrublands			

	Bare Surfaces			

	Land use	Key drivers
b) What are the key drivers of the notable changes in land use	Cultivated Lands	

mentioned above?	Built up areas		
	Plantations		
	Water bodies		
	Wetlands		
	Bare Surfaces		
	Grasslands		
c) Which parts of the community have experienced the most change and why?	Natural forests		
	Shrublands		
	Bare Surfaces		
d) When did the land use changes mentioned above happen?	<5 yrs	>10 yrs ago	>20 yrs ago
4. PROXIMATE AND UNDERLYING CAUSES (DRIVERS) OF LULC CHANGES			
(a). What do you think are the causes of land-use and land-cover changes in your area (RANK ON A SCALE OF 1 to 3; 1 = least important, 2= important and 3 = most important).			
Proximate cause	Rank		
	1	2	3
Natural resource harvesting/firewood			
Timber harvesting			
New residential areas			
Agricultural expansion/abandonment			
Infrastructure development			
Other			

Underlying causes			
Poverty			
Population growth			
Lack of financial resources			
Lack of law enforcement			
Demand for timber			
Change in land use policies			
Climate change			
5. Community perception on the Greater Letaba River as a source for sustainable livelihoods			
a) Do you rely on the Greater Letaba River for water?	Yes	No	
b) If yes, what do use the water for?			
Agriculture	Yes	No	
Tourism activities	Yes	No	
Domestic use	Yes	No	
Other(specify):			
a) Have you noticed/observed any changes in water quantity of the river (river capacity level)?	Yes	No	
b) If yes, what do you think could be the contributing factors(specify):			
e) Have you noticed/observed any changes in water quality of the river?	Yes	No	
Taste	Yes	No	
Smell	Yes	No	

Colour(turbidity)	Yes	No
f) If yes, what do you think could be contributing factors?		
Population growth	Yes	No
Agricultural expansion	Yes	No
Recreational activities	Yes	No
Industrialisation	Yes	No
Negative waste management practices	Yes	No
Other(specify):		
g) How has the changes in water quality and quantity impacted your social life?		
Diseases	Yes	No
Conflicts	Yes	No
Migration	Yes	No
Overgrazing	Yes	No
Changes in land-use policies	Yes	No
Other(specify):		
h) How has the changes in water quality and quantity impacted your economic life?		
Lack of income	Yes	No
Reduction of agricultural land	Yes	No
Decreased infrastructural development	Yes	No
High poverty levels	Yes	No

Decline tourism	Yes	No
Other(specify):		
6. THE MITIGATION AND ADAPTATION STRATEGIES		
a) Are there any mitigations or adaptation strategies that have been adopted to address the challenges of LULC change? Please explain		
b) What do you think can be done to address the challenges of LULC change? Please explain		
c) Are you aware of any mitigation strategies implemented by the local authorities in ensuring sustainable water use (polluter pays principle, irrigation standards etc.)? Please explain		
d) To what extent do you believe the activities aimed at reducing unsustainable land use changes are actually addressing the underlying causes of land use change? Please explain.		

e) What other actions or policies should be implemented to address the drivers of land use change?
f) Does the municipality work close with the traditional authorities, community and local businesses in ensuring that the Greater Letaba River is sustained? Please explain
g) Are there any awareness/educational campaigns undertaken in relation to sustainable use of water as a source of livelihoods? Please explain
h) What is required for actors to change their practices? What types of incentives could they be given to change their practices?
i) Do you have any colleagues/contacts/ people you can recommend for further interviewing?

Thank you for your time