ASSESSMENT OF SUSTAINABLE WATER SECURITY IN THE BOJANALA REGION IN THE NORTHWEST PROVINCE IN SOUTH AFRICA

by

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DECLARATION

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I declare that this thesis is my work and that all the sources that I have used or quoted have been indicated and acknowledged by employing complete references.

I further declare that I submitted the thesis to originality checking software (TURNITIN) and that it falls within the accepted requirements for originality.

I also declare that I have not previously submitted this work, or part of it, for examination at UNISA for another qualification or at any other higher education institution.

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February 2023

SIGNATURE **DATE**

DEDICATION

I dedicate this thesis to God Almighty my creator, my strong pillar, and my source of inspiration, wisdom, knowledge, and understanding.

Also, I dedicate this work to my adorable parents, grandparents, and my brother who took an early lead to heaven! Their loving memories, sacrifices, and life values made me strong throughout my study period.

Lastly, my special dedication goes out to all the special people in my life who have been supporting me in their different capacities.

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I acknowledge that through Christ who strengthens me, I can do all things (Philippians 4:13).

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ABSTRACT

Sustainable water security is essential for human well-being, environmental preservation, economic prosperity, and social stability. Pursuing sustainable water security is instrumental in guiding policymakers, planners, and stakeholders to implement effective and equitable water management practices that can create a resilient and sustainable water future for both current and future generations. The Bojanala District, like many other regions, faces significant challenges regarding water security. Understanding the challenges faced by the Bojanala District in terms of water security is vital to secure a sustainable water future and supporting socio-economic development. The purpose of this research was to assess sustainable water security among households and develop a descriptive model capable of guiding for implementation of reliable interventions regarding water security and supply in the Bojanala District, in the Northwest Province of South Africa. The specific objectives of the study were to identify and analyze the demographic and socio-economic features associated with water security in the study area; assess the water security status among households in terms of availability and access to water, and identify and analyze the factors influencing sustainable water security in the area. In this endeavor, the study employed an explanatory sequential mixed-method design to explore the concept of sustainable water security among households in the Bojanala District. A sample size of 384 participants was selected, allowing for the generalizability of findings to the target population. The combination of stratified random sampling and simple random sampling ensured the representation of diverse perspectives. Data collection at the time of the Covid-19 pandemic necessitated non-contact interviews. The survey was disseminated online to respondents residing across the Bojanala District. The study employed a semi-structured questionnaire divided into sections informed by the specific objectives of the study. The quantitative data was collected through household questionnaire surveys, focusing on water security indicators such as water availability, access, and quality, as well as their impacts on livelihoods, health, and education. Subsequently, qualitative data was gathered through interviews, focus groups, and observations to provide further explanation and context for the quantitative finding. The quantitative data were analyzed using descriptive statistics of SPSS Windows Version 25. The qualitative data obtained from interviews were analyzed using the thematic analysis technique. Triangulation, using multiple data sources and methods, strengthened the validity and reliability of the research

The study comprised a predominantly female population, constituting 63.8% of the participants, while 62.5% of the respondents were single. Furthermore, a substantial proportion, 32.6%, fell within the age bracket of 30 to 40 years. The study findings indicate that a significant majority (51.3%) of the respondents hold the perception that the condition of the water supply infrastructure is poor; a considerable proportion (63.9%) revealed that there have been disputes or disagreements about water shortages, and standing in long queues when fetching water. The majority (49.7%) of participants indicated boreholes as their main source of water supply. The participants, comprising 41.7% of the sample population, hold the view that the diseases observed within their households have a direct

association with water-related factors due to the perceived poor quality of water. Moreover, the findings indicate that a significant proportion of the participants, 93.8%, reported not obtaining water from an in-house tap connected to a private borehole. Additionally, a majority of the respondents, 89.6%, expressed dissatisfaction with the public water source, as it fails to adequately meet the water demands of the current population. The results of logit regression show that when independent variables are added, the model correctly classifies 82.9% of overall cases. The results also revealed that 78.1% of the participants who are water-secured were predicted by the model to be water-secured. Furthermore, the results revealed that 86.4% of the participants who were not water-secured were predicted by the model to be not water-secured. It is also noted from the results that the positive predicted value of 80.6% of all the cases predicted to be water-secured was correctly predicted. The negative predicted value of 84.4% of all the cases predicted to be not water-secured was correctly predicted. The insights gained from our logit regression analysis offer valuable contributions to the field of water security. The model's predictive accuracy and identification of key predictors can significantly enhance water security outcomes by guiding targeted interventions. To address the concerns, the study recommends the following: enhancing the management and maintenance of water sources and infrastructure to ensure a consistent and reliable water supply; Regularly assessing the effectiveness of implemented measures in addressing water shortages and resolving disputes; Implementing appropriate water treatment and purification methods to improve the quality of water supplied to the participants' households. Exploring strategies to optimize water distribution systems and minimize long queues; Implementing a comprehensive water quality monitoring program to assess the safety of the water supply. In other words, addressing these concerns through targeted strategies can lead to improved water security outcomes for the District. Finally, this research makes a significant academic contribution by pioneering an innovative analytical framework in the study area, effectively addressing an existing research gap. It represents the first comprehensive study of its kind in this geographical region, thereby offering valuable insights and relevance to the field

Keywords: Water Security, Descriptive Model, Households, Availability & Accessibility to water, Bojanala Region, North West Province, Water Infrastructure, Sustainable Water Security, Water Supply Interventions, Integrated Water Resources Management (IWRM), Sustainable Livelihood, Socio-Economic, Water Scarcity, Status of Water Security.

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LIST OF ACRONYMS

ANC	African National Congress
BPDM	Bojanala Platinum District Municipality
BB	Bokone Bophirima
BD	Bojanala District
CBD	Convention on Biological Diversity
CMA	Catchment Management Agency
CWDBS	Community-Based Drinking Water System
CWP	Community Work Program
DEA	Department of Environmental Affairs
DWS	Department of Water & Sanitation
DFID	Department for International Development
DWAF	Department of Water Affairs & Forestry
EPWP	Expanded Public Works Programme
ESCWA	Economic and Social Commission. for Western Asia
EWP	Environmental Water Resource
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GWP	Global Water Partnership
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
IWRM	Integrated Water Resource Management
MDG	Millennium Development Goal
NGO	Non-Governmental Organization
NEMA	National Environment Management Act
NWDARD	North West Department of Agriculture and Rural Development
NWP	North West Province
NWA	National Water Act
NWPR	National Water Policy Review

NWRS	National Water Resource Strategy
NWSFSA	National Water Security Framework for South Africa
OECD	Organisation For Economic Cooperation & Development
OWP	Open Working Group
PFMA	Public Finance Management Act
RSA	Republic of South Africa
RWP	Renewable Water Resource
SADC	Southern Development Community
SDG	Sustainable Development Goal
SLF	Sustainable Livelihood Theory
SAWS	South African Weather Service
SWS	Sustainable Water Security
UN	United Nations
UN DESA	United Nations Department of Economic and Social Affairs
UNSDSN	United Nations Sustainable Development Solutions Network
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children Emergency Fund
UNISA	University of South Africa
WEF	World Economic Forum
WGF	Water Governance Facility
WHO	World Health Organization
WPI	Water Poverty Index
WRC	Water Research Commission
WS	Water Security
WSA	Water Security Act
WSA	Water Service Authority
WSI	Water Service Institution
WUA	Water User Association

WWAP	World Water Assessment Programme
WWC	World Water Council

CHAPTER ONE
INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

The United Nations (UN) (2013) definition of water security involves the ability of a population to ensure sustainable access to sufficient amounts of water that meets quality standards. This access is essential for maintaining livelihoods, human well-being, and socio-economic progress. Additionally, water security encompasses measures to protect against water pollution and disasters, as well as efforts to preserve ecosystems in a peaceful and politically stable environment. This definition implies that water is managed sustainably throughout the entire water cycle, with a transdisciplinary approach. As a multifaceted and situationally relative notion, water security can mean different things to different people depending on circumstances such as geography, socioeconomic status, and the relative importance of various stakeholders. For instance, recent research has identified 25 different definitions of water security, however, only three are commonly cited (Global Water Partnership, 2000; World Bank, Grey & Sadoff, 2007; & UN-Water, 2013). In this regard, the UN-Water Analytical Brief on Water Security presents an overview of the concept of water security without claiming to establish a globally agreed-upon definition (UN-Water, 2013). It recognizes that water security is diverse and draws attention to its many facets, including availability, quality, access, and protection against water-related dangers.

Water security is a critical issue facing South Africa, a country that has experienced numerous challenges related to the availability and quality of water resources. One of the main factors contributing to this issue is climate change, which leads to increased temperatures and irregular rainfall patterns. According to the South African Water Research Commission (WRC), these changes are expected to result in reduced water availability and increased water stress in many parts of the country (WRC, 2018). This poses a serious threat to many areas across the country where the water demand is high. Therefore, the assessment of sustainable water security in South Africa is a critical issue that requires attention and action. Also, the difficulties facing the water sector demand further assessment and acceptance of the Integrated Water Resource Management approach that can sustainably solve a variety of water-related problems (Parks, et al., 2022). By collaborating with international partners, South Africa can tap into global expertise and financial resources to implement sustainable practices on a larger scale. Despite its importance, sustainable water security assessment still requires substantial research as part of comprehensive water resource administration (Gerlak, et al., 2018). Sustainable water security refers to the capacity to achieve fair and long-lasting access to an ample supply of clean water while preserving the ecological balance of water resources and ecosystems (Rahaman, et al., 2018). It involves the efficient governance and safeguarding of water resources, taking into account social, economic, and environmental aspects. The aim is to meet the water requirements of present and future generations, both for human communities and ecological systems. Therefore, the assessment of sustainable water security assists in comprehending the depth of the problems that must be remedied to guarantee long-term water security (Hjorth & Madani, 2014). In other words, assessing sustainable water security is helpful because it provides a holistic view of the many complex problems that surround the water sector.

1.2 BACKGROUND OF THE RESEARCH PROBLEM

The concept of water security gained currency in the 1970s, but until recently it had only been discussed in the context of water science research and related subjects, where it had been contractually defined and thought of as a system (Fatahi et al., 2021). The concept of water security has been widely discussed by various scholars and organizations. Different researchers provide their interpretations and frameworks for water security based on their studies and perspectives. Grey and Sadoff (2007) provide a more all-encompassing definition of water security. They argue that by considering the linkages and interdependencies across different sectors, water security provides a comprehensive framework that enables effective dealing with water-related concerns. Adopting a water security perspective allows for a more comprehensive examination of the issues at hand by taking into account a wider range of interests and concerns related to water. Water security acknowledges the interdependence between water and multiple sectors such as agriculture, industry, energy, and sanitation. It emphasizes the need to address the social, economic, and environmental aspects of water management for enduring resilience and sustainability. Altogether, water security can be considered the overarching goal of water resource management toward sustainable development thinking with a focus on meeting water demand for societal and ecological needs (Bolognesi, et al., 2018). This goal is crucial as water challenges and uncertainties continue to rise, necessitating a comprehensive approach to ensure the long-term well-being of communities and the environment

The concept arose from the necessity to balance people’s needs with the conservation of water resources and is explicitly reflected in the United Nations Sustainable Development Goal for Water and Sanitation (SDG 6) (UNESCO, 2019). Generally, the concept has been studied and used in very different ways; for example, the Oxford School argues that it is more pragmatic to approach water security from a risk perspective (Damania, 2020), while others emphasize the role of adaptability and inclusive governance mechanisms in ensuring that water security goes hand in hand with sustainability (Zeitoun, et al., 2016). Water security is thus a key concern worldwide, and it faces dynamic water difficulties as a result of restricted water availability, climate change, and rising water demand. It is still a complex problem that hangs on a plethora of social, economic, public health, governance, anthropogenic, natural risk, infrastructure, and institutional factors that can be difficult to coordinate and manage (Aboelnga, et al., 2019).

The United Nations Educational, Scientific, and Cultural Organization (UNESCO) outlines water security as “the ability of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in an atmosphere of peace and political stability” (Shrestha & Aihara, 2018:25). In simpler terms, water security refers to a society's or community's ability to ensure that its members always have uninterruptible access to a sufficient and safe water supply. This involves meeting the water needs of individuals and communities for their livelihoods, health, and overall well-being. Water security also includes the management of risks associated with water, such as floods, droughts, and other natural disasters. The value of protecting watersheds and ecosystems is also acknowledged. Drawing from this definition, it is apparent that water security plays a critical role in daily life and is directly related to social well-being and public health problems, and environmental risks (UNESCO, 2019). In other words, when water resources in a community become scarce or threatened, the economic, social, and environmental risks increase (UNESCO, 2019). Accordingly, the world’s water security is one of the most pressing or challenging issues of the twenty-first century, and if no significant or substantive action is taken, the water shortage will be worse by 2030 (Kumar, 2018). For instance, water consumption rates have more than doubled and the population growth rate is rising constantly (Araujo, et al., 2019), thus water scarcity is now one of the major problems globally. Similarly, the water security issues are, inter alia, caused by various factors such as climate change, including droughts, floods, pollution, as well as overuse of water, increase in population, economic growth, urbanization, unsustainable use, high levels of waste, and loss, and intensive use of water in agriculture (Alam, 2015). Therefore, as water scarcity seems to worsen, it is imperative to assess the potential impacts that could disrupt social cohesion as a result.

Equally, many people worldwide are affected by water insecurity (Maganda, 2016). For instance, nearly one billion people, approximately one person in seven, struggle to access drinkable water (Pillay, 2017). Seemingly, having safe drinkable water for most people across the world is still a challenge (United Nations, 2015; United Nations World Water Assessment Programme, 2016), and this increases vulnerability among people and is becoming a serious concern (Lall, *et al.*, 2017). According to Kumar (2018), almost half of the world's population is anticipated to be living in areas with high water stress by 2030. Water stress is a situation where the available potable, unpolluted water within a district is less than a district's demand (Muhammad & Muhammad, 2021).

Irrefutably, water security presents a profound challenge to the world in general and South Africa's social well-being and economic growth in particular. To put this in perspective, South Africa is a water-scarce country. Its freshwater supply is inadequate to meet the needs of its growing population. The rainfall distribution across the country is highly uneven, with some areas receiving significantly more water than others (National Water & Sanitation Master Plan, 2018). South Africa has faced acute water shortages which are continuously observed in recent years. Also, the country has encountered the impact of drought conditions and water scarcity in different parts of the nation (DWS, 2018). This has presented significant difficulties in fulfilling the water requirements of the population. The resulting water shortages have had detrimental consequences for communities, agriculture, industries, and ecosystems. In 2018, South Africa's value for renewable internal freshwater resources per capita (cubic meters) was 775.19, which is inherently below the tolerable average of 1,000 (UN-Water, 2014). Renewable water sources are preferable per capita because they factor in the effects of variable annual rainfall, slow-onset phenomena like drought and groundwater recharge, and the effects of fluctuating population sizes. According to the Climate Change Report (2001), water stress is declared to exist when annual water supplies in a country or region fall below 1,700 cubic meters per person as measured by the Falkenmark Water Stress Indicator. In the range of 1,700-1,100 cubic meters per year, water scarcity may occur occasionally or be limited (Muhammad & Muhammad, 2021). However, a country faces severe water shortages when the annual per capita water availability falls below 1,000 cubic meters (UN-Water, 2014).

Located in the eastern part of the North West Province, the Bojanala District is one of the province's four districts, established in December of 2000, after the dissolution of the former Rustenburg and Eastern Transitional District Councils. As water demands continue to increase within the Bojanala District, there is a need for a paradigm shift in how water resources are used and managed (Kumar, 2018). The paradigm shift in water emphasizes how societies are valuing water as a resource and supporting this transition. In this context, exploring efficient alternatives for sustainable water security (including strategies in water supply and demand management) is significant (Baños, et al., 2019). In other words, to ensure water security in the long term, the government needs to prioritize the sustainability of water resources management while simultaneously improving the efficiency of water usage by implementing a range of strategies to manage demand (Sahin, et al., 2017). Nevertheless, given the heterogeneity and current status of water security in Bojanala District, new multidisciplinary and multi-level approaches are needed to secure water for the present and future generations. These new approaches should be aimed toward Integrated Water Resource Management and sustainable water security to benefit all citizens equitably (Kumar, 2018). After all, the Integrated Water Resource Management (IWRM) aim is to improve security and sustainability through better water use efficiency and conservation. In addition to enhancing social and economic conditions, it seeks to guarantee that future generations will always have ready access to clean water and sanitation (UNESCO, 2019).

District and local municipalities have been struggling to overcome decades of underdevelopment in water services (Twomey, et al., 2021). Bojanala District is not immune and remains among the water-scarce districts in the country and it is extremely vulnerable as it is facing great pressure on water supply, and resources. Surface water and groundwater are being rapidly depleted, and the intensity and frequency of droughts are both on the rise due to the combined effects of climate change, population growth, changing lifestyles, and economic development. (Wang, et al., 2018; Pokhrel, et al., 2021). By the year 2030, if the current trajectory remains in place, the district may face a serious, long-term water crisis, since the per capita water supply will drop, thus reaching a water deficit (Yorke, 2016). For instance, various districts around the country face unique water challenges as a function of geographical, social, political, and economic characteristics (Aboelnga, et al., 2020). As a result, UNESCO (2019) asserts that climate change is exacerbating water security challenges by intensifying droughts and changing precipitation patterns, often leading to water-related calamities. Contextually, it may be clear from the above that water security has been in the spotlight as a key concept for sustainable development with many dimensions and acting on different scales (Marcal, et al., 2021).

Therefore, in light of the discussion above, the study deemed it significant to assess the sustainable water security of households in the Bojanala District by first determining the status and identifying factors that influence sustainable water security amongst the households. Secondly, the study sought to analyze the variables that impact sustainable water security. This information thus became fundamental in developing a descriptive model of sustainable water security for the households in the Bojanala District. Considering the role of sustainable water security in household and agricultural activities, the study has contributed methodologically by developing a dynamic model, which is a multi-region, multi-sector, recursively dynamic general equilibrium model. Specifically, the study has developed a descriptive sustainable water security model that is generic and practical enough for any comparable location and it provides planners and policymakers with specific information on domestic water security issues.

The developed model considers the variability in demand and water supply taking into account factors that influence sustainable water security amongst households. This is one of the unique studies to use empirical data to distinguish the descriptive model in its dynamic approach (Nkiaka, 2022) to support and promote sustainable water supply and better utilization of available resources in a sustainable way for households in the study area. This study contributes to the contemporary body of research knowledge on the factors that influence sustainable water security and undermine the achievement of SDG6. The specific targets outlined within Sustainable Development Goal 6 (SDG 6) are: to ensure universal access to safe and affordable drinking water; achieve access to adequate sanitation and hygiene for all, with a focus on vulnerable groups; improve water quality, reduce pollution, and increase recycling and safe reuse of water; enhance water-use efficiency and address water scarcity; implement integrated water resources management and promote transboundary cooperation; protect and restore water-related ecosystems; support developing countries in water and sanitation-related activities through international cooperation and capacity-building

Notwithstanding the above, a sustainable water policy should be developed to improve the provision of water governance toward a District Integrative Approach to water security. After all, South Africa’s constitution states that everyone has the right to adequate food and water supply. Thus, the National Water Act and the Water Services Act, as well as the constitutional imperative, all work together to ensure that everyone has access to reliable water supply and sanitation services. In general, addressing water security issues requires partnerships across spheres of government, communities, and political outskirts, as well as detailed planning and policy development and implementation (European Commission 2015). After all, water security only has weight when it helps every person on the planet, as well as when it helps end poverty, ensure women's rights, guarantee enough food, and protect ecosystems (Kumar, 2018).

1.3 PROBLEM STATEMENT

In developing nations, water scarcity is often cited as a threat to social harmony. In light of Sen's (1981) seminal work, academics and policymakers have come to understand that inadequate supply is the primary factor contributing to resource scarcity. The availability of clean water has increased in developing countries since the 1990s, but many problems still arise because of the scarcity of this resource. Furthermore, new multidisciplinary research and policy studies have lent credence to neo-Malthusian warnings that anthropogenic climate change and population expansion will lead to an even tighter supply of already scarce resources (World Bank 2014; Gleick 2014; Almer, et al. 2017). Several sources (World Bank, 2014; Gleick, 2014; Almer et al., 2017) support this idea. Similarly, policymakers and scholars consider water security as an urgent matter that, if not addressed, could threaten the lives and livelihoods of billions of humankind (Lall, et al., 2017). As such, consistent access to water resources remains one of the key fundamentals of water security to fulfill the demands of mankind and support their livelihoods and standard of life (Asthana & Shukla, 2014). To this end, studies have been performed from the regional, continental, and global levels to assess the water security issues, yet the failure to obtain potable water of adequate quality and quantity remains one of the largest human health problems globally (Kumar, 2018). For instance, on a domestic scale, the appraisal of sustainable water security is inadequate and a cause for concern, especially in Bojanala District. For this reason, assessing water security in Bojanala District is necessary and will permit an understanding of the state of affairs and distinguish challenges and areas that require attention.

The socio-economic development of households, communities, and nations all over the world, as well as all living beings, needs water for survival. Naturally, drinking, cleaning, cooking, and bathing, just to mention a few, are the most recognized characteristics of water security that are associated with access to water for mankind. However, most communities of the Bojanala District do not enjoy this elementary right primarily because of inadequate access to water, and this might be due to, amongst others, insufficient available water, poor water quality, and hardships in accessing water. Seemingly, this problem has been persistent such that the unavailability of water has become a norm in most communities. Equally, the status of water security for households in the District is alarming, and the increasing water demands for domestic consumption and agricultural use are a serious concern. Hence, there is a need for reliable water security profiles to assess the socio-economic status of water security for households. Upon assessment, we can figure out how the deteriorating freshwater resources are adversely affecting socio-economic development and thus constitute a needed reliable water security profile that is focused on sustainable water security amongst the households.

Additionally, of greater concern is that inhabitants (especially women and young girls) travel long distances to collect and carry water for their household chores. Also, the water point and water reservoir storage are not adequate to accommodate the growing populace. Water supply systems and infrastructure are too old and water pressure is thus inevitably very low. There are areas in which water is already or might momentarily become a constraint to economic and social development. Worse, the identification of factors that influence sustainable water security amongst households in Bojanala District has received limited efforts and attention, let alone their impacts; and despite these limitations, there seem to be serious implications or lack of sustainable water security models that aim to address water shortages in the District. It also seems that the problem of water deficiencies in the Bojanala District is intensified by the spatial pattern of social and economic activities, which is essentially out of line with the natural availability of water. While much progress has been made in identifying the complex problems related to the sustainability of freshwater systems, there has been less success in identifying solutions (Pahl-Wostl et al. 2013), the typical gap between what science offers and what decision-makers need. Therefore, to address these complex and interlinked water challenges, a holistic approach that considers the development of a descriptive model of sustainable water security (Raut et al., 2018), taking into account the implementation of new science-based methodologies, and endorsement of principles of Integrated Water Resources Management that can sustainably address various water-related issues, are required (Mishra et al., 2021).

Recent research on the challenges of South Africa's water supply restructuring has focused on technical defects, unnecessary bureaucratic administrative procedures, and the segmentation of essential government agencies (Dube, 2020). In addition, Dube (2020) claims that all water problems are systemic, suggesting that they act as a mask for more fundamental issues like deficit reasoning. Therefore, this study takes a systematic approach to address the above challenges by assessing sustainable water security. In attempting to curb these problems, the study, therefore, proposes a descriptive sustainable water security model that will enhance the best use of the available water. It appears that the abovementioned issues are caused by amongst others the absence of a model for sustainable water security. Furtherly, it also appears that the existing research has tended to focus a lot on water as a scarce natural resource. It is, therefore, evident that there's a lacuna in the literature that relates to sustainable water security. In response to this lacuna, the study constitutes more solid research that focuses on sustainable water security among households. Besides, moving towards better socio-economic water security that is more sustainable, policy instruments should be developed even if the entire water security cannot be fully achieved. Subsequently, future research should advance the integration of social, economic, and ecological research, and generate outcomes that enable the development of effective policies and practices for Integrated Water Resources Management. During policy development, policymakers must strive to improve and extend cooperative institutions to prioritize the sustainability of water resources management.

1.4 MAIN AIM, AND SPECIFIC OBJECTIVES OF THE STUDY

This section discusses the aim and objectives of the study.

1.4.1 Main aim

The main aim of this study was to assess sustainable water security among households and develop a descriptive model that would guide sustainable water security and supply interventions in Bojanala District, North West Province, South Africa.

1.4.2 Specific objectives of the study

The specific objectives of the study are:

a) To identify and analyze the demographics and socioeconomic characteristics that are associated with access to water for households and may contribute to sustainable water security in the study area.
b) To assess the status of water security (availability & access to water) and thereafter constitute a needed reliable water security profile that is focused on sustainable water security amongst the households in the light of the current situation in the study area.
c) To identify and analyze the factors that influence sustainable water security, let alone their impacts which seem to have received limited efforts and have thus resulted in a lack

of a sustainable water security model that aims to address water shortages and supply interventions in the study area.

d) To develop a descriptive model of sustainable water security guided and anchored around the Sustainable Livelihood Theory and the Integrated Water Resources Management (IWRM) to support and promote the sustainable water supply and better utilization of available resources in a sustainable way for households in the study area.

1.5 RESEARCH QUESTIONS

a) Which socio-economic characteristics are associated with access to water for households and may contribute to addressing water security concerns in the study area?

b) What is the status of water security that upon assessment could inform and constitute a needed reliable water security profile amongst households in the study area?

c) Which factors influence sustainable water security and could spontaneously contribute meaningfully to addressing water shortages and supply interventions in the study area?

d) What model will be required to support and promote the sustainable water supply and better utilization of available resources in a sustainable way for households in the study area?

e) What are the implications for water policy in South Africa and knowledge production?

1.6 SCOPE OF THE STUDY

The research project focused on the Bojanala District in the North West Province of South Africa.

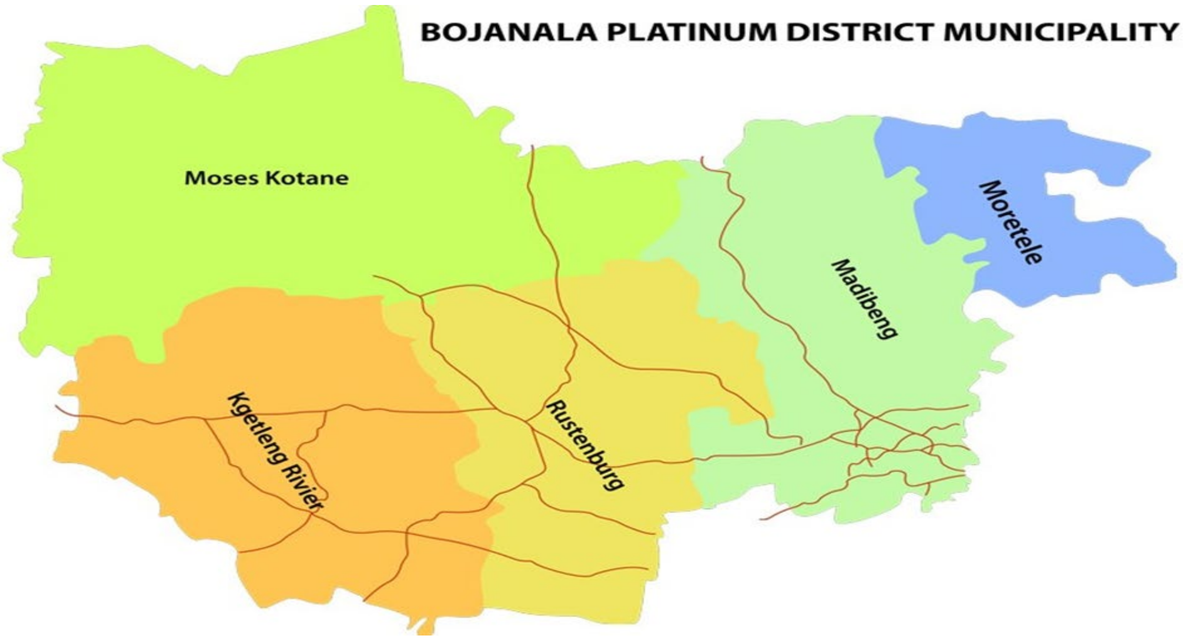


Figure 1.1: Map of Bojanala Platinum District Municipality

Source: StatsSA (accessed from**:** htpp://mapserver2.statssa.gov.za/geographywebsite/africaGIS.html).

The study has covered the five local municipalities that constitute the Bojanala District. The municipalities are:

1. Rustenburg Local Municipality
2. Madibeng Local Municipality
3. Moses Kotane Local Municipality
4. Moretele Local Municipality, and
5. Kgetleng Rivier Local Municipality

The Bojanala District consists of approximately 1 507 505 people, with a majority speaking Setswana (Census, 2016). In addition, the district is one of four districts that constitute the North West Province. The other three are Dr. Kenneth Kaunda District in Klerksdorp; Dr. Ruth Segomotso Mompati District in Vryburg; and Ngaka Modiri Molema District in Mafikeng. The North West Province is commonly known as Bokone Bophirima (BB). In 2018, the North West Province of South Africa officially changed its name to Bokone Bophirima. The provincial government of North West, South Africa, has officially changed the name of the province to Bokone Bophirima, which means "Northwest" in Setswana. The goal of this rebranding effort was to give locals a sense of ownership over their community by celebrating their rich cultural and linguistic history. It's worth noting that even though Bokone Bophirima is the preferred name, North West Province is still the province's official name. It is located on the peripheries of Botswana, Limpopo, Gauteng, Kimberly, and Free State Province. The capital city of the Bokone Bophirima Province is Mafikeng, with a population of 307 520 and a regional gross domestic product (GDP-R) of ZAR18.3bn. Water is sparse across the province of North West the southern districts are mostly watered by the waters of the Vaal River (lower Vaal), and the eastern and central regions receive water from the Crocodile and Groot Marico rivers, respectively. As a result, many communities depend on groundwater for consumption and irrigation purposes.

According to the National Water and Sanitation Master Plan (2018), the Province is experiencing water shortages due to economic and population growth, infrastructure capacity constraints, unsustainable use, and high levels of wastage and loss. As a consequence, the District is more likely to experience intermittent water supplies and severe water shortages after 2025 (DWS, 2017). Similarly, the district is also experiencing significant growth in water requirements driven by growth in mining activities and population growth. According to Cilliers, et al. (2009), the district often experiences droughts, and the precipitation is, for the most part, experienced around October to April, with semi-arid and harsh climatic conditions. Equally, droughts and floods are predominant hazards to water security within Bojanala District and the Province at large. Though the rainy seasons helped greatly, they did not end water shortages entirely, and certain parts of the District continued to face severe water shortages even after the rains ended (NWSFSA Report, 2020). Therefore, there is a need to recognize that water is not an unlimited resource. Besides, the prolonged water shortages are already having significant impacts on socio-economic development and the well-being of the people (NWSFSA Report, 2020). These impacts will be exacerbated if the water crisis is not addressed.

From the foregoing, the scope of the study is therefore reduced to levels manageable to the study, yet remaining significant enough to allow the collection of adequate data that enables the research to respond sufficiently to the study questions and fulfill its objectives. The focus of the study was further scaled down to developing the descriptive model of sustainable water security for the households in the study area. Understandably, water security is a very broad and extensive concept, therefore, the study focused on assessing the sustainable water security of households (sustainable water access and availability of clean domestic water) in the Bojanala District.

1.7 LIMITATIONS OF THE STUDY

Several limitations can impact the writing or collection of data. For instance, there are four substantial districts in the North West Province. However, this study limits itself only to one district (Bojanala District) because of the constraints of time, cost, and availability of information. Some data sources were restricted or required special permissions which hindered the research process. The deficiency or insufficiency of adequate research on the topic has restrained the premise of the literature review which intended to address the research problem that the study has investigated. Limited access to the target population or difficulty in recruiting participants posed a challenge. The disruptions caused by the pandemic, have delayed or interrupted the data collection process, leading to challenges in maintaining consistent data collection timelines. These constraints impacted the scope of the study, the number of participants included, and the depth of data collection. The study is confined to sustainable socio-economic water security of households in the study area to allow the collection of adequate data that enable the research to respond sufficiently to the study questions and fulfill its objectives. However, some data provided by the respondents often contained approximate information rather than precise details, particularly when it came to questions related to the quantity of water used and income. The study is limited to a sample size of 384 registered households within the district. If the sample size is too small or not diverse enough, it may limit the generalizability of the findings to the larger population. The researchers acknowledge these limitations and have carefully considered their impact on the data collected during the pandemic to ensure the validity, reliability, and generalizability of the findings

1.8 SIGNIFICANCE OF THE STUDY

The study holds immense significance in advancing scientific knowledge, addressing critical gaps in the literature, informing policy and decision-making, supporting sustainable development goals, enhancing water management practices, and empowering communities. These contributions have the potential to drive positive change in water security efforts at various levels, making such studies highly relevant and valuable. Furthermore, the study's engagement with theories, empirical research, and the development of a framework for water security represents a significant contribution to the body of knowledge. By reviewing and incorporating existing theories and concepts related to water security, the study ensured that its framework is built upon a robust and well-established knowledge base. Undertaking an empirical study and analysis further strengthened the scientific rigor of the research. The empirical data enabled researchers to quantify and analyze the relationships between different variables, contributing to evidence-based conclusions and recommendations. The scientific significance of the proposed framework lies in its comprehensive and integrated approach, aligning with the SDGs and considering multiple dimensions of water security. By emphasizing community involvement, stakeholder engagement, and the importance of sound decision-making, the model has the potential to create a positive impact or provide a practical framework for achieving enhanced water availability, accessibility, and quality for households and communities. Its potential for global applicability and adaptability makes it a valuable tool in addressing water security challenges in a similar context.

In addition, the significance of this research study is evident in its contribution to addressing water security challenges in the study area and similar contexts. By assessing the status and impact of various factors influencing water security in the region, the study has yielded empirical findings that advance the understanding of sustainable water supply and required intervention. Overall, the study's importance is multifaceted. Firstly, this research's practical relevance is evident in its ability to offer an in-depth understanding of the phenomena studied, providing valuable data for the government of South Africa in shaping water security strategies. Secondly, the findings also serve as a reference for future planning of community-targeted interventions in areas sharing similar characteristics with the Bojanala District. Moreover, the study opens opportunities for further research, encouraging the exploration of unexplored aspects of sustainable water security in alignment with current development policy debates. By advancing knowledge in the field of water security, this research empowers the researcher to contribute to the national efforts aimed at addressing the complex developmental challenge of water security. Thirdly, this research contributes to the development of an analytical framework that holds relevance by being the first of its kind conducted in the study area and addressing a research gap. By addressing the knowledge gap the study sheds light on critical aspects of water security and offers valuable insights for enhancing socio-economic conditions. Lastly, the proposed descriptive model for sustainable water security, if adopted, holds the potential to ensure continued water availability and accessibility for households in the Bojanala District, thus enhancing water security and positively impacting the socio-economic development of the region. Overall, the significance of this study lies in its valuable contributions to the understanding of water security, its practical implications for policymaking, and its potential to drive positive change and sustainable development in the study area and beyond.

1.9 DEFINITIONS OF KEY TERMS

Water Security

Water security, as defined in this context, refers to the ability of a population to ensure sustainable access to sufficient quantities of water that meets acceptable quality standards (UN-Water, 2013). It encompasses the provision of water resources necessary for sustaining livelihoods, promoting human well-being, and facilitating socio-economic development. Moreover, water security includes measures to protect against water-borne pollution and mitigate the impacts of water-related disasters. Additionally, it emphasizes the preservation of ecosystems within a peaceful and politically stable environment (UN-Water, 2013).

Sustainable Water Security

Sustainable Water Security refers to the capacity to achieve fair and long-lasting access to an ample supply of clean water while preserving the ecological balance of water resources and ecosystems (Rahaman et al., 2018). It involves the efficient governance and safeguarding of water resources, taking into account social, economic, and environmental aspects. The aim is to meet the water requirements of present and future generations, both for human communities and ecological systems.

Socio-Economic Development

Socioeconomic development entails advancing and enhancing societal well-being and economic prosperity through various measures. It encompasses endeavors to improve living conditions, quality of life, and overall welfare for both individuals and communities. This encompasses actions aimed at fostering economic growth, productivity, and prosperity. Socioeconomic development encompasses diverse aspects such as education, healthcare, fair distribution of income, employment prospects, infrastructure development, and access to essential services. The ultimate goal is to establish an inclusive and sustainable society that provides equal opportunities for individuals to realize their potential and contribute to the overall progress of the community. (World Bank, 2018).

Sustainable Development

Sustainable development, as defined by the United Nations (2015) Sustainable Development Agenda, refers to a form of development that fulfills the current generation's needs while ensuring the ability of future generations to fulfill their own needs. This definition underscores the significance of simultaneously considering economic, social, and environmental aspects of development in a harmonized and interconnected manner. It advocates for the advancement of inclusive economic growth, social welfare, and environmental conservation to secure a sustainable and prosperous future for all (United Nations General Assembly, 1987).

Sustainability

Sustainability can be defined as the ability to sustain and uphold a process, system, or activity in the long run, ensuring its durability and adaptability. It entails meeting the present generation's needs while safeguarding the capacity of future generations to fulfill their own needs. The concept of sustainability encompasses the conscientious utilization and administration of resources, the safeguarding and conservation of ecosystems and biodiversity, and the promotion of social fairness and economic advancement. It requires striking a harmonious equilibrium between economic growth, social well-being, and environmental preservation, thereby fostering a sustainable and inclusive future for all (United Nations General Assembly, 1987).

Integrated Water Resource Management

Global Water Partnership (GWP) (2000) delineates Integrated Water Resources Management as a procedure that promotes the intended development and management of water, land, and related assets, to enhance the occurrence of economic and social welfare, fairly and without harming the sustainability of important ecosystems.

1.10 THESIS LAYOUT

The thesis has six (6) chapters. The specific chapters are laid out as follows:

Chapter 1: This chapter covers the introduction, background of the research problem, problem statement, purpose, aim & specific objectives of the study, research question & subquestions, scope of the study, limitations and importance of the study, as well as the clarifications of key terms and thesis layout.

Chapter 2: The second chapter provides an overview of the relevant literature, including the conceptual and theoretical frameworks that assisted in directing and shedding some light on the study. A review of literature on water security impacts globally and locally on livelihoods and society is also included.

Chapter 3: This chapter provides an overview of water security in the South African context, highlighting the key factors contributing to the issue and the measures taken to address it.

Chapter 4: The fourth chapter discusses the researcher's methodology and how it fits into the research theory. Furthermore, the chapter discusses the research paradigm, water security as an emerging paradigm, and the research design, as well as sample technique, data sources, and questionnaire; interviews, focus groups, and observations; data analysis, validity and reliability, and study scope and restrictions.

Chapter 5: The chapter presents the discussions and analysis of the results. The study findings, results, discussion, and comprehensive integration of data are presented accordingly.

Chapter 6: This chapter presents the proposed model, implications of the findings, conclusion, and recommendations. The section summarises the findings of the research towards addressing sustainable socio-economic water security in the Bojanala District.

1.11 CONCLUSION

In conclusion, water security is a multifaceted and contextually relative concept that plays a critical role in the well-being and development of communities and ecosystems. It encompasses measures to protect against water pollution and disasters while preserving ecosystems, reflecting a transdisciplinary approach that ensures sustainable management throughout the entire water cycle. Despite its importance, water security can be understood differently depending on geographical, socioeconomic, and stakeholder considerations, leading to various definitions and interpretations. In the case of South Africa, water security is a pressing issue due to climate change, which has resulted in increased temperatures and irregular rainfall patterns, leading to reduced water availability and heightened water stress in many parts of the country. The Bojanala District in South Africa faces specific challenges related to water scarcity, with insufficient access to safe and adequate water supply, posing significant difficulties for households, agriculture, industries, and ecosystems. To address these challenges, it is crucial to adopt a sustainable water security assessment approach that considers social, economic, and environmental aspects. Integrated Water Resource Management (IWRM) provides a holistic framework to manage water resources efficiently and sustainably, meeting the needs of current and future generations. The establishment of reliable water security profiles and the development of descriptive models for sustainable water security are essential steps in identifying factors influencing water security among households and implementing effective solutions.

The main aim of this study was to assess sustainable water security among households and develop a descriptive model that would guide sustainable water security and supply interventions in Bojanala District, North West Province, South Africa. The study focused on the Bojanala District, a region with a population of approximately 1.5 million people, facing significant water challenges. Water scarcity, population growth, infrastructure capacity constraints, unsustainable water use, and high wastage and losses all contribute to the water shortages experienced in the area. The district's semi-arid and harsh climatic conditions, coupled with the impacts of droughts and floods, exacerbate the water security issues faced by communities. The limitations of the study, including time, cost, data availability, and the disruptions caused by the pandemic, influenced the research scope and sample size. Nonetheless, the study holds significance in multiple ways. Moreover, the research contributes to filling knowledge gaps concerning socio-economic activities in the Bojanala District, thus aiding in socio-economic development. The implications of this research extend beyond the immediate study area, serving as a guide for other regions with similar contexts and water security concerns. As water scarcity continues to be a global challenge, the knowledge generated from this study can inform broader policies and strategies aimed at achieving sustainable water security worldwide. In the next chapter, the study delves into the existing body of literature on water security, focusing on its various dimensions and the factors influencing it. The literature review provides a comprehensive understanding of the current state of knowledge regarding water security, particularly in the context of South Africa and the Bojanala District. By critically examining past research, studies, and theoretical frameworks, the study seeks to build a strong foundation for the development of a descriptive model of sustainable water security for households in the study area.

CHAPTER TWO
LITERATURE REVIEW, THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 INTRODUCTION

Water security is a critical global issue, and ensuring its sustainability is essential for societal well-being and ecological balance. This literature review conceptualizes sustainable water security, discusses the importance of sustainable water security, provides an overview of the state of water security in Bojanala District, the concept of water security & scarcity, and explores relevant studies that highlight its key dimensions, challenges, and potential solutions that are related to, and consistent with, the objectives of the study, including a conceptual and theoretical framework that helped to guide and shed some light on the study. The study is anchored around the Sustainable Livelihood Theory as the Theoretical Framework, while the Integrated Water Resources Management approach is the conceptual structure of the research. Both the theoretical and conceptual frameworks are utilized to shed some light on why water is such a critical security issue. Significant issues and practical problems are brought out and critically examined to determine the current knowledge of the subject of the study. The study also presents the knowledge gaps that the chapter seeks to fill. The review sets the foundation for the research methodology that will be employed to investigate sustainable water security

2.2 CONCEPTUALIZING SUSTAINABLE WATER SECURITY

Sustainable water security is a concept that has gained significant attention in the field of water resource management. It encompasses the long-term availability, accessibility, quality, and resilience of water resources, aiming to meet the needs of present and future generations (UN Water, 2013). In South Africa, sustainable water security encompasses various dimensions, including ensuring the long-term availability and reliability of water resources, promoting efficient water use, protecting water quality, and addressing water-related risks and vulnerabilities. The National Water Act of 1998 provides the legislative framework for water management in the country, emphasizing the principles of sustainability, equity, and integrated water resource management (DWS, 2016). The concept recognizes the importance of managing water resources sustainably to ensure their continued availability for various uses, including human consumption, agriculture, industry, and ecosystems. One of the key challenges to achieving sustainable water security in South Africa is the unequal distribution of water resources. Historically, access to water has been inequitable, with marginalized communities and rural areas often facing limited access to safe water sources (Bekker et al., 2019). Efforts have been made to address this issue through various policies and initiatives, such as the provision of basic water services and the implementation of community-based water resource management approaches (Bazaanah & Mothapo, 2023). Climate change poses a significant threat to South Africa's water resources, The impacts are already perceived and are expected to result in severe floods and drought (IPCC, 2014; Ziervogel et al., 2014: Zadawa & Omran, 2018).

Integrated Water Resource Management is a key principle in South Africa's pursuit of sustainable water security. This approach recognizes the interconnectedness of water resources, ecosystems, and human activities and promotes coordinated planning, allocation, and management of water resources (DWS, 2022). Measuring and monitoring water security is another important aspect of sustainable water management. Various indicators and metrics have been developed to assess water security at different scales (Young, et al., 2018). For example, the Water Poverty Index (WPI) provides a comprehensive assessment of water security by considering multiple dimensions such as availability, access, capacity, and use (Sullivan and Meigh, 2007). Equitable access to water is also an integral component of sustainable water security. It recognizes the importance of providing all individuals and communities with physical and economic access to safe and reliable water sources (Biswas & Tortajada, 2018). To achieve sustainable water security, it is crucial to adopt strategies and practices that address the complex challenges associated with water management. This includes balancing water demand and supply through efficient water use and conservation measures (Grey & Sadoff, 2007). Additionally, it is crucial to engage all stakeholders, including governments, communities, civil society organizations, and the private sector. Building partnerships and fostering collaboration among these stakeholders can enhance collective action and improve the overall governance of water resources (Biswas and Tortajada, 2018).

2.3 OVERVIEW OF THE STATE OF WATER SECURITY IN BOJANALA

Bojanala District, situated in the North West Province of South Africa, is a region marked by its substantial mineral reserves, thriving biodiversity, and escalating urbanization. The state of water security in Bojanala District has been affected by various factors such as climate change, population growth, economic activities, and poor management practices (Makhathini, & Ncube, 2021). According to the Department of Water and Sanitation's State of Rivers Report for 2020, most rivers in Bojanala District are classified as being in poor or very poor condition due to high levels of pollution. This poses a significant risk to both human health and the environment. In addition, the report highlights that some areas within Bojanala District are experiencing severe water shortages due to low rainfall and deteriorating infrastructure. Also, the National Business Initiative's Water Stewardship Programme conducted a study on water security in Bojanala District which revealed that only 56% of households had access to piped water (National Business Initiative, 2018). Furthermore, there were concerns about the quality of drinking water supplied by municipalities in the region. According to National Business Initiative's report (2018), this was attributed to insufficient treatment facilities and aging infrastructure. Socioeconomic disparities and challenges in infrastructure development in Bojanala have affected access to safe and reliable water services across different communities (Ginindza, et al., 2019). The water-intensive nature of mining activities further exacerbates these shortages. Simultaneously, pollution from urban trash and mining operations is lowering water quality in Bojanala, which has consequences for human health and ecosystems in the area (Vermeulen et al., 2019). As reported by DWS (2020), contamination has been identified as one of the primary causes of poor drinking water quality. Such contamination affects both human health and agricultural productivity. The impact of climate change is also apparent in the region. According to Oosthuyse et al.(2019), rainfall patterns have become unpredictable which has led to droughts and reduced surface water availability during certain periods of the year. Climatic fluctuations, including rising temperatures, irregular rainfall, and drought occurrences, pose a substantial challenge to maintaining a stable water supply (Nhamo et al., 2019).

According to a report by the Department of Water and Sanitation (DWS) in 2018, the Bojanala District has experienced severe drought conditions that have impacted its water supply systems. These conditions exacerbate existing problems related to water scarcity and negatively affect household food security. Several challenges impede Bojanala's journey toward achieving sustainable water security. One of the critical determinants of water security at the household level is access to safe drinking water. Despite these challenges, Bojanala boasts several strengths in its quest for water security. Notably, the South African government's commitment to improving water infrastructure and management has manifested itself in several projects across the country, including Bojanala (DWS, 2018). In light of the above, achieving water security in Bojanala remains a complex undertaking faced with multiple challenges. However, with targeted initiatives aimed at improving infrastructure and water management, coupled with the potential for sustainable, ecosystem-based strategies, there are promising pathways to securing water for the region. Continued research and concerted action will be pivotal in translating this potential into tangible progress for the residents of Bojanala.

2.4 THE IMPORTANCE OF SUSTAINABLE WATER SECURITY: A FOCUS ON BOJANALA, SOUTH AFRICA

Many regions around the world face significant challenges in ensuring sustainable water security due to various factors such as population growth, climate change, and inefficient water management practices. Bojanala is one such area where the importance of sustainable water security cannot be overstated. One of the primary reasons why sustainable water security is vital in Bojanala is due to the pressing issue of water scarcity. According to Mogale et al. (2019), Bojanala faces severe water shortages, with many households lacking access to sufficient quantities of clean and safe water for their daily needs. This scarcity has far-reaching consequences on health, sanitation, agriculture, and economic activities in the region. A critical aspect is the deteriorating water quality. Moyo et al. (2021) highlight how pollution from mining activities and inadequate wastewater management contribute to the contamination of water sources in Bojanala. This poses serious health risks to communities that rely on these polluted water sources for drinking and domestic use. Access to safe drinking water is fundamental for preventing diseases and improving overall quality of life. Inadequate or contaminated water sources can lead to various illnesses such as diarrhea, cholera, and dysentery. The World Health Organization (WHO) emphasizes the need for clean drinking water as an essential component of public health (WHO, 2021).

According to a study conducted by Mokhele et al. (2017), contaminated water sources were found in various communities within Bojanala due to factors like inadequate sanitation facilities and improper waste disposal practices. This highlights the urgent need for sustainable solutions that can provide clean and safe drinking water to the residents. Furthermore, sustainable water security plays a vital role in promoting food production and agricultural sustainability in Bojanala. As noted by Ncube et al. (2020), agriculture is one of the major contributors to the local economy in this region. However, limited access to reliable irrigation systems hampers agricultural productivity and puts strain on farmers' livelihoods. Implementing sustainable water management strategies like rainwater harvesting techniques or efficient irrigation systems can help enhance crop yields while conserving water resources for future generations. In addition to public health and agriculture, sustainable water security also has significant implications for socio-economic development in Bojanala. A report by StatsSA (2018) highlights how industries such as mining rely heavily on adequate water supply for their operations. Insufficient water availability not only disrupts industrial activities but also leads to job losses and economic instability within the region. Therefore, sustainable water security measures are necessary to support existing industries, attract investments, and foster economic growth in Bojanala. Furthermore, achieving sustainable water security is crucial for promoting social equity in Bojanala. Access to clean water should be a basic human right and should not be limited to certain groups or communities. However, the reality in many areas of South Africa is that marginalized populations often face significant challenges in accessing safe water supplies. According to a study by Olaniran et al., disparities in access to water infrastructure persist among different social groups in the North West Province (2018).

According to a report by the Council for Scientific and Industrial Research (CSIR), climate change is expected to exacerbate water scarcity in South Africa, with regions such as Bojanala being particularly vulnerable (DWA-CSIR 2016). Another study conducted by the Water Research Commission found that groundwater resources in the area were under threat due to pollution from mining activities (WRC 2012). One important aspect of sustainable water security in Bojanala is improving infrastructure. Historical under investment in water infrastructure has resulted in poor supply systems that are unable to meet growing demand during periods of drought. However, the National Development Plan (NDP) recognizes this issue and highlights the need for investment in upgrading existing infrastructure and constructing new facilities. The NDP proposes measures such as drilling boreholes and building dams to increase supply capacity (Department of Planning Monitoring & Evaluation, 2012).

Education plays an integral role in promoting sustainable water practices among communities. Many people living in Bojanala are not aware of their impact on the environment through unsustainable practices like littering or over-extraction from rivers. Education programs aim to raise awareness about these issues and provide practical solutions for addressing them. For example, Greenpeace Africa partnered with local organizations to host workshops on sustainable water use in Bojanala, which included sessions on rainwater harvesting and conservation techniques (Greenpeace Africa, 2021). Sustainable water security is of utmost importance in Bojanala, South Africa. Economic growth depends on reliable access to water for agricultural activities, while public health relies on clean drinking water sources. Environmental conservation and social equity are also closely linked to maintaining sustainable water resources. Addressing these issues requires coordinated efforts from government institutions, local communities, and relevant stakeholders. Investing in infrastructure development, implementing effective management strategies, and raising awareness about responsible water use will contribute significantly towards achieving sustainable water security in Bojanala and similar regions worldwide.

2.5 HOUSEHOLD ACCESS TO WATER IN BOJANALA DISTRICT IN SOUTH AFRICA

Access to water at the household level is a critical component of water security in South Africa, specifically in the Bojanala District. According to the DWS, the Bojanala District has made significant progress in improving access to basic water services. As of the latest available data, approximately 95% of households in the district have access to an improved water source (DWS, 2018). Despite the progress made, there are still challenges in providing consistent access to water services in some areas of Bojanala. Infrastructure limitations, such as aging or insufficient water supply systems and inadequate maintenance, can result in intermittent water supply or service disruptions for certain households (Mashige, et al., 2018). While overall access to water services has improved, disparities in access exist within the district. Some marginalized or underserved communities may still face barriers to accessing safe and reliable water sources, particularly in informal settlements or remote rural areas (Government of South Africa, 2014). Achieving equitable access to water remains an important goal for ensuring water security for all households. In addition to access, the quality of water available to households is crucial for ensuring public health and well-being (NW DARD, 2016). Regular monitoring of water quality is necessary to identify and address any potential contamination issues that may affect the safety of water consumed by households.

The concept of household access to water refers to the availability, affordability, and reliability of water supply for domestic use within individual households (UNICEF and WHO, 2019). Access to water in South Africa is not uniform and varies significantly across different regions and population groups. Efforts have been made to improve access to water for all citizens, including the goal of achieving universal access to basic water supply services. However, challenges persist, particularly in rural and peri-urban areas, where access to safe and reliable water sources remains limited (Cronin et al., 2017). In the Bojanala District, similar challenges exist. The availability of water resources is influenced by the region's semi-arid climate and limited rainfall patterns, which contribute to water scarcity issues (Statistics South Africa, 2019). This scarcity affects household access to water, with some communities experiencing intermittent water supply or relying on alternative, informal sources of water (Cronin et al., 2017). The post-apartheid era in South Africa has seen efforts to improve access to water for previously marginalized communities, with the government aiming to achieve universal access to basic water supply services.

Factors influencing household access to water in South Africa include historical disparities, inadequate infrastructure, governance issues, and socio-economic factors (Kotze and Avenant, 2019). Historically, marginalized communities, particularly those in informal settlements, face significant challenges in accessing water services due to the legacy of apartheid-era policies and inequalities (Mehta et al., 2019). Inadequate infrastructure, such as unreliable or poorly maintained water supply systems, further hampers household access to water. Infrastructure deficiencies are particularly prevalent in rural areas, where the remoteness and dispersed nature of settlements make service delivery challenging (Kotze and Avenant, 2019). Governance issues, including inefficient management, policy implementation gaps, and corruption, also affect household access to water. In some cases, community participation and engagement are limited, leading to decisions that do not adequately address the needs and priorities of the affected households (Cronin et al., 2017).

Socioeconomic factors play a crucial role in determining household access to water. Poverty, unemployment, and income inequality contribute to affordability challenges, making it difficult for households to pay for water services, especially in areas where water is provided on a prepaid basis (Kotze & Avenant, 2019). Addressing household access to water in South Africa and the Bojanala District, in particular, requires multi-faceted approaches (Cousins & Walker, 2017). By adopting a multi-faceted approach, policymakers, water authorities, and relevant stakeholders can work together to tackle the complex issues surrounding household access to water in the Bojanala District and South Africa as a whole. This comprehensive approach recognizes the interconnected nature of the challenges and strives to find integrated solutions that address infrastructure, governance, community participation, and socio-economic factors (Cousins & Walker, 2017). These include infrastructure development, governance reforms, community participation, and socio-economic empowerment. Ensuring equitable distribution, improving service delivery efficiency, and implementing targeted interventions tailored to the specific challenges faced by communities in the Bojanala District are crucial steps toward improving household access to water (Makwela & Tsebe, 2016).

2.6 WATER SECURITY

For Bojanala District, water security has several dimensions. The primary aspect of water security is ensuring that every individual and community in Bojanala District has consistent access to a sufficient quantity of clean water. This includes households for drinking, cooking, and hygiene, and businesses for operational needs (UNESCO, 2012). Water security also means that the water available is of good quality, and safe for its intended use. This relates to managing pollution from agricultural runoff, industrial waste, and other sources to prevent contamination of water sources (Department of Water Affairs, 2010). Water security also implies the sustainable management of water resources, protecting the health of the ecosystem, and maintaining biodiversity (United Nations Water, 2013). For businesses and industries such as agriculture and mining, water security means reliable access to the water necessary for operations. Socially, it involves the equitable distribution of water resources, ensuring that every community and social group has fair access (United Nations Development Programme, 2006).

The idea of water security has gained more and more traction in recent years, both in academic literature and in actual policy decisions. Numerous definitions and interpretations of the concept exist and differ from discipline to discipline, from area to area, and from theme to theme (Honkonen, 2017). This expression emerged around the turn of the century from debates over the importance of providing basic sanitation and water to all people. Water security is a term that is now commonly used in academia, policymaking, and the general public. The idea of water security can be broadened and advanced, and its practical applicability can be raised, by combining quantitative and qualitative assessments (Marttunen, et al., 2019). The concept is essential to human society and it operates at all levels, from the individual, household, and community, to the local, subnational, national, regional, and international settings (Habiba & Shaw, 2014). Water security includes environmental, social, and economic aspects, as well as political matters. It comprises three features, to be specific: social, economic, and environmental sustainability, and, any efforts undertaken to accomplish water security should be centered around these features (Tortajada & Fernandez, 2018). The term water security has been articulated in many different ways, as stated by Besbes et al., (2018), however, the most referred to is that of Grey and Sadoff (2007) who state that it entails tolerable standard and volume of water for livelihoods, human welfare, environment, and production joined with a tolerable level of water-related hazards to humankind, environments, and economies.

After receiving more attention in some studies and debates, the term “water security” has begun to be used more frequently by researchers, development partners, and policy-makers seeking to improve urban water management (Chad, et al., 2018). Academic debates surrounding water security are summarized in depth and brought up by Cook and Bakker (2013). In their review, Cook and Bakker (2013) present findings from four academic fields that each take a slightly different approach to the topic of water security. The first concerns the accessibility of potable water. Second, there is a wealth of information on the dangers and weaknesses of water sources (i.e. contamination, but also terrorism). The third section focuses on the importance of water to living things, and the fourth section emphasizes the importance of sustainable management. Issues of ample quantity, adequate quality, access, ecosystem health, and risk or hazard mitigation all appear to be given equal weight in both theoretical and empirical research (Gerlak et al., 2018). The term “water security” encompasses a wide range of meanings and is evaluated from a variety of angles. New studies reveal that over the past decade, a plethora of definitions have surfaced, each incorporating a unique set of features (Allan, et al., 2018). To date, however, there has been little progress made toward a shared understanding of the dynamics of water security and how best to define and operationalize them. The Global Water Partnership, the World Bank (Grey & Sadoff, 2007), and the United Nations (UN-Water, 2013) all define water security somewhat differently, but they all share important conceptual perspectives (Hoekstra, et al., 2018; Zeitoun, 2016). With its comprehensive and interdisciplinary definition, the UN-Water Annual Report (2019) continues to serve as the foundation of the country’s water security framework. Most national water strategies begin with Integrated Water Resources Management, a process and a useful framework for guaranteeing water security and connecting water with society (Hussein, 2019).

To operationalize the definitions of water security, Thomas (2015) grouped ten measurable indicators into five categories (see Figure 5 below) —” quantity,” “quality,” “accessibility,” “reliability/resilience” and “affordability”—

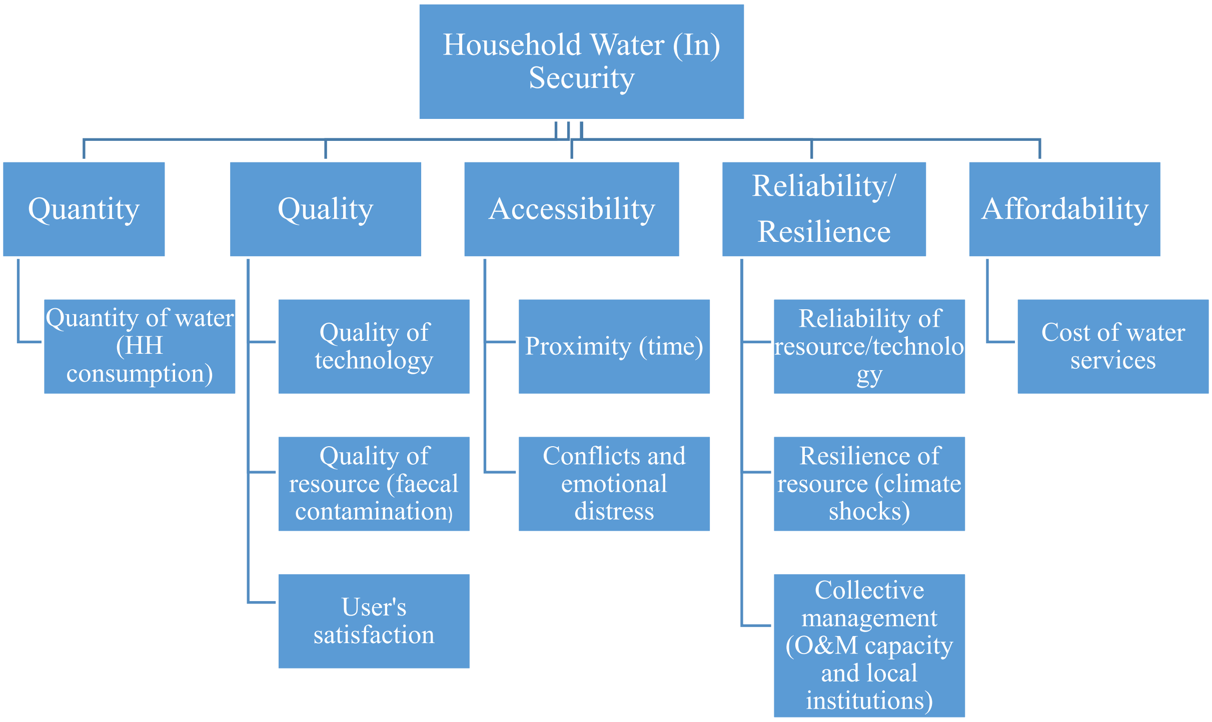


Figure 2.1: The dimensions of household water security

Source: Thomas (2015:13) - The dimensions of Household Water Security.

2.6.1 Dimensions of Water Security in South Africa

Water security is a critical concern in South Africa due to its semi-arid climate, variable rainfall patterns, population growth, and economic development. The dimensions of water security in the country encompass various aspects related to availability, accessibility, quality, and governance. Addressing these dimensions requires a multi-faceted approach involving sustainable water management practices, infrastructure development, improved access to water services, and effective governance mechanisms. In this context, it is critical to understand the dimensions of water security in South Africa:

Accessibility

Accessibility pertains to the physical and economic accessibility of water for all individuals and communities. In South Africa, access to safe drinking water and sanitation services remains a challenge, particularly in rural areas and informal settlements. The South African Human Rights Commission (SAHRC) highlights the disparities in access, stating that marginalized communities, such as those living in poverty, face difficulties in accessing water services (SAHRC, 2019). The South African government has made efforts to address this issue through initiatives like the National Rural Water Supply Program, which aims to provide reliable and sustainable water services to rural areas. However, additional investments in infrastructure, maintenance, and capacity building are necessary to improve water accessibility for all citizens (Department of Water & Sanitation, 2018).

Availability

Water availability plays a crucial role in determining water security in any region, and this is certainly true for South Africa. The country's unique geographical and climate conditions, coupled with various social and economic factors, have contributed to a complex situation regarding water availability. According to the South African Water Research Commission (WRC), the country's water resources are unevenly distributed, with water scarcity prevalent in certain regions, such as the Western Cape and parts of the Eastern Cape. This scarcity is exacerbated by the fact that South Africa receives only half the global average rainfall. The WRC suggests implementing water conservation measures, improving water infrastructure, and promoting sustainable water use to enhance water availability (WRC, 2019).

Quality

Another dimension of water security is the quality of available water sources. According to a report by the Water Research Commission, the deteriorating quality of South Africa's water resources is a growing concern. The report emphasizes the need for stricter regulation and effective wastewater treatment systems to protect water quality (WRC, 2020). Many rural areas in South Africa rely on groundwater sources for drinking water, but these sources can be contaminated by agricultural runoff or other pollutants. This pollution can lead to health problems and reduce the amount of water that is safe for use (Turton et al., 2006). According to a report by the Council for Scientific and Industrial Research (CSIR, 2010), up to 60% of rural communities in South Africa do not have access to safe drinking water due to contamination.

Governance

Water governance refers to the policies, institutions, and decision-making processes involved in managing water resources. South Africa has a well-developed legal framework for water management, including the National Water Act of 1998. However, challenges remain in the implementation and enforcement of water-related policies, especially at the local level. The World Wide Fund for Nature (WWF) emphasizes the importance of effective governance mechanisms, stakeholder participation, and integrated water resource management to achieve water security in South Africa. The WWF suggests strengthening institutional capacity, improving data collection and monitoring systems, and promoting public participation in decision-making processes (WWF, 2019).

2.7 WATER SCARCITY

In South Africa, specifically in Bojanala, water scarcity is a significant problem due to its semi-arid climate. According to the DWS, Bojanala has been categorized as one of the vulnerable areas with limited water resources in South Africa (DWS, 2019). Water scarcity poses a significant and multifaceted challenge in South Africa, driven by a range of factors including geographical limitations, erratic rainfall patterns, population growth, and ineffective water management practices. The country's semi-arid climate and uneven distribution of rainfall further exacerbate the problem, putting immense strain on the availability of freshwater resources (DWAF, 2018). The effects of water scarcity go beyond meeting people's necessities. Water scarcity can hamper agricultural output and the economy as a whole (Rurinda et al., 2018). Food insecurity and economic difficulties can result from an inadequate water supply, which in turn affects agricultural output and the lives of farmers (Rahman et al., 2019). Water scarcity arises when the water demand exceeds the available supply, leading to inadequate access to safe and reliable water sources. The increasing population and urban development in Bojanala contribute to growing water demand (Statistics South Africa, 2017).

Rapid urbanization leads to higher water requirements for domestic, industrial, and commercial purposes. Climate change exacerbates water scarcity in Bojanala. Alterations in rainfall patterns and increased temperatures affect water availability and exacerbate water stress. Irregular precipitation, prolonged droughts, and higher evaporation rates contribute to reduced water resources, intensifying the challenges of water scarcity (Soko et al., 2019). Inadequate infrastructure, inefficient distribution networks, and challenges in water governance can lead to water losses, inadequate water supply, and unequal access to water resources (Vermeulen, et al., 2019). Water scarcity refers to a condition in which the water demand exceeds the quantity of water that is available, leading to restricted access to sufficient water resources to meet the needs of humans, society, and the environment (UNESCO, 2012). This phenomenon is intricate and influenced by multiple factors, including population growth, climate change, ineffective water management approaches, and the uneven distribution of water resources (Jägerskog, et al., 2012).

Therefore, sustainable water management practices are vital to ensure that there is enough clean and safe water available for communities in this area. According to Tlou et al. (2020), sustainable water management practices involve the conservation, protection, treatment, and reuse of water resources. This approach ensures that the available freshwater sources are used wisely while still preserving their quality.

2.8 SUSTAINABILITY

Sustainability and sustainable development concepts are commonly used as interchangeable terms and are so intertwined in the literature that they remain difficult to tease apart (Purvis, et al., 2018). Concerning water security in the Bojanala District, sustainability revolves around the careful and responsible management of water resources to ensure their availability and quality over the long term. This means reducing wastage, promoting water conservation, and implementing effective waste treatment processes to prevent the pollution of water bodies. Regulatory oversight and technological innovations can play significant roles in achieving this (South African National Biodiversity Institute, 2018). Sustainable development is predicated on claims that aim to provide for the current generation without compromising the well-being of future generations (Mathetsa, 2016). The concept has appeared in discussions since the year 1987 when the UN released the Brundtland Declaration (WCED, 1987) which emphasized that it is vital to enforce economic growth that would be in balance with the environment and would not reach a level where the ecosystems and the biosphere could not cope with the results of human activity. Since then, this concept has been adopted as a key element for sustainability, or sustainable development. However, there is no consensus on the concept of sustainability and different people attach different meanings to the concept. The term “sustainability” is used to describe every action that humans take. Most academics, researchers, and practitioners in the field of development use the term to mean fostering and maintaining a thriving economic, ecological, and social system to advance human flourishing (Tjarve, & Zemte, 2016; Mensah & Enu-Kwesi, 2018; Thomas, 2015). To this end, sustainability can be understood as a state of dynamic equilibrium in which a population and the carrying capacity of its environment interact in such a way that the population grows to its full potential without causing irreversible damage to the ecosystem (Ben-Eli, 2015).

Sustainability has been a term and concept used to bring balance and create responsibility for economic activity and development (Muñoz-Pascual, et al., 2019), and is well adopted by all stakeholders in various areas of private and public sectors. Mensah and Enu-Kwesi (2018) state that the description of sustainability must emphasize the idea of intergenerational fairness, which is compelling yet fraught with challenges because the demands of future generations are difficult to define and predict. From this perspective, Thomas (2015) maintains that sustainability should bring to attention human activities and their capability to satisfy human needs and wants without depleting the productive assets at their disposal. However, this provokes thoughts on how people should lead their economic and social lives by drawing on the available ecological resources for human development (Mensah & Casadevall, 2019). It, therefore, becomes significant to understand the ultimate objective of the concept of sustainability which is to ensure appropriate alignment and equilibrium among society, the economy, and the environment in terms of the regenerative capacity of the planet's life-supporting ecosystems. It is this dynamic alignment and equilibrium that must be the focus of a meaningful definition of sustainability that can be placed analogously to all human activities and business processes (Gossling-Goidsmiths, 2018).

2.8.1 Pillars of Sustainability

The concept of sustainability is often depicted through three interconnected pillars or domains: social, economic, and environmental. The pillars of sustainability, also known as the three dimensions of sustainability, are a framework that outlines the interconnected aspects necessary for achieving long-term sustainable development. The pillars of sustainability play a crucial role in addressing water security challenges. When discussing water security in the Bojanala District, we can envision these three pillars and their interconnections in the following way:

2.8.1.1 Social Sustainability

Social sustainability involves ensuring the long-term well-being of communities, maintaining social equality and cohesion, and fostering community resilience. In the context of the Bojanala District, social sustainability intersects with water security in various ways. Access to clean water and adequate sanitation are central to social sustainability as they directly influence public health and quality of life. Disparities in access to these basic needs can lead to social inequalities and health crises, particularly in marginalized communities. The local government, such as the Bojanala Platinum District Municipality, is responsible for ensuring equitable access to these services (Department of Water and Sanitation: Water Services Master Plan, 2019). Local communities must be involved in decision-making processes related to water management. This can foster a sense of ownership, increase understanding of water issues, and promote the sustainable use of water resources (United Nations Development Programme: Governance for Sustainable Development, 2014). Educating communities about the importance of water conservation, sanitation, and sustainable water use is key to social sustainability (UNESCO: Water Security and Education, 2018). Investment in water infrastructure can lead to job creation, which is crucial for social sustainability. Jobs can be created in areas such as water infrastructure construction, maintenance, and water management (International Labour Organization: Water and Jobs, 2016).

2.8.1.2 Economic Sustainability

Economic sustainability refers to practices that support long-term economic growth without negatively impacting the social, environmental, and cultural aspects of the community (Water Research Commission, 2021). Within the Bojanala District, economic sustainability is closely tied to water security, given the region's reliance on industries like mining and agriculture, which are heavily dependent on water. The mining and agricultural industries contribute significantly to the Bojanala District's economy. The sustainability of these sectors depends on efficient water use and pollution control. Industries need to adopt technologies and practices that minimize water use, promote recycling and reusing of water, and prevent contamination of water sources (Department of Water Affairs, 2010). Investing in water infrastructure, such as dams, reservoirs, and water treatment facilities, can promote economic sustainability. This creates jobs in the short term and ensures a reliable water supply for all sectors in the long term, fostering economic growth and stability (World Bank, 2016). The Bojanala District is home to tourist attractions like the Pilanesberg National Park and the Madikwe Game Reserve. Maintaining water security is crucial to preserving these natural environments, which in turn, are vital for the local tourism industry and the jobs it provides (North West Provincial Government, 2022). Water insecurity can result in significant economic costs, such as healthcare expenses from waterborne diseases and business interruptions due to water shortages. By investing in water security, these costs can be significantly reduced, contributing to economic sustainability (United Nations Development Programme, 2016).

2.8.1.3 Environmental Sustainability

Environmental sustainability involves conserving and managing resources to ensure the long-term well-being of the environment and its ecosystems (Water Research Commission, 2021). Concerning water security, environmental sustainability in the Bojanala District can be discussed in terms of protecting water resources, managing waste, and conserving biodiversity. Maintaining healthy rivers, dams, and groundwater resources is crucial to environmental sustainability. This means reducing pollution from mining operations and agriculture, two major sectors in the Bojanala District. Regulatory oversight and best practices in these sectors can help ensure they do not contaminate local water sources (South African National Biodiversity Institute, 2018). Over-extraction of water for agricultural, industrial, and domestic use can lead to environmental degradation, affecting both the quantity and quality of water available. Implementing water-efficient technologies and practices, such as drip irrigation in agriculture, can support sustainability (Food & Agriculture Organization, 2016). Water security is closely tied to the health of local ecosystems. Wetlands, rivers, and lakes in the Bojanala District support diverse ecosystems that are vital for maintaining water quality and preventing soil erosion. Preserving these ecosystems is integral to environmental sustainability (WWF South Africa, 2020). Climate change can exacerbate water insecurity by causing changes in rainfall patterns and increasing the frequency of extreme weather events. Implementing strategies to mitigate and adapt to climate change, such as reforestation and building resilient water infrastructure, can support environmental sustainability (Intergovernmental Panel on Climate Change, 2014).

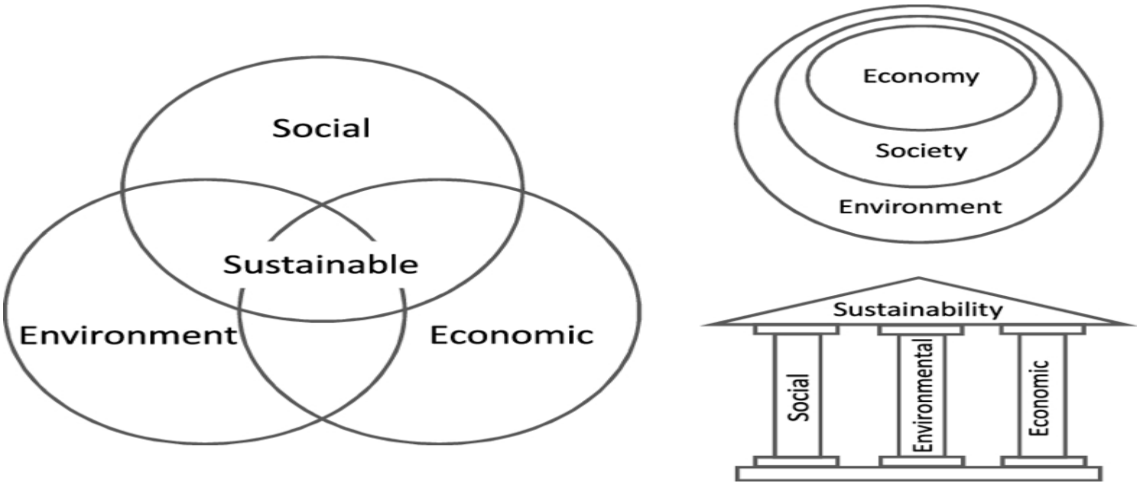


Figure 2.2: **Different Diagrams With Three Pillars Of Sustainability**

Purvis, et al., (2017). Diagram accessed from https://link.springer.com/article/10.1007/s11625-018-0627-5#Sec1.

In gaining insight into the three overlapping circles, it is equally vital to recognize there is "directionality" to each circle's dependence on the others. Pantyley, et al., (2018) argued that a healthy and sustainable community requires the interaction of economic, social, and environmental development. Whilst preferred for their simplicity, the message communicated and the wider 'pillar' conception often is not clear, thus, compromising its ability to be logically operationalized (Purvis, et al., 2019). The social pillar of sustainability emphasizes human rights, equity, and social well-being. In the Bojanala District, it can be related to the provision of safe, clean water for all inhabitants, the engagement and empowerment of local communities in water management decisions, and the promotion of water conservation through education and awareness. The economic pillar relates to the long-term viability of economies and the jobs and incomes they provide. In the context of the Bojanala District, this could include the sustainable use of water in agriculture and mining, the two significant sectors of the local economy. It also encompasses the creation of jobs through investments in water infrastructure and the potential benefits to the tourism industry of maintaining the district's natural beauty through good water stewardship.

The environmental pillar of sustainability focuses on preserving natural resources, biodiversity, and ecosystems. For the Bojanala District, this can involve protecting water sources from pollution, reducing water use to avoid depleting these resources, conserving local aquatic ecosystems, and implementing strategies to mitigate and adapt to climate change, which can affect water availability. In the center of these three pillars is the sweet spot of sustainability where water security can be achieved. It entails socially equitable, economically viable, and environmentally sound water management strategies. This underscores that water security isn't just about managing the resource itself, but also about managing how people and economies use and impact it. The intersection of economic, social, and environmental factors is acknowledged by the overlapping-circles model of sustainability. Thus, the principle of the three pillars of sustainability must be sustainable.

2.8.2 Key Principles of Sustainability

According to Cotter and Hannan (1999:171-172), some of the key principles of sustainability are:

- **Integration:** An integrated approach means that decision-making processes at all levels should include consideration of a broad range of environmental, social, and economic effects. Integration involves developing organizational processes that allow such impacts to be easily seen and considered by all stakeholders before decision-making occurs. Integration also suggests the effectiveness of working more closely and cooperatively with other stakeholders and, most significantly, all sectors of the local community.

- **Community involvement:** Community involvement from inception to the end, allows for resource sharing and fosters supportive and active community participation Community involvement is also essential to monitor the state of the environment.
- **Precautionary behavior:** Precautionary behavior requires careful consideration of possible adverse environmental effects of planning, policy, and practice. Where a threat of serious or irreversible environmental damage exists, it would be imprudent and inadequate to wait for scientific certainty before acting.
- **Equity within and between generations:** This notion of equity implies the importance of maintaining both ecological integrity and the Earth's resources to provide for a certain quality of life, in both the short and long term. As such, present activities should not compromise the right of the present generation, or future generations, to healthy and dynamic environments.
- **Continual improvement:** The declining environmental situation means there is an imperative to take immediate action to become more sustainable and to make continual improvements. The change will not occur all at once, however, it is important to make continual improvements, making the most of advances in technology and scientific understanding about what is sustainable, and increasing community awareness of sustainability issues.
- **Ecological integrity:** This requires the protection of biological diversity and the maintenance of essential ecological processes and life-support systems. These could include maintenance and enhancement of vegetation, waterways, coasts, and wildlife corridors as well as soil, water, and air quality.

2.9 FACTORS INFLUENCING WATER SECURITY

Sustainable water security is influenced by a multitude of factors that interact and shape the availability, accessibility, and quality of water resources. According to Almanjahie, et al., (2019), many factors can cause or influence water scarcity. Hydrological patterns, topographical features, and artificial water storage and conveyance facilities are all examples of physical/infrastructural factors that affect water security. Access to water is impeded by institutional factors like customary laws, statutory laws, and inequality. Gender, wealth, status, culture, and custom are all examples of socio-economic factors. These factors interact in complex ways and often exacerbate each other. For instance, population growth and urbanization can increase water demand and contribute to pollution, while climate change can exacerbate water shortages and disrupt infrastructure. Therefore, achieving water security requires an integrated and comprehensive approach that addresses these interconnected factors. From the foregoing, it suffices to mention that water security can easily be influenced by various factors (Gerlak, et al., 2018). Understanding and addressing these factors are crucial for achieving sustainable water security, especially in Bojanala District. Be that as it may, a point of departure for identifying the influential factors in socio-economic water security consists of the traditional social and economic inputs. However, according to Hinojosa, et al., (2018), generalizations as to the factors influencing water security are not ideal. There are some social and environmental factors, as well as some misperceptions, that need to be altered if water security is to be improved. Due to the broader scope of development, the range of factors considered must be expanded to socio-economic growth. Some of the key factors influencing sustainable water security are discussed below.

2.9.1 Growing population

The increasing population in the Bojanala District has significant implications for maintaining water security. As the population grows, the water demand escalates, exerting pressure on limited water resources. This heightened demand encompasses domestic, agricultural, and industrial needs (Ramontja, et al., 2014). Consequently, existing water infrastructure systems, such as storage, treatment, and distribution networks, become strained (Mavengahama, et al., 2017). Inadequate infrastructure may lead to insufficient water supply, inefficient distribution, and challenges in meeting the expanding population's water requirements. The larger population generates higher volumes of wastewater, which, if not appropriately managed, can contribute to water pollution and the deterioration of water quality (Ncube, et al., 2016). Insufficient sanitation facilities and improper waste disposal practices can contaminate water sources, compromising water security and posing risks to public health. Moreover, the growing population further burdens the already limited water resources in Bojanala, potentially leading to depletion and reduced water availability from surface water and groundwater sources (Van Rooyen, et al., 2015). Addressing the challenges posed by population growth to water security in Bojanala necessitates the adoption of sustainable water management practices. This entails implementing water conservation measures, promoting efficient water usage, investing in the development and expansion of water infrastructure, and adopting policies that support population control and sustainable urban development.

2.9.2 Climate change

Climate change has significant implications for water security in the Bojanala District. The district faces various challenges related to water availability and quality, which are exacerbated by the impacts of climate change. Uncertainties in water availability are caused by changes in rainfall patterns and higher evaporation rates (Schulze, et al., 2009). Although climate change and water are inextricably linked, it is important to remember that climate change will have enormous social and environmental repercussions (Babel et al., 2020). These results present a significant threat to the long-term viability of water security. Both Papadouris and Thopil (2018) and Nyam, et al., (2020) claim that South Africa's general aridity makes it particularly susceptible to the influence of climate change on water. In terms of climate, Bojanala is located in the semi-arid zone (Jovanovic, et al., 2014), which is characterized by low and sporadic precipitation, high evaporation rates, and considerable temperature changes. Bojanala's water supply is under stress because of the region's arid climate. Low precipitation and high evaporation rates make it difficult to ensure enough water supplies for agriculture, residential usage, and industry (Ramontja, et al., 2014). It is, therefore, possible to conclude that the effects of climate change on the water will have an immediate impact on the rural populations located in Bojanala.

2.9.3 Drought

The Bojanala District has experienced recurring drought conditions which have led to water shortages, affecting agriculture, industries, and communities dependent on reliable water supplies (Wolski, et al., 2015). According to Van Averbeke, et al., (2018), the Bojanala District has experienced more frequent and severe drought occurrences as a result of rising temperatures and changing rainfall patterns. Droughts are a major threat to water security because they restrict the amount of water available for agricultural, domestic, and industrial usage. The historical drought conditions in Bojanala District are widely recognized as pivotal for food and water security (Botai, et al., 2016). As a socio-natural disaster, drought causes perturbation and has affected humanity and the ecosystem extensively in the Bojanala District (Núñez, et al., 2017). The prolonged absence of rainfall and high temperatures have severely impacted water security in the district, leading to the implementation of water restrictions. The water reservoirs remain significantly below their 50% capacity, exacerbating the challenges and highlighting the urgent need for sustainable water management strategies (Botai, et al., 2016). Over time, there has been a consistent decline in the water levels of South African reservoirs, aligning with a decrease in both the quantity and irregularity of rainfall across the country as a whole, including the Bojanala District in particular. The largescale high-pressure pattern is the reason why a prolonged period of dry weather, occasionally reaches universal scales (Sheffield & Wood, 2011).

2.9.4 Natural disasters

Natural Disasters have noteworthy repercussions on water security in the Bojanala District (DWS, 2018). Phenomena like floods, droughts, and severe storms have disturbed water infrastructure, jeopardized water quality, and impacted the availability and ease of accessing water resources. The district has witnessed flash floods as a consequence of heavy rainfall, which has caused significant harm to water supply infrastructure, contamination of water sources, and disturbances in water distribution networks (BPDM IDP, 2022/23). Additionally, severe storms like thunderstorms and hailstorms have caused damage to water infrastructure, including pipelines and storage facilities (South African Weather Service, n.d). These destructive events have resulted in disruptions to water supply and treatment systems, leading to challenges in accessing safe and clean water. The susceptibility of water security in the Bojanala District is underscored by these natural disasters. The repercussions of these events on the availability, quality, and infrastructure of water can lead to significant socio-economic and environmental ramifications (Liu, et al., 2019). Hence, water management authorities, local communities, and stakeholders must formulate strategies that focus on preparedness, response, and resilience to address and alleviate the impact of natural disasters on water security.

2.9.5 Contaminants

Water security in the Bojanala District is significantly threatened by contaminants in water sources (Vermeulen, et al., 2019). These contaminants have adverse effects on the quality and availability of water, impacting both human health and ecosystem sustainability. The district's mining industry, particularly platinum mining, contributes to water contamination. Mining activities release various contaminants, including heavy metals such as mercury, lead, arsenic, and acid mine drainage, into surface water and groundwater, posing risks to drinking water supplies and aquatic ecosystems (Vermeulen, et al., 2019). Additionally, agricultural practices, such as the use of pesticides and fertilizers, also contribute to water contamination. Runoff from farms carries pesticides, herbicides, and excess nutrients into water bodies, causing water pollution (Fatoki, O. S., et al., 2012). Insufficient wastewater treatment infrastructure and improper sewage disposal further worsen the problem. Untreated or inadequately treated sewage introduces pathogens, nutrients, and other pollutants into water sources, negatively impacting water quality and public health (Sibanda, et al., 2016). Addressing the challenge of contaminants and ensuring water security in Bojanala requires the implementation of proper wastewater treatment systems, the promotion of responsible agricultural practices, and the enforcement of stricter regulations on industrial effluent discharge.

2.9.6 Mining and oil and gas exploitation

Mining and oil and gas production, according to Soesbergen and Mulligan (2013), have significant implications for water security in the Bojanala District. These activities have put pressure on water resources, leading to reduced availability for other users such as communities, agriculture, and ecosystems (WRC, 2014). They require substantial amounts of water for various purposes, including extraction, dust suppression, and processing. The extraction of groundwater or surface water for industrial purposes contributed to reduced water availability in the region (BPDM IDP, 2022/23). The potential impacts on water security arise from both the quantity and quality of water resources in the region. Mining is a substantial source of mercury contamination in surface waters (Swenson, et al., 2011), whereas oil extraction is the cause of numerous oil spills and the release of untreated wastes to the environment (Napolitano & Ryan, 2007; Orta-Martnez, et al., 2007). Contaminated water poses risks to both human health and the environment, affecting water security in the Bojanala District (BPDM IDP, 2022/23). Ecosystems play a crucial role in regulating water flow, replenishing groundwater, and maintaining water quality. Disturbances caused by land clearance, soil erosion, and habitat destruction can alter the hydrological cycle and impact the overall water availability and quality in the region (WRC, 2014).

2.9.7 Political stability and conflict

Political stability and conflict significantly impact water security in the Bojanala District of South Africa. Maintaining political stability is crucial for consistent investment in water infrastructure maintenance, upgrades, and expansion, as it ensures the allocation of resources to critical water supply systems (Kloos, et al., 2021). Stable governments are more likely to establish and enforce water policies and regulations that support sustainable water use and efficient management practices (Manzungu, & de Sousa, 2020). However, regions affected by political instability or conflict struggle to implement and enforce effective water management measures, leading to water scarcity and insecurity. Conflict and political instability can trigger disputes over limited water resources, intensifying water insecurity among different communities, industries, and sectors (Allan, 2016). These conflicts disrupt water supply and services, resulting in infrastructure damage, operational disruptions, and population displacement (Schmeier, et al., 2015). Restoring political stability and rebuilding water infrastructure becomes vital for water security in the post-conflict phase (Warner, et al., 2017). Efforts to promote political stability, strengthen governance and institutions, foster conflict resolution, and prioritize water infrastructure maintenance and investment are necessary to address the challenges associated with political instability and conflict, ensuring reliable access to clean water for the population in the Bojanala District

2.9.8 Socio-economic factors

In the Bojanala District, water security is significantly influenced by socioeconomic variables. Both the availability of clean water and the efficiency with which it is managed and put to use are influenced by the socioeconomic status of a community. Ginindza, et al. (2019) point out that poverty and wealth disparity can act as barriers to receiving adequate water and sanitation services. Water and sanitation infrastructure may be inadequate in low-income areas because of a lack of funds for their development and upkeep. To ensure water security it is important to ensure that people have access to basic services, including piped water, sanitation, and hygiene facilities (Dwumfour-Asare et al., 2020).

Water availability, sanitation methods, and hygiene standards may vary from one community to another due to inequitable access to these services. Communities' agricultural and industrial practices, in particular, can have a major impact on their water security (Adeoti et al., 2017). Those who depend on water-intensive industries or agriculture for their income are more likely to be affected by water shortages. Ngwenya (2017) states that sustainable water usage and conservation can only be achieved by widespread public education and understanding of the best water management methods. Communities' knowledge of water concerns can be influenced by socioeconomic factors, such as educational levels and awareness campaigns, leading to more effective water management. Reducing poverty and income inequality, expanding access to essential services, fostering sustainable livelihoods and water use practices, raising public awareness, and fortifying governance and institutional capacity are all necessary to ensure water security in Bojanala. By fixing these issues, the district's communities can have safer water supplies and better access to clean water.

2.9.9 Water governance and institutions

Water governance and institutions play a crucial role in ensuring water security in the Bojanala District of South Africa. Effective water governance frameworks and well-functioning institutions are necessary to manage water resources, allocate water fairly, and address the diverse water-related challenges in the region (Mehta, et al., 2019). Effective governance frameworks promote stakeholder participation, transparency, accountability, and equitable decision-making processes. Stakeholder engagement fosters collaboration, knowledge sharing, and consensus-building, leading to more inclusive and sustainable water management practices (Hall, et al., 2019). Strong and capable institutions are essential for implementing water policies, regulations, and management strategies. Institutional capacity includes the availability of skilled personnel, adequate funding, technical expertise, and clear roles and responsibilities (WWAP, 2019). Collaboration among institutions at various levels, including local, regional, and national, is crucial for addressing water security challenges. Coordinated efforts, data sharing, and joint decision-making among institutions enhance the effectiveness of water governance and improve the overall management of water resources (Van den Brink, et al., 2014). By strengthening water governance frameworks, promoting stakeholder engagement, enhancing institutional capacity, adopting integrated water resource management approaches, and fostering collaboration among institutions, water security in Bojanala can be effectively addressed.

2.10 THEORETICAL AND CONCEPTUAL FRAMEWORK OF THE STUDY

The particular line of reasoning that is pursued here is based on assessing socio-economic characteristics among households in terms of the impact of water security. Since theories help explain why things happen the way they do (Bhattacherjee, 2012), the study explored the theory that helped guide the research. The theory is used to gain an understanding and shed some light on the study. As a result, this research relied on the Sustainable Livelihood Framework as its theoretical foundation because it offered a lens through which to examine the underlying factors and multiple facets that contribute to the complexity of water security. The sustainable livelihoods approach takes into account the many external variables that can affect a household's ability to make a living. For instance, the Sustainable Livelihood Framework analyzed factors that influence sustainable water security and water resource use at the household level in the study area. As such, the Sustainable Livelihood Framework explains how families make a living by utilizing their resources and skills to create multifaceted livelihood plans. The Integrated Water Resources Management (IWRM) framework as the conceptual structure of the research takes into account the significance of the water cycle as a whole (including all of the natural aspects and processes associated with it) and its interplay with other ecological cycles in the natural ecosystem. Additionally, it acknowledges the necessity for equitable decision-making in light of the disparate interests of all water consumers across all sectors of society. Therefore, the theoretical and conceptual frameworks are utilized to shed some light on why water is such a critical security issue. In endeavoring to address the goal of this research, a clear distinction that recognizes the two ideas of Sustainable Livelihood Theory and Integrated Water Resource Management is essential. The definition and discussion of these terms are provided within the context of this research below. This assisted in interpreting whether distinctions exist among these terms or not.

2.10.1 Sustainable Livelihood Framework

The concept of livelihood is gaining popularity as a useful tool for figuring out what influences people's lives and long-term well-being. Dimensions, materials, and actions necessary for subsistence are all included. According to Carney (1998), the sustainability of livelihood can withstand and recover from stress and shock, and that can keep growing and thriving over time without diminishing its underpinning natural resources. The livelihood concept is constructed on the proposition that a rural household approaches a base or constrained measure of asset base which can be abridged as human, natural, physical, social, and money-related capital, which can be utilized to concoct livelihood techniques, for example, crop farming, livestock production, off-farm activities, among other techniques (Chambers & Conway, 1992). The framework may be implemented at various distinctive scales – from the person to family, to the family unit cluster, to broadened kinfolk gathering, to town, locale, or even country, with manageable livelihood results evaluated at distinctive stages. The approach aims to ensure that livelihood strategies are sustainable.

In this case, water security is practical on the basis that it can adapt to and recover from stuns such as contaminants, water conflicts, water shortages and scarcity, economic meltdown, and political instability, by appreciating the characteristic asset base (Chambers, & Conway, 1992). The ability of society to cope with various shocks is fundamental to ensuring water security. The framework highlights the complex social and economic realities faced by households and the community at large in the study area. Moreover, the sustainable livelihoods approach is linked to water security, which is a central focus of the study. The approach highlights that water security is not only an issue of profitability or even sustainability of production, or qualifications but relies upon how individuals, particularly needy individuals, access creation and trade (Swift & Hamilton, 2001:84). Sustainable Livelihood Framework is therefore a problem-solving mechanism, suitably contextualized at local conditions to enhance understanding of livelihoods by analyzing factors that influence sustainability at the household and community levels. Consequently, it can greatly reduce the subjectivity in human perception and, thus, help in identifying and analyzing factors that influence water administration to achieve sustainable water security under varying environments more reliably (Wang, et al., 2014b). The discussion on aspects that influence water security will provide the context to understand how and why the water security in Bojanala District results in its current state. Besides, the Sustainable Livelihood Framework is designed to assist in gaining insight into and dissecting, the livelihoods of needy individuals.

A livelihood constitutes the effectiveness, resources, and activities required for a method of survival. A livelihood is sustainable when it is resilient and recuperates from stresses and stuns and supports or develops its adequacy and resources for the contemporary and future, by comprehending the natural asset base (DFID 1999-2000). The livelihoods approach intends to place individuals at the focal point of improvement (regarding investigation and support). It also recognizes that livelihoods and the forces that affect them are vigorous. The point of the Sustainable Livelihood Framework is to enable stakeholders to take part in a discussion about different variables that influence sustainable water security among households, their relative importance, and how they interact. Of course, socioeconomic characteristics have a major influence on the structure of livelihood and can contribute to eradicating poverty in vulnerable segments of society and provide sustainable livelihood advancement for forthcoming generations. It is participatory, accepting that participatory methodologies can recognize glitches and solutions.

The core strength of the approach is that it may be implemented in any form of development activity. The framework moves the focus from perceived "problems, limits, and requirements" to perceived "strengths, opportunities, coping mechanisms, and local initiative" by placing a strong emphasis on natural resources as productive assets in sustaining rural lifestyles (Carswell et al., 2004; Carswell & Jones, 2004). The starting point of the approach is to establish what people have (assets/capital) and what transpires daily (livelihood activities), thus shifting the focus away from what they need. The Sustainable Livelihood Framework is a comprehensive model, and it also permits various factors of livelihood resilience to be put in context and balanced against each other. However, when an approach is so broad, problems are expected to emerge in detecting the most vital needs. Therefore, viewing the entire characteristics of livelihoods, and setting risk reduction and hazard vulnerability in the broader vulnerability and livelihoods context the Sustainable Livelihood Framework is a good model.

Sustainable Livelihood methods arose and became more well-known in the middle of the 1980s, through the work of Robert Chambers. They derive from various works of literature on poverty, vulnerability, coping, and adaptation to social and natural changes (Ellis, 2000). The Sustainable Livelihood Framework (SLF) was highly accepted among policy planners. This framework enhances understanding of livelihood by analyzing relationships between relevant factors at the household and community levels. The Sustainable Livelihood Framework further helps to understand factors that influence water administration to further attain sustainable water security under varying environments more reliably (Wang, et al., 2014b) and to identify people's activities in developing and sustaining their livelihood. The livelihood activities begin with the concept of livelihood and progress through the forms of capital, structures, and processes that shape people's options. The Sustainable Livelihood Framework presented below is espoused from the DFID Sustainable Livelihood Conceptual Framework. DFID (Department for International Development, 1999).

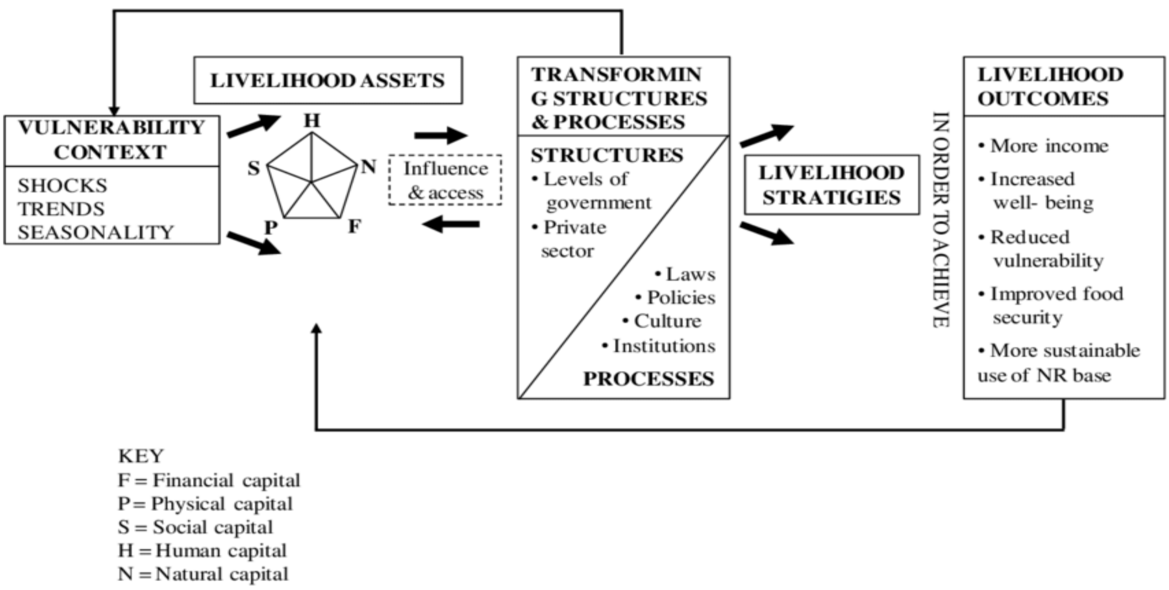


Figure 2.3: **Sustainable Livelihood Framework**

Source: DFID Sustainable Livelihoods (1991). It shows how assets are used in pursuit of different livelihood strategies and outcomes, a process that occurs within a context of vulnerability and is mediated by different structures and processes.

The vulnerability context in the above diagram refers to the world outside which the populace must survive. This includes trends (such as national or international economic trends, changes in available technology, and political systems), shocks (such as illness or death, conflict, weather), and seasonality (of prices, production cycles, and so on). The vulnerability context is significant because the three factors have a direct impact on the possibilities that the destitute have to earn a living now and in the future. The institutions and laws that have an impact on the lives of the poor are included in the box titled "Transforming Structures and Processes," and they range from public and private organizations to national laws and regional customs. All of these have the potential to alter both the context of vulnerability and the resources that are available to the poor. Strategies for achieving a living are called livelihood outcomes. Both actions utilizing and not utilizing natural resources may be considered while making decisions about livelihood choices. The context of vulnerability and access to capital assets are important, but the environment of structures and procedures also affects livelihood choices and results. Structures are the governmental and non-governmental organizations responsible for making laws, enforcing them, providing services, and making and distributing goods and services that people rely on to make a living.

Following the above parallel descriptions, the framework depicts a pentagon with five capital categories: natural (N), physical (P), financial (F), human (H), and social (S). Based on the Department For International Development's (2000) categorization of material and immaterial assets, the following five forms of investment capital have emerged. The term "natural capital" is used to describe the value of natural assets like land, water, forests, air quality, biodiversity, etc. Many of the rural poor depend heavily on the local natural resource base for their survival, making these resources especially important to them (Baumann, 2002). Physical capital includes things like tools and machines, transportation and roads, electricity, adequate water, sanitation systems, and so on that are used in the production process. In this research, where natural water sources are dry for the majority of the year, the availability of reliable water infrastructure, such as a well, is crucial.

Stocks and savings of various kinds, such as bank deposits, jewelry, and cattle, and access to inflows of money through pensions, remittances, etc., are all examples of financial capital. Cash-based transactions are becoming the norm in rural areas of developing countries, a phenomenon known as "monetarization" (Campbel, et al., 2002). Livestock can serve as cash deposits that can be sold and converted into other forms of capital in places like the rural and developing semi-arid world, where there are no traditional financial institutions. Human capital, which includes people's talents, education, experience, and health, is what defines the quality and quantity of available labor in any given household. In rural and impoverished parts of Africa, where people's labor is often their most valuable asset, this factor takes on added significance (Campbel, et al., 2002). For a long time, the effects of the provision of domestic water were only considered in terms of human capital losses. It was hypothesized that better access to water would have a positive effect on people's health and, in turn, their productivity at work.

Last but not least, social capital is described as a community and wider social claims on which humankind and households can demonstrate high moral standards of belonging to social organizations with varied degrees of inclusivity in society (Ellis, 2000). Social capital, as defined by Putman (1993), consists primarily of established ties that can be drawn upon to accomplish goals in the future. Some writers define social capital as "horizontal associations" that promote collaboration and reap benefits for all involved. Among these is the dissection of "vertical associations," which, if successful, could lead to functionally distinct end products (Coleman, 1990). Every definition is infused with the ideas of trust and cooperation (Krishna, 2000) that mold the networks of the future to ensure people's financial stability.

2.10.2 Integrated Water Resource Management Framework

Central to any good empirical investigation is a well-thought-out conceptual framework. According to Ravitch and Riggan (2016), the conceptual framework acts as a guide and ballast to research by providing a method that explicates the links, disjunctures, overlaps, conflicts, and circumstances forming a research environment and the study of phenomena inside that setting. Because of this, the researcher decided to base the study on the Integrated Water Resource Management Framework. The term Integrated Water Resources Management (IWRM) refers to a strategy for managing water resources that promote economic and social growth that is good for everyone without jeopardizing the health of crucial ecosystems and the natural world (GWP, 2000). Because of IWRM's widespread acceptance as the water management ideology of the 21st century, it was chosen as the study's overarching framework (Kuldeep, et al., 2015). In addition, IWRM is a widely used framework in the water industry and has been embraced by policymakers worldwide. When put into action, Integrated Water Resources Management (IWRM) provides a framework for dealing with water-related challenges and issues (Beek and Arriens 2014). One example is the growing demand placed on the world's freshwater supplies, which leaves many people without easy access to the water they need to meet their most basic human requirements. With a growing population, thriving economy, and rising standard of living, the scarce freshwater supply is increasingly a cause of contention. This is why IWRM has been chosen as the overarching framework for this investigation. Besides, the goal of both Integrated Water Resources Management (IWRM) and water security is to enhance water-related circumstances for the benefit of humanity.

As indicated above, the conceptual framework of the study anchors around the Integrated Water Resource Management (IWRM) approach with an emphasis on assessing the sustainable socio-economic water security among households and subsequently developing a descriptive model of sustainable water security. To efficiently sustain monetary development, increase the populace, increase water demand, and water as a rare asset, a coordinated water resource administration approach is essential. The IWRM intends to sustainably amplify the occurrence of monetary and social welfare in a fair-minded way while the environment is not compromised. The Global Water Partnership (GWP) upon the endorsement of IWRM, has pushed an integrative point of view for water administration that is receptive to economic, environmental, and community results. Commonly, IWRM is understood as a sequence of actions that promote the planned development and management of water, land, and linked resources to magnify the occurrence of economic and social well-being appropriately without impacting the sustainability of critical ecosystems (GWP, 2000). The origin and nature of IWRM mainly focus on improving livelihoods among a wider extent of integrated natural resources administration. Inferred in the four rules is the need for individuals to utilize the water assets in a manageable manner to oblige the necessities of who and what is to come. This implies that a general method that concentrates on the relationship between social, economic, and ecological proportions in resolving water assets issues should be investigated. The ultimate objective of IWRM is therefore to permit communities to develop environmentally, socially, and economically by supporting and promoting better utilization of resources sustainably.

There has been a significant analysis and critique beforehand on the theoretical difficulties of IWRM. This led to Walther's (1987) inquiries as to whether genuine issues would ever be understood by any coordinated water asset administration framework, including one associated with water. While the use of IWRM is frequently done on restricted lines, Biswas (2004) posited that IWRM has turned out to be ambiguous, making deliberations meaningless. Molle (2008) contended that the statutes of IWRM (value and productivity) are frequently contradictory. Medema, et al., (2008) highlighted that setting water at the center of IWRM could be defective since it is just a single aspect of the focal concern. Jensen (2013) has demonstrated that IWRM is negated by politics which in actuality are at the center of critical water verdicts. Perhaps most damning, Jeffrey and Gearey (2006) argued that IWRM has never worked, and there is no substantial evidence of its success. However, despite these critiques and arguments, the approach remains relevant to the study as it portrays the current situation with regional and local water administration. It is for this reason that it has been chosen as the main framework of the study to assess sustainable water security among households and a guide to the development of a descriptive model of sustainable water security.

The IWRM framework is among the key bodies of knowledge that frame this research. It is through IWRM that the water-related issues and water policies ought to be surveyed, analyzed, checked in, and settled within a general societal and development setting, otherwise the fundamental targets of water management, for example, improved standard and personal satisfaction of the individuals, destitution alleviating, territorial and equitable income dispersion, and ecological preservation, cannot be accomplished (Biswas, 2008). The initial segment of the study has therefore concentrated on the socio-economic attributes of the household in the Bojanala District. The discussion on these aspects provides the context to understand how and why the water security in Bojanala District results in the current state. The study provides the status of water security across the district for sustainable socio-economic water security among households as part of the IWRM framework. To develop the descriptive model, preliminary knowledge of the socio-economic characteristics has been provided through field investigations and data collected from existing secondary sources. Also, regardless of the diverse physical, economic, social, and environmental circumstances, and independent of the rapidly expanding complexities of water administration practices and procedures, it has regularly been said that coordinated water assets management takes care of the water issues in a heterogeneous world (Biswas, 2008).

2.11 ASSESSING SUSTAINABLE WATER SECURITY

Assessing water security in Bojanala is a complex, multifaceted endeavor, necessitating the consideration of numerous factors that influence both the volume and the purity of accessible water resources. An essential component of assessing Bojanala's water security includes examining the provision and accessibility of potable water for the local inhabitants. As per Mokgolo's (2013) investigation, several areas in the region face limited access to uncontaminated drinking water due to inadequate infrastructure and substandard maintenance of existing facilities. Moreover, there is apprehension regarding the potential contamination of surface and subterranean water sources from agricultural discharge and mining operations. A critical factor to consider while evaluating water security is the sustainability of prevailing usage trends. Mabhaudhi et al.'s (2019) study found that approximately 70% of Bojanala's total water consumption is attributed to crop irrigation, predominantly maize cultivation. However, this substantial level of irrigation is not without its drawbacks: Over-extraction from aquifers may lead to long-term depletion, while inefficient irrigation practices can result in significant losses via evaporation and surface runoff. Recent scholarly work has underscored the implications of climate change for Bojanala's water security. Mafungwashe et al. (2018) reported that increasing temperatures and evolving precipitation trends are projected to intensify water shortages in the region, especially during droughts. This emphasizes the necessity for innovative, adaptive strategies to manage water resources sustainably, like rainwater collection systems and enhanced irrigation methods. Several initiatives have been put in place to confront these challenges and bolster water security in Bojanala. These include infrastructure projects such as new dams and pipelines implemented by the DWS and research conducted by NGOs like the Water Research Commission into sustainable agricultural and industrial management practices. Nonetheless, further efforts are required to ensure Bojanala's long-term water security.

Assessing sustainable water security allows both the understanding of the current situation and the identification of challenges and areas that need attention. According to Allan, et al., (2018), indicators of water security have been a significant part of the discussion around water security in recent years, and standardized assessment frameworks have been developed to track these indicators (availability, accessibility, safety, quality, and management). There exists a clear scalar mismatch because most of these assessments are not well connected with the needs of policymakers (Van den Brandeler, et al., 2019). Seemingly, most researchers have offered different approaches and assessment index systems to evaluate water security from the sustainable triple bottom line. For instance, as part of evaluation procedures, sustainable water security should be reflected using a set of sustainability indicators that offer a condensed but adequate definition of sustainable water security (Huimin, et al., 2019). In essence, assessing sustainable water security is useful because it helps to encapsulate the larger water-related issues. As such, Lautze and Manthrithilake (2012) suggest five dimensions (i.e., basic needs, agricultural production, the environment, risk management, and independence) to consider when assessing sustainable water security. These indicators are critical, especially when designing a descriptive model of sustainable water security that seeks to ensure sustainable water supply and better utilization of available resources.

Sustainable water security assessment remains one of the main components of any comprehensive water resource management (Gerlak et al., 2018), and is, therefore, one of the topics that need to be investigated. The assessment of water security helps understand the breadth and scope of the issues that must be addressed to ensure sustainable water security (Hjorth & Madani, 2014). It is an essential step to prioritize and address issues, inform planning, and implement and monitor water security action. Previously, research on water security assessments mainly involved water-related risks, water poverty, water vulnerability, and water security governance (Global Water Partnership, 2014). However, there is still room for enhancement. Ordinarily, water security problems have a complex nature which is rooted not only in the availability of freshwater resources relative to water demand but also in social and economic factors. For instance, Vörösmarty (2010) used indicators such as watershed disturbance, pollution, water resource development, and biotic factors to assess the global threat to human water security and river biodiversity. Household water security, economic water security, urban water security, environmental water security, and resilience to water-related disasters were the five dimensions used by the Asian Development Bank (2016 & 2013) to assess water security across Asia. As can be seen in Table 2.1 below, there are now several frameworks available for use in evaluating water security in countries all over the world.

Table 2.1: Existing Frameworks For Water Security Assessment

Authors	Elements of water security	Scale of assessment	Application in
Zeitoun (2011)	Security of people and communities; Safety of nations; Safety of water supplies; Safety of food; Safety of energy supply; and Safety of climate.	Countrywide	NA
Lautze and Manthrithilake (2012)	Primitive necessities, food production, ecological standards, risk mitigation, and self-sufficiency.	Countrywide	Asia Pacific
Mason and Calow (2012)	Threats to resources; Uncertainty and risk; Inadequate human productivity; Urgent ecological concerns; Weak leadership	Generic	NA
ADB (2013, 2016)	The ability to withstand water-related disasters; water security for households; water security for the economy; water security for cities; and water security for the environment.	Countrywide	Asia Pacific
Lankford (2013)	Sufficient volume; High-quality water; Safety from flooding; Fair distribution; Variable allocation; High-performance results	Countrywide	NA
UN-Water (2014)	Safe drinking water; Wastewater pollution and water quality; Water resources; Water governance; Water-related disasters;	Countrywide	Worldwide
Fischer et al. (2015)	Variability in runoff; the proportion of external to internal renewable water resources; the ratio of annual water withdrawal to internally expandable water supply; the overall quantity of renewable freshwater resources per person.	Countrywide	NA
Sadoff et al. (2015)	Problems with water supply and sanitation; pollution and degradation of ecosystems; droughts.	Countrywide	N/A

Source: Interpretation by the author according to the sources

Most of the studies listed above were conducted at the country level, and as Vorosmarty et al. (2010) point out, water security assessments conducted at the country level can hide significant variations in security at the local level. This suggests that while a country may be water secure along some metric at the national level, the picture may look very different when looking at the situation at the regional or even municipal level. Though national-scale analysis allows for important and useful conclusions to be drawn, Cook and Bakker (2012) warn that it prevents a fine-grained analysis of sub-national spatial and social variation in water security. The literature review shows that there have been assessments of water security at the international and national levels; however, a key difficulty was determining the state of sustainable water security at the individual household level (Veettil, & Mishra, 2018). The difficulty stems, in part, from the fact that water security is a concept with a vague definition that has been applied to varying degrees at different times and places. Furthermore, a global or national assessment of water security only provides a broad picture of the situation from a countrywide point of view and not a detailed picture at the municipal level (Global Water Partnership, 2014). Because of this, it is clear that assessing water security is just as difficult as defining it. So, evaluating water security is essential, and it is especially important to do so on a local scale. The assessment of water security on a local scale is rare. Because improving things like water security typically requires a “bottom-up” approach, local assessments are still necessary for making the idea of water security work in the real world (APN, 2015). Because of this gap in understanding, this research aimed to fill it by creating a multi-dimensional, descriptive model of sustainable water security, which could then be implemented on the ground.

The lack of a local-level assessment of water security and the implementation of water security measures has been cited in several studies as a major issue (Srinivasan, et al., 2017). Assessing sustainable water security at the local level is significant and helpful in reflecting the wide range of water security dynamics, intending to solve water problems effectively. In other words, this will provide decision-makers with robust policy instruments and measures to achieve sustainable water security (Allan, et al., 2018). In the main, the assessment of water security helps policymakers understand and identify current water security issues in depth. In this regard, a key step in assessing sustainable water security is therefore the adequate “*framing*” of the water security issue. Water security has been defined, framed, and quantified in a variety of ways by several different researchers and organizations (e.g. ADB 2016 & 2013; Cook & Bakker 2012; Grey & Sadoff 2007). The term “framing” was coined by Hines (2012) and means the initial stage that enables businesses to specify the scope and emphasis of problems needing strategic foresight. The major concerns of the hazards of water insecurity and its connections to socio-economic development are accounted for in the framing (progress, affluence, and well-being). For example, seven factors were considered in the GWP (2000) framework, including ensuring a sufficient food supply, safeguarding ecosystems, dividing up water supplies, reducing risk, placing a proper value on the water, and exercising responsible water management. One of the most influential papers on the topic, written by Grey and Sadoff (2007), defined water security as freedom from threats to human and environmental health, with a focus on the latter. Research, however, incorporates stakeholder participation (e.g. a recent APN project Nikitina et al. 2009) and virtual water (e.g. Zeitoun et al. 2010) into the framework development for water security.

The term "*sustainable*" is commonly used in the context of socio-economic development, whilst water security means that people and ecosystems have a supply of water that is sufficient amount and satisfactory (Habiba, et al., 2014). Specifically, the principles of sustainability seem well-suited to this situation, where they can be applied to the issues of ensuring sustainable water security. As such, sustainable water security can, therefore, be thought of as the state where domains of sustainability such as social and economic development are effective and value water for a variety of needs over the long term (Frone & Frone, 2018). According to Koontanakulvong (2019), sustainable water security should depend on the efficiency of integrated water management, water productivity, and the provision of water supply and sanitary services. For instance, from a sustainability point of view, almost all social and economic activities require a provision of sustainable water security to sustain humanity (Vila, et al., 2018). Nonetheless, this is quite a complex and challenging issue because achieving sustainable water security, as well as meeting the needs of society and the environment calls for societal responses to reflect the reality that the households are facing. As a result, Kusuma and Octastefani (2016), state that to achieve sustainable water security and self-sufficiency of water for both current and future generations, the community should uphold a spirit of cooperation to maintain water resistance. This is because a cooperative community approach enables people to combine their resources and encourages them to get involved in their community, where they feel they have a stake in the outcome.

Therefore, achieving long-term water security calls for comprehensive water resource planning, a watershed assessment of supply and demand, increased capacity in existing reservoirs, a focus on water demand management, a more equitable and efficient approach to water use, and a solution to the rising cost of maintaining aging water infrastructure (Frone & Frone, 2018). At its core, a sustainable water security assessment is a process that aims to ensure the long-term availability and high quality of water for a wide range of uses by involving all relevant parties. Thus, the practice of water reuse encourages inhabitants, industry, and agriculture to save water and implement up-to-date water management practices that are vital in achieving sustainable water security (Yousuf, et al., 2018). In the main, both rooftop rainwater harvesting and spring water are key sources to consider as possible solutions or practices for the success of sustainable water security at the household level (Rawat, 2018). Some of these measures are of great social and economic importance as a major source of water for both domestic and agricultural needs.

Seemingly, communities are increasingly becoming aware that the longevity of water usage can only be achieved through sustainable water security. Thus, advancing sustainable water security can be accomplished through a community participation approach and consultation of key stakeholders in water decision-making as well as considering diverse local knowledge (Ale, et al., 2020). The effectiveness of the community approach is already recognized in many local authority programs such as those for waste minimization. Nonetheless, for sustainable water security to be successful, it should consider the use of a wide variety of approaches (technologies, techniques, methodologies, tools, measuring equipment, software, etc.), with a general goal being to meet all particular social and economic needs and, at the same time, not compromising the needs of future generations (Halkijevic, et al., 2019). Further, the adoption of modern technologies and a descriptive water security model that seeks to address and optimize water resource allocation for sustainable use at the household level is significant and commendable. This is because the sustainable use of limited water resources for domestic use, and the overlooked water-related needs of a household, require a deeper understanding to guide the success of sustainable water security assessment (Kukal & Irmak, 2016a, 2016b).

Despite sustainable water security among households becoming a complex challenge, its assessment is spatially and temporally inconsistent and is not universal. Since the effects of water scarcity are often felt first and foremost in individual homes, it is crucial to seek out a locally-based, complete assessment of sustainable water supply (Hailu, et al., 2020). As a result, underdeveloped nations face more dire repercussions from water insecurity because they lack the resources and infrastructure to effectively assess and build a model for long-term water security (UN-WWAP, 2015). Sustainable water security is a niche research area for academia all over the world, hence, it is inevitable that developing countries, including ‘water surplus countries’, will face some sort of water crisis. Despite these facts, there is no known integrated, multidimensional, and comprehensive assessment of sustainable water security at the household level in African countries and South Africa in particular (Hailu, et al., 2020).

In principle, the previous studies suggest that the Water Poverty Index (WPI), as an integrative and comprehensive measure, can be used to assess sustainable water security for households at the local/community level (El Gafy, 2015). The WPI is a helpful and holistic tool to identify areas of greatest need, however, has inherent limitations. For instance, the applications of WPI as an assessment measure in addressing the issue of sustainable water security at the household level are problematic due to spatial, temporal, social, and economic variations. Therefore, prior attempts to contextualize WPI as a measure of sustainable water security, especially at the household level, were insufficient since they lacked explanations on aspects or determinants that influence water security such as economic or social aspects at the household level (Jemmali & Sullivan, 2014). Although the WPI can be calculated on a variety of scales (community, regional, and national) (Juwana, et al., 2012), Water policymakers have begun using the index as a useful tool for allocating and prioritizing scarce water resources (Garriga, & Foguet, 2013). Also, the WPI has incorporated several features that reflect key concerns in emerging economies about water supply infrastructure, the extent of availability of potable water and sanitary facilities, people's ability and capacity to manage water for preserving the availability, diversity of water use, and health of ecosystems which impact on the water supply (El Gafy, 2015).

Unfortunately, most sustainable water security assessments have been undertaken at the global and national levels. As such, its recommendations are not applicable at the local level. For this reason, Lautze and Manthrithilake (2012) have developed a guide to assess sustainable water security, especially at the local level. The guide is a simple summation of five components as shown below:

1. **Basic household needs** – measured in terms of how many inhabitants are privy to an adequate supply of clean water;

2. **Agriculture production** – measured as the extent to which water is available and harnessed for agricultural production;

3. **Environmental flows** – the percentage of renewable water resources (RWR) available over environmental water requirements (EWR);

4. **Risk management** – the extent to which countries are buffered from the effects of rainfall variability through large dam storage; and

5. **Independence** – the extent to which water and food supplies are safe and secure from external changes or shocks.

The guide has brought forth the key aspects of sustainable water security and has stimulated discussions to concretize the concept (Hailu, et al., 2020). However, the guide is criticized as a measure of sustainable water security at the household level because it overlooked the means to access water resources, which are the inherent challenges at the household level, especially in developing countries. Furthermore, the guide does not give any hint on the scale sensitivity of the index (country, region, subnational, household levels), and the authors oversimplified the complex water needs at the household level and centered on a country's water requirement using the concept of relative *verse* absolute water security.

2.11.1 Key aspects in assessing sustainable water security

To achieve sustainable water security at the household level, the following are the core elements synthesized from a broad range of sources (UN-Water, 2011):

- Availability of clean, inexpensive drinking water for fundamental human needs such as sanitation and hygiene and the maintenance of health and well-being.
- Safeguarding Economic Interests, Fundamental Rights, and Recreational Interests.
- Maintenance of ecosystems' capacity to supply and support vital ecosystem services through water allocation and management systems.
- Water resources for economic growth and development (in areas like manufacturing, agriculture, and tourism).
- Used water is collected and purified to prevent harm to human health and the environment.
- Promoting freshwater sustainability and collaboration through collaborative methods to transboundary water resource management within and across countries.
- The capacity to deal with the unpredictability and risks posed by water-related catastrophes such floods, droughts, and pollution; and,
- Effective and adequate legal regimes; transparent, participative, and accountable institutions; appropriately planned, managed, and maintained infrastructure; and capacity

development are all essential components of good governance and the fair treatment of all stakeholders.

2.11.2 Requirements for Sustainable Water Security

According to Babel, et al. (2016), sustainable water security is a major component that needs to be assessed at the local level with access to the improved water supply as a major indicator. However, planning short-term and long-term responses to known and unknown threats requires considering issues on multiple scales (local, regional, and global) at once. The following attributed requirements are synthesized (Aslam, 2013):

- **Water Sources** should be maintained around their renewable capacities without over-exploitation or depletion, and the quality of sources should be maintained by protecting them from contamination, especially biological contamination, at all times.
- **Infrastructure** should be designed for optimized demand and supply and regularly maintained to ensure the satisfaction of continuous consumer demand without interruptions, except for those scheduled for planned improvement of the system.
- **Consumers** should understand the capacity of the sources in their vicinity, their role in optimized water use practices, and their impact on the existing water sources and the overall environment.
- **A stable Economy** provides the required finances and other resources for operational and maintenance needs without relying on external funding resources.
- **Community Institutions** should play an active role in keeping the community alive in their participatory role by ensuring the arrangements for recommended operations and maintenance through adequately trained personnel.

2.11.3 Methodologies for Assessing Water Security

Assessing water security is a complex process that requires comprehensive, integrative, and innovative methodologies to capture its multi-faceted nature. Various methodologies are employed to assess water security, each considering different aspects and dimensions of the issue. Applying these methodologies provides a comprehensive understanding of water security, facilitating informed decision-making and the development of strategies to enhance water resource management. Water security assessment often involves a combination of hydrological modeling, GIS-based spatial analysis, water balance approach**,** socioeconomic and institutional evaluation, and participatory approach, etc (Cook & Bakker, 2012). The section below discusses methodologies commonly used for assessing water security and highlights key indicators that contribute to sustainable water management.

Hydrological Modeling

Hydrological modeling is a key method used for assessing water security. It uses historic and predictive data to estimate future water availability under various climate and socio-economic scenarios. These models typically incorporate data on precipitation, evaporation, groundwater recharge, surface run-off, and storage in water bodies to predict future water balances (Arnell, 2004). They can also consider potential changes in demand due to population growth, economic development, and shifts in water use efficiency (Gosling & Arnell, 2016).

Spatial Analysis

Spatial analysis, particularly when conducted using Geographic Information System (GIS) tools, provides another crucial method. It can help identify areas of water scarcity, contamination hotspots, and communities at risk of water insecurity. Spatial analyses can provide detailed insights into the physical distribution of water resources and how they intersect with demographic patterns (Jongman et al., 2015).

Socioeconomic Analysis

Assessing water security requires considering social and economic aspects. This methodology involves analyzing socio-economic indicators, such as income levels, access to water services, water-related livelihoods, and water governance frameworks. It helps identify vulnerable groups, assess equity, and understand the socioeconomic implications of water management decisions (Warner et al. 2019).

Water Demand Assessment

Understanding water demand is crucial for assessing water security. This methodology involves analyzing current and projected water demands for different sectors, such as domestic, agricultural, and industrial, considering population growth, economic activities, and water-use efficiency. It helps identify potential supply-demand gaps and informs water allocation decisions (Zhang et al., 2017).

Water Availability Assessment

This methodology focuses on quantifying water resources, including surface water and groundwater, to determine their availability for various uses. It involves analyzing hydrological data, such as rainfall patterns, river flow measurements, and groundwater levels, to assess water availability at different spatial and temporal scales (Vogel et al., 2011). By comparing water availability with sectoral water demands, including agriculture, industry, and domestic use, the water balance approach provides insights into potential water shortages or surpluses (Falkenmark and Rockström, 2006).

Water Quality Monitoring:

Assessing water security involves evaluating water quality to ensure it meets health and environmental standards. This methodology includes monitoring water quality parameters, such as chemical contaminants, pathogens, and physical characteristics, through regular sampling and laboratory analysis (Hering et al., 2017).

Participatory Approaches

Participatory approaches involve local communities, water users, policymakers, and relevant institutions in decision-making processes, fostering collaboration, and considering diverse perspectives and knowledge (Smith, et al., 2019). These approaches aim to incorporate diverse perspectives, local knowledge, and social considerations into the assessment process (Mehta, 2007). By involving stakeholders, participatory approaches enhance the understanding of water-related challenges, promote collaboration, and increase the chances of implementing effective water management strategies.

Climate Change Impact Assessment

Given the influence of climate change on water security, this methodology assesses the potential impacts of climate change on water resources. It involves climate modeling, scenario analysis, and hydrological modeling to project changes in precipitation patterns, evaporation rates, and water availability, aiding in adaptation planning (Wilby et al., 2017).

2.11.4 The assessment framework for sustainable water security

The assessment framework for sustainable water security provides a structured approach to evaluating the status and progress toward achieving sustainable water management goals. Regardless of the challenges reported in the literature (GWP, 2014; Biswas, & Tortajada, 2019; Grey et al., 2018) very little empirical evidence of sustainable water security assessment in the Bojanala District is available. Regrettably, studies have not used consistent approaches in assessing sustainable water security directly, especially at the household level. For this reason, Jaeger, et al., (2013) state that there is a need for consistent practical consensus on the assessment of sustainable water security at the household level. Be that as it may, sustainable water security, which guarantees an adequate supply of high-quality water while preventing the wasteful use of natural resources, is currently society's biggest obstacle (Durán-Sánchez, et al., 2018). It is therefore inevitable that achieving water security requires incorporating the notion of sustainability into all aspects of water administration. Nonetheless, the success of sustainable water security requires a consistent and integrated approach that combines analysis of supply and demand, strong government commitment, and consultation of various stakeholders including academia to ensure sustainable water security that includes protection and expansion of water resources (Kusuma & Octastefani, 2016).

Several studies have shown how many different assessment frameworks for sustainable water security have been developed over the past decade (Allan, et al., 2018). There is not a universally accepted method for evaluating water security because the idea is so vague and open to varied interpretations. However, water security can be translated into metrics or frameworks that can help assess and provide information on how to improve it, as stated by Marcal et al. (2021). There is currently no agreement regarding the identification and implementation of an evaluation methodology for monitoring the status and evolution of water security, with a focus on the local level (Aboelnga et al., 2019). As a result, the water security assessment is framed in a variety of ways, with some frameworks emphasizing risks and others emphasizing the need to expand water resources to keep up with growing populations (Giordano, 2017; Garrick & Hall, 2014). Using a standard technique for creating indicators based on the notion of water security, the suggested framework of sustainable water security is designed to assess the existing and future levels of water security in a scientifically sound manner (Aboelnga et al., 2019).

Numerous frameworks, approaches, and tools have been developed over the years to evaluate and investigate water security at various levels (Marcal et al., 2021). Important water security features were built into these frameworks (Lombana et al., 2021; Krause, 2015), including assurances of water availability and wastewater treatment efficacy. Consequently, Van Ginkel et al. (2018) compared the assessment outcomes of their water security framework to those of two other well-known index systems: the Sustainable City Water Index from Arcadis (Arcadis, 2016) and the City Blueprint from KWR (KWR, 2016; Van Leeuwen, 2012). Despite some theoretical differences, they found a strong correlation in their results (Van Ginkel, 2018). Since then, numerous other studies published in the literature have also adopted an index system as part of their proposed water security assessment framework. Indicators and index systems are widely used, but they are not the only ones. Instead of providing a predetermined set of indicators for gauging water security, some conceptual frameworks, like the OECD’s water security framework (2013), lay out a method that can be followed step by step to make an accurate assessment based on the specific circumstances of a given area.

2.11.5 Existing frameworks for water security: Identifying gaps, challenges, and opportunities

Several existing frameworks were found that addressed various aspects of water security. These frameworks included the Water Security Framework proposed by the United Nations Development Programme (UNDP), which focuses on six dimensions of water security: availability, access, quality, governance, productivity, and ecosystem sustainability. Another framework identified was the Human Right to Water Framework developed by the World Health Organization (WHO) and UNICEF. It emphasizes that all individuals have a right to safe drinking water. Other frameworks aimed at addressing specific issues related to water security include the Nexus Approach Framework developed by the Stockholm Environment Institute (SEI). It seeks to integrate policies and practices across sectors such as energy, food, and the environment to ensure sustainable use of resources. The Resilience-Based Management Framework developed by the Pacific Institute also addresses water management during times of uncertainty such as droughts or floods.

Despite these frameworks' existence, several gaps were identified in their implementation and effectiveness. One significant gap is inadequate stakeholder engagement in policy-making processes, limiting community participation in decision-making processes concerning their access to water resources. Additionally, most frameworks do not adequately consider environmental justice concerns or recognize marginalized communities' needs regarding access to clean water. Another challenge faced in implementing these frameworks is funding constraints. Most countries lack adequate financial resources or infrastructure for effective monitoring and enforcement programs required for the successful implementation of these frameworks. Opportunities exist for developing a new comprehensive framework that integrates stakeholders' perspectives from diverse backgrounds into policy formulation tailored towards achieving equitable access to sufficient quantities of safe water resources sustainably. A new framework could provide more robust mechanisms for monitoring progress toward achieving goals and objectives outlined in the framework, especially as it relates to marginalized communities.

The new framework should consider the integration of diverse stakeholders' backgrounds and perspectives to ensure inclusivity in policy formulation, implementation, and monitoring. This approach will help address the existing gaps and challenges related to marginalized communities' access to safe water resources. Additionally, the new framework should incorporate robust mechanisms for monitoring progress toward achieving the goals and objectives outlined in the framework. The development of such a framework presents an opportunity for collaboration among diverse stakeholders, including policymakers, academics, civil society organizations, communities affected by water insecurity, and private sector actors. By leveraging these opportunities, it is possible to create a more inclusive and effective approach to addressing water security challenges worldwide. To this end, examples of different frameworks assessing water-related concepts are presented in Figure 2.5 below. This figure does not present an exhaustive list of the existing frameworks but simply illustrates the diversity of concepts and assessment methods around water issues.

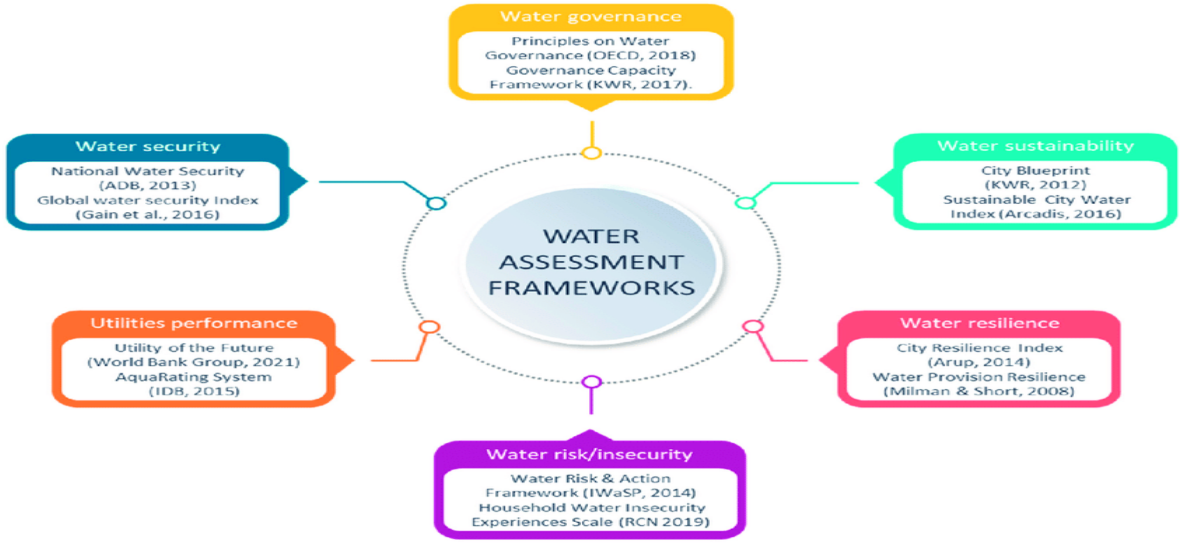


Figure 2.4: Examples of frameworks for assessing different water-related concepts:

Sources: Water Security (Gain, et al., 2016; ADB, 2013); Water Governance (OECD, 2018; Koop, et al., 2017); Water Sustainability (Arcadis, 2016; Van Leeuwen, et al., 2012); Water Resilience (ARUP, 2019; Milman, & Short, 2008); Water Risk/Insecurities (IWaSP, 2021; Young et al., 2019); Utilities Performance (Krause, 2015; Lombana, et al., 2021).

Insofar as frameworks are concerned, some efforts have been made to assess water security, especially at the national and global levels, however, the frameworks lacked a comprehensive and holistic approach. As such, very little work is available in the literature on the assessment of sustainable water security, especially at the community or household level. In this regard, Aslam, (2013) asserts that the comprehensive framework for assessing sustainable water security must be informed by ascribed guidelines below:

- **Holistic**: The framework must be based on a holistic approach, considering all major components of sustainability in a loop as a “closed system”. The sustainability of a single or a few components is not adequate for overall sustainable water security.
- **Simple and cost-effective**: The framework must be simple and inexpensive to administer.
- **Data-friendly**: Data requirements must be minimal and flexible to accommodate the different data types for a meaningful conclusion. Data can be collected at various sites with nominal training of the individuals involved.

- **Stakeholder-oriented**: The priorities for the various elements in the framework must be defined by involving the stakeholders.
- **Adaptable and improvable**: The framework must have the ability to respond to the actual needs of an area without changing the integrated set of priorities.

2.12 OVERVIEW OF DEMOGRAPHIC & SOCIOECONOMIC CHARACTERISTICS ASSOCIATED WITH ACCESS TO WATER

Access to water can be defined from several perspectives, including physical availability, affordability, and quality. Physical accessibility refers to the availability of sufficient water for personal and domestic uses, such as drinking, cooking, personal hygiene, and household chores(WHO & UNICEF, 2017). This also includes the physical reachability of the water source, which should be within a reasonable distance from the household (WHO & UNICEF, 2017). Economic accessibility (affordability) means that water, and water facilities and services, must be affordable for all (UN Committee on Economic, Social and Cultural Rights, 2002). The direct and indirect costs of water – including the time spent to collect it – should not prevent people from satisfying other basic needs. Quality access to water also refers to the safety of the water. Water for personal or domestic usage must be safe and, therefore free from micro-organisms, chemical substances, and radiological hazards that constitute a threat to a person's health (WHO & UNICEF, 2017). These definitions reflect the understanding that ensuring water access involves more than just the provision of a physical water source.

Understanding demographics and socioeconomic characteristics is a critical aspect of ensuring equitable access to water. Access to water is a fundamental human right, and no one should be denied this basic necessity based on socioeconomic status, gender, race, or any other demographic characteristic (Satterthwaite, 2016). Studying these characteristics can help identify patterns of inequality and inform interventions to ensure more equitable water distribution. By understanding the socio-economic and demographic profile of a region, policymakers and planners can better allocate resources and design interventions that cater to the specific needs of different groups (Smits et al., 2010). This can help to optimize the use of limited resources and maximize the impact of interventions. Socioeconomic characteristics can also inform infrastructure planning. For instance, higher-income neighborhoods may have different water needs and capacities than lower-income ones, affecting the design of water supply systems

(Bakker et al., 2008). Demographic characteristics such as population size and density, as well as socio-economic factors like income levels and livelihood types, can influence water demand (Van Rooijen et al., 2010). Understanding these factors can support demand management strategies, which can be particularly important in water-scarce regions. These characteristics often shape who has access to water, the quality of the water they can access, and how much they can afford to pay for it.

The term socio-economic (also known as social economics) is often used as an umbrella term for various areas of inquiry. It is widely used, even though it is often connoted to quite divergent understandings about what it describes (Hellmich, 2015). According to Baker (2014), one's socioeconomic standing is a reflection of both their financial and social circumstances. Predominantly, socio-economic refers to the way social and economic factors influence one another in local communities and households. It attempts to explain how a particular social group or socio-economic class behaves within a society. In the main, UNDP (2012), delineates socio-economic development as alterations to the overall size, shape, and composition of a system as a whole as a direct result of human intervention in a social or economic setting. In this context, it is clear that socio-economic characteristics influence living conditions in the following fields: economic structure, access to public goods and services, relations within a social system, environmental conditions, and life satisfaction (Litwiński, 2017).

Similarly, the socioeconomic characteristics of the households are regarded as variables that influence the level of water consumption of every household (Fan, et al., 2017). Obtained data on the socioeconomic characteristics of households is mostly utilized cumulative by planners and policymakers for measuring several domains of household socio-economic status. For instance, household data can be used to determine communal needs and ecosystems, in the present and the future (Durán-Sánchez, et al., 2018). Such data have become indispensable in economic and social policy analysis, development planning, and program management, along with policymaking at every level. Although Rhodes and Mckenzie (2018) claim to have made some progress in this direction, they still have a long way to go before they can accurately describe the demographics of South African households that have access to piped water. Despite this, there is scant written material that examines the socio-economic status of water-poor households, especially in the last decade when so much progress has supposedly been made in water services.

Household water resource planning and management are becoming increasingly dependent on socioeconomic factors, while excessive use of available water supplies has the potential to undermine both long-term water security and the prospects for equitable and prosperous social and economic growth (Liu et al., 2019). In other words, the system's ability to provide for people's fundamental needs and achieve long-term water security may be jeopardized by the actual and potential role of social and economic characteristics of the households and their impacts on water demand and supply (Gerlak, et al., 2018). Gender, socio-economic status, level of education, cost of water and wastewater services, the share of the energy budget, political leanings, geographical location, cultural norms, and leadership all play a role (Sharaunga & Mudhara, 2016).

Rhodes and Mckenzie (2018) point out that the identification of the socio-economic characteristics of households that access sustainable freshwater has received little attention in the South African context. Nevertheless, the identification of socio-economic characteristics is significant and helps sharpen the focus of water policy in terms of allocating water-based resources, infrastructure provision, and better-targeted water infrastructural development. Domestic water quality is positively correlated with factors such as housing type, income (from wages or remittances), family size, and, to a lesser extent, the gender of the household's primary breadwinner (Dungumaro, 2007). While previous research has identified the socio-economic variables associated with safe/unsafe water, even less independent research has examined the factors that influence sustainable socio-economic water security among households within the South African context. For instance, Kirigia and Kainyu (2000) gathered socio-economic data, including specifics on water security, using 1995 data gleaned from a survey of nearly 4,000 households in the urban, township, farm, and rural areas. Overall, factors such as household size, location, income, health insurance coverage, age, education (formal and health education), race, and employment status were found to significantly affect the likelihood of water security. Agreeing, Mokone et al. (2018) point to a range of socio-economic factors, including age, education level, gender, and external factors like technology use, as having a sizeable impact on the prospect of long-term water stability. Below is the conceptual model for socio-economic characteristics data:

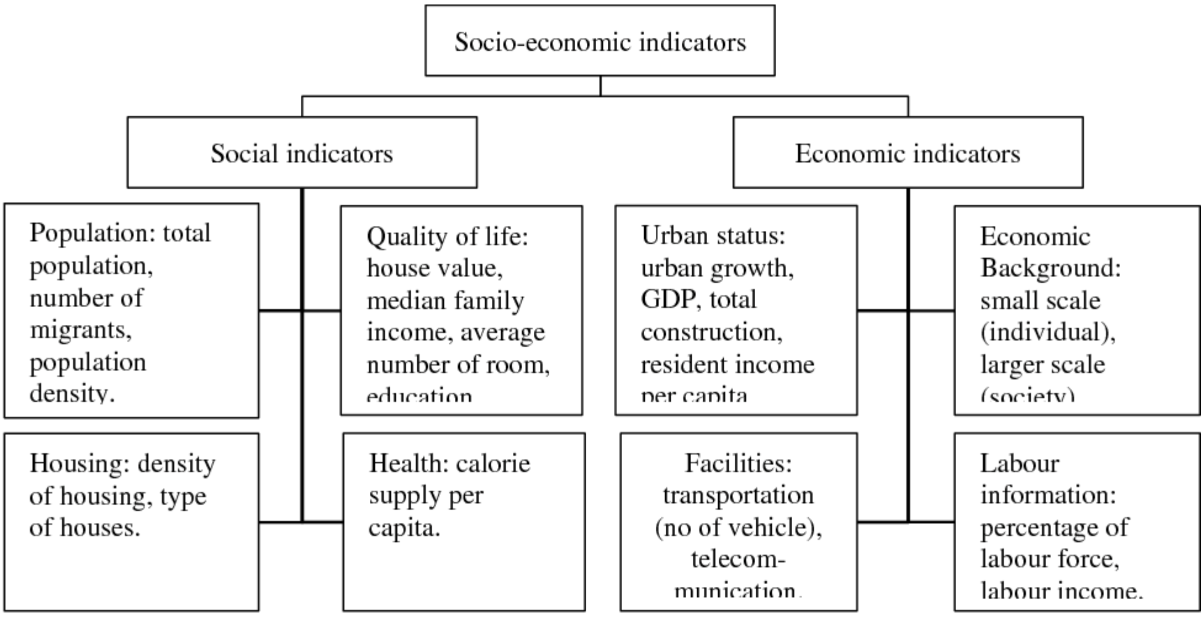


Figure 2.5: **A conceptual model for socio-economic data**

2.12.1 Demographics Associated With Access To Water

Demographics associated with access to water include factors such as location (urban or rural), gender, age, socio-economic status, and ethnicity, among others. These demographic variables can influence the level and quality of access to water resources, as well as the resilience of communities in the face of water scarcity or contamination. Understanding these demographic factors is crucial for identifying disparities in water access and for designing interventions to promote water equity. They include but are not limited to the following:

Location (Urban vs. Rural)

Access to water can vary significantly between urban and rural areas. In many parts of the world, people living in urban areas are more likely to have access to piped water or other improved sources compared to those living in rural areas (Satterthwaite, 2016). This is largely due to the concentration of infrastructure and services in cities.

Gender

In many societies, the responsibility for water collection falls disproportionately on women and girls, especially in rural areas. This gendered division of labor can affect their access to education and other opportunities. Moreover, inadequate access to water and sanitation facilities can pose particular health and safety risks for women and girls (UNICEF, 2016).

Age

Age can also impact access to water. Elderly individuals and children may face physical challenges in accessing water sources, particularly if they are located far away from their homes or if the water sources are difficult to use (Lloyd & Bartram, 1991).

Socio-Economic Status

Wealthier households typically have better access to reliable, high-quality water services. On the other hand, poor households, particularly in urban slums, often struggle to access affordable and safe water (Bakker et al., 2008).

Ethnicity/Caste/Race

In many societies, discrimination based on ethnicity, caste, or race can result in unequal access to water. Marginalized or minority groups are often disproportionately affected by water scarcity or poor water quality (Gupta et al., 2018).

2.12.2 Socio-Economic Characteristics Associated With Access To Water

Socioeconomic factors play a significant role in determining access to water. These factors include wealth or income level, occupation, education, and household size. Each of these characteristics influences both the quality and quantity of water that individuals and households can access. Studying these characteristics is crucial to identifying socioeconomic disparities in water access, understanding their root causes, and developing strategies to promote water equity. They include but are not limited to the following:

Income Level

Wealth or income level is a major determinant of access to water. People with higher incomes are typically more capable of affording the costs of water services, including the initial connection fees and regular water bills (Smits & Ross, 2019). They may also have better access to clean and reliable water sources. Conversely, people in lower income brackets often struggle to afford the same level of access to water.

Occupation

Occupation can also significantly influence water access. For example, individuals employed in agriculture may have different access to water than those in industrial or service sector jobs. This can also influence the time and resources available for collecting water, particularly in rural and peri-urban areas where piped water may not be readily available (Crow & Sultana, 2002).

Education

Education often correlates with better access to water. Education can affect income and occupation, thereby influencing a person's ability to afford water services. Moreover, education can improve understanding of water conservation, hygiene, and methods to secure cleaner water (Gleick, 1998)

Household Size

Larger households may face more challenges in securing enough water for their needs, particularly if they have a low income. This is especially relevant in cultures where water usage is high due to social or cultural practices (Nigatu et al., 2018).

2.12.3 The Nexus of Socio-Economic Context & Water Security

The importance of water to both economic and social development cannot be overstated (Huimin Li et al., 2019). Over the past century, water consumption has increased at a rate that is greater than twice the rate of population growth. Rapid urbanization places enormous strain on the water supplies and ecosystems in the surrounding area. The Convention on Biological Diversity (2013) points out that socioeconomic demands on water resources are impacted by a variety of local and worldwide factors including populace growth, economic development, as well as physical mediations such as engineered infrastructure to shield settlements from flooding, and physical framework to move water from one watershed to the next. These impacts can present more prominent vulnerability concerning the utilization and accessibility of water assets notwithstanding the current vulnerabilities identifying with the earth's climatic framework and hydrological cycle (Convention on Biological Diversity, 2013). These vulnerabilities are at last shown in socio-economic outcomes and decision-making. Set against these vulnerabilities is the day-to-day consumption for each humankind on the planet to have access to 20-50 liters of clean water, liberated from unsafe chemical and microbial contaminants, for drinking, cooking, and cleanliness purposes. The water footprints of human activities are becoming unsustainable, whilst sustainable water administration remains a worldwide concern and a matter of life and death for mankind.

2.12.4 Socio-Economic Indicators

The term ‘indicator’ has been very much in use in statistical literature but has not been adequately defined in a precise manner. The standard dictionaries do not usually go beyond describing an indicator as one that indicates, shows, or points out. The term has, obviously, a wider connotation than the ‘index number’ which has been defined as a quantity whose fluctuations over time or space reveal the behavior of a magnitude that cannot be directly measured or observed (Kendall & Buckland, u.d). Indicators are one of the most used approaches despite the abundant use of specific features and diverse methods and tools for assessing sustainability (Ramos, & Pires, 2013). Politicians, academics, scientists, and members of the public have all had plenty to say about sustainability indicators during the past few decades. They are a useful resource for assessing the relevance of environmental concerns and informing policy decisions for long-term sustainability (Dizdaroglu, 2017). For instance, they are broadly categorized as (a) those concerning individual members of the society or groups of members such as households; and (b) those concerning social services, i.e. institutions providing services to the society.

Selecting the most appropriate indicator can be a challenging task, with considerations including the indicator’s perceived usefulness, its ease of use, its scientific credibility, and its international comparability (Agol, et al., 2014). Several studies have investigated the factors influencing domestic water use, yet no study has investigated the socioeconomic characteristics of households concerning sustainable water security in recent years, especially socioeconomic dimensions, indicators, and variables of households (Sinyolo, et al., 2014). Multiple indicators are used to represent different aspects of domestic water security, and variables are identified to quantify the indicators to conduct an accurate assessment of sustainable water security. Clean water and sanitation are two of the Sustainable Development Goals that inform the definition of sustainable water security (SDG6). This means that a water-secure community requires improved socio-economic dimensions and indicators, as well as optimizing water resource allocation to ease pressure on the water supply. Liu, et al., (2019) point out that to realize the rationale, the authorities should increase the supportability of the water supply and control the population growth rate. Controlling the growth rate of the population and strengthening residents' awareness of water-saving will enhance socio-economic development. From the literature review perspective, such a perception signals the direction of change required to improve and achieve sustainable water security to a certain extent (Liu, et al., 2019). One of the fundamental requirements that must be considered in the creation of a powerful indicator framework is whether or not the indication can be measured.

2.12.5 Water Security Indicators

Indicators are anticipated to make significant contributions across the policy process, from initial problem identification to ongoing monitoring and assessment, and course correction, within the context of evidence-based policymaking (Seaford, 2013). While there is certainly room for skepticism regarding the widespread use of indicators, there are features that can be incorporated into indicator design to increase their usefulness and increase the likelihood that they will be used to inform evidence-based policy decisions (Jensen & Hu, 2018). For water security indicators to be populated, it is often necessary to collect and analyze massive amounts of data (Lehtonen, 2015; Seaford, 2013). Because of this, there needs to be openness and consistency in the creation of compound indicators and indices. Indicators must first be trustworthy (Lehtonen, 2015). For instance, the indicators need to be populated with data, or that data needs to be collectible in a reasonable amount of time, at a reasonable cost, and from a credible source (Jensen & Hu, 2018). Second, for indicators to be widely used, they must have credibility. The process of developing indicators is a major factor in determining their legitimacy. Finally, the salience of an indicator will determine how much weight it is given during the decision-making process. Lehtonen (2015) confirms that many indicators are not used merely because policymakers are not aware of them, suggesting that awareness is key to salience.

Furthermore, Lehtonen (2015) notes that although indicators and index systems are widely used, decision-makers rarely make use of them. Of the many indications available for gauging various aspects of water security, only a few tried-and-true ones are used on the ground. For example, the Water Stress Index (Falkenmark, 1989), one of the most popular indicators, can be adapted for use at the regional level, as in the Aqueduct water risk database (Gassert, et al., 2014). To measure water security on a national scale, the Asian Development Bank (2016) created the Water Security Index, which uses a similar index system divided into five dimensions (household, economic, urban, environmental, and water-related disasters). Indicators play a role here by simplifying complex phenomena into quantifiable indicators that can be easily communicated to and used by policymakers. The Asian Development Bank's urban water security index is one example of a composite indicator that incorporates indicators of urban water security to create a ranking of countries based on their water security (ADB, 2013, 2016).

Indicators, in the end, are typically analyzed with specific categories. Having access to recent, open, and trustworthy data is crucial when deciding on indicators (Marcal, 2016). Some authors classify indicators as belonging to the environmental dimension (Yomo, et al., 2019), while others classify them as belonging to the health and wellbeing (ARUP, 2019) or access to infrastructure (Yomo, et al., 2019) categories. However, authors do not always agree on the same categories or even consider the same dimensions of water security because of the complexity and interconnectivity between different aspects of water security (Marcal, et al., 2016). This is because the scale, context, definition of water security, and methodology used all play a role in determining which categories or dimensions of water security are most relevant.

2.13 SUSTAINABLE WATER SECURITY MODEL

A sustainable water security model refers to a comprehensive framework or approach that integrates principles of sustainability into the assessment, management, and governance of water resources to ensure long-term water security (Biswas, & Tortajada, 2018). It involves balancing the availability, accessibility, and quality of water resources with the needs of present and future generations while considering social, economic, and environmental dimensions. By incorporating sustainability principles, the model aims to achieve equitable and sustainable water management practices. A sustainable water security model embeds certain core attributes:

(a) multi-layer institutional mechanism;

b) clear articulation of roles and responsibilities of institutions;

c) time-bound scheme assessment and approval;

(d) inclusive regulations;

(e) well-devised asset maintenance guidelines; etc.

Such a model is unique and efficient because it differs so drastically from theories that advocate for the use of market processes to bring about improvements in water use. A descriptive model for sustainable water security amongst households captures conditions of local water security; including protections to ensure everyone has the means to live's necessities like clean water and nutritious food and maintains fairness in meeting all stakeholder needs (Ratnaweera, 2016). This allows the model development to be tailored to the needs of the particular community, something that is increasingly needed for different communities. Similarly, the model recognizes the difficulties of accurately estimating surface and sub-surface water that flows into and out of the sub-basin (Ratnaweera, 2016). In addition, the sustainable water security model provides more emphasis on water demand administration and a combination of water supply and demand management strategies for sustainability.

The sustainable water security models resonated with all the political tensions and policy implications related to each degree of sustainable development (Sibran, 2019), hence the model focuses on various alternative frameworks for locating sustainable development within explicit contexts. Importantly, the model of sustainable water security is engrossed in an essential conversion of socio-economic frameworks, whereby humanity puts as much into the environment as it confiscates (Sibra, 2019). In this model, the significance is located in natural processes and groups, instead of individual living substances. In furtherance, the model accentuates the social and economic aspects of development and provides a more detailed arrangement of development indicators that focus on the quality of life and the human component of development. Equally, advocates of sustainable development are mindful that environmental protection is just conceivable if the public can force restrictions on the required model (Sibran, 2019). In addition, they are equally critical of the promotion of the sustainable development idea, however, they contend that failing to specify exactly what degree of natural protection is required, offers governments and industries ways of embracing environmentalism without commitment.

The research conducted by Stubbs and Cocklin (2008) uncovered a set of normative principles that collectively constitute an "ideal type" of a model with a focus on sustainability. These authors were among the first to use case studies to develop theories for models that prioritize sustainability. Among the many structural and cultural characteristics of the best of them were fostering a sense of community and conducting and reporting on sustainability assessments. They also made claims about sustainable-oriented models addressing issues like community assessment, the need to take into account all stakeholders, how nature should be handled, and whether or not community leaders drive the necessary cultural and structural changes to implement sustainable development systems (Schaltegger, et al., 2019). While studies of sustainable models have long been conducted in the field of environmental sustainability, other academics have interpreted these tools as instruments for addressing societal concerns. Sánchez and Ricart (2010), for example, have developed a typology of "confined" and "intuitive" business models in low-salary markets; Seelos (2014) examined novel approaches to enhancing medical care administrations in economically disadvantaged areas. What all of these approaches have in common is an emphasis on value creation, which sustainability researchers have consciously broadened to include consideration for societal and ecological factors.

At the same time, Jun et al. (2015) suggest that the current models are flawed because they rely on the judgments of decision-makers regarding the significance of different water security indicators, which can result in biased assessments and inappropriate adjustments. While some current models make an effort to account for the three most common water-intensive uses (in the home, in industry, and in agriculture), they fall short when it comes to ensuring a steady water supply for the long term. For instance, Alcamo et al. (2003a, b) created a model called WaterGAP (spatial resolution on a 0.5 by 0.5 grid or 55km by 55km at the Equator) that simulates the surface water balance and water use, i.e., water withdrawal and consumptive water use, from agricultural, industrial, and domestic sectors. Similarly, the H08 (0.5) and MATSIRO (0.5) models were created by Hanasaki et al., (2008a, b, 2010) and Pokhrel et al., (2012a, b), respectively. Both models factor in human-caused changes to the water balance, like those caused by irrigation and reservoir regulation. Finally, the water balance and water demand per sector were calculated using the PCR-GLOBWB model (0.5) developed by Wada et al. (2010), Van Beek et al. (2011), and others. A global-scale abstraction of groundwater is also accounted for in the model. It's important to remember that each model serves a unique purpose; consequently, there is a wide gulf between them (Davie et al., 2013; Wada, et al., 2013a, b).

In many regions where water resources are dwindling, the variability between water models is especially pronounced (Haddeland, et al., 2011). Even so, large uncertainties in water models have been brought to light by Schewe et al. (2014). For instance, he neglected to explicitly account for sustainable water use when assessing water scarcity, opting instead to use per capita water availability. However, very few assessments have been constructed to evaluate the impacts of global change on water resources, as many recent studies (e.g., Hanasaki, et al., 2013a, b; Arnell & Lloyd-Hughes, 2014) have instead focused on the historical reconstruction of water used for model validation. According to numerous studies (e.g. Ratnaweera et al., 2006), a sustainable water security model should capture the status of water security on a regional scale by taking into account the effects of water scarcity on all water-related demands. Based on this premise, a key component of a sustainable water security model is nature, the assessment of water supply and demand balances, both now and into the future, as well as the monitoring mechanism and information on water demand, usage patterns, and socio-economic variables (UN, 2019). Generally, this calls for the establishment of user groups, committees, and associations, where the basic structure of authority and decision-making is established to ensure organized water administration, which is worth replicating in other water-scarce regions.

2.13.1 Key Components of a Sustainable Water Security Model

A sustainable water security model encompasses several key components that work together to ensure the availability, access, and resilience of water resources. By incorporating these key components into a sustainable water security model, it becomes possible to achieve long-term water security, promote equitable water access, and protect ecosystems. The model typically incorporates the following key elements:

Water Governance and Institutions: Effective water governance frameworks and institutions are crucial for sustainable water security. They provide the legal and regulatory framework, policies, and mechanisms necessary for equitable water allocation, efficient management, and integrated decision-making (UN-Water 2014).

Integrated Water Resource Management (IWRM): IWRM is a holistic approach that considers the social, economic, and environmental dimensions of water management. It promotes the coordinated management of water resources across sectors and stakeholders, ensuring the sustainable use and allocation of water (GWP, 2000).

Water Infrastructure and Technology: Adequate water infrastructure, including storage facilities, treatment plants, and distribution networks, is essential for sustainable water security. Integrated with appropriate technologies, these infrastructure systems enhance water availability, efficiency, and reliability (World Bank, 2019).

Water Demand Management: Efficient water demand management practices aim to optimize water use across various sectors, reduce water losses, and promote water conservation. This component involves implementing measures such as water-efficient technologies, pricing mechanisms, and public awareness campaigns (Turral, et al., 2010).

Resilience and Climate Change Adaptation: A sustainable water security model takes into account the impacts of climate change on water resources and incorporates resilience-building strategies. It involves assessing vulnerability to climate change, developing adaptive capacity, and implementing measures to ensure water systems can cope with climate-related uncertainties (Arjoon, et al., 2018).

Stakeholder Engagement and Participation: Engaging and involving stakeholders, including communities, water users, and civil society organizations, is vital for sustainable water security. Their participation facilitates inclusive decision-making processes, knowledge sharing, and collaborative action (Lemos, et al., 2012).

Water-Energy-Food Nexus Approach: The water-energy-food nexus approach considers the interconnections and trade-offs between water, energy, and food security. It recognizes the interdependencies among these sectors and promotes integrated planning and management to ensure sustainable resource use and avoid conflicts (UN-Water, 2014).

Economic Efficiency and Water Pricing: Efficient use of water resources and appropriate water pricing mechanisms are important aspects of a sustainable water security model. It involves promoting water use efficiency, incentivizing water-saving technologies and practices, and implementing fair and cost-effective pricing structures that reflect the true value of water (OECD, 2010)

2.14 THE STATE OF WATER SECURITY IN SOUTH AFRICA

Many papers from both academics and those in practice recognize that South Africa is a semi-arid and water-scarce country (Strydom & Struweg, 2016), with deteriorating water resources, that have significant effects on the growing demand. Multiple analyses show that South Africa's water system is unprepared for the impacts of climate change, particularly at the regional and institutional levels (Ncube, et al., 2013; Department of Environmental Affairs, 2013). Per capita, water availability in South Africa is lower than the global average by 30 places, with 450 millimeters per year compared to 870 millimeters per year (Oosthuizen, et al., 2014). South Africa's water is geographically and politically unevenly distributed, and the situation is exacerbated by the country's fastest-expanding population, its increasing urbanization, and the rising middle class, all of whom have larger demands for water, food, and power. Inevitably, South Africa is experiencing natural water scarcity as a result of climate change's devastating effects, especially long-term droughts, and the continued degradation of water quality due to human-caused pollution (Mutamba, 2019). Generally, the current status of South Africa's water sector has been characterized by deteriorating infrastructure, inadequate funding, skills shortages, and declining resource quality, especially in homelands.

It is inevitable that South Africa would have scarce water resources and would experience a water deficit of 17% by 2030. (WWF-SA, 2017). The country also has a large rural population (forty percent), which is difficult to link to water and sanitation grids. Moreover, most South Africans are facing a looming water scarcity crisis with dam water levels dropping below only 12.3% of normal, especially in Cape Town (Andersen, 2017). Cape Town is just one example of how many towns and cities in South Africa, and other semi-arid regions, can be impacted by water stress. Currently, surface water accounts for 77% of South Africa's water supply, with the remaining 9% coming from groundwater and 15% coming from returns flow (Mutamba, 2019). Since domestic supplies are inadequate to meet rising demand, South Africa imports water from neighboring Lesotho to meet basic needs. With demand expected to increase to 17 x 109 m3/yr by 2025, it is clear that water security remains a concern for millions of people in South Africa, as evidenced by the importation from Lesotho.

With South Africa being one of the signatories to the Sustainable Development Goals, about 1 million people in the metros and 17.1 million in rural municipalities still have no access to any form of water supply infrastructure (StatsSA, 2016), and this is a sad reflection on the status of water security in the country. The reality is that South Africans know that although water may be a human right, it is not necessarily guaranteed. For instance, Majuqwanan and Kgaphola, (2018) confirm that many South Africans, especially those living in rural areas, know the difficulties and uncertainties of living with scarce water resources regardless of numerous large storage dams that have been built to control the natural variable flow of rivers. The water security crisis in South Africa has attracted most of the long-standing attention, with unpredictable harsh weather in the form of occasional flooding and severe drought which presents new frontiers (Majuqwanan & Kgaphola, 2018). Sadly, the extent of the water scarcity directly impacts the lives of ordinary populaces and it is gradually cascading onto the broader South African society regardless of race or gender. Consequently, a fundamental encounter confronting South Africa is how to avert water calamities and ensure sustainable water security for all. In other words, to ensure that South Africa is water-secured, clear water laws that prioritize the needs of both humans and ecosystems throughout the water cycle are urgently required (WWF-SA, 2017).

As far as water security in South Africa is concerned, there have been spirited efforts to enhance domestic rainwater harvesting to alleviate rural water deficits. The government of South Africa has promised to cover the upfront costs of installing rainwater storage tanks and other infrastructure in low-income rural areas (Kahinda, et al., 2015). However, South Africa is reaching the limits of what can be achieved to make water available to everyone by traditional methods. In any case, the water needs of any nation will not be met sustainably unless managerial and technological innovation is brought to bear on all facets of water management (Muller, n. d). In this regard, the water experience of South Africa requires urgency to meet increasing water demands on a reliable and sustainable basis. Of significance is that the national status and physical unity of the water resource must be recognized and given legal status, to reflect the value of water and the cost of making it available. Anyway, to overcome water-related problems, aspects such as implementation status and appropriateness of legal frameworks; the practices and processes of administration; administration of supply; ecosystem and social circumstances; practical technology available; regional perspectives, nationwide, and worldwide levels need to be taken into consideration (Sinha & Kumar, 2019).

2.15 THE STATE OF WATER SECURITY IN AFRICA

The vast majority of households in Africa, particularly in rural areas, still cannot access potable water that is both safe and clean to drink. This problem is especially prevalent in sub-Saharan Africa (Heijnen et al., 2014; UNICEF and WHO, 2015). Almost 300 million inhabitants are living in Africa's rural areas, and they are falling further and further behind in terms of the availability of potable water (Hope et al., 2020). According to Holmatov et al. (2017), there is a lack of a diagnostic and analytical framework in Africa, which makes it difficult to determine whether or not the continent has sufficient water security. According to estimates provided by the World Wide Fund (2012), eleven additional African countries will join South Africa and the other nations on the continent that are currently experiencing water shortages by the year 2025. Even though Seychelles and South Africa have the highest economic water security in the Southern African Development Community (SADC), Malawi and Madagascar have the lowest, and water purification systems are still not widely available in rural areas of southern Africa. for economic purposes. Simultaneously, it is estimated that 319 million inhabitants across Sub-Saharan Africa do not have the means to potable water (WHO, 2015). While Africa is home to some of the world's most impoverished nations, it is also vulnerable to water resource instabilities brought on by climate and weather, such as prolonged and recurring droughts, flooding, infrastructure failures, and extreme precipitation events. Africa is a continent with a wide range of distinct features, including a wide variety of social and economic systems, levels of development, and an abundance of natural resources (Nasac, 2014). Due to its complex structure, many of its developmental systems and security challenges require regionally distinct approaches. The diversity of Africa's terrain and climate is vital in determining the specifics of water-related concerns, notwithstanding their universal character. Many African countries still lack adequate water and sanitation infrastructure despite international attempts to achieve the Millennium Development Goals (MDGs) (Nasac, 2014). In their urban areas, Morocco, Algeria, Tunisia, and Egypt are very near to achieving complete universal coverage of water delivery. Urban water service coverage has declined, however, in some nations like Zimbabwe and Zambia. Migration into cities has dramatically increased urban populations and cities have not been able to keep up with the resulting surge in demand.

It is believed that the continent of Africa is home to the largest number of people who rely on untreated water for human use (UNICEF & WHO, 2015). This results in widespread cases of water-related illnesses such as diarrhea, malaria, guinea worm, cholera, typhoid, bilharzia, and a variety of other conditions. Over the past two decades, a great number of studies have been conducted on this issue (Siebrits, et al., 2014; Valipour, 2015). The increased demand for freshwater has resulted in a decrease in the amount of water that is available to each individual in Africa, a region that has also experienced rapid population growth. Water management on the continent is extremely difficult, but it is necessary for the continent's continued existence. Africa is still struggling to address the underlying social and economic disparities that have an impact on the distribution and management of water (Cole et al., 2018). In addition, there is insufficient funding for water supply and sanitation (Nasac, 2014). Along with the implementation of the commonly held Africa Water Vision and Sustainable Development Goals, good governance, societal consensus, innovative technology, and well-developed structures for cooperative action are required to combat these threats.

The provision of sufficient sanitation is lagging behind the provision of sufficient water supply by a significant margin, with the sanitary infrastructure in rural areas being inadequately developed. The supply of potable water and sanitary facilities varies greatly across the entirety of the African continent (Nasac, 2014). For instance, a greater proportion of inhabitants residing in urban areas in the majority of countries have means to reliable water supplies. This is the case in cities of the majority of countries. However, the percentage of inhabitants living in rural areas who have means to reliable water supplies is much lower, and it is extremely low in Somalia, where it is less than 10%. This is a major problem in the country. This necessitates a departure from the traditional practices that have been used throughout history for the management of water resources (Rietveld, et al., 2016). Because water is necessary for Africa's capacity to achieve sustainable development and because it is one of the primary variables in the provision of the most fundamental resource, the availability of water is one of the most important considerations in the process of developing Africa. This is because water is essential to Africa's ability to achieve sustainable development. According to Ritchie and Roser (2019), Africans are among the most disadvantaged in terms of access to clean and sufficient quantities of drinking water. The prediction that as many as 250 million people will reside in regions that are experiencing high water stress by the year 2030 is an even more concerning statistic. Africa is at the center of the water security dilemma because of the need to fortify already over-allocated water resources to sustain inhabitants that are projected to double, by over 2 billion, in the year 2050 (UNECA, 2016).

2.16 THE STATE OF WATER SECURITY GLOBALLY

Water security is a major concern globally, as access to clean and safe water is necessary for human survival. According to the United Nations World Water Development Report 2020, water use has been increasing worldwide by about 1% per year since the 1980s due to a combination of population growth, socio-economic development, and changing consumption patterns. Seventy-one percent of humankind all over the world, or about 4.3 billion people, are dealing with some sort of water crisis right now, with one billion people dealing with severe water scarcity throughout the entire year (Mekonnen & Hoekstra, 2016). There are hundreds of millions of humankind around the world who, according to the Global Water Strategy (2017), cannot access clean water, cannot access reliable water sources, suffer from the negative health effects of inadequate sanitation, and are at risk from natural disasters like floods and droughts. As of 2025, the World Bank estimates that 3.5 billion humankind will live in river basins that are experiencing water scarcity, and there is an anticipated increase in this figure to 5 billion by 2050 if nothing is done to elevate the standard of the world's dwindling water supplies.

Globally, billions of people and countless ecosystems are in danger from water crises caused by human activities like land conversion and land use change (Kristensen et al., 2019). Floods, droughts, and other water-related disasters pose serious risks to the world's 7.3 billion inhabitants as a result of an absence of potable water, inadequate sanitation systems, and other factors

(Young, et al., 2015). Global statistics show that nearly a quarter of humankind all over the world, or 1.6 billion inhabitants, still faces water scarcity (also known as “water stress and/or crisis”) (Maganda, 2016). With the ongoing state of the economy, this figure is likely to have increased. Economic water stress occurs when there is not enough water to go around because of things like broken infrastructure or antiquated technology (Baker, et al., 2016). The inability to adequately purify water supplies is a significant factor in the economic water stress experienced by many regions. If we don’t improve our sanitation infrastructure and water management practices to lessen both the economic and physical stresses caused by water scarcity, people everywhere could face dire consequences (Baker, et al., 2016).

The apparent importance of freshwater availability and accessibility to the attainment of sustainable development goals has sparked widespread concern (UNESCO, 2019). However, Mutamba (2019) claims that water scarcity due to inadequate infrastructure or insufficient human capacity to meet the demand for water in areas where the population cannot afford to use an adequate water source is the main issue, not availability, and accessibility, where demand exceeds supply. There is an annual cost to the global economy of $500 billion due to water insecurity. This is because, in many places around the world, a lack of maintenance has led to water systems that are in disrepair, threatening economic development (Young, et al., 2015). The failure to achieve global water security goals is increasingly being shown to be a threat to economic stability. Access to safe drinking water and sanitary facilities for all people appears to be another global goal that is falling behind schedule. The 2018 UN Report on Sustainable Development Goal 6 is a sobering reminder of this. The provision and efficient administration of water and sewage systems for all people is a stated objective (UNSDSN, 2013). Objective 6 calls for a worldwide investigation of water resources that considers multiple issues at once.

As urbanization and rapid population expansion continue to occur on many continents, there will be a higher growth for additional water to meet the requirements of water supply, agriculture, and industry. This will place an increased strain on the availability of water (UN-DESA, 2019). The unique characteristics of regional challenges in different parts of the world can be attributed to a variety of factors, including geography, society, politics, and economics (Aboelnga, et al., 2020). Several countries are currently experiencing water shortages, and it is projected that many more will see their surface water supplies decrease by the year 2050. (Veldkamp, et al., 2017). Even though Sao Paulo, Brazil does not have a major water shortage problem as a whole, 2014 was the driest year on record. (Fearnside, 2021). Even though it has an abundance of natural and economic resources, the United States is extremely vulnerable to natural disasters and severe weather, which can have catastrophic effects on the country's environment, its agricultural sector, and the lives of its citizens (Meehan, et al., 2020). Even though billions of inhabitants all over the world are dealing with significant problems related to freshwater, the inability to obtain clean water is still one of the most significant dangers to human health in the world (Kumar, 2018).

Every single day, millions of inhabitants worldwide are forced to fight for their lives because they cannot obtain potable drinking water. Every day, freshwater-related problems and conflicts arise in various locations around the globe (Glantz, 2018). If current trends continue, by the year 2030, nearly half of the populace worldwide could reside in regions with acute water scarcity. Because water is such an important resource on a global scale, several countries have been working hard to alleviate a water shortage that may continue for several decades (Glantz, 2018). Nearly sixty percent of the world's freshwater is held by just nine countries: India, Indonesia, Russia, the United States, China, Colombia, the Democratic Republic of the Congo, the United Kingdom, and Canada (Fry et al., 2005). These nine nations contain more than 35% of the total population of the world and account for almost 44 percent of its land area (World Bank, 2016). Even within these countries, the accessibility of water varies greatly from place to place. Because of the negative effects of the water crisis, scientists will likely have to find solutions to ensure a consistent and reliable water supply for the future (Urban Water Reuse Handbook, 2016). Current thought and action aimed at alleviating water scarcity must be driven by concern for the safety and prosperity of the next generation.

2.17 IMPLICATIONS FOR WATER POLICY IN SOUTH AFRICA

Water policy in South Africa has significant implications for the country's economy, social well-being, and environmental sustainability. According to a recent report by the World Wildlife Fund (2020), insufficient water supply and poor management of water resources are among the most pressing challenges facing South Africa today. One of the implications for water policy in South Africa is the need for improved management of existing water resources (DWS, 2022). This includes monitoring and regulating the use of groundwater and surface water sources, as well as developing new storage facilities to capture rainfall during wet seasons. The Department of Water and Sanitation has developed a National Water Resource Strategy which aims to balance supply and demand for water across different sectors. Another implication is the importance of investing in infrastructure to improve access to safe drinking water and sanitation services.

Despite progress made since the end of apartheid, many people still lack access to these basic services. According to a report by WaterAid (2017), an international NGO working on water and sanitation issues, approximately 11 million people in South Africa do not have access to clean drinking water and nearly 20 million do not have access to adequate sanitation facilities.

Another key implication for water policy in South Africa is the need to focus on demand management strategies rather than supply-side solutions. According to the Water Research Commission (2019), demand management can help reduce wastage, increase efficiency, and promote sustainable use of water resources. This approach involves implementing measures such as water metering, leak detection, and public awareness campaigns to encourage responsible water use. An additional important implication for water policy in South Africa is the need to balance economic development with environmental protection (DWS, 2022). This requires careful planning and regulation of sectors such as agriculture, mining, and industry, which are major users of water resources. It also means promoting alternative sources of water such as rainwater harvesting and wastewater reuse. In addition to these implications, it is essential to recognize the importance of community participation in decision-making processes related to water policy. According to a study by the International Water Management Institute (2016), involving local communities in planning and implementation can help ensure that policies reflect their needs and priorities. Community involvement can also foster greater accountability among policymakers and lead to more effective implementation of policies. South Africa's water policy must take into account the impact of climate change on water resources. A report from the Climate System Analysis Group at the University of Cape Town notes that rising temperatures are likely to exacerbate existing challenges related to droughts, floods, and erosion. To address this issue, the report recommends investing in climate-resilient infrastructure and improving water-use efficiency.

Four separate policy documents have been drafted since 1994, when democratic governance in South Africa was established, to ensure the equitable distribution of the country’s water supply. These are the White Paper on Water Supply and Sanitation (1994), White Paper on South Africa’s National Water Policy (1997), White Paper on Basic Household Sanitation (2001), and Strategic Framework for Water Services (2005). All these documents have been interpreted in many different ways, but the original goals of ensuring fair and efficient water distribution have eluded us. However, Section 6(1) (l) of the National Water Act suggests that integrated management of water resources is necessary to ensure efficiency, equality, and sustainability in the water sector (RSA 1998). Although the Act of 1998 does not appear to be explicitly mentioned, the government's National Water Policy Review (NWPR, 2013) made numerous crucial announcements for equitable water allocation. Even the most recent statement on national water policy does not go far enough to address the fundamental issues connected to water. In other words, it only describes the known and accepted difficulties without offering any solutions or clarification (Molobela & Sinha, 2011). The primary objective of bringing clean water to rural families has taken years to accomplish, despite the publication of the new National Water Policy Review (NWPR, 2013). Since the policy's inception, few studies have analyzed the best way to put it into action so that its goals can be achieved. There has not been a post-enactment analysis to determine whether the NWPR (2013) and attendant changes achieved their goal of equitable water distribution in rural South Africa and the factors that contributed to this, even though these studies have been instrumental in advancing frameworks and institutional changes essential for water distribution.

The implications of this policy will have discouraging effects on the water industry in South Africa. The water industry's regulatory and governance framework is extremely difficult to navigate as a result of the proliferation of laws, rules, and institutions that have been established to address the numerous issues that plague the water industry (Muller & Frederick, date unknown). It is not entirely clear which laws will prevail due to the overlap between the Water Services Act and the Municipal Systems Act. This leaves room for ambiguity and declaratory intervention. Because of this, the South African water policy (DWAF, 1997) has set a rather lofty objective, which paves the way for the application of rather complex policy tools in the pursuit of long-term success in ensuring the equitable and efficient exploitation of the nation's water supply. At the same time, the government of South Africa has enacted a series of forward-thinking policies and water sector-specific regulations that ought to be in harmony with the constitution to guarantee a fair distribution of water resources among the population. These policies and regulations were enacted to guarantee a fair distribution of water resources among the population (Hosu, et al., 2018). The legacy of racial segregation shaped these rules, which established a socio-economic pattern governing the distribution and accessibility of resources along racial lines. These rules established a socio-economic pattern governing the distribution and accessibility of resources along racial lines. The apartheid era's water rules and regulations made it difficult to participate in the water sector, which is an inconvenient circumstance (Mogomotsi, 2017).

2. 17.1 Policy Content and Coherence Analysis: National and district-level Policies on water security

South Africa's water security is a crucial issue as the country faces increasing water scarcity due to climate change, population growth, and inefficient use of resources. The government has developed several national and district-level policies and strategies to address this challenge. At the national level, the Department of Water and Sanitation (DWS) is responsible for managing South Africa's water resources. In 2013, the department launched the National Water Resource Strategy (NWRS), which outlines a comprehensive plan to ensure sustainable water management in the country. The NWRS aims to improve access to safe drinking water and sanitation services while also promoting the efficient use and conservation of water resources. It recognizes that achieving these goals will require collaboration across sectors and with stakeholders at all levels. The NWRS also acknowledges the socioeconomic context of South Africa, where poverty and inequality are still prevalent. It highlights the need to prioritize equitable access to water resources for all citizens, particularly those living in rural areas or informal settlements. To achieve this goal, the strategy proposes measures such as subsidizing basic water needs for low-income households and improving infrastructure in underserved communities.

At the district level, municipalities are responsible for implementing water-related policies and strategies within their jurisdictions. One example is the City of Cape Town's Water Demand Management Strategy (WDMS), which was developed in response to severe drought conditions in 2017-18 (City of Cape Town, 2018). The WDMS focuses on reducing overall demand through measures such as public education campaigns, leak detection programs, and restrictions on non-essential uses. However, critics have noted that some of these policies may disproportionately affect marginalized groups who lack access to alternative sources of water or who rely on certain activities like car washing or gardening for income. For instance, during Cape Town's drought crisis, there were reports of informal car washers losing their livelihoods when restrictions prevented them from operating. These concerns highlight the complex political economy context under which any proposed framework would have to be applied. South Africa's history of apartheid and ongoing socioeconomic inequalities mean that water security cannot be viewed in isolation from other issues such as land ownership, economic development, and social justice. Therefore, any policy or strategy aimed at addressing water security must take into account these broader systemic challenges.

To ensure that any proposed framework for water security is effective and equitable, it is crucial to consider the socioeconomic and political-economic context under which it would operate. For instance, Makhanya and O'Donoghue's (2020) study on the politics of drought in South Africa highlights how inequalities in access to water can exacerbate social tensions and political conflicts. They argue that addressing these underlying structural issues requires a more nuanced understanding of the complex relationships between land ownership, economic power, and political influence. Therefore, any proposed framework for water security in South Africa must take into account both national and district-level policies as well as the socioeconomic and political economy context under which they operate. This requires collaboration between government agencies at different levels, civil society organizations, communities, and private sector actors. By working together towards a shared vision of sustainable water management that prioritizes equity and resilience, South Africa can overcome its water security challenges and build a more just and prosperous future for all its citizens.

2.18 KNOWLEDGE PRODUCTION AND GAPS

Water security is a critical concern in South Africa, with the country experiencing severe water scarcity challenges. In response to this challenge, various stakeholders have engaged in knowledge production aimed at identifying appropriate interventions and solutions to address the problem. However, despite these efforts, significant gaps still exist in knowledge production and application toward improving water security in South Africa. There has been an increasing interest in understanding the dynamics of knowledge production around water security issues in South Africa. Scholars have highlighted the need to develop more comprehensive models for assessing water resource availability and demand, as well as for identifying potential gaps in current policies and strategies for addressing water security challenges (Pahl-Wostl et al., 2013). Moreover, they have emphasized the importance of engaging with local communities to understand their unique perspectives on water insecurity and their ideas about possible solutions (Harris et al., 2018). There are several notable gaps in knowledge production related to water security in South Africa. For example, while there is a growing body of research on the physical aspects of water scarcity, such as hydrology and climatology, there is less attention paid to the social dimensions of this issue (Mathebula & Swilling, 2020). There is also a lack of data on the impacts of climate change on water security in different parts of the country (Cullis et al., 2019). Additionally, there remains a significant disconnect between policymakers and practitioners working on water-related issues at various levels (Burt & Winkler, 2016).

One of the key knowledge gaps that exists relates to understanding the dynamics of water demand and supply within different social contexts. Research by Nhamo et al. (2021) highlights that there is a limited understanding of how water users interact with available resources, which has resulted in inefficient use of water resources and increased vulnerability to droughts. The lack of contextualized data also makes it difficult for policymakers to design effective interventions that cater to specific needs within different communities. Another area where knowledge gaps persist is in finance and investment options for water infrastructure development and maintenance. According to Mazvimavi et al. (2018), financing models are critical determinants of the success or failure of water projects, yet there is a dearth of research on innovative financing models that could help bridge funding gaps for such projects. This gap can hinder progress toward achieving sustainable water security as funding remains a critical requirement for implementing long-term solutions. Furthermore, current knowledge production initiatives tend to focus on technical aspects such as engineering solutions rather than addressing broader socio-economic factors contributing to water insecurity. As argued by Nhamo et al. (2021), promoting inclusive governance structures that incorporate community participation is crucial for ensuring equitable access to clean water resources.

To effectively evaluate data, plan studies, and implement a vast array of water supply solutions, it is critical to address knowledge generation and gaps in this area (Mark, et al., 2019). Water is essential to the functioning of both human societies and ecological systems. Since the turn of the century, the disputed waters community has come to view water security as a hot new commodity (Cook & Bakker, 2012). There is a growing body of work from a variety of authors at varying stages and in different places that examine how water security is being disseminated and put into practice. Bolignesi et al. (2018) state that three main constraints prevent the accumulation of knowledge production around water security and, consequently, its utility as a tool for adaptive management. The first problem with learning more about water safety is that there is no standard way to measure it. The current evidence-based policy-making paradigm is affected by this diversity, as the accumulation of general scientific knowledge is being intentionally hampered.

The second obstacle we face when trying to comprehend water security is that our analyses are always tailored to a particular set of circumstances. The acceptance, involvement, and implementation of water security in different conservational and social contexts all over the world are the subject of a huge body of place-based research. Persistent differences in how water security is viewed and implemented demonstrate how scholars tailor the term to the specifics of the cases they study. Sixty percent of studies that propose a definition of water security are case-based, as stated by Gerlak et al. (2018). This may suggest the insufficient transferability of water safety measures, which may impede knowledge production, as well as the need for a more community-contextual approach to understanding and realizing water security (Bolognesi, 2019). Finally, the third shortcoming of water security knowledge accumulation is that it is static or measured cross-sectionally, meaning that samples only cover a single period (mostly a year). Due to this, water security is only seen as a tool for progress and change, and the study of its historical development is forbidden (Bolognesi, & Kluser, 2018).

There is growing evidence that the current system of water management is insufficient due to the complexity and unpredictability of the water supply. According to Turton (2015), one of the keys to improving water accessibility and availability may be reducing the frequency and severity of water disasters. Enhancing water education in such a way that is consistent with the tenets of education for sustainable development is necessary if we are to have any hope of ensuring a secure water supply for the foreseeable future. To further the advancement of scientific knowledge, water education should adopt a method that is both multidisciplinary and interdisciplinary when it comes to the training of scientists as well as the education of water professionals and decision-makers (IHP, 2017). To address these knowledge gaps, researchers have called for greater collaboration among stakeholders involved in managing South Africa's water resources. This includes improving communication channels between scientists studying water security issues and government officials responsible for implementing policies aimed at addressing these challenges (Cullis et al., 2019). There is also a need to prioritize research on the social, economic, and political dimensions of water security to develop more holistic approaches to addressing this issue (Mathebula & Swilling, 2020).

2.19 CONCLUSION

In conclusion, sustainable water security is crucial for ensuring the long-term availability, accessibility, quality, and resilience of water resources in South Africa. The National Water Act of 1998 and the Integrated Water Resource Management approach play significant roles in addressing water security challenges. The case of Bojanala District exemplifies the complexities of achieving water security, with pollution, infrastructure issues, and unequal access to safe water being key concerns. To enhance water security, multi-faceted approaches are essential, including infrastructure improvements, efficient water management, and community involvement.

Collaboration between various stakeholders is vital in securing a sustainable water future for South Africa and regions like Bojanala, while also addressing climate change and pollution impacts. Achieving water security in Bojanala District, South Africa, requires addressing various dimensions such as access to clean water, water quality management, and sustainable water resource protection. A multi-faceted approach encompassing social, economic, and environmental sustainability is essential. Equitable access to water services, efficient water use, and preservation of water resources are crucial components. Collaboration among stakeholders and responsible water management practices will contribute to a more secure and sustainable water future. However, continuous research, policy innovation, and dedicated efforts are needed to ensure a resilient and equitable water supply for present and future generations.

The research explored the impact of water security on households in the Bojanala District, South Africa, by analyzing socio-economic characteristics. Two theoretical frameworks, the Sustainable Livelihood Framework, and the Integrated Water Resources Management (IWRM) framework guide the study. The Sustainable Livelihood Framework considered capital assets and resilience in achieving sustainable water security. The IWRM framework served as an overarching strategy for managing water resources sustainably, focusing on economic, social, and environmental aspects. The research provides valuable insights into water security issues and emphasizes the importance of considering social, economic, and environmental factors for a resilient and sustainable water supply. Policymakers should promote equitable decision-making, responsible water use, and community participation to address challenges and secure a water future for the region. Further research and collaboration are vital to tackle evolving water-related issues. Assessing water security in Bojanala District involved considering factors impacting water quantity and quality. Issues like limited access to safe drinking water, contamination from agriculture and mining, and sustainable water usage must be addressed. Climate change adds urgency, requiring innovative water management. Assessing water security helped us understand the situation, identify challenges, and prioritize solutions. A sustainable water security model is vital for the long-term management of water resources, considering social, economic, and environmental aspects. It emphasizes equitable and sustainable water management to meet current and future needs. Core attributes of the model include multi-layer institutional mechanisms, clear roles, time-bound assessments, inclusive regulations, and asset maintenance guidelines. However, significant knowledge gaps remain in South Africa, related to water demand and supply dynamics, financing models, and socio-economic factors contributing to water insecurity. Collaborative efforts and community involvement are crucial to address these gaps. Policymakers should prioritize integrated water resource management, focus on demand strategies, and invest in climate-resilient infrastructure. Addressing knowledge gaps and adopting holistic approaches can lead to effective policies and safeguarding water resources for the well-being of the population and environment.

As a semi-arid and water-scarce country, South Africa faces significant challenges in managing its water resources effectively. Factors such as climate change, population growth, and urbanization have worsened the situation, leading to water stress and scarcity in various regions. The current state of South Africa's water sector is characterized by deteriorating infrastructure, inadequate funding, skills shortages, and declining resource quality. Despite efforts to improve water access and sanitation, a considerable portion of the population, especially in rural areas, still lacks sufficient clean drinking water. Furthermore, the country's water system is ill-prepared to cope with the impacts of climate change. To address these challenges, policymakers must prioritize sustainable water management practices that take into account social, economic, and environmental aspects. Integrated water resource management and demand management strategies should be key components of water security efforts. Collaboration with local communities through inclusive governance structures is essential to address knowledge gaps and achieve equitable and sustainable water security. The water security challenges faced by South Africa are not unique; they are widespread across Africa and the globe. Many regions on the African continent lack access to safe and clean water, leading to water-related illnesses and economic stress. As population growth and urbanization continue, the water demand will further strain already limited resources. Addressing water security on a global scale requires collective efforts, innovative technologies, and effective governance. The Sustainable Development Goals and the Africa Water Vision offer valuable frameworks to tackle these issues. However, achieving universal water access and sanitation demands continued commitment and investment. Overall, water security is a pressing concern affecting billions of people worldwide. Policymakers, researchers, and communities must collaborate to implement sustainable water management practices, enhance water infrastructure, and ensure equitable access to clean and safe water for all. Only through such collective endeavors can we safeguard this critical resource and secure a better future for generations to come. The following chapter provides an overview of water security in the South African context, highlighting the key factors contributing to the issue and the measures taken to address it.

CHAPTER THREE
WATER SECURITY: SOUTH AFRICAN CONTEXT

3.1 INTRODUCTION

South Africa's water security problem is complex and pressing for many reasons, including the country's geography, climate, and socioeconomic status. Located in Southern Africa, the country faces difficulties in securing a consistent water supply due to its varied topography and erratic precipitation. The country has been facing severe water challenges, particularly in rural areas where access to clean drinking water is limited. This lack of access to safe water affects not only the health of individuals but also economic development, food security, and ecological well-being. One major challenge facing South Africa’s water security is climate change. With increasing temperatures and unpredictable rainfall patterns, droughts are becoming more frequent and intense. This has led to reduced river flows, lower dam levels, and depleted groundwater reserves. As a result, farmers have lost crops, leading to food insecurity, while industries have struggled with production due to an insufficient water supply. Another challenge is poor infrastructure maintenance, which leads to leakage from pipes and significant losses in urban areas. In rural areas, there is often no infrastructure to begin with, as the government struggles to provide basic services such as piped water supply for households. This results in women and children spending hours each day collecting water from distant sources instead of attending school or engaging in other productive activities.

South Africa has several threats to its water supply, many of which can be mitigated with better management of the water supply. The National Water Act of 1998 established a legal framework for water management in the country based on the values of fairness, sustainability, and efficiency. The adoption of an IWRM strategy to encourage coordinated efforts in water resource planning, allocation, and management is crucial for reaching these objectives. Yet, problems with enforcing and carrying out these rules and regulations remain a constant obstacle. Despite the country's significant water resources, there are still severe water challenges faced by various communities across the nation. The potential consequences of inadequate access to water are grave and could lead to national instability if not addressed urgently. Therefore, the South African government must prioritize investments in innovative solutions while promoting the efficient use of existing resources through community-based approaches. By adopting these strategies, the country can achieve sustainable water management for all South Africans and ensure that future generations benefit from this vital resource

3.2 OVERVIEW OF THE WATER SITUATION IN SOUTH AFRICA

South Africa is classified as a water-stressed country because it receives less than 500 mm of rain per year, well below the world average of 860 mm (FAO, 2016). The semiarid environment and erratic rainfall patterns in the country add to the problems with water supply (Bhattacharya et al., 2018). South Africa is one of many countries that has experienced severe water shortages in recent years and is forecast to run dry in the not-too-distant. Stress on water supplies is exacerbated by periodic droughts and decreased surface water flow in key rivers (DWAF, 2019). South Africa continues to struggle with the difficulty of providing potable water to a sizable portion of the population. In addition, many people in South Africa, particularly those who are black and who reside in the poorest areas of townships or so-called "informal settlements," as well as those who live in the majority of rural communities, lack continuous means of potable water (Marcatelli, & Büscher, 2019). Even if the infrastructure for delivering water, such as pipes and taps, is in place, there is no guarantee that it will be used. The situation appears to be particularly dire in rural areas, where pictures of people "queuing" with empty buckets at a dry community tap have become all too common (Marcatelli & Büscher, 2019).

One major cause of South Africa's water crisis is the persistent drought that has been affecting the country for several years. The Western Cape Province was particularly affected by this drought from 2015 to 2018 (Cape Town Tourism, n.d.). As a result, dams and reservoirs in the region reached critically low levels which led to strict water restrictions being implemented across many cities. However, even after some rains in recent years, some regions still face severe drought conditions. Another contributing factor to South Africa's water crisis is poor management practices such as the illegal abstraction of water by farmers and industries. A report by the Council for Scientific and Industrial Research reveals that up to 37% of South Africa's available surface water is being used illegally (Council for Scientific and Industrial Research, 2017). Generally, South Africa's water situation is relatively adverse to other countries. In other words, South Africa falls into the category of periodic or regular water stress, and it will face chronic water scarcity by 2025 if current population growth trends continue and move towards absolute scarcity in the foreseeable future (Muller, u.d). Already, South Africa is worse off in terms of meeting the increasing water demands on a reliable and sustainable basis, and its water resources are already under pressure and are set to become so in all areas in the future.

The Council for Scientific and Industrial Research (CSIR) conducted a review in 2017 on the status of water availability and security in South Africa. They found that the country's water resources are already overburdened due to various factors such as climate change, pollution, and inadequate infrastructure. There are not enough freshwater resources to meet the needs of South Africa's growing population and industry (DWAF, 2018). In addition, there are knowledge gaps and research needs that must be addressed to ensure sustainable use and management of water resources (CSIR, 2017). According to the Department of Water and Sanitation, South Africa's water resources are under immense pressure due to population growth, urbanization, climate change, and pollution (Department of Water & Sanitation, 2020).

It is estimated that by 2030, the country will have a water deficit of 17% (World Wildlife Fund South Africa, n.d.). This means that there will not be enough water to meet the demand for drinking, irrigation, sanitation, and industrial needs. The multifaceted nature of water security in the country necessitates an understanding of its interconnected components (Mnguni, & Nkuna, 2019). By acknowledging and effectively managing these key components, South Africa can engender the enduring viability and resilience of its water resources, thus bestowing consequential benefits upon its populace, the economy, and the environment. South Africa may improve its water security and guarantee its residents' access to clean water if it takes a comprehensive approach to address these critical components (DWAF, 2017). To keep up with the country's ever-changing water problems, South Africa requires concerted action from a wide range of stakeholders, strategic long-term planning, and constant monitoring and adaptation.

3.3 WATER RESOURCES IN SOUTH AFRICA

Compared to the rest of the world, South Africa's water supply is extremely limited and scarce. About 49 200,000,000 m3 of water flows through the country's rivers per year (Year Book, 2016). Due to the erratic pattern of precipitation across the country, water is not uniformly distributed. More than two-thirds of the country's mean annual run-off is stored in dams to compensate for the uneven distribution of water resources and to manage floods and droughts. Although surface water is the primary source of water for cities, factories, and farms in South Africa, groundwater is critically important, especially for rural areas (Year Book, 2017). Many parts of the country have nearly exhausted their potential to develop and utilize their surface and groundwater resources. To promote efficiency, equity, and sustainability in the water sector, the National Water Act of South Africa requires the sustainable management of water resources. However, this is not happening (RSA 1998). Water of sufficient quality should be available to support a robust economy, high social standards, and healthy aquatic ecosystems for many generations if water resources are carefully managed, allocated, and used (Year Book, 2017).

Several institutions, whose authority comes from several pieces of water legislation and non-legislative arrangements, work together to manage South Africa's water resources. A CMA, WUA, or IWMB is classified as a water administration organization in provisions of the National Water Act, as is anyone who implements the functions of a water administration organization in terms of the Act (RSA, 1998). (RSA, 1998). Advisory committees, catchment forums, IBs, and the water tribunal are all examples of other institutional entities concerned with water resource management beyond those defined by the National Water Act. According to Muller (2015), the management of South Africa's water resources is a complex issue that touches on economics, politics, ecology, ethics, values, and logic. Because of this, it poses unique challenges in terms of governance and administration to guarantee its long-term existence and resilience.

To effectively and efficiently administer water resources successfully in South Africa, a well-defined institutional relationship is essential. In other words, in a water-stressed nation such as South Africa, the effective administration of water resources is pivotal in ensuring the social and economic well-being of the nation. In this context, when the average annual per capita supply of water in a country is less than 1500 cubic meters, that nation is said to be experiencing "water stress" (UNESCO, 2012). Therefore, the water stress in South Africa is likely to be worse by 2030, regardless of having signed bilateral cooperation agreements with six neighboring countries, (Botswana, Lesotho, Namibia, Swaziland, Mozambique, & Zimbabwe) and constructing dams and registering them in terms of section 120 of the National Water Act to serve as supplies of water and to meet the prescribed water requirements to ensure good administration of water resources (Sinha & Kumar, 2019). Notwithstanding the latter, the bulk of South Africa's water resources are transboundary and are shared amongst four international river basins, namely Orange, Inkomati, Limpopo, and Maputo (Steeven & Van Koppen, 2015). In the area of shared river basins, South Africa continues to participate in joint water commissions to form part of Africa's bilateral Joint Permanent Cooperation. South Africa's water resources are diverse and comprise various sources, including the following:

3.3.1 Surface runoff

The surface runoff in South Africa is affected by a range of elements, such as precipitation patterns, topography, soil properties, and land use practices. The country's heterogeneous geographical features, which encompass mountainous areas and coastal plains, contribute to the variability of runoff patterns observed in different regions (Wolski et al., 2014). Comprehending the surface runoff patterns in South Africa holds significant importance in the realm of efficient water resource management and evaluation of flood risks. It aids in ascertaining the accessibility and allocation of freshwater resources, particularly in regions where water scarcity poses a substantial issue (Wolski et al., 2014). According to Mwendera and Atyosi (2018), South Africa's surface water resource is approximately 12,000 million m^3 per year, but more than 80% of this water is already allocated for various purposes. The country exhibits an annual mean runoff value of 40 mm, which is only about one-seventh of the global average of 260 mm.

Approximately 8% of the surface water is estimated to be lost through evaporation from storage and conveyance along rivers, while 6% is lost due to land-use activities (South African Yearbook, 2010). South Africa exhibits a diverse array of precipitation patterns, encompassing arid and semi-arid regions in the west and more humid areas in the east (Knight, 2019). The distribution of rainfall across different regions directly impacts surface runoff, as areas characterized by higher levels of precipitation tend to generate larger volumes of runoff. The eastward increase of both runoff and baseflow in South Africa correlates with higher precipitation, although the increase is more significant for runoff (Knight, 2019). If the average rainfall were to remain constant, the greater variability of stream flow would lead to decreased natural water availability and reliability. Water abstractions, alterations in land use, and inter-basin transfers all contribute to a discrepancy between the natural and measured values of individual river systems (Knight, 2019). To maintain the natural environment along watercourses, a portion of the runoff, known as the Ecological Reserve, needs to be retained in rivers.

3.3.2 Groundwater

Groundwater plays a crucial role in ensuring water security for urban areas in South Africa, especially as population growth and suburban expansion strain existing water supplies and infrastructure (Foster and MacDonald, 2014). Groundwater also serves a vital role in providing water to small communities and settlements located in the arid regions of South Africa. Frequently, communities that rely on groundwater have limited alternative sources of water that are feasible and sustainable. There is significant potential for further exploration and utilization of groundwater sources to supplement the existing water resources (South African Yearbook, 2018/19). Gaining a comprehensive understanding of South Africa's groundwater potential and harnessing it effectively is of utmost importance in tackling the water security issues faced by the country. Groundwater is increasingly relied upon as a vital water source, ranging from individual boreholes to large-scale, advanced supply systems (WWF, 2016). The available quantity of usable groundwater in South Africa is estimated to be 4,500 million m3 annually, which is less than half of the total yield of surface water (DWS, 2018). The exact volume of groundwater that exists but remains inaccessible is unknown (Knight, 2019).

The mining activities in South Africa have significantly influenced the characteristics of groundwater. Acid mine drainage has been identified as the primary cause of adverse effects on both groundwater and surface water resources resulting from mining operations. To address national water security challenges, it is essential to understand and tap into South Africa's groundwater potential. The South African Department of Water Affairs (DWA, 2013) reports that groundwater accounts for 15% of total water consumption in the country and serves as the sole water source for a significant portion of the population, approximately 65%. This highlights the critical significance of groundwater in meeting the water needs of a large segment of the population. Consequently, there is significant potential for substantially increasing groundwater supplies in South Africa. Managing this valuable resource necessitates scientifically informed, socially equitable, economically balanced, and environmentally conscious efforts due to the diverse needs and opportunities for groundwater utilization.

3.3.3 Rainfall

South Africa exhibits four distinct rainfall seasonal zones, each characterized by unique mechanisms that contribute to rainfall patterns throughout the year (Kruger, 2007). These zones include summer, late summer, winter, and all-year maxima. In the summer rainfall region of

South Africa, local convective-type thunderstorm activity plays a significant role, whereas, in the winter rainfall region, mid-latitude frontal systems are the primary drivers of precipitation (DWS, 2021). These frontal systems can extend across the entire country at various times throughout the year. Along the coastal areas, rainfall is often influenced by advection from the Indian Ocean, while the Eastern parts of the country may experience heavy rainfall and widespread flooding due to the impact of tropical cyclones (DWS, 2021). With an average rainfall of less than 500 mm/year and significant annual and seasonal variability, only 9% ends up as water in rivers and aquifers (DWAF, 2013).

The global ranking found South Africa to be the 30th driest country in the world. The reason for this is that its seasonal rainfall—which is almost half of the global average—is much lower than average (Cole, et al., 2018). Rainfall levels in South Africa exhibit significant variability, ranging from over 1,900 mm in the eastern and mountainous regions to nearly negligible amounts in the western and northwestern parts of the country (McBride, et al., 2022). This variation can be attributed to South Africa's geographic position, situated between 22° and 34°S, its complex topography, and the influence of the warm Agulhas current along the eastern coast and the cold Benguela current along the western coast (Tyson & Preston-Whyte, 2000). South Africa has been declared a water scare and semi-arid nation with a Falkenmark index of 918 m^3/c/a (StatsSA, 2016). However, Hosu, et al., (2018) posit that South Africa’s rainfall has a water supply potential with a projected 1 100 m3 of water per person and mean annual precipitation of 450mm, which is just over half the world average of 860mm.

3.4 WATER GOVERNANCE IN SOUTH AFRICA

Increases in market participation (through privatization of water services), civil society participation (through water user associations and increased public participation), and the presence of independent bodies are all part of the developing idea of “water governance” (Kanyerere, et al., 2018). Water governance encompasses the spectrum of political, social, economic, and administrative structures in place to develop and administer water resources, and the delivery of water services (Global Water Partnership, 2012). Water governance is a term that has exploded in popularity over the past two decades. Along with its growing use in official documents, the term has also become associated with a field of study, as evidenced by the plethora of books bearing the title (Wires Water, 2017). The focus of policymaking has shifted from physical structures to the administrative, financial, and institutional frameworks that are necessary to control water distribution. The World Bank and other funders have converged on a single definition of the term "governance" in their lending programs to developing countries. Historically, the term "governance" has been employed in the context of water to normatively prescribe or aid the creation of certain institutional, organizational, and financial structures for making choices about water and regulating water (Wires Water, 2017). Instead of a solid empirical understanding of how water governance works, most of the scientific foundation for such prescriptive governance recipes comes from frequently ideologically driven predictions about what society or development should be.

Major international targets for water governance have been established since the Dublin Conference in 1992. According to the GWP Framework for Action (GWP, 2012), developed at the 2000 World Water Forum in The Hague, one of the top priorities for action is to improve the effectiveness of water governance because the water issue is frequently a governance crisis. Water governance was deemed the most pressing issue after the ministers discussed the topic at length during the 2001 Freshwater Conference in Bonn. They suggested countries put in place multi-level arrangements to manage water resources and speed up reforms in the water industry when necessary (GWP, 2012). World leaders at the 2002 World Summit on Sustainable Development endorsed this goal, setting a firm deadline for the development of IWRM and water efficiency plans. Subsequently, over the past few years, various international organizations, including the United Nations, the World Bank, the Global Environmental Facility, the Organization for Economic Co-operation and Development (OECD), and others, have joined forces with government, academic, professional association, NGO, and other private sector representatives to investigate efforts to improve water governance (Fanning, et al., 2015). All of these initiatives highlight the importance of exchanging knowledge and insights to spread successful methods. Also mentioned are discussions about methods other than those now in use to deal with water scarcity, water quality, and water sanitation problems.

Concerns over water as a societal risk, sparked by increased competition of use in a changing context, have helped propel the concept of water governance to the forefront in recent decades (Woodhouse & Muller, 2016). However, the term water governance needs to be carefully defined, as it may not be readily understood. The OECD (2015) outlines water governance as how decisions on water resource management are made, executed, and evaluated, including the official and informal procedures, practices, and regulations that govern these processes.

In light of the foregoing, Akmouch and Correia (2016) discussed the evolution and implementation of the OECD Principles on Water Governance and reviewed the OECD's recent work on water governance. The OECD Water Governance Initiative, a multi-stakeholder platform of over 100 delegates from public, private, and non-profit sectors, drafted the Principles to encourage concerted efforts toward expanding governance's responses to water's societal challenges. Since the Principles' inception, they have gained support from 42 different nations and over 140 different major stakeholder groups. Effectiveness, efficiency, and the capacity to generate trust and engagement are the three main drivers around which the Principles are organized, as defined by the OECD (2015):

- **Effectiveness** refers to the role of governance in establishing and achieving long-term, attainable goals and objectives for sustainable water policy at all governmental levels.
- **Efficiency** relates to the role that governance plays in achieving maximum benefits for the greatest number of people from sustainable water management at the lowest possible cost.
- **Trust and Engagement** connect with the role that governance plays in fostering trust and promoting inclusiveness among stakeholders by upholding democratic legitimacy and social justice.

Table 3.1: Twelve OECD Principles on Water Governance

Enhancing the Effectiveness of Water Governance	
1	Distinguish roles and responsibilities for water policymaking, policy implementation, operational management, and regulation, and foster coordination across these responsible authorities.
2	Manage water at the appropriate scale(s) within integrated basin governance systems to reflect local conditions and foster coordination between the different scales.
3	Encourage policy coherence through effective cross-sectoral coordination, especially between policies for water and the environment, health, energy, agriculture, industry, spatial planning, and land use.
4	Adapt the level of capacity of responsible authorities to the complexity of water challenges to be met, and to the set of competencies required to carry out their duties.
Enhancing the Efficiency of Water Governance	

Enhancing the Effectiveness of Water Governance	
5	Produce, update, and share timely, consistent, comparable, and policy-relevant water and water-related data and information, and use it to guide, assess, and improve water policy.
6	Ensure that governance arrangements help mobilize water finance and allocate financial resources in an efficient, transparent, and timely manner.
7	Ensure that sound water management regulatory frameworks are effectively implemented and enforced in pursuit of the public interest.
8	Promote the adoption and implementation of innovative water governance practices across responsible authorities, levels of government, and relevant stakeholders.
Enhancing Trust and Engagement in Water Governance	
9	Mainstream integrity and transparency practices across water policies, water institutions, and water governance frameworks for greater accountability and trust in decision-making.
10	Promote stakeholder engagement for informed and outcome-oriented contributions to water policy design and implementation.
11	Encourage water governance frameworks that help manage trade-offs across water users, rural and urban areas, and generations.
12	Promote regular monitoring and evaluation of water policy and governance where appropriate, share the results with the public, and make adjustments when needed.

Source: OECD, 2015

The word governance encompasses the entire societal system of governing, not just the government in its narrower sense as the primary political decision-making organization. That is to say, governance entails more than just government and law, or the direct chain of events that can be traced back to factors like lawmaking and law promulgation (Meissner, et al., 2017). Complexity and diversity in governance critics are increasing. According to Meissner et al. (2017), the term governance refers to a set of interactive socio-economic and political systems of governing that involve different non-state and state institutions, as well as individuals. By extension, water governance encompasses all the institutional frameworks within which public and private actors collaborate to address water-related challenges and seize opportunities (Hassenforder & Barone, 2019). This means that water governance is best understood as a system in which the government is just one part of a much larger framework involving multiple stakeholders and sectors. However, WGF (2015) deduced that water governance refers to the process of deciding who has access to what quantity and quality of water, when and how, and for what purposes. It regulates how much water is used for industrial, agricultural, municipal, and ecological purposes, striking a balance between human needs and those of the environment. To put it differently, water governance entails defining who is responsible for what in terms of water resources and services, and establishing and enforcing the laws and institutions necessary to do so. The WGF identifies four fundamental dimensions of water governance:

1. **Social:** The effects of unequal access to water on different demographics and socio-economic strata.

2. **Economic:** The significance of water to economic development and the effectiveness of water allocation and use.

3. **Political:** All parties with an interest in water should have an equal say in policymaking. Increased participation in decision-making, implementation, and conflict resolution leads to better outcomes.

4. **Environmental:** Sustainable use of water and related ES. The sufficient flow of water of appropriate quality is critical to maintaining ecosystem functions and services that build upon them (2015).

While the national DWS acts as the governing authority and custodian of water resources in South Africa (Boonzaaier & Brent, 2019), the NWA is responsible for the management of water resources, and the WSA is in charge of water supply and sanitation service delivery. Water Services Institutions (WSI) are responsible for delivering water to homes and businesses, while the Department of Water and Sanitation (DWS) oversees the distribution of water to the public at large, including monitoring and control (rights and licensing), dam management, and infrastructure upkeep (including boreholes and storage reservoirs) (installations, metering, and billing). Local governments, water utilities, and private businesses are all considered WSA, which means it is their responsibility to supply drinking water to homes in their areas. Distribution and consumption of water are municipal responsibilities under the WSA. Therefore, the Constitution of South Africa and other water-related laws, such as the National Water Act (NWA; Act 36 of 1998) and the Water Services Act (WSA; Act 108 of 1997), which are enforced by the DWS, are the primary drivers of South African water governance (RSA, 1997, 1998).

Finally, the NWA acknowledged the importance of having suitable water management institutions to achieve effective water management. Catchment Management Agencies (CMAs) and Water Users' Associations (WUAs) are two examples of the types of water management institutions that are spelled out in the Act (WUAs). Specifically, the NWA planned to create a CMA in each of South Africa's 19 Water Management Areas (areas of operation of CMA). Within the context of the South African National Water Resource Strategy, a CMA was established to empower regional or catchment-level water resource management with community input (Mwenge-Kahinda et al., 2016). The CMA administers its catchment management strategy to the management of water resources within its designated water management area. Communities are encouraged to get involved in water management through CMA structures like Catchment Management Committees and Catchment Management Forums. All human and ecological needs, including the need for water, are recognized as water rights by the NWA. This means that there are three dimensions to South Africa's water governance system: international, national, regional, local, and neighborhood levels; (ii) the responsibilities of government, non-government organizations, and civil society; and (iii) the responsibilities of individuals and groups (WRC, 2018).

3.5 INSTITUTIONAL ARRANGEMENTS FOR THE WATER SECTOR IN SOUTH AFRICA

The framework of the institutional arrangement for the water industry consists of three major tiers. The three tiers are critical in guaranteeing the effective distribution of unpolluted drinkable water to the public (Toxopeüs, 2019). They comprise the DWS, CMAs, and WUA. The organizations providing water services were amended to incorporate over 184 establishments, which work alongside the DWS for the enhancement and administration of water infrastructure. The four establishments are the Water Services Authority, Water Services Provider, Water Board, and Water Services Committee. According to Rodina and Harris (2016), before 1994, all of South Africa's water supplies were managed by the Department of Water Affairs (DWA), formerly known as the Department of Irrigation under the authority of the Water Act of 1956. The Department of Water and Sanitation is the latest incarnation of a national water agency that has seen many name changes DWS). The DWA is the lead actor overseeing water supply at the national level, including regulating other actors, devising policies, managing bulk infrastructure, and acting as a custodian of the country's water resources (DWA, 2015). Be that as it may, the research conducted by Hornby et al., (2016) in South Africa shows that there exists a gap between government agencies and grassroots groups. Given the above context, it is, therefore, imperative to discuss the roles and responsibilities of the selected major water management institutions and actors and the water services institutions that seek to ensure the provision of sustainable water security as prescribed in the legislation

3.5.1 Department of Water and Sanitation

The first and most important tier in the structure for managing water is the DWS. It is one of the South African government organizations in charge of creating and carrying out regulations for the water sector (DWS, 2014: 10; DWS 2015: np). The Department of Water and Sanitation (DWS) also serves as a regulatory authority, formulates sector-wide policies, and backs up the water industry. At every stage of the water supply chain, the DWA is at work. Management of water resources, extraction of water, treatment of water, distribution of potable water, and disposal of wastewater are all links in the water value chain (Market Intelligence Report, 2014). Although the DWA is responsible for many of these tasks, some of them are constitutionally delegated to other organizations in relevant industries. Both the Water Services Act (1997) and the National Water Act (1998), which is part of NEMA (National Environmental Management Act), 107 of 1998, regulate the DWS (Masindi & Duncker, 2016). Through the municipalities and provincial governments, the department warrants acceptable provision of water supply to all inhabitants across the country (Ojo, 2018). Generally, the DWS strives to offer equitable and long-term water and sanitation services that encourage socio-economic growth and the development of present and future livelihoods (DWS, 2015c: 14).

In addition, DWS oversees and warrants that appropriate policies and regulations are instigated across nine provincial offices and four water management clusters to regulate the water sector (DWS, 2013). DWS also assesses how well the industry is doing, recommends changes to the business climate in which the key stakeholders must operate, and regulates the quality of drinking water and effluent following industry standards. DWS (2013) has since steadfastly maintained that committing to the necessary planning and execution of water resource development activities has led to widespread ownership of enormous dams and other water resource infrastructure.

3.5.2 Catchment Management Agency

Second, in the hierarchy of water management is the Catchment Management Agency (CMA) (DWS, 2015). Catchment Management Agencies (CMAs) are created under the National Water

Act (Act 36 of 1998) and are responsible for managing water resources within their catchment areas (DWA 2013). The process of establishing the CMA may be traced back to the late 1990s when South Africa began a reform process of its water regulations. Current CMAs in South Africa were created under Section 78(1) of the National Water Act (Act 36 of 1998). (RSA, 1998). From their findings, Meissner et al. (2017) conclude that government agencies and the requirements of legal frameworks and policies are not the only factors in the formation of Catchment Management Agencies. Thus, numerous interested parties were contacted throughout the formation of the South African CMAs. The DWS was the most influential participant, and private consultants like Derek Weston from Pegasys Consulting and Sandra Naumann from FGG Elbe helped (Meissner & Funke, 2014).

The CMA is responsible for a variety of water management tasks and is tasked with facilitating cooperation and reaching consensus among a wide range of parties with an interest in water issues (Meissner, et al., 2017). The Public Finance Management Act of 1999 includes the Catchment Management Agency as one of its service delivery agencies (Act No. 1 of 1999). To guarantee financial stability and sound management, they are tied to Treasury Regulations (DWA, 2013). According to Meissner and Funke (2014), Catchment Management Agencies (CMAs) are tasked with formulating a strategy for addressing catchment issues. “Realize the preservation, use, development, conservation, management, and control of water resources in respective WMA” is the stated goal of this strategy (Meissner and Funke, 2014: 185). Beyond that, the strategy follows the National Water Resource Strategy in the areas where it is responsible for water management (DWAF, 1998: 10; DWA, 2013c: 25). Similarly, the CMAs are required to coordinate the actions of water consumers and organizations in charge of managing water in their WMA as mandated by DWA (Oyo, 2018).

Finally, the South African government planned to create 19 CMAs through the creation of 19 water management areas by October 1999 (Meissner and Funke, 2014). (WMAs). The DWS (2012), however, cut back from the original 19 CMAs to just 9. Assessments of the administration model, capital, capability, skills, and expertise in regulation and monitoring related to water resources informed the cut (Meissner et al., 2017). The nine CMAs include Berg-Olifants (Western Cape), Berg-Olifants (Mpumalanga Province), Berg-Olifants (Western Cape), Berg-Olifants (Inkomati-Usutu), Vaal, Orange, Mzimvubu-Tsitsikamma, Breede-Gouritz, and Vaal (DWA, 2013). Only the Inkomati-Usuthu and Breede-Overberg CMAs are functioning as of this writing. Since the remaining 7 CMAs are still being founded, they are known as proto-CMAs (Meissner, et al., 2017).

3.5.3 Water User Associations

Water User Associations (WUAs) are the third layer of the water management framework, as designated by the National Water Act (Act 36 of 1998) (DWA, 2013: 6-7). (WUA). Under the National Water Act, the Minister may create a water user organization. In addition, WUA is a group of people who share a common interest in water and want to work together on projects that will benefit everyone. Activities including agriculture, household water distribution, municipal bulk water distribution, and similar ones are normally carried out on a smaller scale by this group (Sinha & Kumar, 2019). They are designed to facilitate confined and local water administration by cooperative user role actors. A WUA helps locals pool their resources (financial, human, and otherwise) to carry out water-related projects more efficiently. Members can benefit from WUA's focus on regional concerns. Typically, the scope of operation for WUAs is limited to a very small geographic area. For instance, they allow for local implementation of the catchment management approach. What this means is that WUAs are crucial in eradicating poverty and guaranteeing food security.

In light of the above, it is evident that to ensure effective and efficient supply and distribution of unpolluted drinkable water to the community, the above three tiers (DWS, CMA, and WUA), are vital and should collaborate to achieve and safeguard satisfactory clean drinkable water as prescribed in the Constitution. The following section explains other institutions, as mandated by the Water Act.

3.5.4 National Government

Overall, the water industry is governed by the national government. The Minister of Water Affairs is the head of the government agency in charge of water and forest management, and the Department of Water Affairs and Forestry is responsible for putting the Minister's policies into effect (DWS, 2015). To put it simply, the national government ensures that everyone plays by the rules in terms of economic, social, political, environmental, and technical preferences as laid forth in all applicable policies and laws.

3.5.5 The Provincial Government

Under the overarching principles of cooperative government, the provincial government is actively involved in the process of water control. In addition to carrying out its other tasks, such as those of planning and control, and fulfilling its broad mandate to monitor the activities of the local government, the provincial government is also responsible for performing regulatory functions.

3.5.6 Local Government

The Municipal Systems Act is the primary piece of legislation outlining the duties of local governments in terms of service delivery. Municipalities are required to provide at least the minimal level of basic municipal services to all residents under Section 73(1) of the Act. This law should be read as a legislative effort to ensure everyone has access to clean water. Every municipality within the meaning of the WSA is required, under section 11(1) of the WSA, to provide water supply and sanitation services in a way that is efficient, inexpensive, economical, and sustainable. However, for WSA, not all municipalities qualify as water services authorities (Toxopeüs, 2019). Some municipalities in South Africa’s North West Province, such as the Bojanala Platinum District Municipality and the Dr. Kenneth Kaunda District Municipality, do not function as water authorities. South Africa has 278 municipalities; however, only 169 of them are WSAs (StatsSA, 2017).

Often, municipalities contract these services out to water services providers or enter into a joint venture with another water services institution to provide the services (DWS, 2015). Under such circumstances, Section 27 of the WSA stipulates that if a municipality performs the functions of a water services provider itself, it must manage and account separately for those functions. Therefore, municipalities are obligated to generate an enhancement strategy for water services that will feed into the Municipality’s Integrated Development Plan (IDP), outlining the Municipality’s strategy for supplying residents with means to water amenities. Based on the foregoing, DWS (2013) demonstrates that a municipality that has been tasked with ensuring that its constituencies have the means to water amenities is known as a WSA. Not all of South Africa’s 278 municipalities (8 Metros, 44 DMs, and 226 LMs) qualify as WSAs.

3.5.7 Water Boards

Water boards were the only authorized organizations to sell water in bulk before 1997. Taking into account the national decentralization policy, the WSA revamped water provision governance (South African Yearbook, 2016). Therefore, water boards are set up under Schedule 3b of the Public Finance Management Act (1999) as national government business enterprises, having been authorized to do so by the Water Services Act (1997). According to Toxopeüs (2019), water boards are state organs established by the Minister that primarily engage in providing bulk water services to other water services institutions within a defined geographic area (section 28(1)(a) read in conjunction with section 29 of the WSA). The Minister of Water Affairs has the authority to order water boards to revise their strategic plans as necessary to ensure compliance with the Water Services Act of 1997 (South African Yearbook, 2016). The three largest water boards in South Africa are Rand Water in Gauteng, Umgeni Water in KwaZulu Natal, and Overberg Water in the Western Cape (Toxopeüs, 2019). Some water boards also perform a limited retail or reticulation function in addition to their primary role of providing bulk water to various municipalities within a specific geographical area (DWA 2014a). In addition to their vital role in managing water supplies, they play a crucial role in the operation of dams.

Municipalities that choose not to rely on water boards for regional bulk water supply infrastructure may still do so provided they adhere to the guidelines established by the Water Services Act, the National Water Act, and any other applicable legislation or initiatives (DWS, 2013). Over large areas and to many people, water is transported and distributed by water boards (via regional water supply schemes). The Minister of DWA has the final say over all matters related to this position. Since the passage of the Water Services Act, additional duties have fallen on local governments, which must now formally appoint Water Boards or other water service providers to carry out these functions (DWS, 2013).

3.6 CONSTITUTIONAL RIGHT TO WATER IN SOUTH AFRICA

The recognition of the right to water as a constitutional right came about in 1994 when South Africans voted their first democratic government into power. The new government recognized the need for universal access to basic services such as water, sanitation, and electricity. Thus, they incorporated these rights into the country's constitution. As such, every person in South Africa is acknowledged to have the right to sufficient food and water in the country’s Bill of Rights, which is enshrined in the Constitution of South Africa in 1996 and serves as a pillar of democracy in the country. This right is, however, contingent on the availability of resources that the government can provide. In 1996, liberated from the iniquities of apartheid, the South African constitution proclaimed the right to enough food and water belongs to everyone (South African Constitution, 1996). This proclamation set South Africa far ahead of other countries in the effort to transform the human right to water from an idealistic aspiration into a binding, significant law. Equally, the South African Constitution was prudently conscripted by constitutional experts and has been inevitably credited internationally. In this regard, the promulgation of the Constitution of the Republic of South Africa, more especially clauses 24, 26 & 27, advocates for human rights as it relates to the study:

> *Clause 24 deals with the environment as well as sanitation: "Everybody has the right to...a world that is not dangerous to their health or well-being; and ……" (Republic of South Africa, 1996: clause 24), while clause 27(1) deals with health care, food, water, and social security: "Every person has the inherent right to...... enough food and water; and……" (Republic of South Africa, 1996; clause 27(1)(b). This obligation, however, is extended in section 27 (2), according to which "the state, within its means, shall adopt appropriate legislative and other steps to ensure the progressive realization of each of these rights.* (The South African Constitution, Sections 7-39)

In this case, it is crucial to recognize that the right to adequate water resources interacts with environmental rights and serves as a foundational right that makes it possible for other rights to be realized (Choma & Ramphabana, 2015). With this in mind, during his Dialogue on the Human Right to Water, Pope Francis (2017:513) stated:

> *Having the right to means of water is essential for the survival of persons and decisive for the future of humanity. . . Respect for water is a condition for the exercise of the other human rights. . . Our commitment to give water its proper place calls for developing a culture of care (cf. ibid., 231) and encounter.*

It is one thing to assert that all people should have a basic supply of potable water and it is another to implement that in a country where most destitute reside far away from sources of water with few rivers, seasonal rain, and recurrent droughts such as in South Africa. Nevertheless, the South African Constitution provides broad protections for a water right, stating that the "state must adopt appropriate legislative and other means, within the scope of its resources, to ensure that everyone has the opportunity to enjoy the human right to water (SA Constitution., 1996).

Conversely, a similar school of thought has taken hold on a global scale: governments should stop handing out free water to prevent resources from being wasted. Unfortunately, Takacs (2016) challenged this view on the premise of the South African Constitution, which declares that every person has the right to have the means to have enough potable water. Certainly, the incorporation of Article 27 into the Constitution entitles South Africans privilege of having sufficient water supply regardless of their financial position. The Water Services Act (1997), states that providers of water utilities cannot arbitrarily refuse customers' requests for these essential services because of their affordability if they can prove that they are unable to pay for such services. Further, the Act proclaims that the destitute are entitled to free basic water use, that is about 25ℓ per person per day.

Lastly, Takacs (2016) notes that the Declaration of Rights and Duties of Citizens of South Africa guarantees all citizens the right to clean drinking water and that the country's national water policy, legislation, and strategies are all being developed with this goal in mind. In this regard, the Constitution declares that the state shall adopt reasonable legislative and other measures, within its available resources, to achieve the gradual realization of the water right (SA Constitution, 1996). Water, as a basic human need, must be explicitly recognized and well-defined in both domestic and international legal systems to ensure its full and effective realization and to establish clear obligations on the part of governments to satisfy fundamental water requirements (Takacs, 2016). Because of this, in 1997, the Water Services Act 108 of South Africa was passed to guarantee the establishment of potable water and adequate hygiene facilities for all humankind. Further, "the rights to potable water and adequate sanitary facilities are essential to guarantee a healthy and safe living condition as listed in the Act's preamble. Section 3(1) states that everyone has a right to access to basic water supply and basic sanitation, while Section 3(2) mandates that all water authorities take logical measures to ensure that this right is realized for all of their customers.

3.7 CONCLUSION

In conclusion, South Africa's water security problem is a complex and urgent issue shaped by its geography, climate, and socioeconomic context. The country's semiarid environment and erratic precipitation patterns pose significant challenges in securing a consistent water supply, especially in rural areas where access to clean drinking water is limited. This scarcity of safe water negatively impacts health, economic development, food security, and ecological well-being. Climate change, with increasing temperatures and unpredictable rainfall patterns, exacerbates water stress, leading to more frequent and intense droughts, reduced river flows, and depleted groundwater reserves. Additionally, poor infrastructure maintenance and lack of basic services further contribute to the water security challenge. To address these issues, the South African government has implemented the National Water Act of 1998, which emphasizes fairness, sustainability, and efficiency in water management. The adoption of an Integrated Water Resource Management strategy is crucial for coordinating efforts in the planning, allocation, and management of water resources. However, challenges in enforcing regulations and addressing knowledge gaps persist. Despite having significant water resources, South Africa still faces severe water challenges, and its water resources are already overburdened due to climate change, pollution, and inadequate infrastructure. South Africa's water resources comprise surface runoff, groundwater, and rainfall, each influenced by unique geographical and climatic factors. Managing groundwater resources effectively is crucial, as it serves as a vital water source for urban areas and rural communities. However, mining activities have influenced groundwater characteristics, and careful management is necessary to balance social, economic, and environmental considerations.

International efforts to improve water governance have been established since the Dublin Conference in 1992, with major targets for action set during subsequent conferences and summits. The principles of water governance endorsed by organizations like the OECD emphasize effectiveness, efficiency, trust, and engagement as crucial drivers for success. While there is growing recognition of the importance of water governance, the scientific foundation for prescriptive governance often lacks solid empirical understanding, leading to ideologically driven predictions about societal development. In the context of South Africa, the institutional arrangements for water governance involve multiple tiers, including the Department of Water and Sanitation, Catchment Management Agencies, Water User Associations, and Water Boards. These institutions collaborate to ensure the effective distribution of clean, drinkable water to the public. The South African Constitution recognizes water as a fundamental human right, enshrining the right to sufficient food and water for all citizens. However, despite these positive developments, challenges persist in achieving universal access to clean water. South Africa faces issues of water scarcity, inequality in water access, and a need for improved coordination between government agencies and grassroots groups. The establishment of water management institutions, such as Catchment Management Agencies and Water User Associations, is seen as essential in addressing these challenges and promoting sustainable water security. Overall, the concept of water governance is crucial for addressing the growing water challenges faced by societies worldwide. Its evolution and implementation must be informed by sound empirical research and consider the complexities of governance involving multiple stakeholders and sectors. In South Africa, the constitutional recognition of the right to water emphasizes the importance of providing equitable access to water resources for all citizens. By fostering collaboration and participatory decision-making, effective water governance can contribute to ensuring a sustainable and secure water future for societies around the globe. The following chapter expounds on the research methodology used to gather data for this study. As a scientific and academic piece of work, several key elements are highlighted to provide a better understanding of the research process. Firstly, it delves into the chosen research paradigm that underpins the entire study, followed by an elaboration on the study area and its relevance. The research design is then outlined alongside the rationale behind it, providing a framework for conducting the study.

CHAPTER FOUR
RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter provides a comprehensive overview of the research methodology employed to gather data for this study. Specifically, it elucidates the research paradigm, study area, research design, and the rationale behind the chosen design. Additionally, it discusses the sampling technique, sample size, and study population, as well as the data sources, instruments used for data gathering, and the strategies employed for data analysis. Furthermore, this chapter outlines the measures taken to ensure the validity and reliability of the findings, including plans for pilot studies and ethical considerations. Notably, a mixed methods research technique was employed in this study, and the intricate details of this approach are expounded upon in the following sections. The discourse within this chapter adheres to academic and scientific conventions, offering a rigorous framework for the research methodology implemented in the study.

4.2 DESCRIPTION OF THE STUDY AREA

This study was carried out in the Bojanala District. The Bojanala District, located in the North West Province of South Africa, grapples with significant challenges concerning water security. It is named after the Bojanala River, which flows through the district. The district covers an area of approximately 18,333 square kilometers and is home to a diverse population. The Bojanala District encompasses areas that were previously part of the Bophuthatswana homeland in South Africa. The district is divided into five local municipalities, including Rustenburg, Madibeng, Moses Kotane, Kgetleng Rivier, and Moretele. Rustenburg, the largest city in the district, serves as its administrative center and is an important economic hub. The district's water security is influenced by various factors, such as its geographical characteristics, population growth, economic activities, and the impacts of climate change.

Geographically, the district relies on water resources derived from rivers, dams, and underground aquifers. However, the semi-arid climate and uneven rainfall patterns in the region affect the availability and reliability of these water sources. Droughts and water scarcity are recurrent issues in the district, particularly during periods of low rainfall, posing challenges to maintaining a sustainable and secure water supply for local communities. Climate change further compounds the water security challenges in the Bojanala District. Rising temperatures, changing rainfall patterns, and increased frequency of extreme weather events pose risks to water availability and intensify water scarcity. These climate impacts require adaptive strategies and resilient water management practices to ensure long-term water security in the district. The district's growing population and urbanization further contribute to water security concerns. As urban areas expand, the demand for water increases, placing additional stress on existing water infrastructure and resources. Inadequate access to clean and reliable water services in peri-urban and rural areas exacerbates the water security situation. Furthermore, the Bojanala District is known for its rich mineral resources, particularly platinum. Intensive mining activities, particularly in the platinum sector, exert pressure on water resources in the Bojanala District. Mining operations consume significant amounts of water and can potentially contaminate water bodies, impacting both water quality and quantity for human consumption and ecological health.

4.3. CLASSIFICATION OF RESEARCH PARADIGM

By understanding and engaging with different research paradigms, researchers can navigate the scientific landscape more effectively, and contribute to knowledge in their field. For this reason, the study considered and explained each paradigm to enhance the theoretical foundation and demonstrate how it fits within the broader research landscape. Research paradigms play a fundamental role in shaping the entire research process, from formulating research questions to collecting and analyzing data, and interpreting findings. They provide a lens through which researchers view the world and help them make sense of their observations. Multiple paradigms have been considered in the academic literature, but scholars cannot agree on how many categories should be used to describe them. For instance, research paradigms can be categorized as positivism, interpretivism, post-positivism, critical theory (ideology), constructivism, and/or pragmatism To provide a comprehensive understanding, the study considered the following paradigms (positivism, interpretivism, and pragmatism):

4.3.1. Positivism

Positivism is a philosophical approach that emphasizes the importance of empirical evidence and scientific methods in understanding the world. Augustine Comte was instrumental in the inception of the positivist paradigm, characterizing it as a perspective that emphasizes empirical observation and rationality to elucidate human conduct. This paradigm posits individuals as entities susceptible to systematic scientific inquiry (Ugwu, et al., 2021). In the context of sustainable water security in Bojanala, positivism was applied to achieve two primary objectives: identifying and analyzing demographics and socioeconomic characteristics associated with access to water for households, and assessing the status of water security. The first objective involved using positivist research methods such as quantitative surveys to collect data on household demographics and socioeconomic factors. This data was analyzed statistically to identify patterns and correlations between variables and access to water. For instance, a survey asked participants about their income level, education level, employment status, and other relevant factors to determine which groups are most likely to experience inadequate access to water.

The second objective was to assess the current status of water security in Bojanala. This involved collecting data on factors such as boreholes and municipal water supply networks. By gathering empirical evidence through scientific methods, the researcher gained a better understanding of both the quantity and quality of available water resources in the area. However, it is important to recognize that there are limitations to any research approach. For instance, positivism assumes an objective reality that can be measured and observed, but there may be aspects of water security that are harder to quantify or capture through traditional research methods. Additionally, positivism tends to prioritize quantitative data over qualitative insights, which may overlook important nuances in people's experiences of water insecurity. Despite these limitations, applying positivism in the study of water security in Bojanala was a valuable tool for addressing this critical issue. By combining scientific rigor with an understanding of local context and community perspectives, researchers and policymakers can work together to develop effective solutions that promote sustainable water use and ensure equitable access for all.

4.3.2 Interpretivism

Interpretivism pertains to the theoretical frameworks that underscore the significant aspects of individuals' persona and involvement in societal and cultural spheres (Elster, 2007; Walsham, 1995). In essence, interpretivism is an approach to social research that emphasizes the importance of understanding human behavior from the perspective of those being studied. It recognizes that people's interpretations of reality are shaped by their experiences, values, beliefs, and culture. Therefore, interpretivism was particularly relevant when studying complex social issues such as water security in Bojanala. Water security is a crucial issue that affects many aspects of people's lives, including health, livelihoods, and ecosystems. In this context, interpretivism was applied to gain insights into how people perceive and respond to water-related challenges. Interpretive research approaches such as qualitative interviews, and focus groups, helped the researcher understand the subjective experiences of individuals and communities regarding water access and use. For example, conducting interviews with households in different areas of Bojanala provided valuable information about how they manage their water needs during droughts or other emergencies. Similarly, participant observation provided insights into local cultural practices related to water use and conservation.

One advantage of interpretivism over positivist approaches is its flexibility to adapt to changing circumstances. The dynamic nature of water-related issues requires continuous monitoring and evaluation to capture emerging trends and changes in stakeholders' perceptions. Interpretive methods allow for ongoing data collection and analysis that can inform adaptive management approaches. However, it should be noted that applying interpretivism alone could not provide a comprehensive understanding of all aspects related to water security in Bojanala. Therefore, complementing interpretive research with quantitative methods enhanced our understanding of broader patterns associated with water availability, quality, consumption rates, and trends over time. For example, collecting data on water consumption patterns by households provided insights into the amount of water used per capita, which is a critical indicator of water security. The positivist approach was useful for analyzing factors that affect water security in Bojanala. For instance, regression analysis helped identify demographic and socioeconomic variables associated with disparities in access to clean drinking water.

4.3.3 Pragmatism

The pragmatist approach has helped the researcher choose the best way to probe the topic of sustainable water security and answer the research issue at hand. Pragmatism is a philosophical perspective that highlights the significance of accomplishing tasks and gaining knowledge from past errors to make more informed decisions going forward (Makumane, et al., 2021). This concept originated as a response to Pierce's (1878) work and was further developed by James and Burkhardt (1975) as well as John Dewey (1929), constituting a distinct school of thought. Pragmatism assumes that the world we inhabit is not static but rather dynamic, constantly changing (Kaushik and Walsh, 2019). The term "pragmatism" itself derives from the Greek word pragma, denoting action (Pansiri 2005). The pragmatic justification for the study's shift to a more widely accepted methodology was provided by the need to answer the research questions. Pragmatism is a philosophical approach that emphasizes practicality over theory. When applied to water security in Bojanala, the researcher focused on finding solutions that work in practice rather than relying solely on theoretical models. This pragmatic approach recognized the complex interplay of social, economic, and environmental factors that affect access to and availability of clean water in the region. One key application of pragmatism in addressing water security issues is collaboration between different stakeholders. A pragmatic approach recognizes that no one group can solve these problems alone, so it's important to bring together representatives from government agencies, NGOs, community groups, and private industry to find common ground and work toward effective solutions. Another important aspect of applying pragmatism to water security is a focus on outcomes rather than outputs. In other words, success should be measured based on whether or not people have reliable access to clean water rather than simply how many wells have been dug or how much money has been spent on infrastructure projects. When it comes to assessing the status of water security in Bojanala, a positivist approach was useful.

Positivism is a philosophy that emphasizes objective observation and measurement as the basis for understanding reality. By using quantitative data such as household surveys and water quality, the researcher gained a better understanding of the current situation regarding access to clean water in the region. However, it's important to recognize that positivism has its limitations when it comes to studying complex social phenomena like water security. Simply counting how many households have access to clean water does not necessarily tell us why some do while others do not. To fully understand the factors contributing to (or hindering) sustainable water security in Bojanala requires a more holistic approach that takes into account the social and economic context of the region. Ultimately, any study of water security in Bojanala must take a pragmatic approach that recognizes the complex interplay of factors affecting access to clean water. While positivist methods can be useful in identifying specific factors affecting access to clean water, they must be used in conjunction with a more holistic understanding of the social and economic context of the region. By taking a collaborative approach and working towards practical outcomes, researchers can develop effective policy recommendations for improving water security and promoting sustainable water management practices in the Bojanala District. Ultimately, this will contribute to the well-being of local communities and ensure that water resources are managed in a way that benefits both people and the environment.

4.4 PARADIGM GUIDING THE RESEARCH

This study employed the pragmatic paradigm as its theoretical foundation, providing a framework for the qualitative or quantitative methods employed in the study's execution (Creswell & Creswell, 2018; Kivunja & Kuyini, 2017). The selection of the research paradigm was based on the researcher's theoretical and conceptual framework usage, as suggested by Varpio, Paradis, Uijtdehaage, and Young (2020). Understanding research paradigms is crucial as they guide scientific discoveries through their assumptions and principles (Park, Konge, and Artino, 2020). Concurrently, since paradigm issues are so fundamental, a researcher must have a firm grasp on the particular paradigm(s) that inform and direct their work (Guba and Lincoln, 1994). Deshpande (1983) argues that researchers can benefit from using a paradigm in different ways. For instance, it serves as a guide for researchers, for one thing, by highlighting the most pressing problems in any field. Second, it paves the way for the construction of models and theoretical frameworks that help researchers find answers to these questions. Third, it specifies the criteria for the research tools needed to address the problems, including the methodology, instruments, and data collection. Fourth, it lays out the guidelines for how to approach similar issues in the future. In addition, the selection of the right research paradigm is necessary to take the research in the right direction. However, the choice should solemnly depend on the intent, questions of the research, and the resources accessible (Patton, 1990).

From what has been discussed thus far, particularly the position of research within the pragmatic paradigm, it is apparent that proponents of this paradigm favor a mixed methodologies approach, i.e., a hybrid of quantitative and qualitative techniques. For instance, although they do not go into great detail, Grafton et al. (2011) describe pragmatism as the paradigm for conducting mixed-methods research. However, pragmatism has been cited repeatedly in the literature on mixed methods research as the best-guiding principle for this type of study (e.g. Patton, 2002; Maxcy, 2003; Teddlie & Tashakkori, 2003, 2006; 2009; Scott & Briggs, 2009; Johnson & Gray, 2010; Creswell & Plano, 2011). Quantitative and qualitative data are collected and analyzed separately, then combined at a later stage of the research process to conclude (Johnson & Onwuegbuzie, 2004; Tashakkori & Creswell, 2007). It is intended that by integrating these elements, a deeper grasp of the study issue will be achieved, allowing for the provision of more thorough and accurate answers to research questions (Creswell & Plano Clark, 2011). Tools such as interviews, observations, focused group discussions, and questionnaires are integrated into this research paradigm (McKenzie & Knipe, 2006).

Due to its synthesis of quantitative scientific methods and qualitative naturalistic approaches, this paradigm was well suited to this investigation in the manner expressed by Kaushik & Walsh (2019) and Ngubane-Mokiwa & Khoza (2021). Also, this is because pragmatism focuses on the 'what' and 'how' of the research problem engaging on what's best to accomplish the ideal outcomes and therefore forming the underlying framework for mixed-methods research. It is important to note that pragmatism is seen as a paradigm when it is applied to the production of knowledge in a social setting (Morgan, 2014a). That is to say, according to pragmatism, one acquires knowledge through interactions of belief and action, which are primarily considered to be social (Kaushik & Walsh, 2019; Morgan, 2014b). The research's goals, drivers, and standards are all established by the paradigm used. A paradigm is the starting point from which all other methodological, design, and approach decisions can be made (Okesina, 2020).

4.5 METHODOLOGY

Researching sustainable water security in the Bojanala District required a mixed-method approach that combined qualitative and quantitative techniques. The mixed method approach enabled the researcher to collect both numerical and non-numerical data, which enriched the analysis of the research findings. By combining these two approaches, a comprehensive understanding of the research topic was achieved, incorporating both subjective insights and objective measurements. Also, this influenced the researcher to gain a holistic understanding of sustainable water security through the aggregation of data that allowed him to examine the phenomenon from multiple angles (Shorten & Smith, 2017). The use of mixed methods was critical in capturing aspects of water security not measurable by traditional quantitative means alone. This type of research is essential as it helps policymakers develop effective policies to address water security challenges. Nguyen (2019) explains that the methodology encompasses all aspects of a study's execution, from the choice of methods to their connections to the paradigm, theoretical framework, literature, and ethical standards that guide the investigation. These authors' viewpoints make it abundantly clear that the term "methodology" includes not only research techniques but also paradigms, strategies, procedures, and methods. The methodology, then, is concerned with the overarching research strategy employed, and it would specify the data collection methods to be employed following the proposed research strategy (Alharahsheh & Pius, 2020).

4.6 RESEARCH DESIGN: A MIXED-METHOD SEQUENTIAL EXPLANATORY DESIGN

This study employed a mixed-method design. More specifically, an explanatory sequential design was used, where the researcher first collected and analyzed the quantitative (numeric) data. The qualitative data was then collected and analyzed to help explain or elaborate on the quantitative findings The design allowed the researcher to integrate qualitative and quantitative methods to explore research questions from multiple perspectives and obtain a more comprehensive understanding (Creswell, & Plano Clark, 2017) of sustainable water security among households in the Bojanala District. The researcher collected and analyzed quantitative data and then followed it up with qualitative data collection and analysis to provide further explanation and understanding of the quantitative findings. Qualitative data was gathered through interviews, focus groups, and observations, capturing subjective experiences, perceptions, contextual information, and potential solutions related to water security. Quantitative data was collected through household questionnaire surveys. In other words, surveys were used to collect quantitative data on water security indicators such as availability, access, and quality of water, as well as impacts on livelihood, health, and education. The researcher used both stratified random sampling and simple random sampling to select participants for both qualitative and quantitative data collection and to ensure that the sample represents the target population and provides diverse perspectives to address the research questions comprehensively. The combination of stratified random sampling and simple random sampling improved the generalizability of research findings and enhanced the external validity of the research and its relevance for sustainable water security.

The qualitative and quantitative data analyses were analyzed separately to derive insights and findings from each data type. Qualitative data analysis involves interpreting and making sense of textual or non-numerical data obtained from interviews, focus groups, and observations. Thematic analysis was used to identify and analyze themes from the qualitative data. Quantitative data analysis involved analyzing numerical data collected through household questionnaire surveys. For instance, the quantitative data were analyzed using statistical software to examine the relationship between different variables. Integration of qualitative and quantitative findings was a crucial step. The researcher compared and merged the qualitative and quantitative results to provide a comprehensive understanding of the research water security in the study area. Triangulation, which involved using multiple data sources, and methods, to corroborate findings, was used to enhance and strengthen the validity and reliability of the research findings. The researcher followed Unisa's ethical guidelines, including obtaining informed consent, ensuring confidentiality, and respecting the rights and welfare of participants. Lastly, the researcher provided a comprehensive and robust account of the research concerning sustainable water security in the study area.

To develop a descriptive model that guides sustainable water security and supply interventions, the researcher conducted a thorough review of existing literature on water security, supply interventions, and sustainability frameworks. This literature review provided a foundation for understanding the current state of knowledge, identifying gaps, and informing the development of the descriptive model. Based on the literature review, key dimensions and factors relevant to sustainable water security and supply interventions were outlined. Relevant data was collected to support the development of the descriptive model. The data covered factors like household socio-economic characteristics; water use and consumption; water sources and water governance, compliance, monitoring, and evaluation. The collected data was analyzed using statistical and thematic analysis. The researcher developed the descriptive model based on the findings from the data analysis. The model takes the form of a conceptual framework that represents the complexities and dynamics of sustainable water security and supply. The researcher validated the developed descriptive model by seeking feedback and input from relevant stakeholders and incorporated their insights and suggestions to refine and improve the model to reflect local realities.

A research design is defined as the process through which data are gathered, analyzed, interpreted, and reported (Creswell & Plano Clark 2007). It refers to the overarching approach taken to bridge the gap between theoretical questions and practical (but still reasonable) studies. In other words, the study design specifies how the data will be collected, how it will be analyzed, and how all of this will contribute to answering the research objectives (Grey, 2014). The research design's core goal is to transform an identified research issue into analyzable data to answer research questions efficiently and economically (Asenahabi, 2019). Consequently, this part introduces the most popular forms of mixed-methods studies now used in the field. Several authors have compiled lists of the many different mixed-methods studies that can be conducted (Plano Clark & Ivankova, 2016; Terrell, 2012; Wilkinson & Staley, 2019). Because of their ability to help researchers comprehend the most effective choices available for mixed methods study designs, (Creswell & Plano Clark, 2018) regards these central designs as economical and useful. In general, there are three distinct varieties of mixed-method studies: Parallel convergent mixed techniques; sequential mixed methods for the explanation, and sequential mixed methods for exploration (Asenahabi, 2019). Each approach is described below:

4.6.1 Parallel convergent mixed methods

In the context of sustainable water security, the parallel convergent mixed method allowed for the exploration of socioeconomic characteristics. The approach enabled the researcher to explore different aspects of sustainable water security simultaneously, examining both the subjective experiences and perceptions of individuals and the objective measurements and statistical relationships. The qualitative component of this design involved interviews, focus groups, and observations to capture rich and nuanced data related to people's attitudes, beliefs, values, and behaviors regarding water security. Qualitative data provided insights into the social, and cultural factors that influence water management practices and decision-making processes. It helped to understand the complexities, perceptions, and experiences of stakeholders involved in sustainable water security initiatives. The quantitative component, on the other hand, utilized household surveys, or statistical analysis to generate numerical data. It helped in quantifying and measuring different variables related to water resources, such as water quality, quantity, availability, and usage patterns. Also, it provided statistical evidence and generalizability, allowing the researcher to identify trends, patterns, correlations, and predictive models related to sustainable water security. After collecting and analyzing both qualitative and quantitative data, the integration phase involved merging the findings to create a comprehensive understanding. This was done through data triangulation, where the qualitative and quantitative findings were compared and contrasted to identify areas of convergence or divergence.

4.6.2 Explanatory Sequential Mixed Methods

The purpose of sequential mixed methods design is to provide a thorough understanding of a study issue through the collection and analysis of both quantitative and qualitative data (Creswell, & Clark, 2017). In the context of sustainable water security, the researcher explored the relationships between quantitative variables and gained deeper insights into the underlying reasons and mechanisms through qualitative exploration. The explanatory sequential design started with the collection and analysis of quantitative data. This quantitative data provided a broad overview and allowed for generalizations. After the quantitative phase, the second phase involved collecting and analyzing qualitative data to further explain and contextualize the quantitative findings. Qualitative data helped the researcher to understand the underlying reasons and mechanisms behind the quantitative patterns, providing a deeper and more nuanced understanding of the research topic. The integration phase involved merging the quantitative and qualitative findings to provide a comprehensive and integrated interpretation of the research topic. The integration was done through data merging, where the qualitative and quantitative findings are compared and contrasted to identify areas of convergence or divergence. It allowed the researcher to explore how qualitative insights enhance or challenge quantitative patterns and vice versa. The integrated findings provided a more robust and comprehensive understanding of sustainable water security.

4.6.3 Exploratory Sequential Mixed Methods

In the context of sustainable water security, the researcher explored the complex issues and dynamics through qualitative inquiry and then validated and generalized the findings through quantitative investigation. This qualitative inquiry helped in understanding the lived experiences, perspectives, and challenges faced by participants, and identified key themes, factors, and relationships that influence water security practices and outcomes. Once the qualitative phase was completed, it was followed by analyzing the qualitative data and using the emerging themes, and concepts to inform the design of the quantitative phase. The aim was to validate, generalize, or quantify the findings from the qualitative phase and explore the relationships and patterns identified during the initial exploration. The integrated findings allowed the researcher to gain a deeper understanding of the research topic by combining the strengths of both qualitative and quantitative approaches. In contrast to an explanatory sequential design, an exploratory sequential mixed method employs a backward order of procedures (Asenahabi, 2019). The purpose of an exploratory sequential mixed methods design is to systematically investigate and evaluate emergent discoveries through the collection and analysis of both qualitative and quantitative data (Creswell & Clark, 2017).

4.7 CHOOSING THE CORRECT RESEARCH DESIGN

The explanatory sequential mixed methods design was deemed appropriate and relevant for this doctoral study. In essence, the explanatory sequential mixed methods design was selected for two reasons. Firstly, the explanatory design provides a superior comprehension of the environment within which the issue exists by outlining the exact nature of the problem

(McDaniel & Gates, 1995). Secondly, the explanatory design is suitable for this study since it is generally anxious about assessing what is transpiring and exploring new experiences about a social phenomenon. This explanatory sequential design has included two segments: the underlying quantitative stage, and a qualitative data-gathering stage. The qualitative stage has built directly on the outcome from the quantitative stage. In this manner, the quantitative findings are thoroughly clarified through the qualitative data. Therefore, the Phase 1 outcome has been utilized to develop factors that inform the identification and determination of Phase 2 which has served as the foundation of the study. As such, the mixed-methods design has to an extent empowered the researcher to respond simultaneously to the questions of the study. Additionally, determining what aspects of a situation may have led to the problem's emergence is crucial for gaining insight into the matter at hand (Creswell, 2003). In support of this claim, the researcher asserts that answering research questions is possible using only an explanatory research design. Given the foregoing, the researcher decided to use an explanatory mixed-method research design, which combines quantitative and qualitative methods, to evaluate water security in the area under investigation. The point of any study's design is to cut down on wasteful variables and maximize reliability while staying within budget. By drawing on their familiarity with the various research design options and finding guidance from a close inspection of the research statement of the problem, the research questions, the conceptual/theoretical framework, and the analysis of the related literature, the researcher should be able to select the most appropriate design (Asenahabi, 2019).

4.8 INTEGRATION OF QUANTITATIVE AND QUALITATIVE DATA

The researcher integrated quantitative and qualitative data to gain a more comprehensive understanding of sustainable water security in Bojanala District. The researcher compared and contrasted findings from quantitative and qualitative data to validate and corroborate the results. By combining quantitative and qualitative data, the researcher strengthened the reliability and credibility of the study findings. For instance, quantitative survey data on water usage patterns were triangulated with qualitative interview data to gain a deeper understanding of the underlying reasons and motivations behind those patterns. Quantitative and qualitative data were analyzed separately but in relation to each other. The researcher examined the quantitative data to identify patterns, trends, and associations, while the qualitative data provided contextual insights and explanatory narratives. The findings from both data sources were synthesized to generate a more comprehensive understanding of sustainable water security in the Bojanala District. The researcher employed a sequential design where quantitative data collection and analysis were followed by qualitative data collection and analysis.

The findings from each phase informed the subsequent phase, allowing for a deeper exploration and understanding of sustainable water security. Integrating quantitative and qualitative data offered the advantage of complementarity, allowing the researcher to overcome the limitations of each approach and provide a more comprehensive and nuanced analysis. It enabled a deeper understanding of the complexities, and context of the research topic, leading to more robust conclusions and actionable recommendations. O'Cathain, et al. (2010), Fielding (2012), and Fetters et al. (2013) all agree that integrating data yields a deeper understanding of the data by bringing together quantitative results and qualitative findings. Integrating data improves the efficacy of mixed-methods studies and compensates for the limitations of individual research approaches (Fetters et al., 2013). Beginning with the formulation of research aims and objectives and continuing through design, procedures, analysis, and findings, integration can occur at any point in the research process. Incorporating Plano Clark's (2019) definition of integration allows for variation in the "what," "when," and "how" of integration while still preserving its "essence" in mixed-methods studies like the one at hand. Perspectives, methodologies, data sources, and methods of analysis from both a qualitative and quantitative standpoint are all part of the package.

4.9 SAMPLING TECHNIQUE

Given the nature of the study, the researcher used both stratified random sampling and simple random sampling. Using both stratified random sampling and simple random sampling provided a comprehensive and representative sample. The researcher benefitted from the strengths of each method. Stratified random sampling ensured that important subgroups were adequately represented, allowing for more precise analysis within those groups. On the other hand, simple random sampling ensured unbiased selection across the entire population, providing a broader perspective. By employing a combination of stratified and simple random sampling, the researcher achieved a balance between representativeness, precision, and generalizability in the study. Since it was impossible and difficult to observe all elements of a target population, the researcher applied a sampling technique to reduce the number of cases as outlined below:

4.9.1 Stratified Random Sampling

If the population to be studied has a variety of distinguishing characteristics, stratified random sampling can be an efficient means of collecting that information (Singh & Masuku, 2014). The stratified random sampling technique has been utilized to select the household or respondents in the study area since the number of households was not the same across the five local municipalities. Using this strategy, the entire population was segmented down into manageable subsets based on a single demographic variable (e.g. gender, age, religion, socio-economic level, education, diagnosis, etc.). From these strata, simple random sampling was used to obtain a sample of 384 registered households from the five local municipalities. This technique was employed to ensure a fairly equal representation of the variables for the study. Also, it was to ensure that every stratum is adequately represented (Ackoff, 1953).

4.9.2 Simple Random Sampling

The simple random sampling technique has been utilized to select the households within the study area which were treated as strata. The selection of households was informed by the list of registered households obtained from the Local Municipalities in each locality within the District. A number was allocated to each head of the household name on the list, and then households were selected from the registered list utilizing a table of random numbers. To obtain a sample from a population, Gregoire, and Valentine (2008) state that a sampling frame, or a means of identifying and localizing the sampling units within the population, must be at hand. The sampling frame design is the criteria by which the elements of the target population are ranked on the list from which the sample is drawn (e.g., names, addresses, or phone numbers) (Kölln, 2019). As far as the research is concerned, there are four distinct sampling frame designs. The researcher collected the samples from the registered list of all the households in the five Local Municipalities in the study area. For objective four, the participants were invited to a focus group or through a focus group discussion from respective local municipalities.

When creating reliable research protocols, it is customary to specify the types of people who will and will not be allowed to take part in the study. By "inclusion criteria," we mean the specific demographic and geographical characteristics of the study population that will be used by the researchers as a basis for concluding their research question (Patino, & Ferreira, 2018). In contrast, exclusion criteria refer to characteristics that could compromise the study's ability to collect data, keep participants safe, or both (Kamangar, & Islami, 2013). Ineligible participants are often omitted from studies because of characteristics that make them more likely to be lost to follow-up, miss appointments to collect data or provide inaccurate data that could skew the results. For this study, the inclusion sampling criteria were all the households that are on the registered list while the exclusion sampling criteria were offices, hotels, hospitals, clinics, schools, and so forth from the housing units of the five Local Municipalities. Participants were selected based on their relevance to accomplishing the aims of the research. The study's exclusion criteria relied on factors unrelated to the respondents that were thought to introduce error or bias into the findings.

4.10 SAMPLE SIZE AND STUDY POPULATION

A sample size of 384 participants was selected from a total population of 611,145 individuals. The selected sample of 384 participants was representative of the larger population, allowing for the generalizability of findings to the target population. In selecting a sample size of 384 participants, the researcher considered factors such as available resources, time constraints, and the desired confidence level and margin of error for estimating population characteristics. The sample size of 384 represents a fraction of the total study population, allowing for a manageable and feasible data collection process while still striving for meaningful and reliable results. The sample size was sufficient to collect sufficient data to provide a sufficient explanation and answer to the research questions. The adequacy of the sample size depended on various factors, including the research design, sampling technique, desired level of precision, and the heterogeneity of the population. The data was consolidated from a survey, which was disseminated online to participants across the district.

Based on the large size of the population, a stratified random sampling technique was employed to ensure adequate representation of various subgroups within the population. In-depth interviews were conducted with 14 knowledgeable respondents from the Department of Water and Sanitation (DWS), Department of Agriculture, Magalies Water, and the Local Municipalities within the Bojanala District The data obtained from the water-related divisions within each organization was utilized to ascertain the overall number of individuals who were interviewed. The researcher examined the respondents' biographical information by posing a set of inquiries regarding their position, age, experience, and educational background. These factors were considered significant as they aimed to gauge the participants' comprehension of sustainable water security. For this study, the sample size of 384 was determined using the Krejcie and

Morgan 1970 model as shown below. The list of household heads in the study area was obtained from the local municipalities within the District. Only the registered households within the local municipalities participated to constitute the sample size of the study. The following formula (Krejcie & Morgan, 1970) was used to determine the sample size of the target population:

$$S = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

Where:

S = Required Sample size
X =value of Z (e.g. 1.96 for 95% confidence level)
N = Population Size
P = Population proportion (expressed as a decimal) (assumed to be zero point five (50%)
d = Degree of accuracy (5%), expressed as a proportion (.05); It is a margin of error.

The total number of registered households in the Bojanala Region is 611 145. Putting the total number of registered households in the formula above has given a sample size of 384 as depicted below. The sample size of a study must be large enough to be statistically significant (Majid, et al., 2017) and strong enough to exclude the possibility that random variation in the population of interest explains the results of the study. The researcher did not consider the sex or ethnicity of the study's subjects. Males and females of various racial and ethnic backgrounds took part. In each local municipality, the random sampling method was utilized to select households to constitute the respective samples. The samples for the respective local municipalities are presented in the table below:

Table 4.1: Represents the total number of households across the Bojanala Region

LOCAL MUNICIPALITY (LM)	NO OF REGISTERED HOUSEHOLDS	SAMPLE CALCULATIONS	SAMPLE SIZE
Rustenburg LM	262 576	$\frac{262\ 576}{611\ 145} \times 384$	165
Madibeng LM	193 364	$\frac{193\ 364}{611\ 145} \times 384$	121
Moses Kotane LM	80 654	$\frac{80654}{611\ 145} \times 384$	51
Moretele LM	55 764	$\frac{55\ 764}{611\ 145} \times 384$	35
Kgetleng Rivier LM	18 787	$\frac{18\ 787}{611\ 145} \times 384$	12
Total	**611 145**		**384**

Source: Compiled by Author: Total household numbers retrieved from *https://link.www.municipalities.co.za/demographic/139/BPDM*.

The size of the sample is one of the most crucial steps in the sampling procedure. The process of deciding how many observations to include in a sample is called "sample size determination" (Singh, & Masuku, 2014). In any study or investigation where generalizations about the population at large are sought, the size of the sample is crucial. Sample sizes in scientific studies are often set by taking into account both the resources required to acquire the data and the required level of statistical power. To what extent can we expect a statistical test to identify a real difference? (Singh, & Masuku, 2014). It should be stressed that various methods exist for establishing the appropriate size of the sample. A census may be used for smaller populations, sample sizes from similar studies may be mimicked, published tables may be consulted, and formulas may be used to determine an appropriate sample size (Singh & Masuku 2013; Glenn 1992). Sample sizes in Taherdoost, (2016) are based on the number of responses, not the total number of questionnaires sent out. A large enough random sample is necessary to generalize from it without introducing sampling errors or biases. For instance, the sample size needs to be determined cautiously to ensure it is large enough to draw reliable and applicable conclusions. To select a sufficient sample, researchers need detailed information on the nature of the issues being studied and the characteristics of the target population. In this study, data was captured on a questionnaire or schedule before the inquiry ever began with the samples (Singh, & Masuku, 2014). In most cases, multiple statistical formulas are taken into account when choosing a sample size. Fowler (2002) contends that the population fraction used to determine the sample size is rarely a significant issue when choosing a sample size because it typically has a negligible impact on the sample's ability to accurately represent the population (Fowler, 2002). This means that determining the appropriate sample size for categorical data can be done in several ways, each of which may involve a unique set of calculations:

$$\boldsymbol{n = \frac{P\,(100 - P)\,Z^2}{E^2}}$$

n= p (100-p)z2 /E2 n is the required sample size

P is the percentage occurrence of a state or condition

E is the percentage maximum error required

Z is the value corresponding to the level of confidence required

According to Bartlett et al. (2001), there are two primary considerations in the aforementioned calculation. The researcher's comfort with uncertainty and the desired degree of precision are the first factors to consider. The researcher's tolerance for uncertainty, denoted by the letter "E," is the margin of error. The standard margin of error for social science research is 5%. Because the sampling error is directly proportional to the square root of n, the smaller the value of E, the larger the sample size must be. However, even a huge sample size cannot ensure precision (Bryman & Bell, 2003).

The letter Z is concerned about the level of confidence that the results revealed by the survey findings are accurate. This indicates how certain we are that our sample survey accurately represents the whole population. In statistical parlance, the necessary degree of certainty is expressed as a quantitative value, usually written as Z. The basic idea is that you may get a good approximation of the true value of a population by repeatedly sampling that population and averaging the answers to any particular variable or question.

Population variance or heterogeneity estimation is the second most important part of a sample size formula (P). Therefore, Bartlett et al. (2001) recommend that researchers choose a P-value of 0.5 since it maximizes variance and yields the largest possible sample size (Bartlett et al., 2001). In addition to the purpose of the study and population size, three criteria in determining the appropriate sample size need to be specified: the level of precision, the level of confidence or risk, and the degree of variability in the attributes being measured (Miaoulis & Michener, 1976).

4.11 DATA SOURCES

Both secondary and primary data sources were utilized to identify and analyze the factors influencing sustainable water security among households. Information obtained through firsthand observation is called primary data. The term secondary data is used to describe facts and figures gleaned from a source that has previously been made available to the general public (Kabir, 2016).

4.11.1 Secondary Sources

The published and unpublished materials of both public and private documents, memos, and literature have informed the secondary source of data. To compile the theoretical chapters and gain understanding, accessible literature was utilized. The reference list consists of the complete list of secondary sources used for the study.

4.11.2 Primary Data and Fieldwork

The primary data was gathered through questionnaires, focus group discussions, interviews, and observations.

4.12 DATA COLLECTION INSTRUMENT

The researcher used both primary (through interviews) and secondary (through documentaries) sources to compile the data. The researcher devised a schedule for conducting interviews. Interview questions (Appendix I) were designed to pry out data on sustainable water security in the area under investigation. Importantly, all data was collected following UNISA COVID-19 standards. The researcher recognizes that face-to-face interviews and focus groups were not possible due to the COVID-19 pandemic due to social distancing and the requirement to wear masks. Data collection at the time of the COVID-19 pandemic necessitated non-contact interviews. The survey was distributed online to respondents throughout the Bojanala District, and the data collected from their responses was consolidated. In this regard, online data collection is just as effective as face-to-face interviews in many cases (Kenny, 2005; Hinchcliffe & Gavin, 2009; Campbell et al., 2001).

In May 2021, when a second wave of coronavirus illnesses was hitting South Africa, the data-gathering period got underway. To acquire information, the researcher used digital voice and video recording, which we then transcribed into text. The researcher reached out to community gatekeepers via phone and digital web media to set up meetings and interviews with knowledgeable staff. Contacts for the above groups of participants were accessed through the assistance of the District Municipality. As such, telephones, text-based instant messaging systems such as WhatsApp, and video calling platforms such as Skype, Zoom, or Microsoft Teams were used to conduct the interviews. The use of video calling was favored over all other methods because it made it easier for the researcher and participants to interact with one another to decipher non-verbal signs, which added dimension to the interview. Additionally, it improved the data collection process across wide geographical areas, especially in the absence of social distancing techniques (Greeff, 2020).

Throughout the study, online platforms were used in place of face-to-face interviews and focus group discussions. Online host software makes it possible for people all over the world to have a conversation at their leisure without ever having to meet in person (Rodham & Gavin, 2006). Important interviewees included members of the public. Councilors and community leaders were contacted to refer potential participants for the study because of their positions as gatekeepers. Issues of connectivity, online accessibility, and data costs were considered when switching to online means of data collection. According to Jowett (2020), any technological solution to a lockdown must take into account ethical factors like confidentiality, health, and well-being of participants, and social desirability of interviews.

To address the safety of participants and the researcher, and to ensure that the data collection process was not compromised, the quality of the online platform connection was addressed by discussing with service providers to ensure that the technical quality was guaranteed in the best way possible. This included ensuring that the quality does not compromise the ability of the researcher to read body language and facial expressions during interviews and discussions. Confidentiality was addressed by saving the data in the researcher's data storage facility and deleting all data from public platforms.

The transcripts of all in-depth conversations and interviews were recorded as advocated by Greeff (2020). There was a risk of not being able to interview some participants who did not have access to video call facilities. However, arrangements were made to secure facilities for them. All the above arrangements were conducted very strictly, as it was part of ensuring research rigor and contributing to the trustworthiness, reliability, and credibility of data and research findings. The above methods aligned with the COVID-19 regulations for social distancing were covered in the participant information sheet and informed consent letter, including any risks associated with online meeting platforms, which the researcher was not able to mitigate. Where the consenting process was conducted online, the process was recorded to ensure there is a record of the participant's consenting. This has included recording the consent form and signing with witnesses (Greeff 2020). The objectives of the study were utilized to develop and inform the questionnaire for data collection purposes. The interviewees were allowed to share their thoughts and feelings using a mixture of open-ended and closed questions.

Supplementing the collected data with information from scholarly journals and government documents was done. Information for the study was gathered from a variety of sources, including online journals, government documents, and online publications. By triangulating with data from interviews, document analysis bolstered the study's validity and reliability.

4.13 QUESTIONNAIRE

The study employed a semi-structured questionnaire divided into four parts. The first section of the questionnaire asked participants basic demographic questions about themselves, such as their age, gender, level of education, occupation, marital status, number of children, and household size. Subsequent questions asked respondents to rate the importance of various factors in ensuring sustainable water security on a Likert scale or provide a yes/no answer to gauge their level of agreement or disagreement. The Likert-scale responses underwent factor analysis using the Statistical Package for the Social Sciences (SPSS) to remove unreliable data and identify interrelated variables among a wide range of variables. Several other questions were formulated to evaluate water security and, once answered, could provide essential data for constructing a trustworthy water security profile. The survey was disseminated online to respondents residing across the Bojanala District. The data gathered from their responses was then consolidated and analyzed. To gather information pertinent to the objectives of the study, a total of 384 questionnaires were disseminated online to respondents. These questionnaires were completed by the respondents to provide the required data. According to the results of the study, there was a 100% response rate throughout the entire study. Response rate is the proportion of potential participants who end up taking part in the survey or interview. Research questions were based on the researcher-created survey "Assessment of Sustainable Water Security in the Bojanala District in the North-West Province in South Africa" (Appendix I). There were four parts to the questionnaire:

Section (1) Household socio-economic characteristics;
Section (2) Water use and consumption;
Section (3) Water Sources and
Section (4) Water Governance, Compliance, Monitoring, and Evaluation

In a Likert-style format, the instrument provided a range of discrete choices for responses. During questionnaire development, the researcher consulted a statistical expert for advice on how to ensure that the data collected is reliable.

For this study, a questionnaire was developed and validated. It was decided to use experts in the field of Development Studies to validate the questionnaires used in this study. Professionals in the field reviewed the study's questions and questionnaire to ensure they were adequate and relevant. Once the questionnaire was confirmed to be accurate, it was pilot-tested on a small group of people (8) living in the study area. The purpose of this was to gauge the subject's level of comprehension, the questionnaire's likelihood of eliciting useful responses, and the importance of including additional items in any given section. Observations from the preliminary examination were incorporated into the final examination to refine the questions. Also, the researcher was able to understand the ambiguity of some items and make adjustments to bring them up to the questionnaire standard after conducting the pilot study. In other words, the researcher simplified their language to make their point. The questionnaires were given to the study's representative sample after they had undergone pilot testing and any necessary revisions. The questionnaire goes beyond a simple collection of questions or forms. A well-crafted questionnaire can be used as a reliable scientific tool for surveying large populations. A questionnaire is a type of research instrument that consists of questions and other types of prompts meant to elicit information from respondents (Kabir, 2016). If the questionnaire is well-designed, it will yield information that is straightforward to compile, tabulate, and analyze. Considering these benefits, it is easy to see why questionnaires are so widely used.

4.14 INTERVIEWS

The researcher conducted in-depth interviews with a total of 14 knowledgeable employees in the field to enhance the results obtained from the survey. The participants consisted of individuals from provincial and local governments as well as state-owned enterprises. Their perspectives and insights were collected through a questionnaire. To validate and reinforce the findings obtained from the questionnaire, the data from these participants were imported into ATLAS. ti, a software used for qualitative analysis. This qualitative analysis aimed to confirm and provide additional support for the views expressed by the participants in the questionnaire. With this in mind, scientists often raise the question of how many interviews should be conducted and considered in research.

Patton (2002) and Marshall, et al., (2013) suggest that a small sample size is inadequate, they did not provide empirical evidence to support this claim. On the other hand, Creswell (2013) proposes a minimum sample size ranging from 5 to 25, while Hagaman and Wutich (2017) argue that 16 or fewer interviews are sufficient. Due to the lack of consensus among scientists regarding sample size determination in qualitative studies, this research relied on the perspective put forth by Ryan and Bernard (2003). They assert that the significance lies not in the quantity or number of participants, but rather in the relevance of the data. The data collected from interviews were then categorized into different thematic groups based on perceived benefits. Sections of each organization concerned with water provided the information used to determine the total number of people interviewed. In this case, the sample size of 14 experts was sufficient for characterizing the relevant issue and answering the research questions. All members of the target groups were offered the chance to participate in the interviews by their respective organizations. Most of the officials who were questioned held managerial positions. These upper-level managers were experts in their fields and a wealth of data was gleaned from them. For instance, two (2) seniors informed personnel from the Department of Water & Sanitation (DWS) were interviewed; five (5) seniors informed personnel from the Department of Agriculture (sub-district) interviewed; two (2) seniors informed personnel from Magalies Water, and five (5) seniors informed personnel from the five (5) local municipalities within the Bojanala District were interviewed.

By conducting in-depth interviews with people from a wide range of professional backgrounds, researchers can learn about the experiences and perspectives of people who have dealt with the phenomenon of interest from a variety of angles. The people interviewed were well-informed experts who provided a plethora of data useful for achieving the aims of the study. Interviews are a great way to get to know people and learn about their thoughts and opinions on a topic (Grey, 2014). This approach was deemed appropriate for the study because it allowed the researcher to collect detailed information from the viewpoints of key informants on the topic of sustainable water security. The interview helped with the process of variable setup and provided answers to the study’s sub-questions in particular. Additionally, the researcher used interview data to help put the quantitative findings into perspective. To assess household sustainable water security in terms of socio-economic factors, the researcher developed and piloted an interview guide for key informants upon consenting. The reliability of results may be improved by conducting interviews with people holding different viewpoints (Rubin, & Rubin, 2005). The descriptive summary of key informants who were interviewed for the study is presented in the table below:

Table 4.2: **Number of key informants that were interviewed for the study**

Organizations	Rustenburg	Madibeng	Moses Kotane	Moretele	Kgetleng Rivier
Dept. of Water & Sanitation		2			
Dept. of Agriculture (Sub-district)	1	1	1	1	1
Magalies water	2				
Municipalities	1	1	1	1	1
Total	**4**	**4**	**2**	**2**	**2**

Source: Compiled by Author

4.15 FOCUS GROUP DISCUSSIONS

The researcher conducted focus group discussions to learn more about residents' perspectives, attitudes, and beliefs regarding the topic of sustainable water security in the study area. The research incorporated a total of fourteen (14) focus group discussions, following which data saturation was observed. Notably, the data collection process did not account for any margin of error. Knowing the reasons and motivations behind people's actions is impossible without first grasping the lens through which they view the world. Each focus group was guided by a list of questions compiled from the research questions. This provided the researcher with the opportunity to gain insight into the experiences of people with similar demographics. Participants in the focus group were led and guided by the researcher. The group's composition was determined by the study's overarching objectives. Quality data could not have been gathered without everyone's full engagement in group discussions. Discussions were held in an informal setting so that all participants felt comfortable speaking their minds. Focus group discussions were informed by various participants, namely: community representatives, decision-makers, water officials, local business forums, and government employees.

For each local municipality, a focus group discussion comprised six (6) to twelve (12) participants. The number of groups that were organized depended on when the saturation point was reached in the respective local municipalities. In the process of gathering knowledge, saturation occurs “when no fresh or relevant information comes to the newly created hypothesis” (Given & Saumure, 2008: 197). Therefore, the researcher does not intend to conduct any further data collection. Focus group discussion was used to collect anecdotal evidence, which was gleaned from participants’ actual experiences and perspectives. All of the primary information came from tape recordings, handwritten notes, and the observations of the participants. The researcher accounted for the length of the meetings based on the difficulty of the subject under study. According to Nyumba et al. (2018), participants are more likely to become fatigued during longer discussions. The rule of thumb is 1–2 hr. Therefore, each session of the focus group lasted from 60 to 90 minutes. For the focus group, an interview guide was created and used. ATLAS ti was used for the analysis, and the data were organized using a thematic structure. To better understand people’s perspectives on sustainable water security, the researcher primarily used focus groups. A look into how they think about sustainable water security was provided by their responses. They helped determine how safe the water supply was in the area under investigation.

When researchers need to hear a variety of perspectives on a topic and gain insight into the implications of those perspectives, focus groups can be extremely fruitful. Several recent studies (Harisha & Padmavathy, 2013; Mfune, 2013; Wibeck, 2011) support this theory. According to Lewis (2000), this style of interviewing yields a more complete picture of the topic at hand and can serve as a starting point for more comprehensive research. It is clear from the findings of the study by Nyumba et al. (2018) that focus group discussion is a versatile method that can be adapted at any point during the research process. It’s a great chance to delve into questions that haven’t been thoroughly investigated before. Krueger (1994) recommends using a homogenous group because, in his view, valuable data can only be obtained when all group members participate actively in the debate.

Krueger (1994) argues that researchers should recruit people who are representative of the target population in terms of age, gender, race/ethnicity, and socio-economic status. By recruiting a representative sample, researchers can increase the validity, reliability, and relevance of their findings while addressing important sociodemographic factors that may influence the research outcomes. Researchers generally agree with the concept of homogeneity but advocate for a blind sample to promote open and frank discussion and a diverse set of replies. A focus group discussion is a technique used by researchers to learn about a topic from the varied viewpoints and experiences of a group of people (Cornwall & Jewkes, 1995; Hayward, Simpson, & Wood, 2004; Israel, Schulz, Parker, & Becker, 2005). While focus groups have been used for quite some time as a standard method of data collection in fields like sociology and psychology, their popularity in the field of social science as a whole has recently been on the rise (Bennett, et al., 2017). The method's origins can be traced back to its function as a bridge between scientific research and conventional wisdom at the grassroots level (Cornwall & Jewkes, 1995). It is regarded as a "cost-effective" and "promising alternative" in participatory research (Morgan, 1996), providing a forum for opposing ideologies or worldviews (Guba & Lincoln, 1994). The purpose of this method is not to collect data from a random selection of people, but rather to learn more about a specific subset of the population.

4.16 OBSERVATIONS

In academic literature, definitions of observation are scarce. However, observation studies, according to Gorman and Clayton, "involve the systematic recording of observable phenomena or behavior in a natural setting" (2005: 40). Other authors define observation in terms of ethnography or, more narrowly, participant observation. But one thing that all of these definitions have in common is the emphasis on studying and comprehending human beings in their natural settings. Researchers can learn more about people and how they see the world by observing them in their natural habitat, as suggested by Baker (2006). Observation is used in the social sciences to learn about and understand various societies, institutional structures, and cultural norms (Kawulich, 2012). Observation is a key part of both quantitative and qualitative research designs. As a data collection method, observation is ubiquitous across all academic fields. It's a great method for gathering information in many settings, but it demands a sharp memory and careful note-taking.

Notwithstanding the above, to acquire direct experience and understanding of the phenomena in the field, in-depth interviews, and focus group discussions with households affected by water security were video recorded, transcribed, and analyzed in detail. Detailed notes were archived throughout the period and wide inquiries; questions were phrased in an open way to gain insight into what the various conversational participants thought before inadvertently narrowing down the options for questioning. A variety of materials were utilized to enhance sensual observations The observations were noted in a notebook and, when required, screenshots were captured to support the essential data gathered. The researcher used all of his capacities (including digital voice and video recording) to learn as much as he could about the phenomenon (Adler & Adler, 1994). Some authors have even gone so far as to call video recording an "instrumental extension of our senses" (see Collier and Collier, 1986).

4.17 DATA ANALYSIS STRATEGIES

Both the qualitative and quantitative data obtained were analyzed separately. The quantitative data were analyzed using descriptive statistics of SPSS Windows Version 25. This technique enabled data to be captured and analyzed and produced frequency tables and diagrams that ensured quick interpretations of the data obtained. The qualitative data obtained from interviews were analyzed using the thematic analysis technique. Thematic analysis technique was used to classify data into themes for interpretation and discussions. The research involved the researcher conducting interviews and recording information. The researcher took notes and recorded audio and video to compile their findings. In addition to audio-recording interviews, the researcher also took copious notes based on our observations at the time. While some indigenous tongues were utilized, English was the primary language of interaction. This was not a problem because the researcher was fluent in several of the languages spoken in the area. The information was then rendered into English. Transcribing the recordings word for word allowed for a more accurate analysis of the data. Rapid transcription was performed to determine whether or not the participants met the study's inclusion criteria and whether further questioning and clarification were necessary. Finally, the remaining analyses and data organization were completed so that conclusions could be drawn. The study's data collection and analysis were conducted using SPSS. SPSS is one of the most popular statistical analysis tools used (McCormick, Salcedo & Poh 2015:10). The purpose of the research was to look for statistical connections between the survey data and socio-economic variables.

Analyzing both numerical and anecdotal data is what mixed-method researchers do (Creswell & Plano Clark, 2007). However, the data were analyzed separately as this is a proper approach to take in explanatory mixed-method designs (Creswell & Plano Clarke, 2011). In other words, both the quantitative and qualitative methods used were, in general, appropriately reported individually. Furthermore, the data were analyzed according to the respective objectives of the study using SPSS version 25. For instance, for objectives one (1), two (2), and objective three (3), the study used descriptive statistics analysis. Mean, Frequency, Standard Deviation, Graphs, and Charts were used to present the results. Further, objective three (3) logit regression model was utilized to analyze the factors influencing sustainable water security among the households.

The Logit Model was utilized for dichotomous results of variables. The dependent variable is dichotomous – Households may be either water-secure or not.

In the Logit Model, the log odds of the result are displayed as a linear consolidation of the indicator factors. The logit function is determined as the inverse of the sigmoidal utilized in mathematics, especially in statistics. When the probability of p is represented by the function's parameter, the logit function provides the log odds or the logarithm of the odds $p/(1-p)$.

The logit of a number p between 0 and 1 is given by the formula:

$$\operatorname{logit}(p) = \log\left(\frac{p}{1-p}\right) = \log(p) - \log(1-p) = -\log\left(\frac{1}{p} - 1\right). \tag{4.1}$$

The "logistic" function of any number α is given by the inverse-logit:

$$\operatorname{logit}^{-1}(\alpha) = \frac{1}{1+\exp(-\alpha)} = \frac{\exp(\alpha)}{\exp(\alpha)+1} \tag{4.2}$$

If p is a likelihood, $p/(1-p)$ is the corresponding odds; the logit of the probability is the logarithm of the odds. Similarly, the distinction between the logit of two probabilities is the logarithm of the odds ratio (R), thus giving a shorthand for the accurate combination of odds ratios simply by adding and subtracting:

$$\log(R) = \log\left(\frac{p_1/(1-p_1)}{p_2/(1-p_2)}\right) = \log\left(\frac{p_1}{1-p_1}\right) - \log\left(\frac{p_2}{1-p_2}\right) = \operatorname{logit}(p_1) - \operatorname{logit}(p_2). \tag{4.3}$$

So assembling this, the key equation (usually termed the "multivariate logistic regression equation" or "multivariate logistic regression model") to which one fits the data is:

$$\log\left(\frac{p_i}{1-p_i}\right) = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \cdots + \beta_p X_{ip} \tag{4.4}$$

where Pi is the likelihood that Y_i is 1. $P_i/(1-P_i)$ is referred to as the "odds". In the analysis, the function is projected with the maximum probability technique, and Y = 1 when a household is water-secure; and Y = 0, when a household is not water-secure. The table below presents the independent variables to be considered in the study.

Table 4.3: Variable labels and their expected effects

Independent variables	Variable label	Expected effect
X_1	Number of dependents per household (continuous)	Positive
X_2	Age (continuous)	Negative
X_3	Monthly revenue of household (continuous)	Positive
X_4	Participate in water programs (yes = 1, no = 0)	Positive
X_5	Level of education (continuous)	Positive
X_6	Distance to the water point (continuous)	Positive
X_7	Do you have a commercial business that uses water? (yes = 1, no = 0)	Positive
X_8	Do you have your own tap? (yes = 1, no = 0)	Positive
X_9	Do you own a borehole? (yes=1, no=0)	Positive
X_{10}	Gender (male = 1, female = 0)	Positive
X_{11}	Does the household have transport to fetch water? (yes = 1, no = 0)	Positive
X_{12}	Do you sell water as a source of income? (yes = 1, no = 0)	Positive
X_{13}	Do you have water management skills? (yes = 1, no = 0)	Positive
X_{14}	Is the water quality good? (yes = 1, no = 0)	Positive
X_{15}	Are there any water committees? (yes = 1, no = 0)	Positive
X_{16}	Water awareness (yes=1, no=0)	Positive
X_{17}	How often do you have access to water? (continuous)	Positive
X_{18}	Do you store water? (yes = 1, no = 0)	Positive
X_{19}	Are you employed (yes = 1, no = 0?	Positive
X_{20}	The main source of water (1= Municipal; 0= otherwise)	Positive

Dependent Variable

Sustainable water security = Y= Frequency of water supply (Never; occasionally; Often; Always).

Y=0 (Never + occasionally) = Not water secured

Y=1 (Often + Always) = Water secured

A thematic analysis of the responses to the open-ended questions in the home survey, as well as the interviews with key informants, focus group sessions, and direct observations, allowed us to achieve the fourth objective. The application of thematic analysis allowed for the detection, investigation, and reporting of recurring themes or patterns within the data. The strengths of thematic analysis include their flexibility, suitability to a pragmatic framework, ease of use, academic acceptability, and ability to highlight similarities and differences between different data sets (Braun & Clarke, 2006). It is a flexible descriptive technique that uses as little information as possible and integrates well with various approaches to data analysis (Castleberry & Nolen, 2018:808). Because of its flexibility in answering a wide range of research questions, thematic analysis has become a popular data analysis tool for use with all types of qualitative research designs. Also, it is a technique for analyzing qualitative data that involves observing patterns across several data sets and reporting those findings (Kiger & Varpio, 2020:847). This strategy can find meaningful patterns in a dataset that provides an answer to the research topic at hand (Du Plessis 2017). It involves interpretation when choosing codes and developing themes and is used to give context to data. Studies employing this technique are ultimately labeled qualitative research, omitting specifics about how the data was distilled into themes and conclusions (Castleberry & Nolen, 2018:808).

4.18 CONCERN FOR VALIDITY AND RELIABILITY

To guarantee the reliability and validity of the study, several measures were taken. A pilot study was conducted to ensure the validity and reliability of the survey questions. By conducting a trial run, the researcher evaluated the survey's suitability for its intended purpose. According to Saunders et al. (2003), the pre-testing of a survey can help eliminate issues with the survey's length and time commitment. In addition, data from surveys and interviews with key informants were taken into account to provide alternative explanations when necessary during the analysis process. This approach is vital, especially when working in the direction of hypothetical legitimacy as well as to guard against researchers' prejudice. Concerning the reliability of the study, questions were posed precisely as they appear in the questionnaire without paraphrasing. Information gathered was double-checked against alternative potential sources and in this manner, the level of quality and exactness of data was improved. According to Morse et al. (2002), research loses its value, becomes fiction, and has no practical use when its rigor is lacking. Research rigor, as defined by the author, is a measure of how effectively the study's technique and design come together to solve the study's stated problems. In contrast, Davies and Dodd (2002) argue that rigor is the research's quality and trustworthiness and that this notion has a quantitative bias. The precautions to prevent the spread of the COVID-19 virus through social distancing and no face-to-face meetings have affected the original plans to have face-to-face in-depth interviews and focus group discussions. The application of online meeting platforms has enabled virtual in-depth interviews and focus group discussions, where the technology made it possible for the researcher to interact and be able to read facial expressions, and the meeting is taped for replay and transcription. It is not anticipated that the online platform could compromise the rigor of the research. The reliability of the online platform was secured.

4.19 ETHICAL CONSIDERATIONS

According to Weisner (2005), research ethics is a set of ethical values that offer principles, guidelines, and behavioral assumptions regarding the most exact conduct. To prevent scientific misconduct, ethics provides a researcher with guidelines on moral conduct. Insofar as research ethics are concerned, the research has adhered to the University of South Africa (UNISA) standards, and the process has been standardized and made uniform for all participants. The University of South Africa's Research and Ethics Committee provided its approval for this study to proceed. Official letters were communicated with concerned institutions after acquiring institutional consent. Permission to collect data was requested from and granted by Bojanala Platinum District Municipality.

The informed consent letter and participant information sheets were developed, outlining the rights of the participants and the obligations of the researcher. This is in line with the UNISA research ethics policies and procedures. Importantly, the participants were informed about the objective of the study, such that they operate from informed consent. Participation was voluntary, and the rights of the households not to participate were reserved and respected especially since participation was voluntary, and at any time should they choose to withdraw from participating during the interview they were allowed to do so. Participants were assured of their anonymity such that there was no violation of privacy. Thus, the respondents' identities remained concealed even if they chose to identify themselves on the surveys. Besides, participants were assured that the information they provided during data collection was treated with respect and confidentially. The risk of exposure of the participants and research to the COVID-19 virus was fully addressed by applying the University of South Africa COVID-19 Guidelines. The guidelines prescribe telephone and/or online platform interaction with human participants and Online quantitative research for surveys (Meyiwa, 2020). These methods suit the data collection for the in-depth interviews and focus group discussions, through online platforms and the online questionnaire survey.

4.20 CONCLUSION

In conclusion, this study adopted a pragmatic paradigm and utilized a mixed-methods sequential explanatory design to investigate sustainable water security among households. The chosen paradigm guided the research process and aligned with the use of both quantitative and qualitative methods to gain a comprehensive understanding of the research topic. The research design involved collecting and analyzing quantitative data first, followed by qualitative data to provide further explanation and depth to the quantitative findings. Stratified and simple random sampling techniques were employed to ensure the sample represents the target population and enhances the research's external validity. Qualitative data analysis focused on interpreting textual or non-numerical data from interviews, focus groups, and observations using thematic analysis. Quantitative data analysis involves statistical analysis of numerical data obtained through household questionnaire surveys, examining relationships between variables. Quantitative and qualitative data were analyzed separately using appropriate techniques. For instance, descriptive statistics were applied to the quantitative data, while thematic analysis was used for the qualitative data. The analysis allowed for a comprehensive understanding of sustainable water security in the study area. The integration of qualitative and quantitative findings through triangulation strengthened the research's validity and reliability. The study employed a sample size of 384 participants selected from a total population of 611,145 individuals in the Bojanala District. The sample size was determined using the Krejcie and Morgan model, taking into account factors such as available resources, time constraints, and desired confidence level and margin of error. The selected sample was representative of the larger population, allowing for the generalizability of findings to the target population.

Ethical guidelines were followed throughout the research process to ensure participant consent, confidentiality, and respect for their rights and welfare. The study employed a combination of primary and secondary data sources to investigate sustainable water security. Non-contact interviews were conducted using online platforms due to the COVID-19 pandemic, ensuring the safety of participants and the researcher. A semi-structured questionnaire was used to collect data on various aspects of water security, and in-depth interviews were conducted with knowledgeable participants to gain qualitative insights. The data collected from both sources were analyzed using qualitative and quantitative methods, allowing for a comprehensive analysis of sustainable water security in the Bojanala District. The integration of primary and secondary data sources, along with adherence to ethical guidelines, enhanced the validity and reliability of the study findings. Likewise, this study utilized focus group discussions as a method to gather insights into residents' perspectives on sustainable water security. Fourteen focus group discussions were conducted, guided by research objectives and including participants from various backgrounds. The discussions provided valuable anecdotal evidence and allowed participants to express their thoughts openly. The following chapter presents data analysis and interpretation of the results obtained from the questionnaire, interviews, focus group discussions, and observations conducted among all the local municipalities and key stakeholders in the Bojanala region.

CHAPTER FIVE
FINDINGS AND ANALYSIS

5.1 INTRODUCTION

In the prior chapter, an exhaustive examination was conducted, encompassing the contextual characterization of the description of the study area, classification of research paradigms, the paradigm underpinning this study, methodological considerations, research design, integration of qualitative and quantitative data, sampling technique, sample size, and study population, data collection instrument, questionnaires, interviews, focus group discussions, observations, data analysis strategies, concern for validity and reliability, and ethical considerations. The ensuing chapter elucidates the data analysis and provides interpretations of findings sourced from questionnaires, interviews, focus group dialogues, and observations directed at all the local municipalities and principal stakeholders within the Bojanala district.

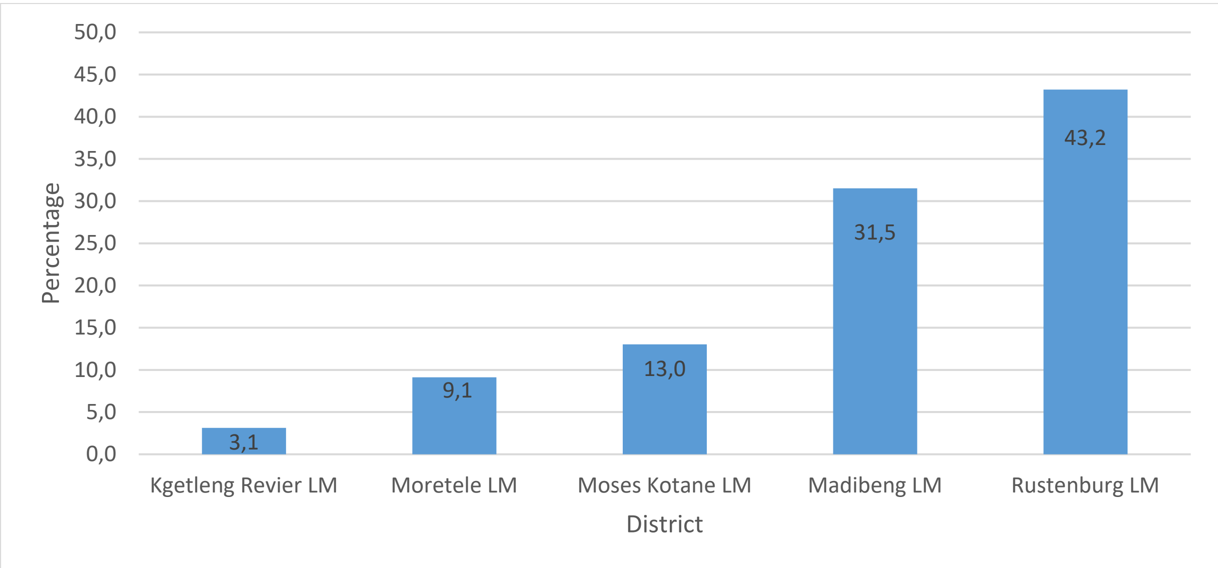
5.2 DESCRIPTIVE STATISTICS

This section of the study discusses the descriptive statistics of the household's socio-economic characteristics.

5.2.1 Descriptive statistics of household socio-economic characteristics

This subsection presents the results of the household socio-economic characteristics from 384 respondents who participated. The socio-economic characteristics are presented using charts.

Figure 5.1: Local municipality



According to Figure 5.1, out of 384 respondents that participated, the majority (43.2%) of the participants were from the Rustenburg Local Municipality, followed by 31.5% of participants from Madibeng Local Municipality and the least were from Kgetleng Revier Local Municipality with a proportion of 3.1%. The representation of participants from different Local Municipalities provides a more comprehensive picture of the perceptions, experiences, and practices related to water security in these areas. Studies often leverage such diversity to better understand water-related issues from a holistic perspective (Biswas, 2004). The variation in participant numbers across municipalities may reflect underlying socioeconomic disparities. For instance, each municipality may face different challenges regarding water quality, and these challenges may be influenced by a range of factors including local water sources, infrastructure, and local water management practices (Ntengwe, 2004). Rustenburg, as the municipality with the highest proportion of participants, might have different characteristics, such as higher population density, economic activity, or infrastructure development compared to the other municipalities. Exploring these differences in socioeconomic factors can contribute to a more nuanced understanding of the study results. Many studies have pointed to differences in demographics and socioeconomic position as the primary causes of disparities in the availability of safe drinking water (Andres, et al., 2018; Pullan, et al., 2014). Both demographics and socio-economic development have been identified as factors that influence the sustainable provision of water (Zawahri, 2017).

5.2.1.1 Head of household

Of the 384 respondents that participated in the study, the majority (52.9%) of the participants were not heads of households, while 47.1% held the position of head of household. This distribution has important implications for water security, as the role of household heads in water management and decision-making is critical. The concentration of participants in the head of the household category signifies a significant portion of the population with direct influence over water usage and conservation measures. Household heads often play a central role in determining water usage patterns, resource allocation, and decision-making related to water security within their households. As such, their awareness, knowledge, and attitudes toward sustainable water practices are vital for achieving sustainable water security objectives. Furthermore, recognizing the significant proportion of participants who are not heads of households is also crucial for water security initiatives. While they may not have direct decision-making authority, their actions and attitudes toward water use can still impact overall water security. According to a study conducted by the United Nations Development Programme (UNDP) in 2017, women-headed households were more likely to face water scarcity than male-headed households.

The study also found that women-headed households had less access to safe drinking water sources and sanitation facilities. This often leads them to resort to unsafe water sources that can cause illness and disease. Moreover, they have limited financial resources which makes it difficult for them to purchase or install water storage tanks or other equipment that can help improve their water security. The household head plays a critical role in ensuring water security within the home. The link between household heads and water security is evident in various studies (Alemu et al., 2018; Shahzad et al., 2020; Mekonnen & Hoekstra, 2016) that have shown how gender, income levels, education, and climate change affect access to safe drinking water. Women-led homes are particularly vulnerable due to societal expectations that limit their mobility outside of the home while increasing their workload inside it. Overall, policymakers and stakeholders need to recognize the crucial role of household heads in achieving sustainable water security for all members of society. By recognizing the influence of household heads and engaging all individuals within households, we can work towards achieving sustainable water practices and enhancing water security. Additionally, by promoting a culture of sustainable water use and management, we can ensure the availability and accessibility of clean water for present and future generations, thus contributing to long-term water security

Figure 5.2: Age group

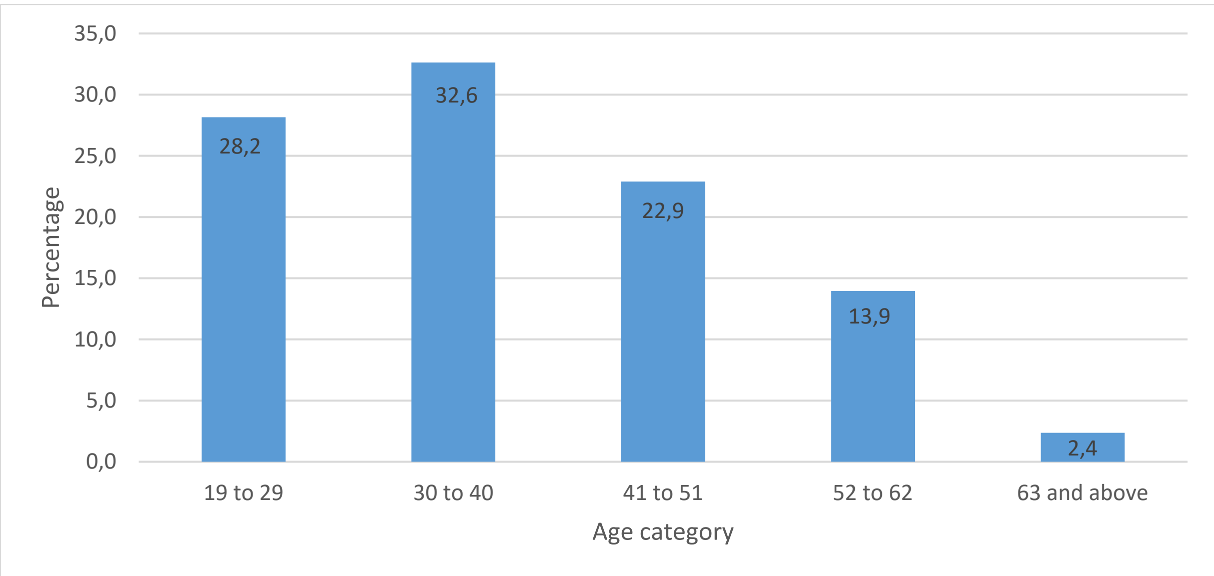


Figure 5.2 shows that from the 384 respondents that participated in the study, the majority (32.6%) of them fall within the age range of 30 to 40 years, followed by 28.2% belonging to the age group of 19 to 29 years. In contrast, the least represented age group is those who are at least 63 years old, comprising only 2.4% of the sample. These age disparities have significant implications for water security, considering the diverse water needs and behaviors associated with different age groups. The age distribution of participants is relevant to understanding water consumption patterns and the potential challenges that different age groups may face in terms of water security. The concentration of participants in the 30 to 40 years age range indicates a potentially significant demographic with greater responsibilities and household needs. This age group often consists of individuals who have established families and households, which may translate to higher water demands. The dominance of those in the 30-40 years age group can be linked to the global trend of high water demand among established households, as this demographic typically includes people who have families and are homeowners (Fielding et al., 2012). They often require more water for domestic use, including cooking, cleaning, and maintaining hygiene, especially in households with children (Syme et al., 2004).

Participants within the age range of 19-29 years (28.2%) are also significant. This demographic, typically composed of younger adults, might have different attitudes and practices toward water use and conservation. Some studies indicate that younger adults tend to be more conscious of environmental issues, including water conservation (Tam, 2013). The limited representation (2.4%) of the 63+ age group in the study aligns with the fact that older populations often face unique challenges related to water security. Age-related factors such as health conditions, mobility limitations, and financial constraints can influence their ability to access and manage water resources (WaterAid, 2018). For instance, older adults may have unique water-related needs, including potential health concerns and increased reliance on water for daily activities. Ensuring access to clean and safe water for this demographic is crucial for maintaining their well-being

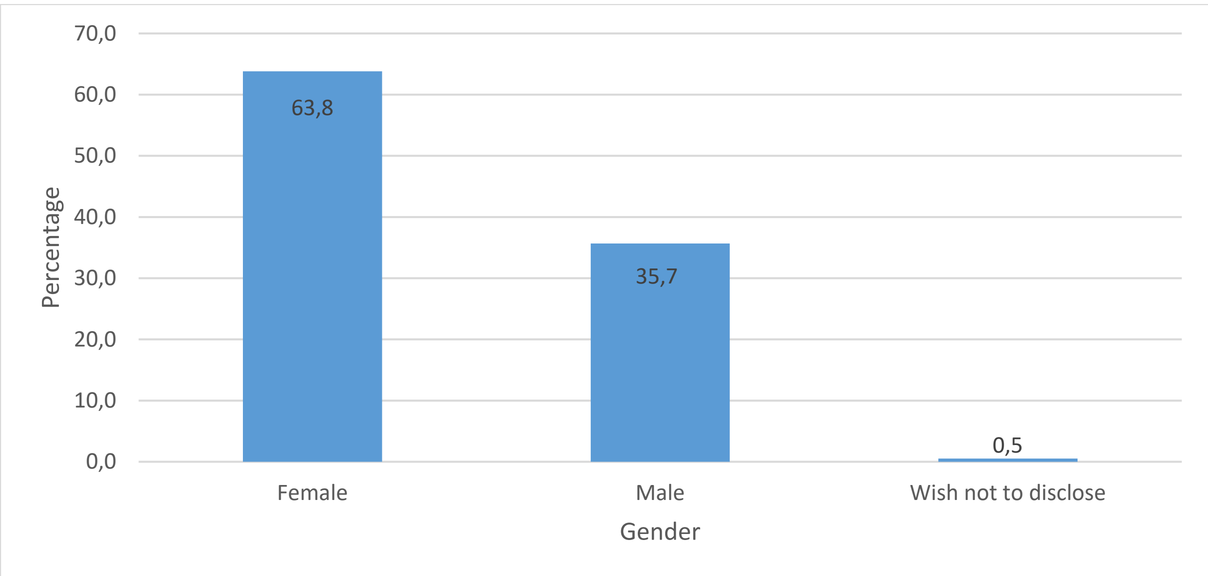
Age is one of the demographic factors that can impact water security since older adults are more vulnerable to water scarcity and contamination (Morrow-Almeida et al., 2011). Even though the elderly are more water-aware than children, who typically use it for play, Balling, Gober, and Jones (2008) and Schleich and Hillenbrand (2009) found that the elderly still consume more water than younger generations because they spend more time indoors. Gondo and Kolawole found that people's ages were a significant factor in whether or not their homes had reliable access to clean water in the long term (2019). Numerous studies appear to suggest that increased water security can be achieved by better distributing older people within households (Schleich & Hillenbrand, 2009; Kenney et al., 2008; Musolesi & Nosvelli, 2007). The elderly and those living in low-income households in rural southern Africa are disproportionately affected by the water crisis, according to some reports (Mudau, 2016; Geere, et al., 2010; Majuru, 2015). Other studies have confirmed that older household heads have the necessary experience and expertise to handle communal water issues and challenges (Sinyolo, 2013). The age distribution of participants in this study provides valuable insights into the demographic factors influencing water security. By understanding the water-related needs, behaviors, and challenges associated with different age groups, policymakers and stakeholders can develop targeted interventions to promote sustainable water practices and ensure long-term water security for all age demographics. This entails addressing the specific concerns and requirements of each age group through educational campaigns, technological advancements, infrastructure development, and policy measures. A holistic approach that accounts for the diverse age-related factors will contribute to a more resilient and sustainable water future.

5.2.1.2 State of employment

The findings presented in the study provide insights into the employment status of the participants and its implications for water security. Out of the 384 respondents, the majority (54.9%) indicated that they are employed, while 45.1% reported that they are not employed. This distribution highlights the potential influence of employment status on water security, as access to reliable income can significantly impact an individual's ability to meet their water needs. Employment status is closely linked to income and financial stability, which are critical factors in ensuring water security. Individuals who are employed generally have a more consistent and reliable income, making it easier to afford clean water and access water services. On the other hand, individuals who are not employed may face financial constraints and challenges in accessing and affording sufficient quantities of clean water. It is important to recognize that employment status is not the sole determinant of water security. Other factors, such as income level, household size, and geographical location, can also influence an individual's ability to access and manage water resources effectively. A comprehensive approach to water security should consider the intersectionality of these factors and tailor interventions accordingly.

The relationship between the state of employment and water security has been examined by scholars who have highlighted the importance of this link. One study by Kukandakwe et al. (2020) focused on the impact of water scarcity on informal sector employment in Uganda. They found that limited access to water resources had negative effects on the productivity and profitability of small businesses, leading to job losses and reduced income levels. This demonstrates how water scarcity can directly affect the state of employment in certain sectors. Employment has a significant impact on sustainable water security. Oskam et al. (2021) provide support for the findings of the study by pointing out that employed people are more likely to have the financial resources to have water delivered to their homes, whereas unemployed people may have more time to gather water. This finding lends credence to the findings of the study. Because of this, the amount of time that working people have available to find and use a clean water source is reduced. Angoua et al. (2018) found that households in which all adults worked were less likely to perform household chores, which reduced the availability of sustainable water sources and thus supported this conclusion. This is a speculative defense that needs to be investigated further. Additional research is required to test the plausibility of this explanation. In other words, the link between employment and water security is a complex issue that requires careful consideration. Therefore, policymakers and stakeholders must consider both economic and environmental factors when making decisions regarding water management policies. By doing so, we can ensure a more sustainable future for both employment and water resources.

Figure 5.3: Gender



The study findings reveal that gender dynamics significantly influence water security. The gender distribution among participants in this study highlights the need for gender-responsive approaches to water management and resource allocation. This gender disparity has important implications for water security, as gender dynamics play a significant role in shaping water-related challenges and opportunities The predominance of female participants in this study highlights the importance of recognizing and addressing the specific water security challenges faced by women. Additionally, recognizing the diverse roles and experiences of men in water security is also important. Engaging men in discussions on gender equality and water security can help challenge existing norms and promote more equitable sharing of responsibilities and decision-making power. It is crucial to address the needs of individuals who choose not to disclose their gender as well. Respecting individuals' choices and ensuring their full participation and inclusion in water security initiatives is essential for achieving equitable and sustainable outcomes. By recognizing and addressing the specific challenges faced by different genders, policymakers, water managers, and stakeholders can ensure equitable access to clean water, improve livelihoods, and contribute to the overall well-being of communities.

Only a handful of studies have looked into whether or not the availability of water varies depending on a person's gender. According to the findings from Bisung and Elliott's (2018) investigation, households that are headed by women are statistically less likely to have dependable access to clean water. Women consume more water than men do because, according to Makki et al. (2003), they are the ones who typically take care of the water needs of the household. Men tend to be the breadwinners in the household. However, research conducted specifically on men and women has shown that both sexes are negatively affected by a dearth of clean water sources for drinking (Al-Delaimy, et al., 2014; Atalabi, et al., 2016; Holvoet, et al., 2016; Akombi, et al., 2017; Barker, et al., 2018). It has also been established that gender plays an important role in determining whether or not a family has access to clean drinking water (Jordán-Cuebas et al., 2018; Joshi, 2020; Fielding, Russell, Spinks, & Mankad, 2012). These studies were conducted by Jordán-Cuebas et al., 2018, Joshi, 2020, and Fielding, Russell, Spinks, and Mankad. For instance, the research conducted by Weng and Nitivattananon (2007) found that women in Malaysian households play a central role in water management and have a significant impact on efforts to conserve water. This finding was based on the observation that women tend to be more knowledgeable about water issues than men.

In addition, the majority (63.8%) of the people who participated in the study were single women, and these women reported that they had a significant amount of work to do because they did not have a male household member. Because of this burden, people are unable to focus on their development and the pursuit of employment that fulfills them to their satisfaction. Girls and women in today's society have a shorter amount of time compared to women and girls in previous generations to engage in enjoyable activities such as resting and relaxing or to provide valuable services such as caring for children and the elderly. According to Graham et al. (2016), the act of traveling to and collecting water from water source locations puts women and girls at a high risk of experiencing both physical and psychological stress, as well as acts of gender-based violence. This risk is compounded by the fact that women and girls are more likely to be victims of such acts. Academics have paid a great deal of attention to the topic of women in leadership roles in the water industry (Buechler & Hanson, 2015; Nguyen, et al., 2019), and for good reason. Even though the case studies in this literature cover such a wide range of topics, a common thread that runs through all of them is that women are the ones who take care of the water requirements of their families.

Recent successful studies have also linked insufficient access to clean water in the home to mental health problems like depression and anxiety (Brewis, et al., 2019; Miller, et al., 2021). Because more women than men in the area under study are responsible for water or housework-related responsibilities, women have a higher risk of experiencing mental health problems than men do. According to the findings of Subbaraman, et al., (2015), a lack of water security in India is linked to women's distress. This distress is caused by unfinished housework, strained relationships with family members, domestic conflicts over water, compromised community cohesion, and resentment toward household water activities. Other factors that contribute to this distress include a compromised community's ability to remain cohesive. In a similar vein, Workman and Ureksoy (2017) link women's mental health issues to dirty water, a lack of access to clean water, and poor hygiene practices.

Figure 5.4: Marital status

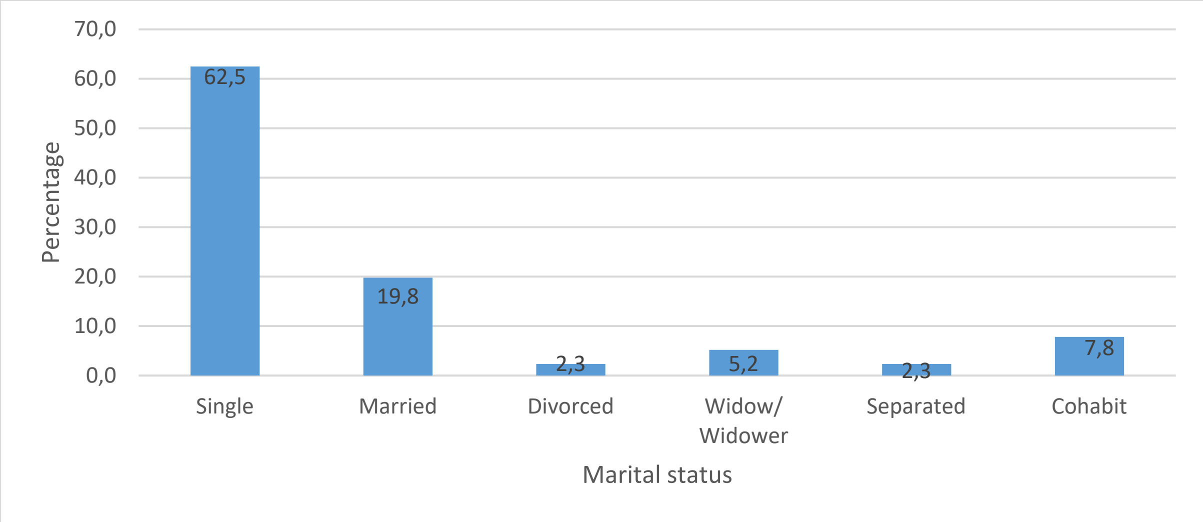
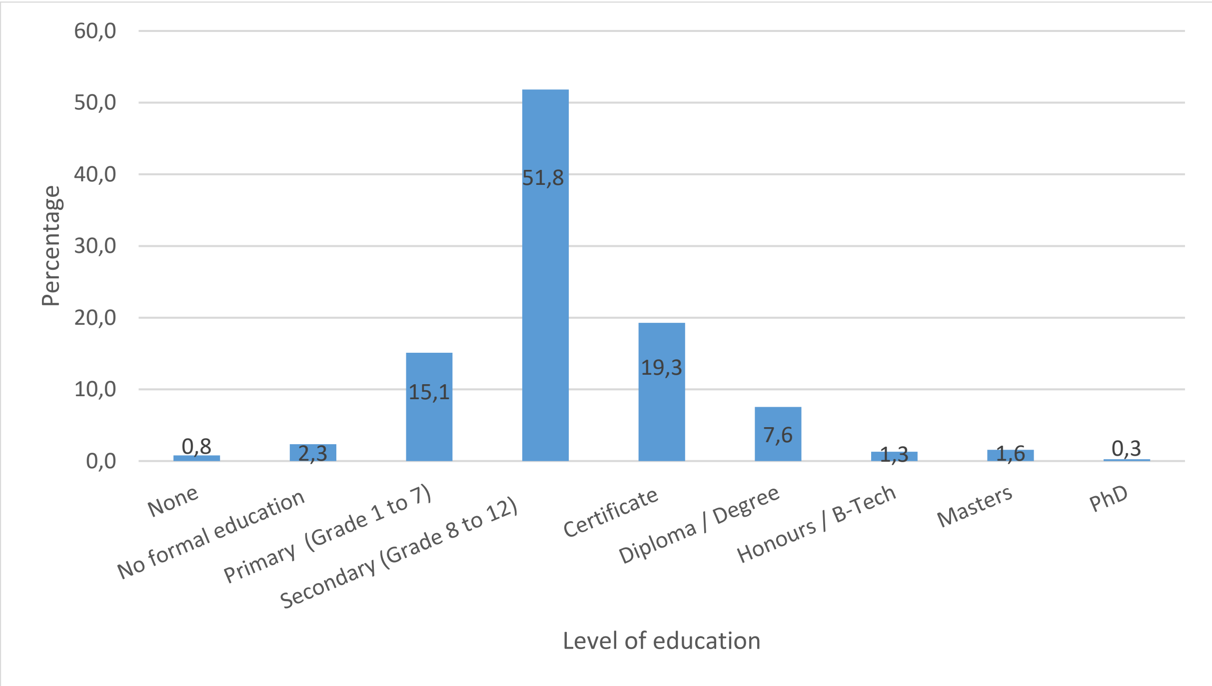


Figure 5.4 above reveals the marital status distribution among the 384 participants who took part in this study, with the majority (62.5%) identifying themselves as single. This is followed by 19.8% of the participants who reported being married, while the least represented categories are divorced and separated, each accounting for 2.3% of the sample. Marital status can influence water usage patterns and the corresponding water security challenges. Considering the predominance of single individuals in the participant pool, it is crucial to address the water needs and behaviors of this demographic. However, it is important not to overlook the water security implications for married individuals and those who are divorced or separated. Water management strategies should account for the diverse needs and circumstances of these groups. In the case of divorced or separated individuals, water security considerations may extend to issues of water access and affordability. Those living alone may face challenges in meeting their water needs, while individuals living with children may require additional support to ensure an adequate water supply for their households. To ensure comprehensive water security, policymakers, water resource managers, and relevant stakeholders should consider the varying water usage patterns and needs associated with different marital statuses.

According to Irianti et al. (2016), a household in which the head of household is married is more likely to have access to improved water sources than a household in which the head of household is a single person who has never been married. Irianti et al. (2016) concluded that the frequency with which a household moved was inversely related to the degree of water insecurity that the household experienced. As a consequence of this, it was found that married households are more secure and less likely to move. On the other hand, Adams et al. (2015) investigated the factors that affect water access in Ghana and found that married households are less likely to be water-secure than those who have never been married. As such, by recognizing the relationship between marital status and water security, society can develop inclusive and effective approaches that cater to the diverse needs of individuals and households. Through collaborative efforts and holistic water management strategies, we can safeguard water resources, promote sustainable water practices, and ensure a secure water future for all.

Figure 5.5: Level of education



The findings of this study also highlight the educational distribution among the participants, with the majority (51.8%) holding secondary education (Grades 8 to 12) as their highest level of education. This is followed by 19.3% of participants who possess a certificate qualification, and another notable proportion with primary education (Grades 1 to 7). However, the least represented qualification level among the participants is a doctoral degree, accounting for only 0.3% of the sample. These educational disparities have important implications for water security. The concentration of participants with secondary education as their highest qualification suggests that a significant proportion of the population possesses a moderate level of formal education. This provides a basis for promoting water security through targeted educational initiatives, such as awareness campaigns, workshops, and educational programs that focus on sustainable water practices.

By engaging individuals with secondary education, it is possible to disseminate information and foster behavior changes that contribute to the preservation and responsible use of water resources. However, it is important to acknowledge the lower representation of participants with higher education qualifications, particularly at the doctoral level. Individuals with advanced educational degrees often possess specialized knowledge and skills that can significantly contribute to addressing complex water-related challenges. Their expertise can play a crucial role in water resource management, research, policy development, and innovation in sustainable water technologies. Encouraging participation and inclusion of individuals with higher education qualifications in water security initiatives can harness their potential and expertise to address pressing water challenges effectively.

According to Adams, et al. (2016), families headed by educated people were more likely to have reliable access to clean water. This assertion contradicts the findings of Salman, Al-Karablieh, and Haddadin (2008), who found that educational attainment had no bearing on the water use habits of individuals within a home. However, there is evidence that suggests that a person's quality of life improves in conjunction with their educational attainment (Abu-Bakar, et al., 2021; Babel, Gupta, & Pradhan, 2007; Nauges & Whittington, 2010). For instance, Gondo, et al., (2020) proclaim that a person's level of education impacts whether or not they have access to better water. It follows that someone with a low education level has fewer options and less leverage to advocate for better facilities and services from the government (Gondo & Kolawole, 2020). The findings of the study suggest that respondents' education level has the potential to increase water access and provide sustainable water security in the study area. Corroborating these findings, Adams et al. (2016) found that families with at least some education were significantly more likely to have reliable access to clean drinking water than those with less education. The study postulated, based on the preceding data, that a high level of household education positively affects sustainable water security.

Figure 5.6: The total number of dependents in a household

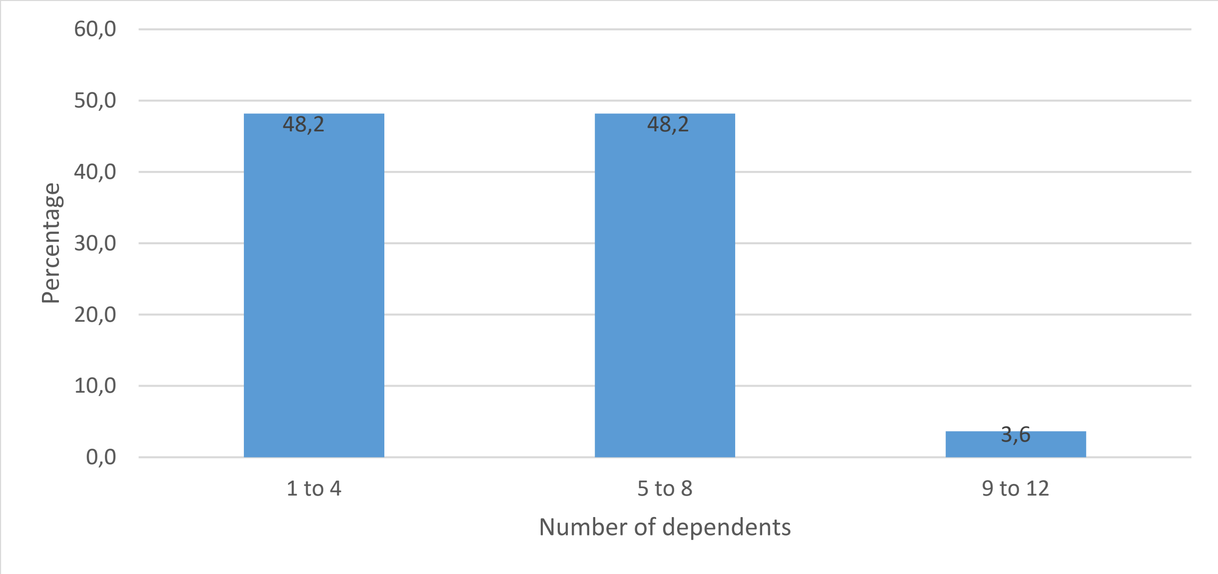
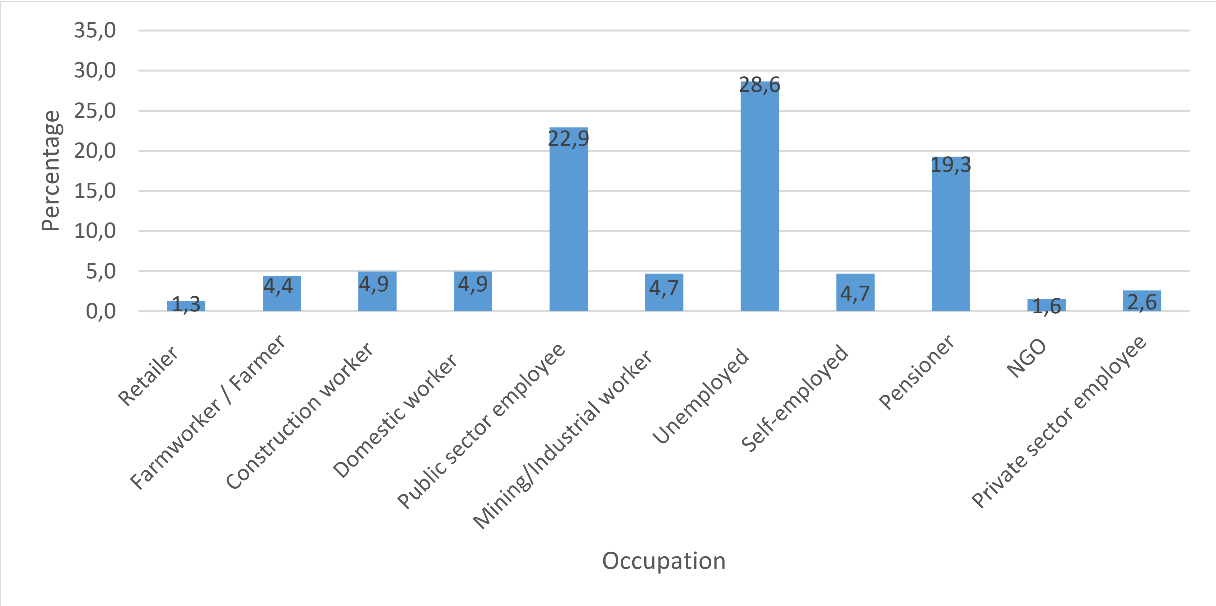


Figure 5.6 depicts the majority (48.2%) of the 384 respondents who participated in the study have either 1 to 4 or 5 to 8 dependents. The variation in family size has important implications for water security The concentration of participants in the 1 to 4 dependents and 5 to 8 dependents categories suggests that a considerable portion of the population falls within family sizes that require significant water usage. The lowest proportion (3.6%) of the participants have 9 to 12 dependents. While this category represents a smaller portion of the overall population, it may still have significant implications for water security. Larger families with 9 to 12 dependents likely have higher water demands, necessitating more extensive water infrastructure and management strategies to ensure sufficient supply and distribution. In the majority of instances, the number of people who reside in a household has a significant influence on how reliably they have access to clean water over the long term (Sharaunga & Mudhara, 2020).

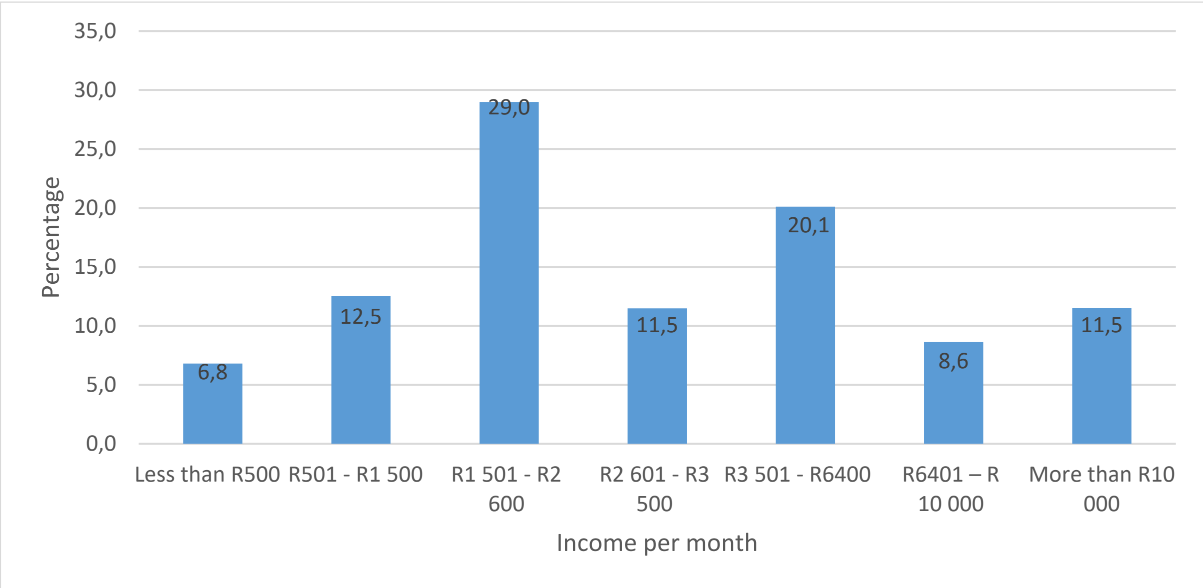
Dolnicar et al. (2012) concur that the size of a person's household is an essential factor in gaining an understanding of domestic water management. According to the findings of several different studies, the ability of a household to keep a steady supply of drinkable water increases in direct correlation with the number of people living in the home (Schleich & Hillenbrand, 2009; Hoffmann et al., 2006; Arbues, et al., 2004). The findings of this study add to the growing body of evidence suggesting that families with more members each have higher individual water needs (Dotse, 2016). However, earlier research conducted by Arouna and Dabbert (2010) suggested that larger households may have a labor advantage when collecting water from shared faucets, particularly in rural areas. By recognizing the relationship between family size, and water security, stakeholders can develop targeted strategies and policies that address the specific water needs and challenges faced by different households. This holistic approach to water resource management will help promote long-term water security while ensuring the well-being and livelihoods of individuals and families across various demographic groups. This was the case in both urban and rural settings. Based on these empirical findings, it is clear that we have a lot more to learn about how the size of a family affects access to clean water.

Figure 5.7: The main occupation of the head of the household



The findings presented in Figure 5.7 reveal that the majority (28.6%) of participants indicated that the head of the household is unemployed, followed by 22.9% who reported that the head of the household is employed in the public sector, and 19.3% stated that the households are pensioners. Retailers represent the smallest proportion, accounting for only 1.3% of the participants. These employment patterns are important factors to consider when examining access to water resources, affordability, and overall water security. The high percentage of participants indicating that the head of the household is unemployed (28.6%) highlights the vulnerability of these households. Unemployment often correlates with limited financial resources, making it more difficult to meet basic needs, including water requirements. These households may face difficulties in accessing safe and reliable water sources, leading to potential water insecurity. The presence of a significant proportion of participants reporting that the head of the household is employed in the public sector (22.9%) suggests a relatively stable income source. The proportion of households consisting of pensioners (19.3%) indicates a reliance on pension funds as a source of income. Given the typically limited nature of pension income, households in this category may face challenges in meeting their water needs, particularly if water prices are high or access to safe water sources is limited. It is worth noting the small proportion of participants representing households involved in retail businesses (1.3%). While this category may encompass a diverse range of incomes and economic circumstances, retail businesses often face uncertainties and challenges that can impact the financial stability of households, potentially affecting their ability to ensure water security. Mainly, the findings emphasize the significance of considering the employment status of the head of the household when addressing water security. The employment patterns observed among participants underscore the diverse financial circumstances and challenges faced by households in accessing and affording safe water.

Figure 5.8: Household income per month

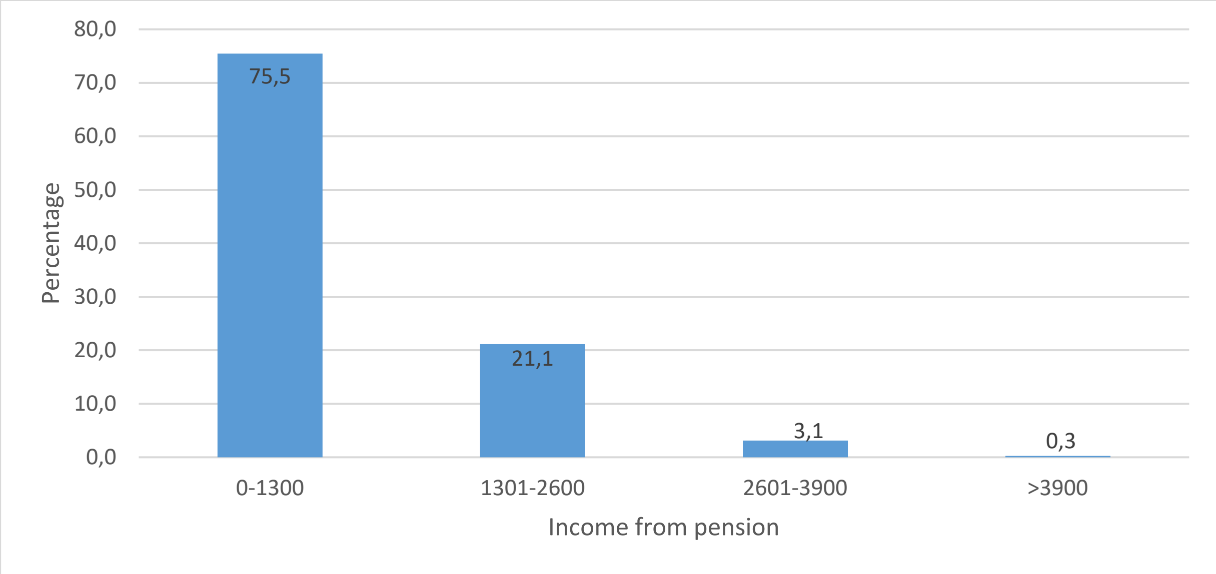


The findings presented in Figure 5.8 provide insights into the monthly household income distribution among the participants. According to the data, the majority of participants (29.0%) reported a monthly household income between R1 501 and R2 600, followed by 20.1% reporting a monthly income between R3 501 and R6 400. The least represented income group consisted of participants earning less than R500 per month, comprising only 6.8% of the sample. These findings shed light on the income disparities within the sample population and their potential implications for water security, emphasizing the role of income levels in accessing and affording water services. The high percentage of participants (29.0%) reporting a monthly household income between R1 501 and R2 600 suggests a significant portion of the sample population falls within a moderate income range. This income level may provide some financial stability and allow for basic needs to be met, including water-related expenses. However, it is important to note that this income bracket still falls within the lower to middle-income range, highlighting potential financial constraints and limited discretionary funds available for various household needs.

The substantial representation of participants (20.1%) reporting a monthly income between R3 501 and R6 400 indicates a higher income segment within the sample population. Individuals or households within this income bracket may have relatively better financial capacity to meet their daily needs, including water-related expenses. The small percentage of participants (6.8%) reporting a monthly income of less than R500 highlights a vulnerable segment of the population. Individuals or households within this income group face significant financial constraints and may be at higher risk of experiencing water insecurity. Affording basic water services and meeting other essential needs can be challenging, potentially leading to reduced access to clean and safe water, increased reliance on unimproved water sources, and compromised water-related hygiene and sanitation practices.

There is a significant disparity in monthly incomes, with the lowest amount being R500 and the highest amount being over R10,000. The food poverty line, which was established by Statistics South Africa in April 2018 at 582 ZAR/cap/month, the lower-bound poverty line, which was established at 785 ZAR/cap/month, and the upper-bound poverty line, which was established at 1183 ZAR/cap/month serve as the basis for our analysis (Statistics South Africa, 2018). According to the findings, a sizeable portion of the participants was surviving on less than the national poverty threshold (11.5% of them were above the line). The majority of homes in the study region cannot afford water-enhancement measures like yard taps and rainwater collection tanks due to their excessively high costs. Furthermore, the study finds that an increase in a household's monthly income may result in a corresponding rise in the household's water usage. This is because the family has sufficient resources to pay for the high cost of water used in activities like bathing, cooking, cleaning, and related pursuits. The findings here are in line with those of other studies (Arbues & Villanua, 2006; Gaudin, 2006; Gondo et al., 2020; Schleich & Hillenbrand, 2009). Following the foregoing, the study hypothesized that low household income would have a deleterious effect on sustainable water security.

Figure 5.9: Household income from pension



The findings presented in Figure 5.9 provide insights into the sources of household income among the participants, specifically focusing on income received from the pension. According to the data, the majority of participants (75.5%) reported that their household income of at most R1 300 is received from the pension, followed by 21.1% who reported income ranging from R1 301 to R2 600, also received from the pension. The least represented category consisted of participants whose household income of at least R3 900 was received from the pension, accounting for only 0.3% of the sample. These findings shed light on the significance of pension income as a primary source of household income and its implications for water security, emphasizing the economic dynamics and financial vulnerability of the participants. The high percentage of participants (75.5%) reporting that their household income of at most R1 300 is received from the pension reflects the reliance on pension payments as a vital source of financial support. Pensions are typically provided to retired individuals or senior citizens, serving as a form of social security and income replacement in their later years.

The reliance on pension income suggests that a significant portion of the participants are either retired or have reached an age where they are eligible for pension benefits. It highlights the financial vulnerability and limited income resources within the sample population. A significant proportion of participants (21.1%) reporting household income ranging from R1 301 to R2 600, also received from a pension, further illustrating the reliance on pensions as a primary income source. This category likely includes individuals or households with slightly higher pension amounts or additional supplementary benefits. However, even within this category, the income levels remain relatively low, indicating potential financial constraints and limited discretionary funds available for various expenses, including water-related costs. The small percentage of participants (0.3%) reporting a household income of at least R3 900 received from the pension suggests that only a few individuals or households receive relatively higher pension amounts. This group may have additional benefits or factors that contribute to the higher pension income, such as longer work histories or specific pension schemes. Nonetheless, the low representation of this category indicates that the majority of participants rely on lower pension amounts, potentially limiting their financial capacity to meet various needs, including water-related expenses.

Figure 5.10: Household income from grant

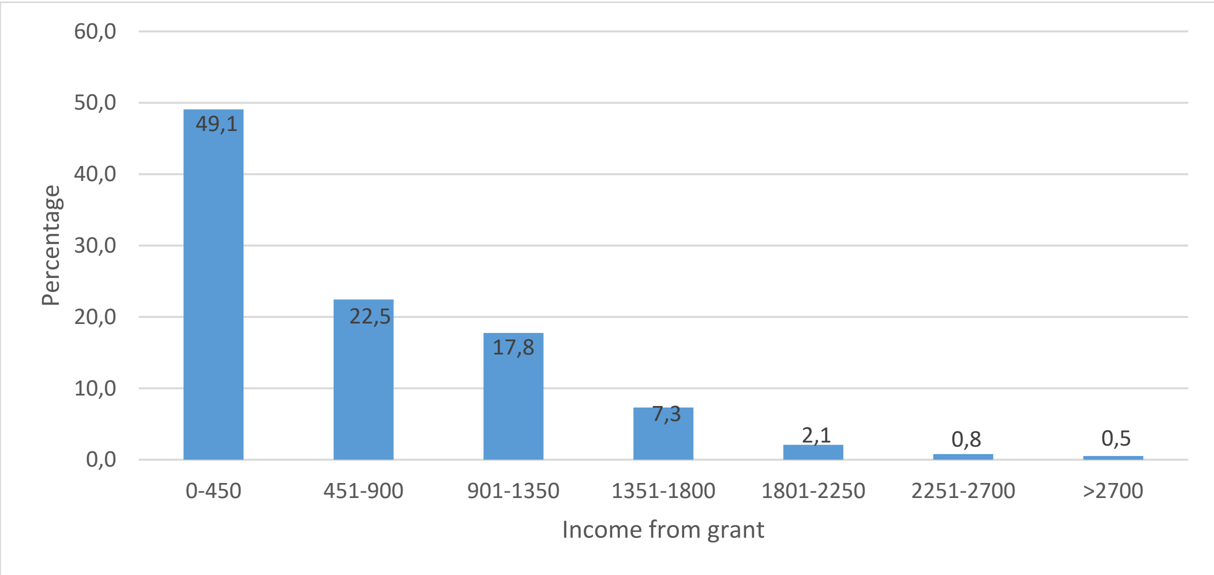


Figure 5.10 depicts that the majority (49.1%) of the participant's household income of at most R 450 is received from grants, followed by R451 to R900 of household income received from a pension with a proportion of 22.5%, and the least (0.5%) proportion of the household income of at least R2 700 received from grants.

Figure 5.11: Household income from salary

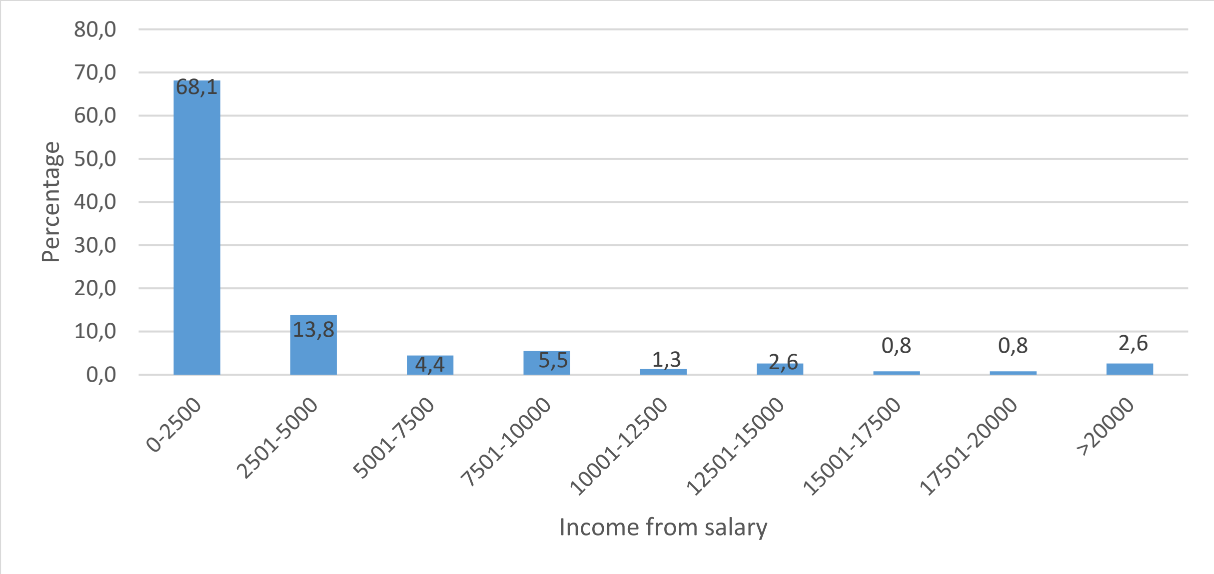


Figure 5.11 shows that the majority (68.1%) of the participant's household income of at most R2 500 is received from salaries, followed by 13.8% of the participant's household income of R2 501 to R5 000 received from salaries, and the least proportion of household income obtained from salaries of either R15 001 to R17 500 or R17 501 to R20 000 with a proportion of 0.8 each category.

Figure 5.12: Household income from investment

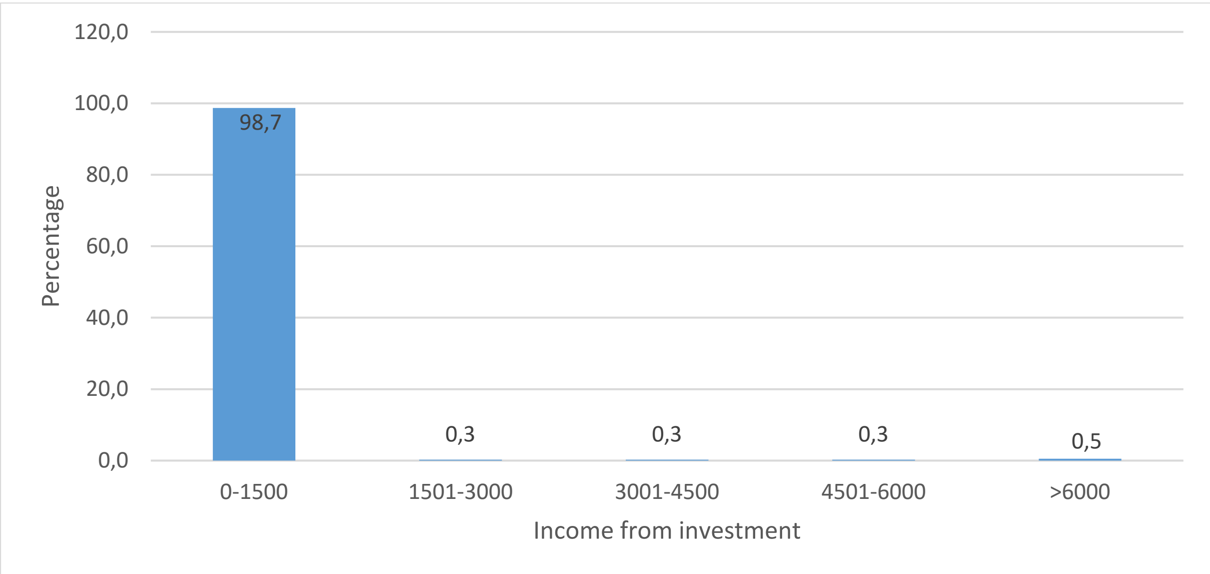


Figure 5.12 shows that the majority (98.7%) of the participants' household income of at most R1 500 is received from an investment, followed by at least R6 000 of household income received from investment with a proportion of 0.5%, and the small proportion of participants' household income of R1 501 to R3 000 or R3 001 to R4 500 or R4 501 to R6 000 is received from investment with an equal proportion of 0.3%.

Figure 5.13: Household income from remittance

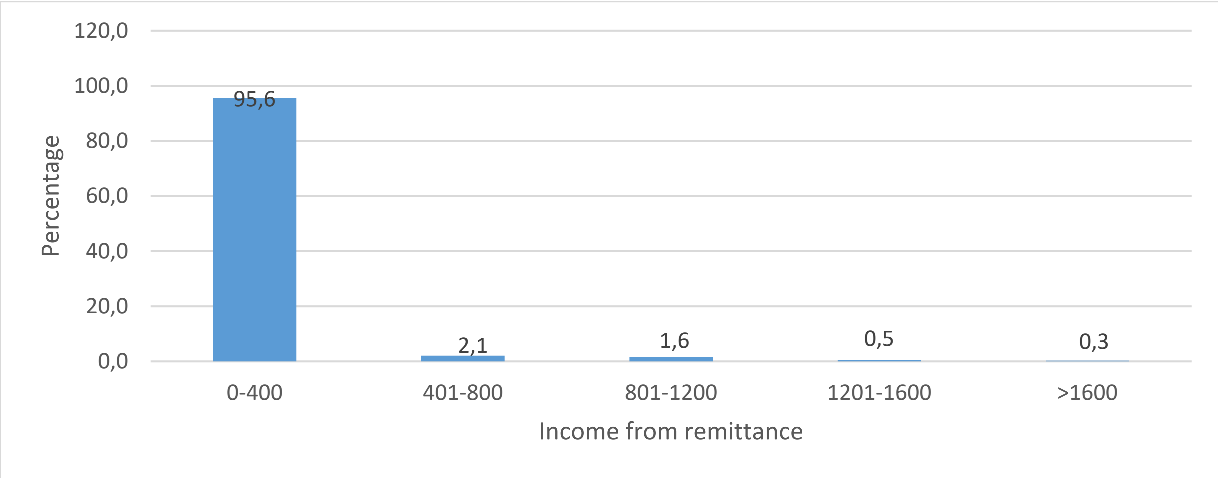


Figure 5.13 depicts that the majority (95.6%) of the participant's household income of at most R400 is received from remittance, followed by R401 to R800 of household income received from remittance with a proportion of 2.1% and the least (0.3%) proportion of the household income of at least R1 600 is received from the remittance.

5.2.1.3 Household income from the retailer

The findings from the 384 respondents provide insights into the sources of household income received from retailers among the participants. According to the data, the vast majority of participants (99.7%) indicated that they receive about R1 000 to R2 000 of their household income from retailers, while a very small percentage (0.3%) reported not receiving any income from retailers. These findings shed light on the significance of retailers as an income source for households and their link to water security, emphasizing the role of economic activities in supporting access to water and overall well-being. The high percentage of participants (99.7%) receiving household income from retailers suggests the importance of these economic activities in the community. This finding is supported by literature that recognizes the importance of the retail sector as a major source of livelihood, particularly in developing economies. For instance, Bhowmik (2005) discusses how informal retailing represents a significant proportion of urban employment in many developing countries, contributing to household income and thus potentially supporting basic needs like water services. Retailers may include various types of businesses, such as grocery stores, shops, or market vendors. The income generated from these activities can support households in meeting their basic needs, including water expenses.

The reliance on retailer income highlights the role of local economic activities in providing livelihood opportunities and contributing to the economic well-being of individuals and households. The small percentage of participants (0.3%) indicating no income from retailers suggests that a very limited number of participants do not derive any financial support from these economic activities. These individuals may rely on alternative sources of income or engage in non-retail activities for their livelihoods. Evidence of diversification of income sources as a strategy for livelihood security can be found in several studies. For example, Ellis (1998) discusses the importance of a diversified income portfolio in enhancing household resilience in the face of economic shocks. Understanding the dynamics of income sources is essential for assessing the economic resilience and stability of households, which in turn can have implications for their ability to access and afford water services.

Figure 5.14: Household income from piece jobs

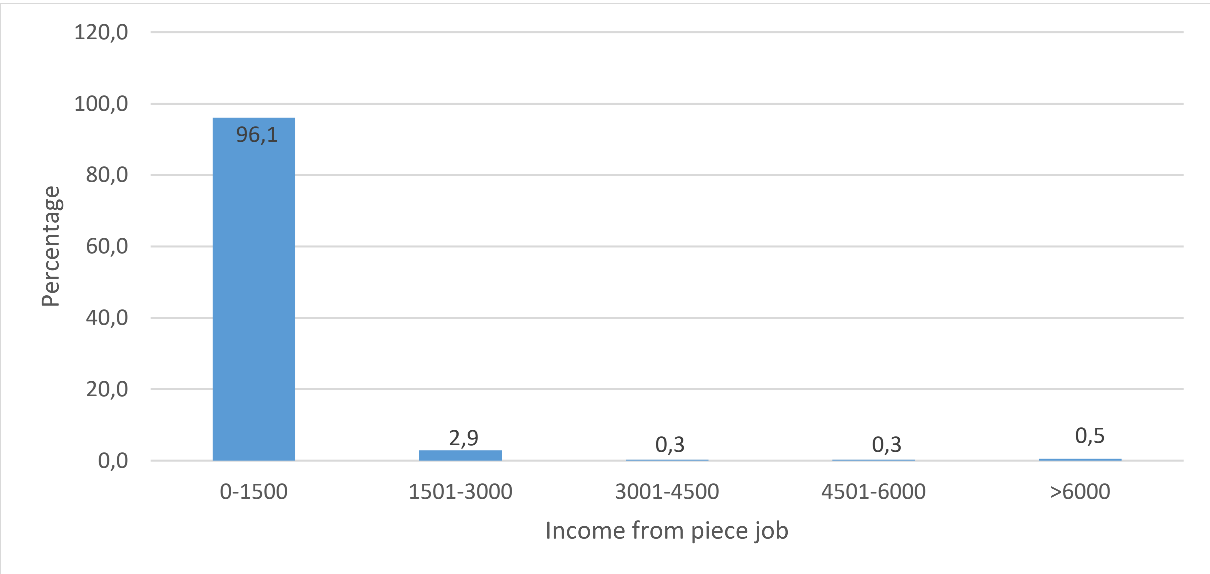


Figure 5.14 shows that the majority (96.1%) of the participant's household income of at most R1 500 is received from piece jobs, followed by R1 501 to R3 000 of household income received from piece jobs with a proportion of 2.9% and the least proportion of the household income of

R3 001 to R4 500 or R4 501 to R6 000 is received from piece jobs with an equal proportion of 0.3%.

Figure 5.15: Household income from other sources

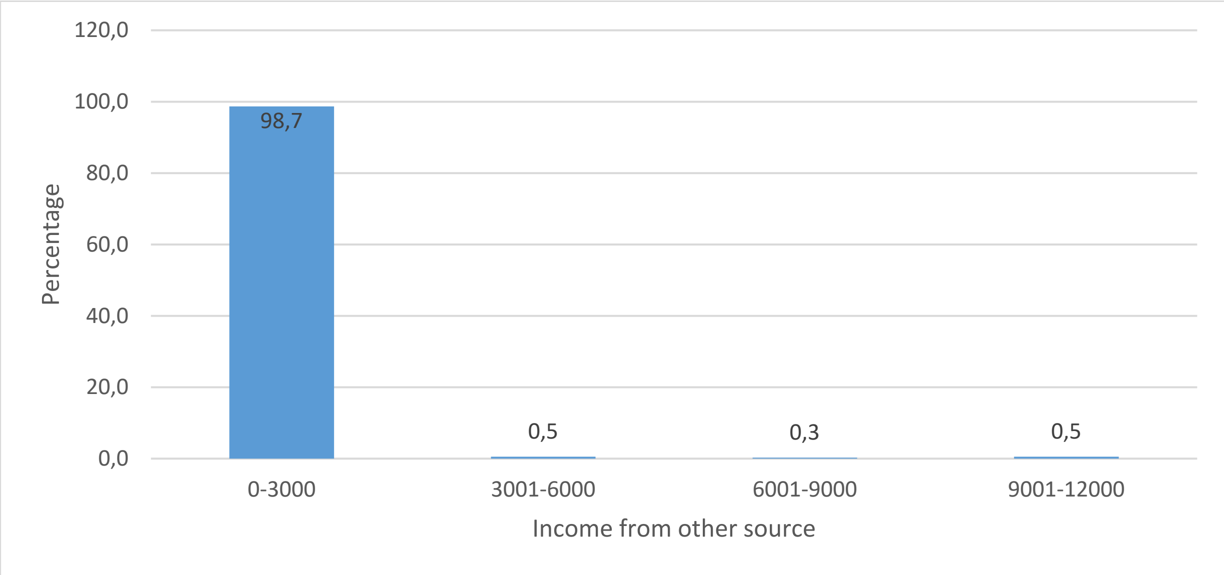


Figure 5.15 depicts that the majority (98.7%) of the participants' household income of at most R3 000 is received from other sources of income not specified and the least (0.3% proportion of the household income of R6 001 to R9 000 is received from other sources of income not specified.

5.2.2 Descriptive statistics of water use and consumption

This subsection presents the results of water use and consumption from 384 respondents who participated. The results are presented using the following tables and charts.

Table 5.1: Source of water

Source	No	Yes
River/canal	98.4%	1.6%
Public standpipe	22.1%	77.9%
Yard tap connected to municipal system / DWAF	52.9%	47.1%
Yard tap connected to the community system	92.7%	7.3%
Yard tap connected to a private borehole	91.9%	8.1%
In-house tap connected to municipal system / DWAF	83.1%	16.9%
A house tap connected to the private borehole	93.8%	6.3%
Rainwater	16.4%	83.6%

Source	No	Yes
Other	91.9%	8.1%
N= 384		

Table 5.1 above shows that, of the 384 respondents that participated in the study, 77.9% use public standpipes as their primary source of drinking water. Those surveyed believe they do not have access to water from a river or canal, a community system, a private borehole, or a municipal or DWAF-supplied tap in their backyard or at home. A yard tap requires a household to have enough money to hire a plumber for installation or labor. Natural water sources like rivers, streams, and springs were used by rural households without access to municipal services, contrary to the findings of Lebek et al. (2021). In addition, people living in areas with insufficient access to clean drinking water must rely on other, non-public supplies (Sakai, et al., 2018). Because of this, people in rural areas are forced to rely on alternative sources of water for their daily requirements, such as wells, ponds, springs, lakes, rivers, and rainwater harvesting. It is common practice to drink such water straight from the source (Rufener, et al., 2010). The use of water from such untreated sources poses a serious threat to public health (Edokpayi, et al., 2015). In contrast, participants often used public standpipes in the study area. This may be because the government of South Africa has set piped water as the bare minimum for the provision of safe drinking water (African Ministers' Council on Water, 2011).

It is also possible to conclude the significance of public standpipes in the study area, which provide residents with additional access to potable water. In theory, standpipes still play a significant role in the ongoing initiative to increase access to drinkable water. In addition, 93.8% of respondents said they do not use water from their home's taps that are connected to a private borehole, from rainwater, or any other unspecified source. The majority of respondents (72.4%), despite reporting ownership of a private tap, said they do not use that tap to obtain drinking water (taps ran dry). Elliott et al. (2019) and Kelly et al. (2018) suggest that households in rural communities in Zambia, Ghana, and Kenya frequently use multiple water sources to meet their daily water demands, with sources selected based on usage and often changing with the seasons. Many people use a variety of water sources to compensate for the unreliability of the main water supply. While this study shows that there are multiple water sources in the area, it does not guarantee that residents will have a constant flow of water from their taps.

Table 5.2: **General statement relating to the source of water**

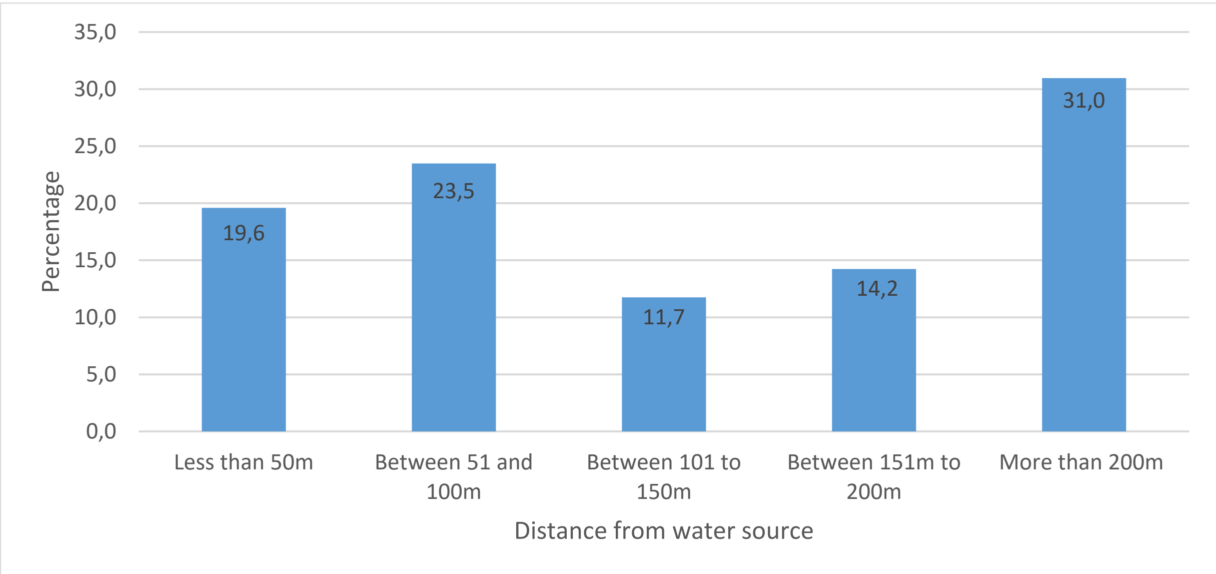
Statement	No	Yes
Own a private tap?	41.8%	58.2%
If yes, you get water from this tap	72.4%	27.6%
The public source provides sufficient water to cover the needs of the present population	89.6%	10.4%
This source is secured	75.8%	24.2%
There was a dispute or significant disagreement about the water source.	4.7%	95.3%
You pay something to your community organization/government for the operation and maintenance of the source	87.8%	12.2%
N= 384		

According to the results in Table 5.2, the majority (58.2%) of the participants indicated that they own a private tap and 72.4% of them indicated that they do not get water from the tap they own. Owning a private tap can enhance water security by providing direct access to safe and reliable water sources. Studies have shown that households with private taps are more likely to have improved access to clean drinking water compared to those relying on shared or public water sources (Bain et al., 2014). Private taps can offer convenience, reliability, and greater control over water availability, contributing to enhanced water security. The result further revealed that most (89.6%) of the participants indicated that the public source does not provide sufficient water to cover the needs of the present population and that the source is not secure. Insufficient water supply from public sources can significantly impact water security. When the available water resources cannot meet the demands of the present population, it can lead to inadequate access to clean and safe water for various purposes, including drinking, sanitation, and hygiene. Studies have shown that water scarcity and inadequate supply can result in water stress and negatively affect water security (United Nations, 2021).

The type of public source used by household members contributes to water security in one way or another. Most of the participants (95.3%) are of the view that there was a dispute or significant disagreement about the water source. Water-related disputes or disagreements appear to be on the rise. The growing severity of water-related conflicts in the region provides some insight into the underlying causes of the problem at hand as well as the scope of the problem itself. Water disputes and armed wars can arise under a wide range of conditions, as discussed by Gleick and Iceland (2018). Disputes and conflicts often arise as a result of increased water insecurity, in addition to other socio-economic factors. The nature of the disagreements, however, can be different in each instance. In some cases, the disputes come in the form of diminished water supply or diminished water quality, politically destabilizing, or increased water demand. These circumstances and other pathways produce conflicts or disputes, especially where governance or states are weak (Sadof et al., 2017).

The findings further revealed that the majority (87.8%) of the participants do not pay anything to their community organization/government for the operation and maintenance of the source. In this regard, Global Water Partnership (2006) postulates that if a system fulfills all people's needs, and if they have a strong stake in it, they will be more willing to pay for its establishment and upkeep. Anecdotal evidence from around the world shows that allowing for the productive use of water in domestic schemes makes men (and women) more willing to engage in maintenance. And, importantly, people are better able to pay if they can earn more income from their increased access to water. For instance, several experts have asserted that households who pay for water tend to be more water-secure than those who do not (Pinto et al., 2018; Dlamini, 2015; Kujinga et al., 2014). According to research conducted by the World Bank in 1993, the willingness of rural residents of developing nations to pay for water varies according to both income and the quality of the water available. In light of the foregoing, it is not clear that instituting a water pricing system would improve safety measures.

Figure 5.16:The distance from the water source at which water is being collected

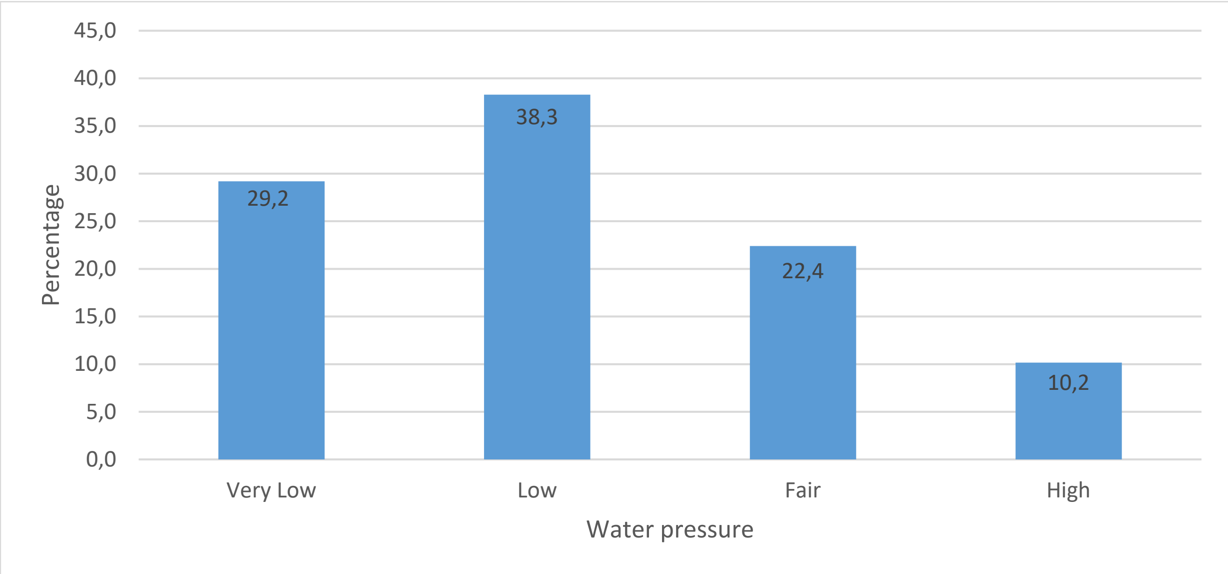


From the 384 respondents that participated, the majority (31.0%) of participants indicated that the water source is more than 200 meters from their homes and that the water pressure is low as presented in Figure 5.16. Furthermore, 23.5% of participants noted that there is a distance of approximately 51 to 100 meters between their homes and the water source, while 19.6% reported a distance of less than 50 meters. The smallest proportion (11.7%) of participants indicated a distance of 101 to 150 meters between their homes and the water source. The high percentage of participants who reported that the water source is more than 200 meters away from their homes (31.0%) suggests that a significant portion of the population may face challenges in accessing water. A greater distance between homes and water sources can lead to difficulties in transporting water, particularly for vulnerable individuals such as the elderly, disabled, or those with limited mobility. Additionally, low water pressure can further impede water accessibility and efficiency. The proportion of participants reporting shorter distances between their homes and the water source (less than 50 meters or approximately 51 to 100 meters) indicates relatively easier access to water. However, it is important to consider other factors, such as the reliability and quality of the water source, as well as the capacity of the infrastructure to deliver water consistently and with adequate pressure.

Corroborating this finding are Majuru et al. (2012) who observed that people living in rural South Africa may have to walk 600 meters or further to get to a water source (2012). Additionally, Mark, et al., (2019) reported that in sub-Saharan Africa, 29% of the population lacks access to clean and close water supplies, with women and girls bearing the brunt of water collection from remote regions. At the same time, Geere and Cortobius (2017) discovered that traveling long distances to fetch water poses a significant challenge to sustainable development and domestic water security. They conclude that the time it takes to collect water in rural areas is a major barrier to sustainable development and household water security, particularly for the poor (Greere & Cortobius, 2017). Pickering and Davis (2012) found the same outcomes, arguing that the time cost of water fetching has been hypothesized to affect the amount of water gathered by households. This means that homes close to the water source have a higher probability of withdrawing more water, while homes further from the source receive less water, resulting in a sense of water insecurity.

Similarly, Cairncross et al. (1987) found that people living in villages with insufficient access to clean water often only cooked once a day because they had to travel long distances to water. Additionally, households without access to reliable water sources or those located in areas with limited access to water sources may have difficulty engaging in economically and socially significant activities (Evans et al., 2013; Majuru, 2015) due to a lack of water. Therefore, it appears that little thought has been given to how people's ability to participate in productive and meaningful work is impacted by the time and effort required to go to and from distant water sources. For this reason, Hutchings et al. (2022) conclude that people are unable to participate in cultural and social activities due to the extensive distances they must travel to obtain water. As a result, this lowers one's chances of obtaining a diverse range of decent employment, particularly jobs that require precision and neatness in their performance. In this regard, the research project hypothesized, based on the evidence presented above, that the amount of time spent by households on water collection impact negatively on the ability to maintain sustainable water security.

Figure 5.17: Water pressure from the public or private water source



The findings presented in Figure 5.17 provide insights into the perceptions of participants regarding the water pressure from public or private water sources. According to the data, the majority of participants (38.3%) indicated that the water pressure is low, followed by 29.2% who indicated very low water pressure. A smaller percentage (10.2%) perceived the water pressure to be high. These findings shed light on the challenges related to water infrastructure and its impact on water security, emphasizing the importance of adequate water pressure for ensuring a reliable and efficient water supply. The high percentage of participants (38.3%) indicating low water pressure suggests a common issue faced by the community. The findings align with literature that discusses the impacts of poor water infrastructure and maintenance on water pressure (Biswas, 2004). Low water pressure can negatively impact various water-related activities, such as bathing, washing dishes, and doing laundry. It can result in slower flow rates and reduced water volume, causing inconvenience and inefficiency in water use. A significant proportion of participants (29.2%) perceived very low water pressure indicates a more severe problem in terms of water supply reliability and functionality. Very low water pressure can result in restricted access to water for essential domestic needs, leading to challenges in maintaining hygiene and sanitation standards. It may also limit the ability to carry out tasks that require an adequate flow of water, such as irrigation or certain industrial processes. Studies have shown that very low water pressure can limit access to water for essential needs and impact hygiene and sanitation standards (Cairncross et al., 1980).

This points toward the need for robust infrastructure and maintenance practices. The smaller percentage of participants (10.2%) perceiving high water pressure suggests that a minority of the community experiences a relatively stronger water flow from their water sources. The finding aligns with studies indicating that while high water pressure can be beneficial for certain uses, it can also lead to water waste and infrastructure damage (Beecher, 1996). Addressing low water pressure issues and ensuring sufficient and consistent water pressure is crucial for achieving water security. Investments in infrastructure upgrades, maintenance efforts, and efficient management practices are necessary to improve water pressure and enhance the reliability and availability of water supply. Collaborative efforts among stakeholders, including water service providers, policymakers, and communities, are essential for implementing strategies that address water pressure challenges and contribute to sustainable water security.

Figure 5.18: The status of the water supply infrastructure

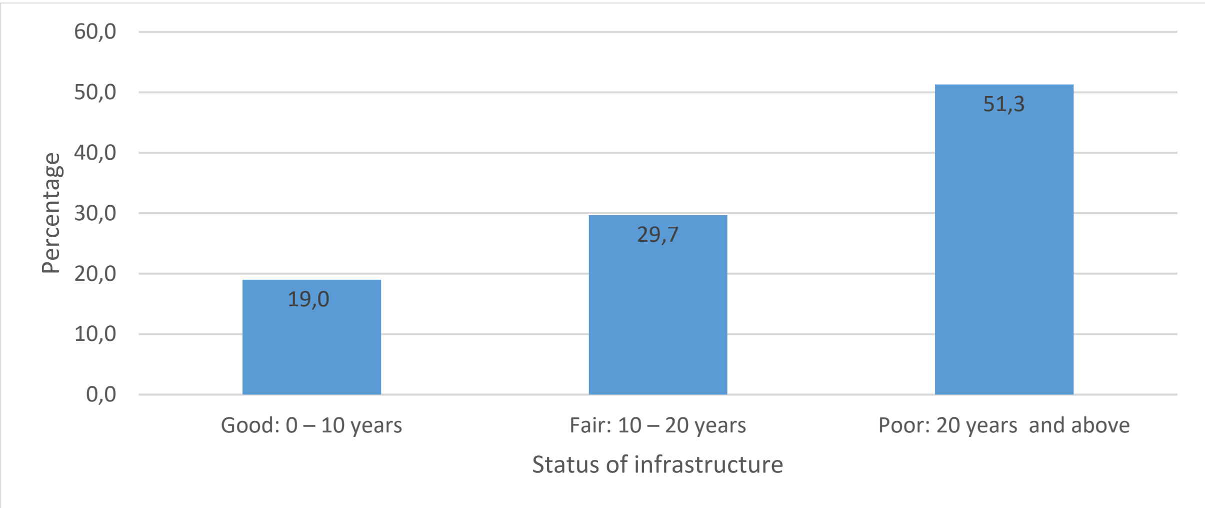


Figure 5.18 depicts that the majority (51.3%) of participants are of the view that the state of the water supply infrastructure is poor, while 29.7% perceive it as fair, and 19.0% perceive it as

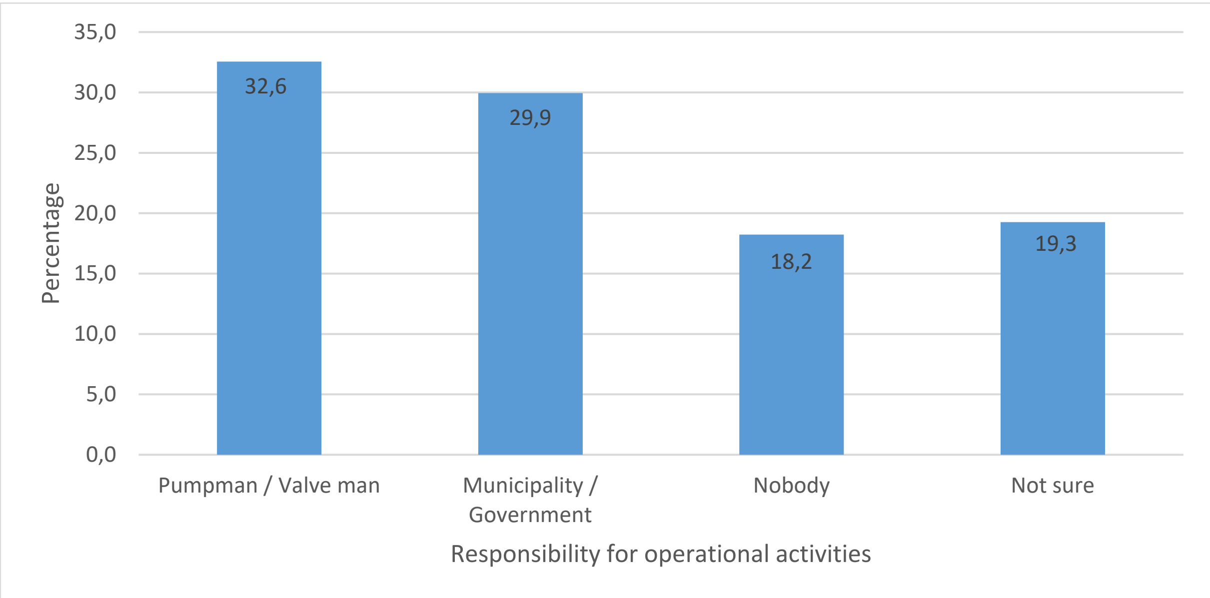
good. These perceptions are essential in understanding the current state of water security and can provide insights into the challenges faced by communities in accessing safe and reliable water. The perception that the state of the water supply infrastructure is poor among a significant proportion of participants (51.3%) indicates potential deficiencies or shortcomings in the water supply system. This perception may be driven by factors such as frequent water interruptions, low water pressure, inadequate infrastructure maintenance, or limited access to clean and reliable water sources.

The perception of a fair state of the water supply infrastructure reported by 29.7% of participants suggests a moderate level of satisfaction or acceptance of the current state of the water supply system. While it is not considered poor, this perception still indicates room for improvement and potential challenges that need to be addressed to enhance water security. The perception of a good state of the water supply infrastructure reported by 19.0% of participants indicates a relatively positive view of the water supply system. These participants may perceive the water supply infrastructure as well-maintained, with reliable water access and acceptable water quality. While this perception is positive, it is important to validate it with objective assessments and data to ensure that the infrastructure meets established standards and regulations for safe and reliable water provision.

The status of water supply infrastructure is a significant determinant of water security in any given region. Inadequate or poor-quality infrastructure can lead to challenges such as water scarcity, pollution, low reliability, and affordability issues, among others. Well-maintained and efficient infrastructure ensures a consistent and sufficient flow of water, minimizing interruptions and meeting the demands of various sectors, including domestic, industrial, and agricultural (Vairavamoorthy et al., 2012). The deteriorating state of the nation's water infrastructure is a major contributor to the shortage of drinkable water (Alcamo et al., 2000). Rephrased, this means that gaps in municipal water services and inadequate infrastructure are the root causes of water inequality. In support, Lebek, et al. (2019) maintain that when water infrastructure is developed slowly and poorly, it increases the likelihood of water conflicts and the misuse and vandalism of newly installed infrastructure, which can undermine efforts to improve water service delivery and sustainable water security. The poor state of water infrastructure calls for a reassessment (Colvin et al., (2016), otherwise, water security at the household level is threatened by deteriorating water infrastructure, especially in most rural communities.

Besides the poor state of water infrastructure, the lack of technical capacity and skills within the water sector, as well as a lack of transparency and citizen trust in water service delivery, pose the greatest threats to sustainable water security (Sershen et al., 2016). Previous case studies have also discussed the challenges of water scarcity and the absence of municipal water services in rural areas of South Africa. Poor operation and repair of water infrastructure, illegal yard connections, and the interference of political interests in water infrastructure development were determined in a case study conducted by Mothetha et al. (2013) in rural areas of Limpopo to be factors limiting municipal water service. As such, we can use the hydro-social cycle as a lens to examine the connections between water services, infrastructure conditions, and human intervention. Water and human society are constantly transforming and reforming one another in the hydro-social cycle (Linton & Budds, 2014). From the standpoint of the hydro-social cycle, new water infrastructure will reroute water in ways that will sustainably benefit some users at the expense of others. Our conclusion might not be universal, but we do think it's a step in the right direction and can be replicated and tested in similar contexts or circumstances.

Figure 5.19: Responsibility for the operational activities of the source

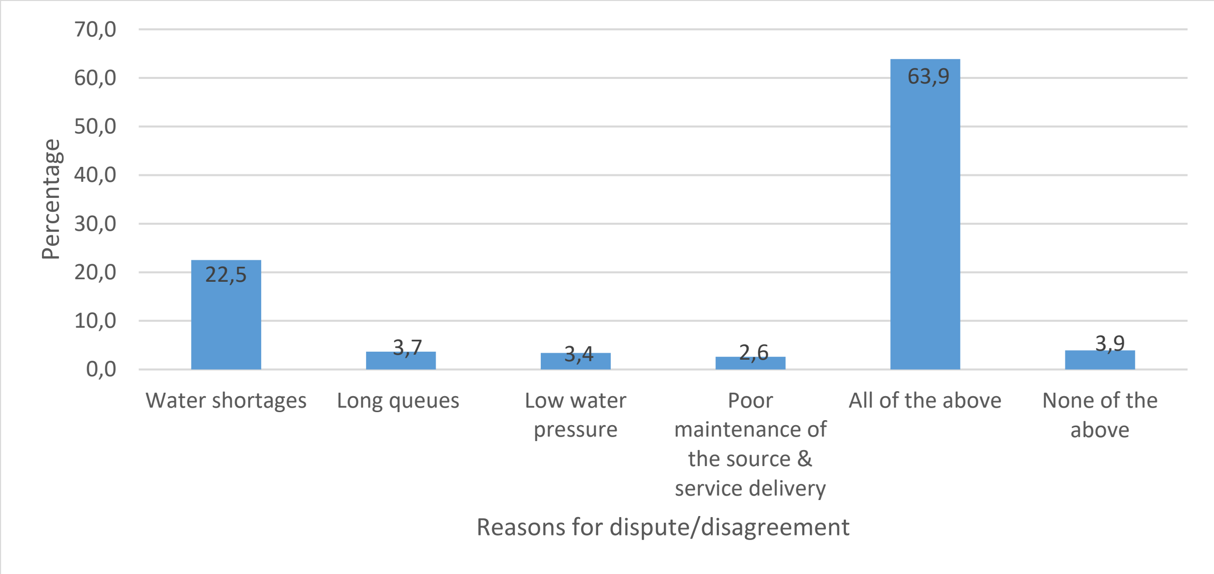


The findings presented in Figure 5.19 provide insights into the perceived responsibility for the operational activities of the water source among the participants. According to the data, of the 384 respondents that participated, the majority (32.6%) of them identified the pumpman/valve man as responsible for the operational activities of the source, followed by 29.9% who indicated the municipality/government and the smallest proportion (18.2%) reported that there is no one responsible for the operational activities of the source. These perceptions of responsibility for water source operations have implications for water security and the efficient management of water resources. The identification of the pumpman/valve man as the responsible party for operational activities by the majority of participants suggests a localized and decentralized approach to water source management. This perception reflects the involvement of individuals directly responsible for operating and maintaining the water source infrastructure at the community level.

The recognition of the municipality/government as responsible for operational activities by a significant proportion of participants (29.9%) highlights the role of institutional bodies in water management. Municipalities and government agencies often have the mandate and resources to oversee water infrastructure and ensure the provision of safe and reliable water services to communities. Their involvement in operational activities is crucial for effective water management, resource allocation, and infrastructure maintenance. The perception that there is no one responsible for the operational activities of the water source, as reported by 18.2% of participants, is concerning. It suggests a lack of clarity or accountability regarding the management and maintenance of the water source. This situation can pose challenges to water security, as the absence of a responsible entity may result in neglected maintenance, inefficient operations, and compromised water quality.

Water security is a complex issue that involves multiple stakeholders and operational activities, including water sourcing, treatment, distribution, and management. Those responsible for the operational activities of the source play a critical role in ensuring water security. The link between the two lies in the fact that any disruption or failure in operational activities can lead to adverse impacts on water security. Water security relies on the ability of responsible entities, such as water utilities or operators, to efficiently operate and maintain water supply infrastructure, treatment plants, and distribution systems (Haider et al., 2019). Proper operational practices can minimize disruptions, optimize resource utilization, and enhance overall water security. Those responsible for operational activities play a critical role in maintaining and updating water infrastructure. Regular maintenance, repair, and upgrading of water source infrastructure, including pipes, pumps, and treatment facilities, are essential to ensure the continued functionality and reliability of the water supply system (Butler et al., 2016). Neglecting maintenance can lead to infrastructure deterioration, increased failures, and compromised water security.

Figure 5.20: The disputes or disagreements

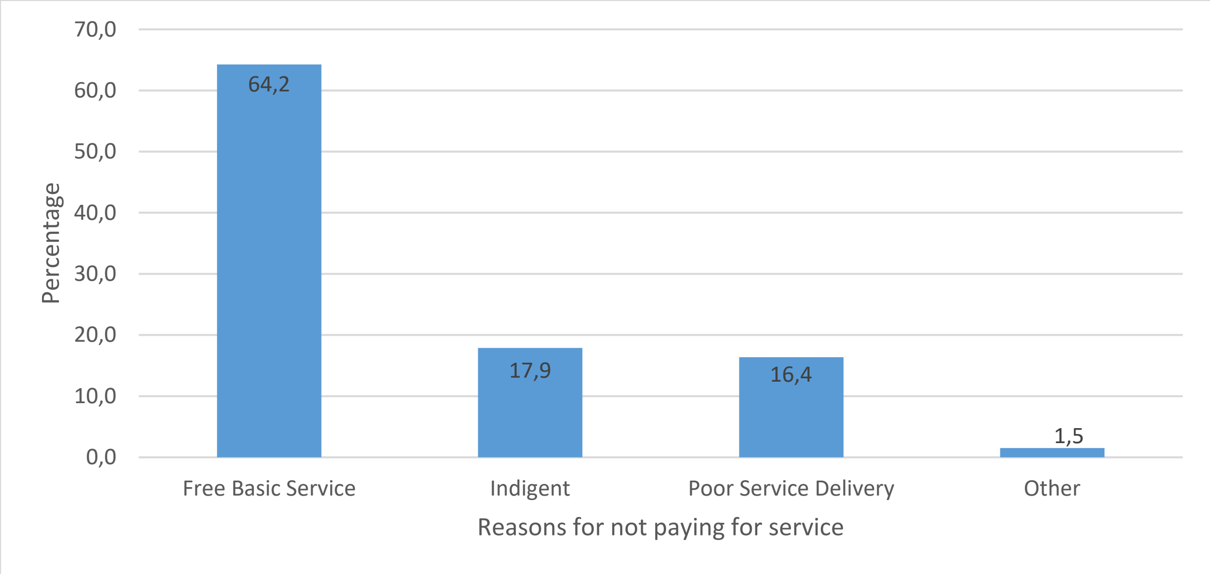


The findings presented in Figure 5.20 provide insights into the occurrence of disputes or disagreements related to water shortages, long queues, low water pressure, and poor maintenance of the water source and service delivery among the participants. According to the data, out of 384 respondents who participated, the majority (63.9%) of participants indicated the presence of disputes or disagreements regarding these water-related issues, while 22.5% reported disputes or disagreements specifically related to water shortages. These disputes and disagreements have implications for water security and highlight the need for effective conflict resolution and improved water management practices. The high percentage of participants reporting disputes or disagreements related to water shortages, long queues, low water pressure, and poor maintenance suggests a significant level of dissatisfaction and frustration among the community regarding these water-related issues. These disputes may arise from the inadequate provision of water services, such as insufficient water supply, frequent disruptions, or prolonged waiting times, which can impact the availability and accessibility of clean water for households.

Water supply conflicts significantly and negatively impacted the prospects for sustainable water security. The findings of the study suggest that several factors contribute to water conflicts, all of which have the potential to increase localized violence and instability. The study's findings are at odds with those of Mason and Blank (2013), who argue that disagreements over water are typically the result of divergent central and local governments' approaches to water management, infrastructure development, and economic growth. In this context, tensions and struggles over water access, control, management, and use are major causes of conflict. That conclusion is supported by the United Nations, which has acknowledged that competing public and private water demands are the root cause of water conflicts (The UN World Water Development Report, 2020). According to Turton (1999), despite the existence of a plethora of laws and regulations meant to prevent water conflicts, they can still be sparked by the use of water. While it may be challenging and time-consuming, it appears that addressing these conflicts and disputes requires fostering negotiation and participation from all relevant parties (Gholizadeh & Niknami, 2020).

Notwithstanding the above, some of the disputes or conflicts over water back many years and result from various causes. Horizontal disparities are likely to be the cause of social unrest related to water (Sanchez & Rylance, 2018). For instance, conflict is more likely to be mobilized when power and resources are unequally divided amongst groups based on race, culture, language, or religion. In this regard, interdisciplinary studies show that the misallocation of water resources, rather than scarcity, is the root cause of the likelihood of disputes or conflicts. The complex web of community disputes or conflicts as a result of water-related security challenges is on the rise and is often ignored in the water-conflict literature (Gleick 2019b). In light of the growing number of water-related disputes, communities everywhere must adopt long-term strategies to ensure their access to clean water. Tensions caused by water scarcity can be alleviated with better water management and utilization strategies (Gleick, et al., 2020). Better water management can have far-reaching benefits, such as increased community involvement and a decrease in disputes. Therefore, we need to implement a system of Integrated Water Resources Management that accounts for the principles and responsibilities of working to better people's livelihoods as part of a larger framework of integrated natural resources management. The current research shows that the water conflict poses serious threats to sustainable water security and calls for a comprehensive and collaborative response. Robbins backs this up (2006).

Figure 5.21: Reason for not paying for the operation and maintenance of the source

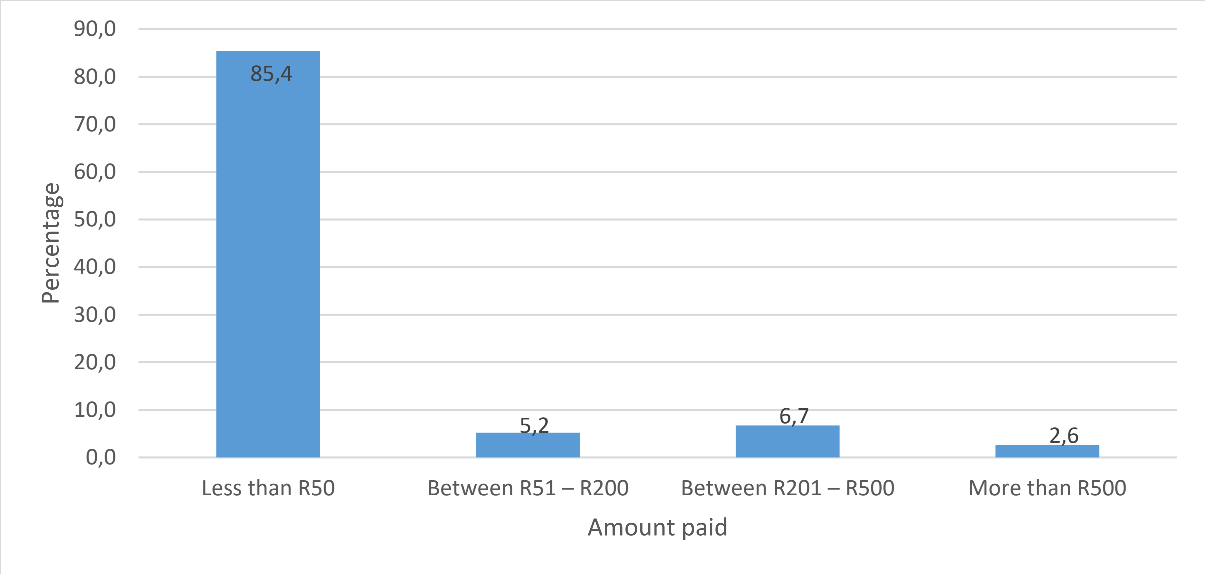


The findings presented in Figure 5.21 provide insights into the reasons given by participants for not paying for the operation and maintenance of the water source. From the 384 respondents that participated, the majority (64.2%) indicated that the reason for not paying is that it is considered a free basic service, while 17.9% reported that they are indigent and unable to afford the payments. Additionally, 16.4% of participants mentioned that they are not paying due to poor service delivery. These reasons reflect the complex dynamics of water access, affordability, and service provision, and they have implications for water security and the sustainable operation of water sources. The high percentage of participants indicating that they do not pay for the operation and maintenance of the water source because it is considered a free basic service (64.2%) highlights the perception that water provision should be provided as a basic right without direct financial obligations. This perception is in line with the concept of free basic water services, which aims to ensure that vulnerable and low-income households have access to a basic amount of water without incurring significant costs. However, this perception can pose challenges to sustainable water management and maintenance, as it may result in limited financial resources for operations and upkeep of water infrastructure.

The proportion of participants reporting that they are indigent and unable to afford payments (17.9%) underscores the financial constraints faced by some households. This indicates the need for social support mechanisms and targeted subsidies to ensure that all individuals can access affordable and reliable water services. The perception of poor service delivery as a reason for not paying (16.4%) reflects concerns regarding the quality, reliability, or overall satisfaction with the water services provided.

Consistent with these results is the United Nations (1977) declaration, which provided one of the first explicit references to water as a basic human need for domestic use and framed legal protections for means to potable water under basic needs: “All peoples, everyone regardless of the level of enhancement and social and economic conditions, they have the right of access to drinking water in a quantity and quality adequate to meet their basic needs.” In addition, the incorporation of Section 27 into the Constitution of South Africa ensures that all citizens, regardless of their socio-economic standing, have the right to obtain sufficient quantities of water. Seemingly, one of the most important aspects that play a role in determining household water security is whether or not households pay for water. According to the findings of several studies, households that are paying for water are typically in a better position to have reliable access to water than those households that are not paying (Pinto et al., 2018; Dlamini, 2015; Kujinga et al., 2014). Research conducted by the World Bank (1993) indicated that in rural areas of developing countries, people’s willingness to pay for water varied depending on income and the characteristics of the existing water supply. Therefore, based on the information presented policymakers and stakeholders can contribute to enhanced water security and promote equitable access to reliable and affordable water for all by implementing targeted subsidies, improving service delivery, and raising awareness about the value of water services.

Figure 5.22: Amount paid for the water source



The findings presented in Figure 5.22 above provide insights into the cost of accessing the water source among participants. According to the data sourced from 384 respondents who participated, the majority (85.4%) of participants indicated that they paid less than R50 for the water source, while 6.7% reported paying between R201 and R500. The smallest proportion (2.6%) of participants indicated paying more than R500 for the water source. These variations in the cost of accessing clean water have implications for water security, as affordability is a crucial factor in ensuring reliable and equitable access to safe water. The high percentage of participants paying less than R50 for the water source suggests relatively affordable access to clean water for a significant portion of the population. However, it is important to note that even though the majority of participants pay less than R50, there may still be individuals or households for whom this amount may be a significant financial burden.

The proportion of participants paying between R201 and R500 (6.7%) suggests a higher cost of accessing the water source for a smaller segment of the population. This higher cost may be due to various factors, such as a more extensive water distribution network, additional infrastructure maintenance expenses, or limited access to alternative water sources. The smallest proportion of participants (2.6%) paying more than R500 for the water source suggests a significant financial burden for this specific group. This higher cost may be due to factors such as the limited availability of clean water sources, the need for specialized water treatment processes, or a lack of economies of scale in the water supply system. Such high costs can pose challenges to water security, particularly for low-income households or communities with the limited financial capacity to afford clean water.

The cost of accessing clean water varies from one region to another, and this has a significant impact on the level of water security in these areas. According to Gulati & Narayanamoorthy (2019), low-income households often pay more for their drinking water than high-income households due to inadequate public supply systems. Consequently, the cost of accessing water affects the availability and quality of water sources, which directly impacts water security. The link between the amount paid for the water source and water security cannot be ignored. Policymakers and stakeholders should also consider regional disparities in the cost of accessing clean water and address any affordability challenges that may arise. Tailored interventions, such as regional pricing structures or targeted support for specific areas facing higher costs, can help promote water security and address the needs of communities with varying levels of financial capacity. By implementing targeted support measures, addressing regional disparities, and exploring innovative financing mechanisms, policymakers and stakeholders can contribute to enhanced water security and equitable access to clean water for all individuals and communities.

Figure 5.23: Paying for the maintenance/operation of the source at a certain frequency

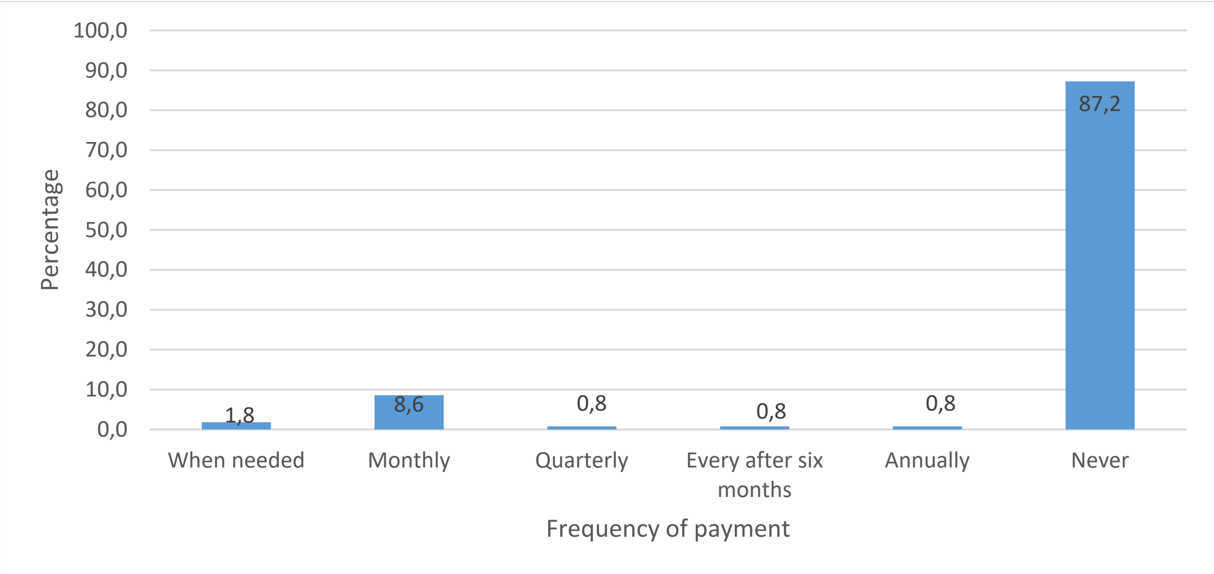
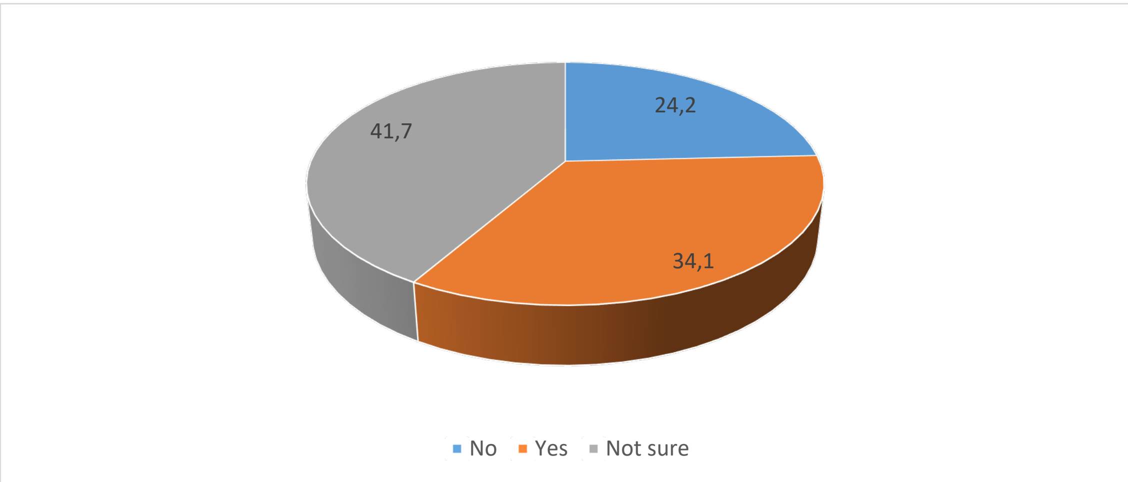


Figure 5.23 above depicts the point that the majority (87.2%) of the participants are of the view that they never pay for the maintenance/operation of the source followed by 8.6% of the participants who indicated that they pay for the maintenance/operation of the source monthly while 1.8% indicated that they pay for the maintenance/operation of the source when needed. A small proportion of the participants indicated that they pay for the maintenance/operation of the

source either quarterly, every six months, or annually with an equal proportion of 0.8%. Effective management of water resources entails the regular maintenance and operation of water supply systems. This includes ensuring that the infrastructure is functional, safe, and efficient. The cost of maintaining and operating such systems can be significant and varies depending on a range of factors, including the size of the system, its location, and the frequency at which it needs to be maintained.

Regular payment for the maintenance and operation of the water source is crucial for ensuring the functionality and reliability of the water infrastructure. In other words, timely payment helps sustain the infrastructure necessary for delivering reliable water services. Adequate funding enables ongoing maintenance, repairs, and upgrades to infrastructure components such as pipelines, pumps, treatment plants, and storage facilities (Hope, 2006). Paying for the maintenance and operation of the water source at a certain frequency is essential for ensuring the financial sustainability of water systems. Reliable and consistent revenue streams enable water utilities to cover operational costs, invest in infrastructure improvements, and plan for long-term water security (Pearce et al., 2018). Adequate financial resources support sustainable water management practices and system resilience.

Figure 5.24: Some of the diseases in your house are water-related



The findings presented in Figure 5.24 shed light on the participants' perceptions regarding the water-related nature of diseases existing or having existed in their houses. From the 384 respondents that participated, the data shows that the majority (41.7%) of participants indicated that they do not think any of the diseases in their house are water-related. On the other hand, 34.1% of participants believe that some of the diseases in their house are water-related, while 24.2% were unsure about the water-related nature of the diseases. The high percentage of participants who do not perceive any of the diseases in their houses as water-related (41.7%) suggests a lack of awareness or knowledge about the potential influence of water sources and quality on disease transmission. This knowledge gap may hinder the adoption of appropriate water management practices and preventive measures. The group of participants (34.1%) who perceive some of the diseases in their houses as water-related demonstrates a relatively higher level of awareness. These individuals recognize the potential impact of water on disease transmission and may be more inclined to take precautions and adopt water-related preventive measures. The proportion of participants (24.2%) who were unsure about the water-related nature of the diseases highlights the need for further education and awareness campaigns. Clarifying the association between water and disease transmission can empower individuals to make informed decisions and take appropriate actions to protect their health and enhance water security.

Corroborating the findings of the study is the WHO (2019) which states that some of the diseases within the house that are water-related include diarrhea, cholera, dysentery, typhoid fever, and hepatitis A. These diseases are caused by microorganisms such as bacteria, viruses, or parasites that thrive in contaminated water. According to a study conducted in Bangladesh by Mahmud et al. (2020), most households use unsafe drinking water sources such as pond water for daily activities like cooking and washing clothes. The same study concludes that poor sanitation facilities in households contribute significantly to the prevalence of diarrheal diseases among children aged five years and below. It's worth noting that children are more vulnerable to these water-related infections than adults because their immune systems are not fully developed. To prevent and control these diseases within households, several measures can be taken. One approach is improving access to clean water sources such as piped water systems or wells fitted with sanitary seals to avoid contamination from surface runoff or sewage infiltration (WHO, 2019). Another measure is promoting proper sanitation practices such as hand washing before meals and after using toilets. Overall, the link between water-related diseases and households cannot be ignored. It is a global public health issue that requires immediate attention from policymakers, healthcare professionals, and individuals alike. Through collective efforts, we can create a healthier world where everyone has access to clean water and lives free from preventable illnesses caused by contaminated water sources.

Table 5.3: The following diseases/sicknesses are common among both the young and old

Disease	None existed	Most common	Least Common
Diarrhea	54.9%	18.5%	26.6%
Cholera	89.3%	2.1%	8.6%
Malaria	94.3%	0.5%	5.2%
Tuberculosis	90.4%	4.2%	5.5%
Misc Stomach problems	37.0%	28.1%	34.9%
Covid-19	89.8%	1.0%	9.1%
Other	90.6%	9.4%	0.0%
N=384			

The findings presented in Table 5.3 provide insights into the participants' perceptions of the presence or absence of various diseases in their households. Of the 384 respondents that participated, the data reveals that a significant proportion of participants indicated that they are not afflicted by diseases such as diarrhea, cholera, malaria, tuberculosis, COVID-19, and other unspecified diseases. These perceptions can have implications for water security, as diseases linked to water quality and sanitation directly impact public health and access to safe water. The high percentage of participants indicating the absence of diarrhea (54.9%), cholera (89.3%), malaria (94.3%), tuberculosis (90.4%), and other unspecified diseases (90.6%) in their houses may suggest a positive perception of the overall health and cleanliness of their living environments.

These findings highlight the need for further investigation to determine the accuracy of participants' perceptions and to identify any discrepancies between perception and reality. This can involve conducting comprehensive health assessments, water quality testing, and epidemiological studies to gain a more accurate understanding of disease prevalence and its association with water sources, sanitation practices, and hygiene behaviors. Addressing the perceptions of participants is crucial for promoting water security. Even if the reported prevalence of certain diseases is low, it is important to maintain vigilance and encourage continuous adherence to safe water practices and hygiene behaviors. Overall, the findings indicate varying perceptions regarding the presence or absence of diseases in participants' houses. These perceptions can influence water security, as diseases related to water quality and sanitation directly impact public health and access to safe water. It is essential to validate these perceptions through comprehensive assessments and studies to inform evidence-based strategies for waterborne disease prevention. By addressing the actual prevalence of water-related diseases and promoting safe water practices, policymakers and stakeholders can contribute to improved water security and public health outcomes.

5.2.2.1 The diseases mentioned above are water-related

The findings of this study reveal the participants' knowledge regarding the relationship between certain diseases and water. From the 384 respondents that participated, the data shows that the majority (71.9%) of the participants indicated that they are aware that the mentioned diseases are water-related, while 28.1% of the participants reported not knowing about the water-related nature of these diseases. This knowledge gap has significant implications for water security, as understanding the connection between water and diseases is crucial for promoting public health and ensuring safe water practices. The high percentage of participants who are aware of the water-related nature of the mentioned diseases is promising, as it suggests a reasonable level of understanding regarding water-related health risks. This knowledge can contribute to the adoption of preventive measures, such as proper water treatment, maintaining sanitation practices, and practicing safe hygiene habits.

However, the presence of a considerable proportion (28.1%) of participants who reported not knowing that the diseases mentioned are water-related is a concern. This knowledge gap can indicate a lack of awareness about the potential health risks associated with water sources and the need for adequate water treatment and hygiene practices. Bridging this knowledge gap is crucial for improving water security and public health outcomes. Corroborating the findings of the study are the research findings by the Government of Canada (2017), and Ahmad and Satter, (2010) which both extrapolate that the lack of clean water and sanitary facilities is a contributing factor in about 80% of diseases across Africa. For instance, many studies show that diarrheal illness can be reduced by better water interventions, and drinking water is a major vector for the spread of infectious diseases (Reller et al. 2003; Fewtrell et al. 2005).

As it pertains to human health and well-being, the United Nations and the World Health Organization have both stated that everyone on the planet should have access to clean water (UN & WHO, 2010). Because of this, having access to potable water that has been treated to remove any harmful bacteria and having access to adequate sanitation facilities are fundamental requirements for human survival. Water-related illnesses can be reduced if more people in rural areas have access to clean, safe drinking water. According to WaterAid (2017), expanding the availability of potable water is a crucial part of a holistic strategy to reduce poverty, enhance health, and lessen hunger. The relationship between water-borne diseases and water security is undeniable. The availability of safe drinking water and proper sanitation facilities plays a critical role in reducing the spread of water-related illnesses.

5.2.2.2 There has been at least one death in your family due to water-related diseases during the past 15 years

Of the 384 respondents that participated in the study, the majority (79.4%) indicated that there have been no deaths in their family due to water-related diseases during this period, while 20.6% reported that deaths have occurred in their family due to such diseases. These perceptions provide insights into the potential impact of water-related diseases on human health and highlight the importance of effective water management and access to clean water for ensuring water security. The high percentage of participants reporting no deaths in their families due to water-related diseases suggests positive health outcomes and relatively effective water management practices. This perception indicates that the participants' families have been able to maintain good health and avoid severe waterborne illnesses within the past 15 years. It is worth noting that this perception aligns with the goal of water security, which encompasses access to safe and clean water for all individuals, thereby reducing the risk of water-related diseases and associated fatalities. The proportion of participants reporting deaths in their families due to water-related diseases (20.6%) highlights the potential health risks and vulnerabilities associated with inadequate access to clean water or poor water management practices. The occurrence of deaths within families due to water-related diseases underscores the urgency to address water-related health risks and improve water security.

In line with the findings of the study, the World Bank (2017) reports that the inability to have potable water is a leading cause of death worldwide. Diseases that are spread through drinking contaminated water are called waterborne diseases (Nwabor, et al., 2016). Many waterborne diseases cause diarrhea, which is characterized by an increase in bowel movement frequency and volume, which can lead to dehydration and death. Lack of clean water and sanitation is a leading cause of the spread of diseases, including cholera, diarrhea, dysentery, hepatitis A, typhoid, and polio. Ingestion of contaminated water or food can cause a variety of illnesses, the most common of which is diarrhea (WHO, 2022). Because of inadequate potable water and sanitary conditions, and regular hand-washing opportunities, an estimated 829, 000 people lose their lives each year to diarrhea (WHO, 2022). One of the primary causes of death among young children in South Africa is diarrhea (Edokpayi, et al., 2018).

It is estimated that every year, 297, 000 kids under the age of 5 suffer fatal consequences from diarrheal illness. These deaths are entirely preventable if the risk factors associated with diarrhea are addressed. Furthermore, an estimated 1.8 million deaths occur every year due to diarrheal diseases, making up 4.1% of the total daily global burden of disease (WHO, 2005). Approximately 1.8 million people worldwide die annually from diarrhoeal diseases, many of which have been linked to diseases acquired from consuming contaminated water and seafood, according to the World Health Organization (2005). The KwaZulu-Natal Province in South Africa was hit particularly hard by the cholera epidemic, which was responsible for the majority of the country's 114,000 cases and 260 deaths (Hemson, 2016). Governments around the world are concerned about the effects of contaminated water supplies on public health because water-borne diseases are a leading cause of death (Vidyasagar, 2007). From the foregoing, policymakers and stakeholders can work towards preventing water-related diseases, reducing fatalities, and safeguarding public health by implementing comprehensive water management strategies, improving water infrastructure, and promoting awareness about proper water practices

5.2.2.3 Water storage

An overwhelming majority (98.4%) of the 384 respondents who participated in the study indicated that they store water, while only a small proportion (1.6%) reported not storing water. This distribution sheds light on the prevalence of water storage as a strategy to enhance water security, especially in areas where water availability may be limited or unreliable. The high percentage of participants engaging in water storage practices suggests a recognition of the importance of water security and the need to mitigate potential water supply disruptions. Storing water allows individuals to build resilience in the face of uncertainties, such as droughts, infrastructure issues, or natural disasters, which can impact water availability. Moreover, it is important to consider the reasons why a small proportion of participants do not engage in water storage. Factors such as limited knowledge, access to suitable storage containers, or cultural practices may contribute to the lower percentage of individuals not storing water. Addressing these barriers and providing support and resources to those who do not store water can improve their water security preparedness. Water storage practices are a vital component of water security, as demonstrated by the high percentage of participants indicating their engagement in water storage. By promoting and supporting proper water storage techniques, policymakers, water managers, and stakeholders can enhance water security at the individual and household levels. It is crucial to provide education, resources, and assistance to individuals who do not currently store water, ensuring they have the means to build resilience and secure their water needs during times of scarcity or disruptions.

By fostering a culture of water storage and preparedness, the study can contribute to the overall resilience and sustainability of water resources and enhance water security for communities. The IPCC describes resilience as the capacity of a system and its parts to foresee, accept, adapt, or recover from the consequences of a catastrophic occurrence in a timely and systematic manner (IPCC, 2012). So, water storage helps water management adapt to changing conditions, keep services running smoothly, and bounce back quickly from disruptions (e.g. floods). To accommodate people's shifting and unpredictable wants and needs, water storage is essential. Having a private water storage tank is still a necessity in many parts of the world, especially in developing countries (Manga et al., 2021). As a result of water storage, modern cities can get water whenever they need it, increasing their adaptive capacity and decreasing their vulnerability to unforeseen events. Most rural poor in developing countries do not have access to piped water supply systems, so they must rely on traditional methods, such as hauling water from rivers, springs, community standpipes, and boreholes, and storing it in their homes (Moropeng & Momba, 2020). Even if drinking water is piped into homes, it is not always accessible, so water storage is still necessary. To rephrase, storage is essential for reducing the effects of periodic shocks and the temporal variability of water resources (Gaupp et al., 2015). It is clear from the study that storage is essential to achieving sustainable water security (Grey and Sadoff, 2007).

Table 5.4: Water storage options

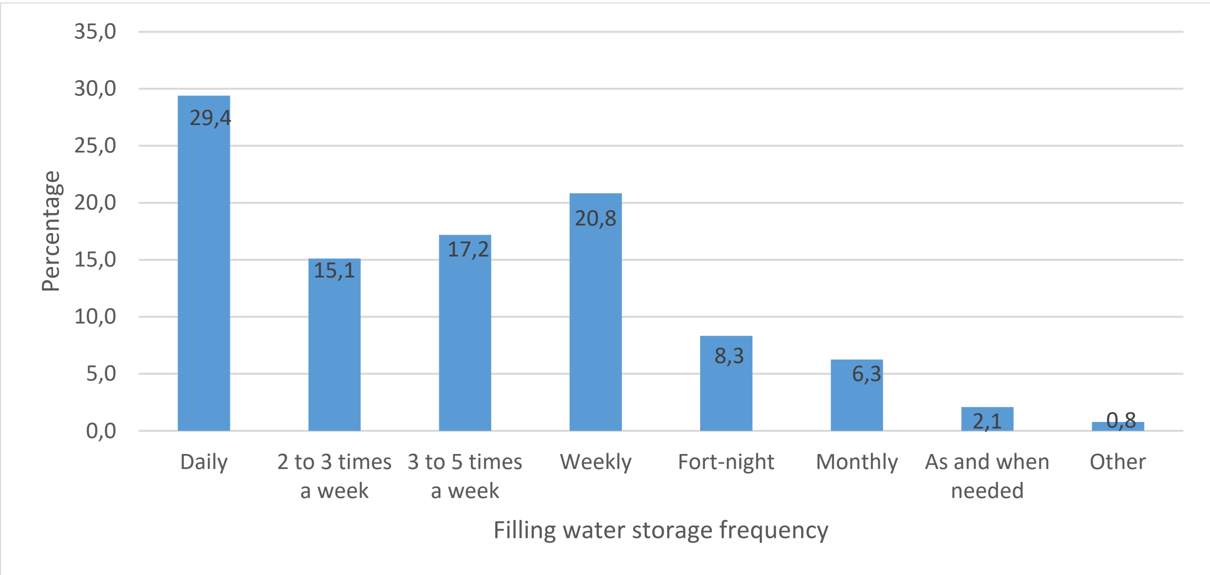
Storage options	No	Yes
Bucket	12.5%	87.5%
Jojo	56.0%	44.0%
Drum	34.6%	65.4%
Container	54.6%	45.4%
Running Pipe	65.3%	34.7%
Other	88.0%	12.0%
N=384		

The findings in Table 5.4 are based on the responses of 384 participants, showing that the majority (87.5%) of them store water in a bucket, while 44.0% store water in a Jojo tank, and 65.4% store water in a drum. Furthermore, 45.4% of participants indicated that they store water in a container, 34.7% store water in a running pipe, and 12.0% store water in other unspecified sources. These diverse water storage methods reflect the resourcefulness and adaptability of individuals in ensuring their water security. The prevalence of various water storage methods among the participants highlights the range of approaches adopted to maintain a reliable water source. The high percentage of participants storing water in buckets, Jojo tanks, and drums suggests their effectiveness and suitability in water storage practices. Buckets are often readily available and easy to use for collecting and storing water. Jojo tanks, known for their larger storage capacity, are commonly used to store rainwater or as supplementary storage for households. Drums are also frequently employed for water storage, particularly in areas with limited access to piped water. However, it is important to consider the limitations and potential challenges associated with certain water storage methods. For instance, containers used for water storage should be made of safe and non-toxic materials to ensure water quality. In the case of running pipes, there may be concerns regarding potential contamination or the risk of water loss if the pipe system is not properly maintained. Additionally, the category of "other unspecified sources" highlights the existence of alternative water storage methods that require further investigation and understanding.

Corroborating the findings of the study is Yu et al. (2021) who indicate that there is a wide variety of storage options available, each with its own set of advantages and disadvantages (Yu et al., 2021). The scale of man-made water storage ranges from individual homes to reservoirs, and manmade lakes of varying sizes produced by damming rivers or streams, water tanks, etc. Volume, practicality, flexibility, operability, dependability, susceptibility, area of control, affordability, and sustainability are only a few of how different forms of storage vary from one another (Yu, et al., 2021). In the delineated study area, the majority of respondents engaged in water storage practices primarily employ buckets. This was closely followed by the use of Jojo tanks and drums, as a measure to guarantee uninterrupted access to potable water for consumption purposes.

A majority of households within these areas displayed a liking towards the storage of potable water in a variety of containers including jerry cans, buckets, drums, basins, and other locally fabricated receptacles. This trend not only resonates with the outcomes of our study but also echoes the research findings of García-Betancourt et al., (2015), thereby substantiating their conclusions. Certain services require a constant supply of water of a certain quality and quantity that is not always available. Yu et al. (2021) suggest using storage for such services. The ability to store water can serve as a hedge against the risk of future water shortages or as a buffer during times of water abundance. Water storage is a key component in ensuring a reliable supply of water. The diverse water storage practices observed among the participants demonstrate their resourcefulness in ensuring water security. Understanding the range of water storage methods and their effectiveness is essential for developing targeted interventions and policies that enhance water security. By providing education, resources, and support, stakeholders can promote safe and sustainable water storage practices.

Figure 5.25: Frequency of filling water storage

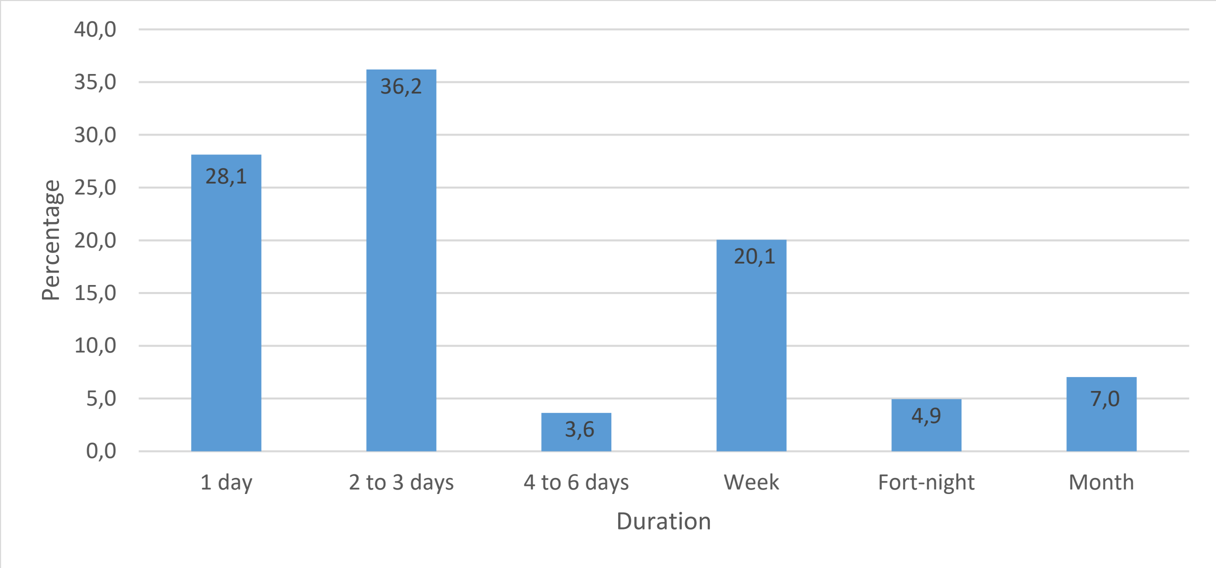


The insights into the frequency at which participants refill their water storage are derived from the findings of 384 respondents, as depicted in Figure 5.25. According to the data, the majority (29.4%) of participants indicated that they fill their water storage daily, followed by 20.8% who fill it up weekly, and 17.2% who refill it 3 to 4 times a week. Additionally, a small percentage (2.1%) of participants reported filling their water storage as and when needed. These findings shed light on the water management practices of participants and their efforts to ensure a continuous water supply, which is essential for water security. The high percentage of participants indicating daily refilling of their water storage (29.4%) reflects a proactive approach to managing their water supply. Daily refilling suggests that participants recognize the importance of having a consistent and adequate water supply for their daily needs. This practice can contribute to water security by ensuring that households have access to sufficient water for drinking, cooking, hygiene, and other essential activities.

The proportion of participants refilling their water storage weekly (20.8%) indicates a different approach to water management. This practice suggests that participants can plan and ration their water usage to last throughout the week. The percentage of participants refilling their water storage 3 to 4 times a week (17.2%) suggests a higher frequency of water refilling compared to the weekly refill group. This may indicate either higher water consumption needs or limited storage capacity, requiring more frequent replenishment. The frequency of refilling in this category may also be influenced by the availability and reliability of the water source and the participant's ability to collect water as needed. The small percentage of participants (2.1%) indicating that they refill their water storage as and when needed suggests a flexible approach to water management. These participants may adapt their refilling frequency based on their water needs, availability of water sources, or other factors that influence their access to water. However, it is important to ensure that participants have access to a reliable and clean water source when they need to refill their storage.

There was a discrepancy in how long the water was stored, with some claiming it would last for 1 day and others claiming it would last for 2-3 days. Results are consistent with those found by StatsSA (2014) in Limpopo province, where people reported receiving municipal water for two days at most. Daily refilling, weekly refilling, and more frequent refilling patterns reflect the efforts of participants to ensure a continuous water supply for their household needs. By promoting efficient water use practices, ensuring access to reliable water sources, and raising awareness about water conservation, policymakers, and stakeholders can contribute to enhanced water security and sustainable water management practices.

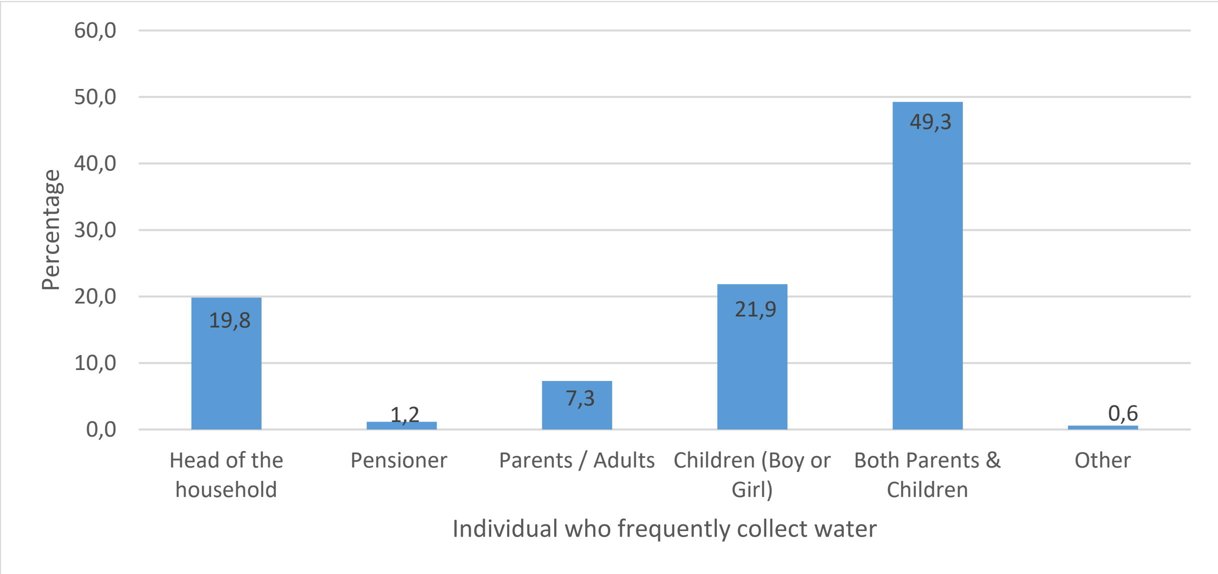
Figure 5.26: The duration for which this water lasts



The insights into the duration for which participants' stored water supply lasts were derived from the findings of a study conducted with 384 respondents, as presented in Figure 5.26. According to the data, 36.2% of participants indicated that their stored water lasts for 2 to 3 days, while 28.1% reported that it lasts for 1 day. Additionally, a smaller proportion (3.6%) of participants indicated that their stored water supply lasts for 4 to 6 days. These findings highlight the adequacy of participants' water storage capacity and the potential challenges they face in ensuring a continuous water supply, which are important considerations for water security. The high percentage of participants reporting that their stored water lasts for 2 to 3 days (36.2%) suggests that a significant portion of participants has sufficient water storage capacity to meet their daily water needs for a couple of days. This indicates a reasonable level of preparedness in terms of water storage, allowing participants to have a buffer in case of interruptions in the water supply. The proportion of participants reporting that their stored water lasts for 1 day (28.1%) suggests a lower capacity for water storage. This may indicate limited storage capacity or higher water consumption needs that require daily replenishment of their water supply. Participants in this category may be more reliant on daily water availability or have limited access to larger storage containers.

The smallest proportion of participants (3.6%) indicating that their stored water supply lasts for 4 to 6 days suggests a longer duration of water availability. Participants in this category may have larger water storage containers or practice more conservative water use, enabling them to stretch their stored water supply over a longer period. This longer duration of water availability can contribute to increased resilience and water security, particularly in situations where water sources may be unreliable or inaccessible for extended periods. In general, the findings emphasize the duration for which participants' stored water supply lasts and their water storage capacity. Adequate water storage capacity and longer duration of water availability contribute to water security by ensuring a continuous water supply during disruptions or shortages. By promoting larger water storage containers, water conservation practices, and investments in water infrastructure, policymakers, and stakeholders can enhance water security and resilience at the household level, improving the overall access to clean and reliable water for communities.

Figure 5.27: The individual who frequently or predominantly collects water



The insights into the individuals primarily responsible for water collection among the participants were derived from the findings of a study conducted with 384 respondents, as presented in Figure 5.27. According to the data, 49.3% of participants indicated that both parents and children often or mostly collect the water, while 21.9% reported that children (both boys and girls) often or mostly perform this task. Additionally, 19.8% of participants indicated that the head of the household often or mostly collects the water, and a smaller proportion (3.2%) mentioned that pensioners often or mostly engage in water collection. These findings shed light on the distribution of water collection responsibilities within households, highlighting the potential impact on water security and the burden it places on different members of the household. The high percentage of participants reporting that both parents and children often or mostly collect the water (49.3%) suggests a shared responsibility and participation of multiple household members in the water collection process. This division of labor may be influenced by cultural norms, gender roles, and household dynamics. In many contexts, water collection tasks are often assigned to women and children, with women bearing the primary burden.

The proportion of participants indicating that children (both boys and girls) often or mostly collect the water (21.9%) highlights the involvement of children in water-related responsibilities. Child involvement in water collection can have implications for their education, well-being, and overall development. While it is essential to recognize the valuable contribution of children to household chores, including water collection, it is also important to ensure that their participation does not hinder their education or expose them to potential risks associated with long-distance water collection or carrying heavy loads. The percentage of participants indicating that the head of the household often or mostly collects the water (19.8%) reflects the responsibility placed on household leaders in securing water resources for their families. The head of the household is often responsible for making important decisions and managing household affairs, including water collection. This finding suggests that household leaders, who may be primarily responsible for income generation or other household tasks, also bear the burden of water collection, potentially affecting their time availability and productivity in other areas. The smaller proportion of participants mentioning that pensioners often or mostly collect water (3.2%) indicates the involvement of older adults in water collection activities. This finding may be influenced by various factors, including physical ability, proximity to water sources, and the availability of support from other household members.

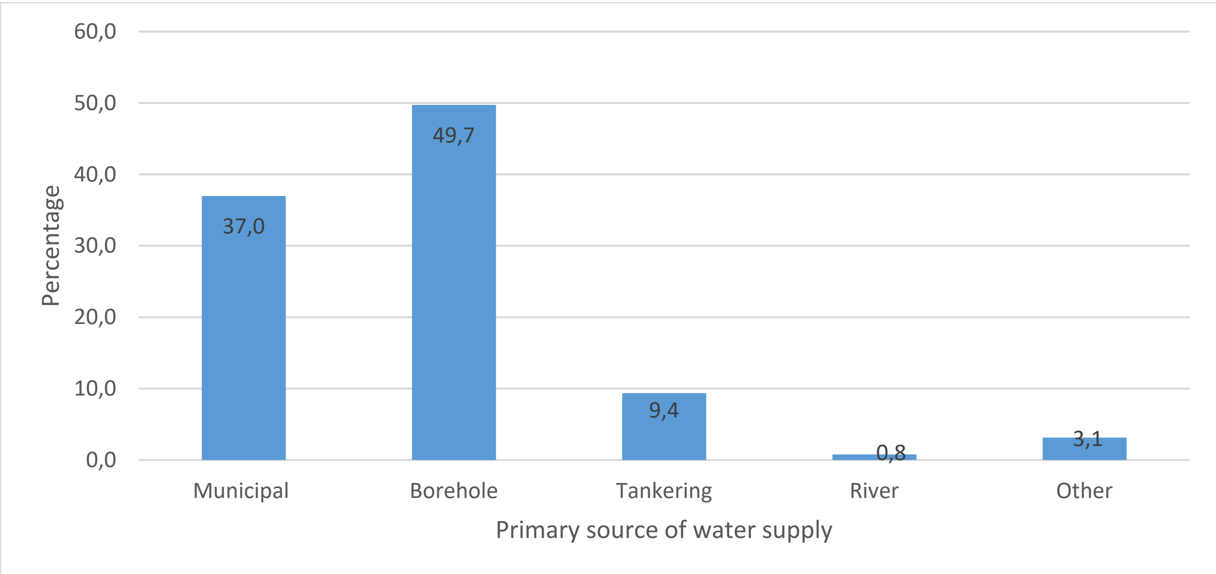
The study findings are consistent with those of Bakker and Hemson (2012) who state that women and children are disproportionately responsible for traveling long distances to collect water from unreliable sources. Compared to households that do not spend much time collecting water, those that do have a greater assurance of a reliable supply of potable water (Lewis, 2016). From the time it is drawn from the source and delivered to the home, the JMP recommends no more than 30 minutes (UNICEF & WHO, 2018). Reduced travel time to water sources is emphasized in Sustainable Development Goal (SDG) Target 6.1, and national norms and standards for domestic water and sanitation state that people should never have to walk more than 100 meters to reach a public standpipe (Department of Water & Sanitation, 2017). This is why there should be public standpipes every 200 meters along the roads, but this was not the case in the study area. The time it takes to collect water can vary greatly depending on several factors, including how far each household must travel to the nearest water source, the characteristics of that water source (flow/pressure), and the number of households that share that water source (Lebek, et al., 2021).

Mainly, the findings emphasize the distribution of water collection responsibilities within households. Involving multiple household members, promoting gender equity, and ensuring access to safe and nearby water sources can contribute to reducing the burden of water collection, improving water security, and supporting the overall well-being of household members. By considering the needs and capabilities of different household members, policymakers and stakeholders can work towards more equitable and sustainable water management practices that enhance the resilience and quality of life for communities.

5.2.3 Descriptive statistics of the frequency of water supply

This subsection presents the results of the frequency of water supply. The results are presented using the following tables and charts.

Figure 5.28: Primary source of water supply

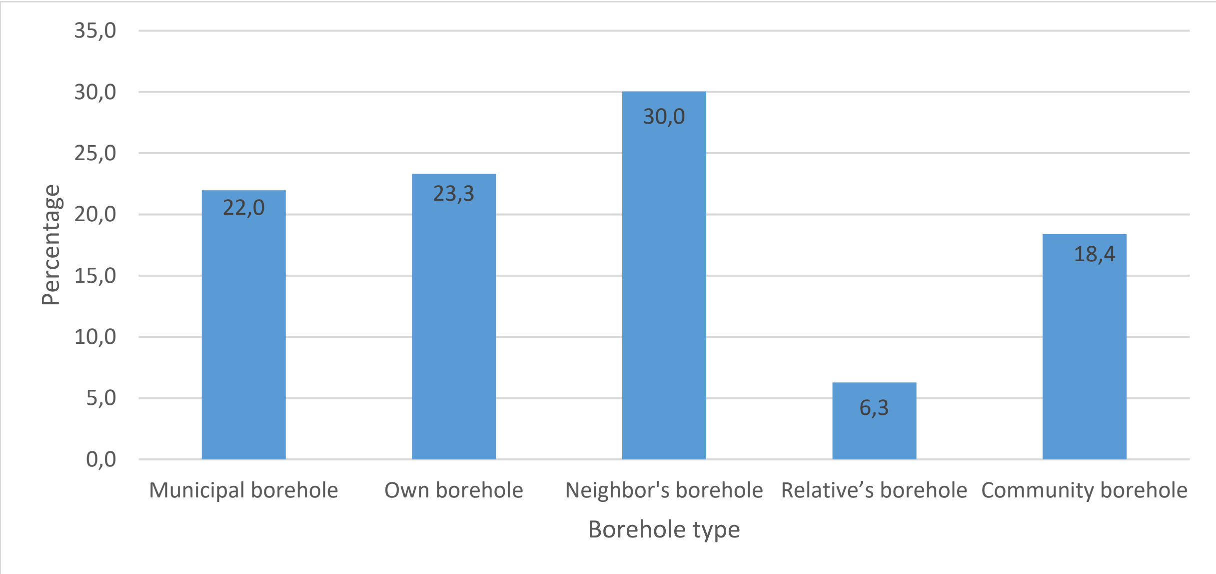


The main sources of water supply among the participants were derived from the insights obtained from a study conducted with 384 respondents, as presented in Figure 5.28. According to the data, the majority (49.7%) of participants indicated that their main source of water supply is a borehole, while 37.0% reported that their main source is the municipality supply. A smaller proportion (0.8%) mentioned that their main source of water supply is the river. These findings shed light on the primary sources of water access for participants and their implications for water security and sustainability. The high percentage of participants indicating a borehole as their main source of water supply (49.7%) suggests that groundwater from boreholes plays a significant role in meeting water needs within the community. Boreholes are often private water sources that rely on groundwater reserves. This indicates a degree of self-reliance in water supply and may provide a sense of control and security over water access. However, the sustainability of borehole water supply depends on the availability and replenishment of groundwater resources.

The proportion of participants indicating the municipality supply as their main source of water (37.0%) suggests a reliance on centralized water supply systems managed by local authorities. Municipal water supply systems usually draw water from surface water sources such as rivers, reservoirs, or dams. This centralized approach to water supply can provide consistent access to clean water for communities. However, challenges such as aging infrastructure, water scarcity, and water quality issues can affect the reliability and quality of municipal water supply. The small proportion of participants mentioning the river as their main source of water supply (0.8%) indicates a reliance on surface water sources. Surface water sources, such as rivers, can provide a readily available and accessible water supply. However, the use of surface water for drinking and domestic purposes requires proper treatment to ensure water safety and prevent waterborne diseases. The vulnerability of surface water sources to contamination, pollution, and variability in water availability highlights the need for appropriate water treatment and management practices to ensure water security.

The findings of the study are consistent with those by Bender (2022), who explains that people in many parts of the country have long since resorted to ingenious methods and a wide variety of water sources to cope with drought. It is especially true in the area under investigation, where residents are forced to get creative to make do with alternative water sources due to the lack of accessible, affordable public water. For example, those who cannot afford private water systems must rely on water obtained from other sources, such as streams, dams, public wells and boreholes, rainwater harvesting, public standpipes, community or commercial water sources, water vendors, tankers, processed water, bottled and sachet water (Karnib 2015; Majuru et al. 2016). Also, they can get water from their neighbors at no cost (Baisa et al., 2010; Coulibaly et al., 2014). Isaacman and Musemwa (2021) corroborate that individuals, families, and communities have developed ingenious solutions to the shortage of potable water, such as the installation of boreholes and Jojo tanks, which are regularly refilled. Both choices, however, require substantial financial resources that the vast majority of the poor simply do not have. Most people in the study do not have access to their water supply because borehole installation can be costly to equip for average families. Essentially, the findings emphasize the main sources of water supply among participants, with boreholes and municipal supply being the primary sources mentioned. Balancing the use of groundwater and surface water sources, ensuring their sustainability, and addressing the associated challenges are essential for achieving water security. By promoting sustainable water management practices, investing in water infrastructure, and implementing appropriate water treatment measures, policymakers and stakeholders can contribute to reliable and equitable access to clean water for communities, thus enhancing water security and the well-being of individuals and households.

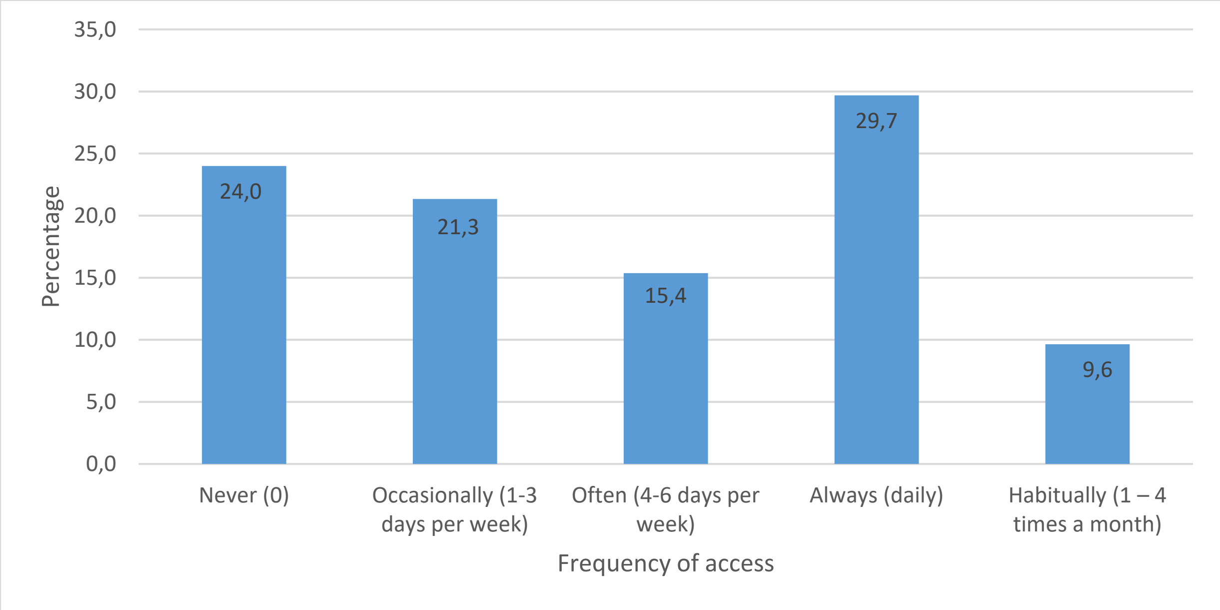
Figure 5.29: If borehole, specify the type employed



The findings presented in Figure 5.29 provide insights from a study conducted with 384 respondents regarding the utilization of different borehole sources as the main water supply among the participants. According to the data, among those who indicated a borehole as their main source of water supply, 30.0% mentioned using a neighbor's borehole, while 23.3% reported using their borehole, and 6.3% mentioned using a relative's borehole. Additionally, 22.0% and 18.4% of participants reported using municipal and community boreholes, respectively. These findings shed light on the various sources of borehole water access and their implications for water security, community collaboration, and sustainability. The high percentage of participants mentioning the use of a neighbor's borehole (30.0%) as their main source of water supply indicates the reliance on shared resources within the community. This suggests a cooperative approach to water access, where neighbors allow each other to access water from their boreholes. Such collaboration promotes community resilience and highlights the importance of social cohesion in ensuring water security. However, it is important to consider the capacity and sustainability of neighbor's boreholes to meet the increased demand for water from multiple households. The proportion of participants reporting the use of their boreholes (23.3%) suggests individual ownership and control over water access. Having one's borehole provides a sense of independence and self-reliance in the water supply. Participants in this category have the advantage of direct access to water without relying on external sources. However, the sustainability and maintenance of privately owned boreholes are crucial to ensure long-term water security.

The small proportion of participants mentioning the use of a relative's borehole (6.3%) as their main source of water supply indicates the reliance on family ties for accessing water. This reliance may be due to proximity or a mutual understanding between family members. Access to a relative’s borehole can alleviate the burden on individual households and strengthen intergenerational cooperation. The percentage of participants mentioning the use of municipal (22.0%) and community (18.4%) boreholes highlights the significance of shared water sources in meeting the water needs of a larger population. Municipal and community boreholes are communal resources that serve multiple households or the entire community. They play a crucial role in ensuring water access, particularly in areas where private boreholes may be limited or inaccessible. All in all, the findings emphasize the utilization of different sources of borehole water access among participants, including neighbor’s boreholes, private boreholes, relative's boreholes, municipal boreholes, and community boreholes. These various sources highlight the importance of community collaboration, individual ownership, and shared resources in ensuring water security. By fostering community engagement, promoting sustainable management practices, and addressing potential challenges associated with borehole water access, policymakers and stakeholders can contribute to the resilience and sustainability of water supply, ensuring reliable and equitable access to

Figure 5.30: The frequency of access to municipal water



The findings presented in Figure 5.30 provide insights from a study conducted with 384 respondents regarding the frequency at which participants access municipal water. According to the data, 29.7% of participants indicated daily access to municipal water, 24.0% reported never accessing municipal water, 21.3% mentioned occasional access (1-3 days per week), and a smaller proportion (9.6%) indicated habitual access (1-4 times a month). These findings shed light on the patterns of municipal water usage among participants and their implications for water security, reliability, and availability. The high percentage of participants reporting daily access to municipal water (29.7%) suggests a regular and consistent reliance on this water source for their daily needs. Daily access to municipal water can contribute to household water security by ensuring a continuous and reliable supply of clean water. Participants in this category may benefit from a well-functioning municipal water supply system that meets their daily demands and provides a convenient and dependable water source. However, it is important to ensure the sustainability and reliability of the municipal water infrastructure to meet the increasing demands and maintain consistent service.

The proportion of participants indicating never accessing municipal water (24.0%) suggests reliance on alternative water sources or limited availability of municipal water in their area. This may be due to factors such as insufficient infrastructure, intermittent supply, or inaccessibility to the municipal water network. Participants in this category may depend on other sources such as boreholes, wells, or rivers to meet their water needs. Lack of access to reliable municipal water can pose challenges to water security, as alternative sources may not always provide safe and sufficient water for household consumption. The percentage of participants mentioning occasional access to municipal water (21.3%) indicates an intermittent reliance on this water source, typically 1-3 days per week. Participants in this category may have access to municipal water, but the supply may not be continuous or available every day. This intermittent access can affect water security, as participants may need to store water or rely on alternative sources during days when municipal water is not accessible. The small proportion of participants indicating habitual access to municipal water (9.6%) suggests infrequent reliance on this water source, typically 1-4 times a month. This pattern of access may indicate limited water needs or the availability of other sources that fulfill most of the participants' requirements. Participants in this category may use municipal water for specific purposes or supplement their water supply from other sources.

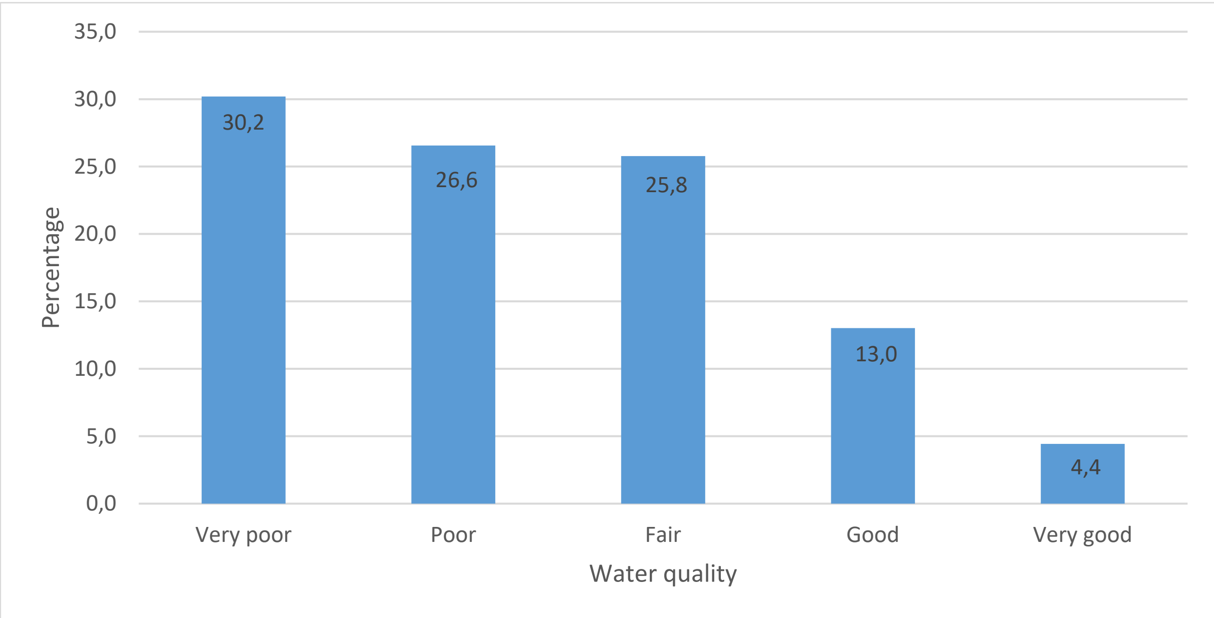
The study's findings are supported by a claim by Lebek et al. (2021) that 89% of South African households currently have access to water supply infrastructure. Despite this, water reliability has dropped to 64% nationwide and 42% in the priority district municipalities (Department of Water and Sanitation, 2019). While access to clean water is important, many parts of the world, including the region under investigation, face challenging conditions (Goncalves et al., 2019. In countries where the economy is still in its early stages of development, the availability of drinkable water often depends on natural water sources such as springs, ponds, and rivers. As an example, rivers, streams, and springs are essential for the daily needs of people living in rural areas that lack access to conventional municipal services. Poorly maintained wastewater treatment plants and businesses are mostly to blame for the degradation of these water supplies by releasing untreated effluents and raw sewage into the environment (Department of Water and Sanitation, 2019).

Despite the Republic of South Africa's pledge to achieve the SDGs, more than three million people still lack access to a reliable source of safe drinking water, despite the country's progressive and aspirational water legislation. Most of them are found in suburban and rural settings. Over three million South Africans, the vast majority of whom live in rural areas, do not have access to even the most fundamental source of clean drinking water, despite the country's relatively new water legislation and its commitment to the Sustainable Development Goals (Lebek and Krueger, 2021). For "The provision of potable water to all people," that is both safe and easily accessible," regardless of where they live, is one of the SDGs, with a commitment to "leave no one behind." This means that addressing inequalities in access to drinking water services and helping low-income and disadvantaged rural households is crucial. Essentially, the findings of the study emphasize the different patterns of municipal water access among participants, including daily access, occasional access, no access, and infrequent access. Ensuring reliable and continuous municipal water supply is vital for water security while addressing the challenges faced by participants who lack regular access is crucial. By improving infrastructure, implementing efficient water management practices, and promoting equitable access to municipal water, policymakers and stakeholders can enhance water security and contribute to the well-being and resilience of communities.

5.2.4 Descriptive statistics of the quality of water

This subsection presents the results of the quality of water. The results are presented using the following tables and charts.

Figure 5.31: The quality of the water



The findings presented in Figure 5.31 provide insights from a study conducted with 384 respondents regarding the perceived quality of water among the participants. According to the data, the majority of participants (30.2%) indicated that the quality of their water is very poor, followed by 26.6% who mentioned poor water quality, and 25.8% who reported fair water quality. Additionally, 13.0% of participants mentioned good water quality, while a smaller proportion (4.4%) indicated very good water quality. These findings shed light on the participants' perceptions of water quality and their implications for water security, health, and well-being. The high percentage of participants reporting very poor water quality (30.2%) suggests significant concerns regarding the safety and suitability of their water supply for various uses, including drinking, cooking, and personal hygiene. Poor water quality can pose health risks, leading to waterborne diseases and related health issues. Participants in this category may experience challenges such as contamination, turbidity, chemical pollutants, or microbial hazards in their water sources.

The proportion of participants indicating poor water quality (26.6%) suggests ongoing challenges in maintaining satisfactory water quality. Participants in this category may encounter issues such as discoloration, odor, taste, or the presence of impurities in their water supply. Poor water quality can negatively impact daily activities, health, and overall quality of life. It is important to identify and address the sources of water contamination or degradation, including pollution, inadequate treatment processes, or infrastructure-related issues. Investments in water treatment technologies, regular monitoring, and quality assurance measures are necessary to improve water quality and ensure water security. The smaller proportions of participants reporting good water quality (13.0%) and very good water quality (4.4%) indicate positive perceptions of their water supply. Participants in these categories perceive their water quality to meet acceptable standards and may experience minimal issues with taste, odor, or impurities. Good water quality promotes water security by ensuring a safe and reliable water supply that meets health and hygiene requirements.

Although water quality is typically sampled and analyzed in laboratories, there has been rising public interest in the quality of drinking water since the late 20th century. There are a variety of sensors currently in use that allow for remote monitoring of water quality indicators like pH, turbidity, and dissolved oxygen levels (Li and Liu, 2018). The term “water quality” is used to describe the chemical, physical, and biological characteristics of water according to predetermined standards. Human activities like sewage discharge, pollution from industry, using water bodies as heat sinks, and excessive use (which can cause the water level to drop) all contribute to the deterioration of water quality, which is also affected by the local geology and ecosystem (International Water Resources Association, 1982). Water quality is one of the most crucial factors in determining how readily potable water can be obtained (Boyd, 2015).

The value of water depends on how it will be used. Water serves numerous functions in our daily lives, from entertainment to nutrition to agriculture to industry. Each of these uses has its own unique set of chemical, physical, and biological prerequisites. For example, the quality standards for potable water are stricter than those for water used in agriculture and industry, as stated by Shaltami and Bustany (2021). The breadth of water quality indicator measurements is indicative of the breadth and depth of the subject (Li and Liu, 2018). As such, laboratories often need water samples that must be collected, stored, transported, and analyzed away from the point of collection to conduct more intricate tests. All in all, the findings emphasize the participants' perceptions of water quality, ranging from very poor to very good. Ensuring access to clean and safe water is crucial for water security and the overall well-being of individuals and communities. By implementing effective water treatment and quality control measures, addressing sources of contamination, and promoting community engagement, policymakers and stakeholders can work towards improving water quality, enhancing water security, and safeguarding the health and welfare

Table 5.5: The main problems with water quality

Questions	No	Yes
Salinity	51.4%	48.6%
Mud/Sludge	44.0%	56.0%
Colour	48.2%	51.8%
Pollution/contamination	49.5%	50.5%
Other	86.5%	13.5%

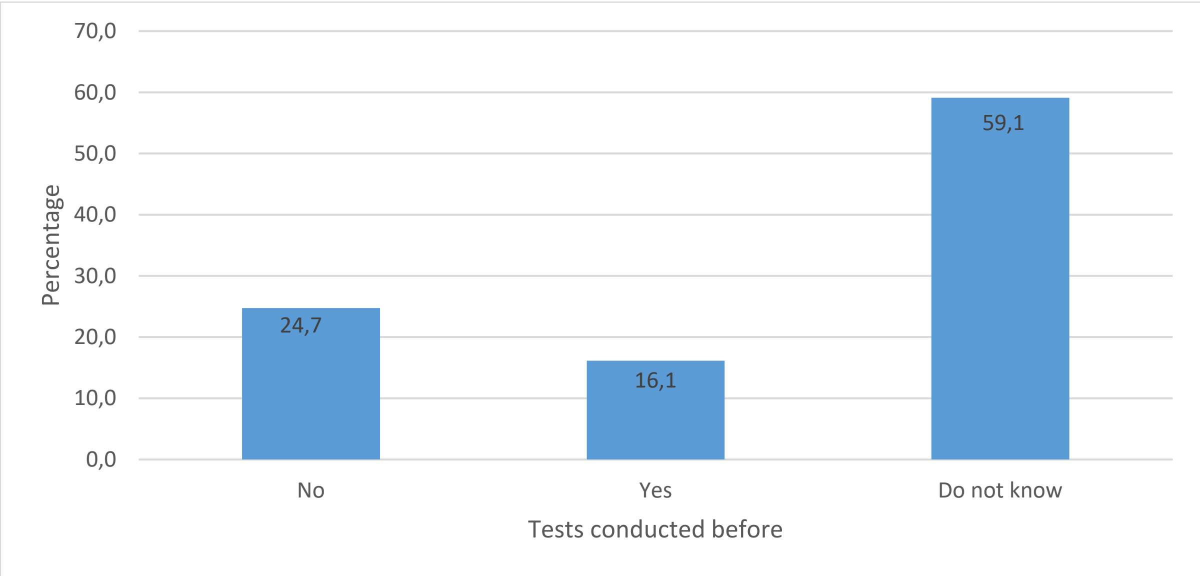
Table 5.5 presents the insights derived from a study conducted with 384 respondents regarding their perceptions of the main problems related to water quality. According to the data, the majority of participants indicated that the main problem with water quality is not salinity (51.4%), mud/sludge (56.0%), and color (51.8%). Additionally, a significant proportion of participants mentioned pollution/contamination (50.5%) as the main problem, while a smaller proportion indicated other unspecified problems (13.5%). These findings shed light on the perceived challenges related to water quality and their implications for water security, health, and well-being.

The high percentage of participants indicating mud/sludge (56.0%) as the main problem with water quality suggests issues related to suspended particles or sediment in their water sources. The presence of mud or sludge in water can lead to turbidity, affecting the clarity, taste, and overall aesthetic quality of water. These particles may also contribute to clogging of pipes, filters, and water treatment equipment. The problem of mud/sludge identified by 56.0% of participants indicates a concern for suspended solids in water. The U.S. Geological Survey has detailed the harmful effects of suspended solids in water bodies, contributing to turbidity and potentially impacting the health of aquatic ecosystems (U.S. Geological Survey, 2016). The presence of such particulates in drinking water has also been associated with various health risks (Nieuwenhuijsen et al., 2009). The proportion of participants mentioning color (51.8%) as the main problem with water quality highlights concerns related to water discoloration, which may be caused by natural or anthropogenic factors. Discolored water can be aesthetically unappealing and may raise concerns about potential health risks. The presence of color in water can be indicative of dissolved organic matter, minerals, or chemical contaminants. Concerns about watercolor, identified by 51.8% of participants, can be linked to various factors such as the presence of dissolved organic matter, minerals, or chemical contaminants (American Public Health Association, 2017).

The high percentage of participants indicating pollution/contamination (50.5%) as the main problem with water quality underscores the significance of waterborne pollutants and contaminants. Pollution and contamination can arise from various sources, including industrial activities, agricultural practices, inadequate sewage treatment, and improper disposal of waste. The issue of pollution and contamination, identified by 50.5% of the participants, has been extensively documented in the literature. For instance, the World Health Organization has repeatedly pointed out the severe health and environmental impacts of water pollution, linking it to diseases such as cholera and typhoid (WHO, 2017).

Research has also shown that industrial activities, agricultural runoff, and inadequate sewage treatment are significant contributors to water pollution (Smith, 2021). The percentage of participants mentioning other unspecified problems (13.5%) as the main issue with water quality suggests the presence of additional concerns beyond the specified categories. These may include taste, odor, hardness, presence of specific chemicals, or other localized issues that participants identified as significant challenges to water quality. Overall, the findings emphasize the participants' perceptions of the main problems associated with water quality, including mud/sludge, color, pollution/contamination, and other unspecified issues. Addressing these challenges is crucial for ensuring water security, safeguarding public health, and promoting the overall well-being of communities. By implementing targeted water quality management approaches, enhancing treatment processes, and adopting proactive measures to prevent pollution and contamination, policymakers and stakeholders can contribute to improved water quality and enhanced water security for all.

Figure 5.32: Conducted water quality tests before



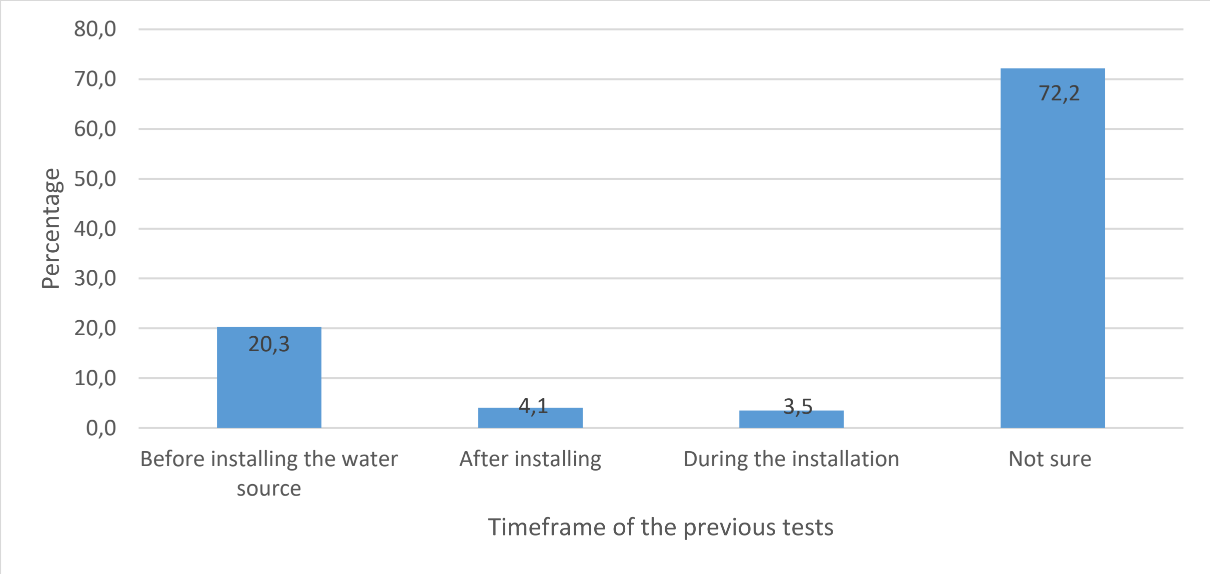
Insights into the participants' knowledge and awareness regarding the conduction of water quality tests were gained by analyzing the findings from 384 respondents, as presented in Figure 5.38. According to the data, a majority of participants (59.1%) indicated that they did not know whether water quality tests were conducted before. Additionally, 24.7% of the participants mentioned that water quality tests were not conducted before, while 16.1% indicated that water quality tests were conducted. These findings shed light on the participants' understanding of water quality monitoring practices and their implications for water security, health, and well-being. The high percentage of participants indicating that they do not know whether water quality tests were conducted before (59.1%) suggests a lack of awareness or information regarding the monitoring and testing of water quality. This may be due to limited communication, inadequate community engagement, or insufficient transparency regarding water management practices.

Research by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2012) emphasizes the role of public awareness and education in sustainable water management. The proportion of participants reporting that water quality tests were not conducted before

(24.7%) raises concerns about the lack of monitoring and assessment of water quality. The absence of regular water quality testing can result in undetected contamination or deterioration of water sources, posing risks to public health. The implementation of routine testing protocols is vital for identifying potential hazards, addressing water quality concerns, and ensuring that water supplies meet established standards. Regular water quality testing is essential to ensure safe water supplies and public health (Bain et al., 2014). A lack of testing can result in unidentified contamination, leading to potential public health crises, as seen in various outbreaks of waterborne diseases globally (Hunter et al., 2010).

The percentage of participants indicating that water quality tests were conducted before (16.1%) suggests some level of proactive monitoring and assessment of water quality. Participants in this category may have benefited from initiatives or programs that involve periodic water quality testing. This aligns with global initiatives emphasizing the need for frequent water quality testing and compliance with health-based targets, as outlined in the World Health Organization's Guidelines for Drinking Water Quality (WHO, 2017). All in all, the findings highlight the participants' knowledge and awareness regarding water quality testing. The lack of awareness and knowledge, as indicated by the high percentage of participants who do not know whether water quality tests were conducted, underscores the need for improved communication and transparency in water management practices. Regular water quality testing and monitoring are crucial for ensuring water security and protecting public health. By increasing public awareness, expanding testing programs, and promoting transparent reporting of water quality results, policymakers and stakeholders can enhance water security, instill public confidence, and safeguard the well-being of communities.

Figure 5.33: The time frame of the previous tests



The insights into the participants' knowledge and awareness regarding the timing of water quality tests were derived from the findings of a study conducted with 384 respondents, as depicted in Figure 5.39. According to the data, of those participants who indicated that water quality tests were conducted before, a majority (72.2%) mentioned that they did not know when the tests were conducted. Additionally, 20.3% of participants indicated that water quality tests were conducted before installing the water source, while a smaller proportion (3.5%) mentioned that the tests were conducted during installation. These findings shed light on the participant's understanding of the timing of water quality testing and its implications for water security, health, and well-being. Furthermore, the data highlights the gap in participant awareness about the timing of water quality tests, emphasizing the need for improved communication and transparency in water management practices. This mirrors the sentiments expressed in global literature discussing the importance of public awareness and understanding of effective water management and health protection (Jong et al., 2017). The high percentage of participants indicating that they do not know when water quality tests were conducted (72.2%) suggests a lack of information or communication regarding the timing of these tests. This lack of awareness can hinder the participants' ability to assess the reliability and safety of their water sources. Knowing when the water quality tests were conducted is important for evaluating the validity of the results and understanding whether subsequent changes or interventions may have affected the water quality. Literature supports the need for stakeholders to understand the timing of water testing to accurately assess water safety and changes in water quality over time (Gundry et al., 2004).

The proportion of participants reporting that water quality tests were conducted before installing the water source (20.3%) suggests a proactive approach to ensure water safety and quality from the initial stage. Conducting water quality tests before installing the water source allows for the identification of potential issues or contaminants that may exist in the water supply. This approach helps in making informed decisions about the suitability and appropriateness of the water source. Early testing allows for the identification and mitigation of potential water quality issues before the establishment of a new water source, a practice recommended by World Health Organization guidelines (WHO, 2017). The small percentage of participants indicating that water quality tests were conducted during installation (3.5%) implies a more immediate assessment of water quality. Testing the water quality during installation provides an opportunity to identify any immediate concerns or issues that may affect the initial water supply. This approach allows for prompt interventions and corrective measures to ensure the delivery of clean and safe water from the start. This supports the importance of real-time water quality monitoring, as suggested by Storey et al., (2011).

Table 5.6: General questions relating to water quality

Statements	No	Yes
Knowledge about the water awareness program within your area or in the municipality	85.4%	14.6%
Participation in water awareness programs	79.2%	20.8%
Existing municipal water policies address the water problem in your area	77.9%	22.1%
A new water model is needed to address the water shortages	18.2%	81.8%
Climate change is contributing to your water problems	32.6%	67.4%
Have a commercial business that uses water	89.3%	10.7%
Have water management skills	73.4%	26.6%
Sell water as a source of income	93.5%	6.5%
There are water committees in my area	81.0%	19.0%
Households have transport to fetch water	77.6%	22.4%
N=384		

The findings from 384 respondents who participated as presented in Table 5.6 provide insights into various aspects related to water awareness, participation in water programs, policy effectiveness, and community resources in addressing water problems. According to the data, the majority of participants lack knowledge about water awareness programs within their area or municipality (85.4%) and do not participate in such programs (79.2%). Additionally, a significant proportion of participants believe that the existing municipal water policy does not adequately address water problems in their area (77.9%). Furthermore, participants expressed a need for a new water model to address water shortages (81.8%) and acknowledged the contribution of climate change to their water problems (67.4%). The data also revealed low levels of engagement in water-related activities, such as commercial water use (89.3%), water management skills (73.4%), selling water as a source of income (93.5%), presence of water committees (81.0%), and personal transportation for fetching water (77.6%). The findings showcase a pressing concern regarding the lack of awareness, low participation, and insufficient policy effectiveness in addressing water-related issues among participants. This aligns with a growing body of literature underscoring the importance of public awareness, participation, and effective policies in managing water resources.

The high percentage of participants lacking awareness about water programs (85.4%) indicates a need for increased communication and outreach efforts to inform community members about available resources, educational initiatives, and opportunities for participation. As per the literature, awareness campaigns play a crucial role in improving water conservation behaviors and attitudes (Inman & Jeffrey, 2006; UN-Water, 2019). Therefore, increasing participation in water awareness programs can empower individuals to take an active role in addressing water problems and promoting sustainable water management practices. The low percentage of participants actively participating in water awareness programs (79.2%) suggests a potential gap between the availability of programs and community involvement. Participation is a key factor in the successful implementation of water management strategies, fostering local ownership, and enhancing water governance (Gleick, 2003; Medema et al., 2008). Encouraging community participation is essential for building a sense of ownership and collective responsibility toward water resources.

The perception that the existing municipal water policy does not effectively address water problems in the area (77.9%) highlights the need for policy reforms or the development of new policies to address local water challenges. Water policies should align with the specific needs and context of the community, considering factors such as water scarcity, infrastructure limitations, climate change impacts, and socioeconomic factors. The acknowledgment by participants that a new water model is needed to address water shortages (81.8%) reflects an understanding of the evolving water challenges and the need for innovative approaches. Developing and implementing new water management models can involve strategies such as water conservation, rainwater harvesting, water reuse, and integrated water resource management. These models should consider local conditions, including climate change impacts, population growth, and available water sources, to ensure sustainable water supply and long-term water security. The recognition of climate change as a contributing factor to water problems (67.4%) aligns with the global understanding of the impact of climate change on water availability and quality. Climate change can lead to altered precipitation patterns, increased water scarcity, and changes in hydrological systems. The low engagement in commercial water use (89.3%), water management skills (73.4%), and selling water as a source of income (93.5%) indicates limited economic opportunities related to water resources within the community. Encouraging entrepreneurship, capacity building, and skill development in water-related sectors can create employment opportunities, improve livelihoods, and contribute to sustainable water management practices. The limited presence of water committees (81.0%) suggests a potential gap in community-level involvement in decision

5.2.5 Descriptive statistics of the multiple uses

This subsection presents the results of the multiple uses of water from 384 respondents who participated. The results are presented using the following tables and charts.

5.2.5.1 Utilization of water for purposes beyond domestic needs, such as drinking, cooking, washing, bathing, and the like

From the 384 respondents who participated, a significant majority of participants (72.9%) indicated that they use water for non-domestic purposes, while a smaller proportion (27.1%) reported using water solely for domestic purposes. These findings shed light on the diverse water needs within the community and their implications for water security, resource management, and sustainability. The findings highlight the multi-faceted use of water resources by participants, beyond domestic consumption. This is in line with the literature emphasizing the multiple roles that water plays in societies and economies (WWAP, 2015). The high percentage of participants using water for non-domestic purposes (72.9%) suggests a range of additional water demands beyond domestic requirements. In many developing regions, water is central, not only to domestic needs, but also to economic activities, such as irrigation for farming, livestock watering, and small-scale industries (FAO, 2011).

Non-domestic uses of water can include activities such as agriculture, industrial processes, commercial operations, and community services. These sectors often require substantial volumes of water and contribute to the overall water demand within the community. The proportion of participants using water solely for domestic purposes (27.1%) indicates a focus on meeting basic household needs such as drinking, cooking, bathing, and sanitation. These diverse uses of water underscore the need for IWRM that considers all uses and users of water in policy-making and planning (GWP, 2000). Domestic water use is essential for human health, hygiene, and well-being. Ensuring reliable access to clean and safe water for domestic purposes is a fundamental requirement for achieving water security. The UN's Sustainable Development Goal 6 aims to ensure the availability and sustainable management of water and sanitation for all, reflecting the importance of water for domestic purposes (UN, 2015).

Table 5.7: The specific uses of water

Questions	No	Yes
Garden Watering	37.2%	62.8%
Car Wash	78.6%	21.4%
Business	81.4%	15.6%
Livestock watering	77.6%	22.4%
Growing food	34.6%	65.4%
Recreation	91.4%	8.6%
Sanitation and waste disposal	67.7%	32.3%
Other	99.7%	0.3%
N=384		

The findings from 384 respondents that participated as presented in Table 5.7 provide insights into the specific non-domestic uses of water reported by participants. The data highlights the various ways in which water is utilized beyond domestic needs and its implications for water security, resource management, and sustainability. Among the participants who reported using water for non-domestic purposes, a significant proportion (62.8%) indicated that they use water for watering the garden. This finding suggests the importance of water for agricultural and horticultural practices, which contribute to food production and self-sufficiency. Also, the finding aligns with the global trend of increased use of water for gardening and small-scale agriculture (Tiwari, Nayak, & Sen, 2016). Water plays an indispensable role in food production and maintaining green spaces in communities, both of which contribute to food security and community aesthetics respectively.

Regarding car washing, the majority of participants (78.6%) stated that they do not use water for this purpose. This indicates a potential awareness of the water-intensive nature of car washing and a willingness to adopt alternative methods, such as waterless or water-efficient car washing techniques. Such practices contribute to reducing water consumption and minimizing environmental impacts associated with car washing activities Studies have shown a growing trend of adopting water-saving techniques in car washing as a part of sustainable water management practices (Hartley, 2006). Similarly, a significant majority of participants (81.4%) reported not using water for business purposes. This finding implies that water-intensive businesses might not be prevalent within the community, or that alternative water sources or practices are employed for commercial operations The low usage of water for business purposes (81.4% not using it for this purpose) suggests that the community may not have many water-intensive businesses or could reflect the use of water-efficient strategies in commercial operations (Vörösmarty et al., 2010).

Regarding livestock watering, a substantial proportion of participants (77.6%) indicated that they do not use water for this purpose. This suggests a potential low dependency on livestock farming or the availability of alternative water sources, such as natural watering holes or dedicated water infrastructure for livestock. Water availability significantly influences livestock production and the well-being of rural communities where livestock plays an essential role. In terms of growing food, a notable proportion of participants (65.4%) reported using water for this purpose. This finding aligns with that of Rosegrant et al., (2002). This highlights the significance of water for agricultural activities, specifically for food production. The majority of participants (91.4%) reported not using water for recreational purposes, suggesting that water-related recreational activities might not be prevalent within the community.

This finding may indicate limited access to recreational water bodies or a focus on water conservation measures rather than recreational water use. According to Bryant (2006), this might suggest a lack of water-based recreational facilities or a community preference for water-saving behaviors. However, providing opportunities for safe and sustainable water-based recreation can have positive impacts on community well-being and social cohesion. Participants largely reported not using water for sanitation and waste disposal purposes (67.7%). This could imply the presence of alternative waste management systems, such as sewerage infrastructure or septic tanks, or adherence to water-efficient sanitation practices. Finally, the overwhelming majority of participants (99.7%) indicated that they do not use water for other unspecified purposes. This indicates that the reported non-domestic water uses are comprehensive, covering the main categories of water utilization within the community.

5.2.5.2 Water sources are utilized for the same purposes such as domestic uses

The findings from 384 respondents who participated provide insights into the participant's usage of the same water sources for domestic purposes. According to the data, an overwhelming majority of participants (99.2%) indicated that they use the same water sources for their domestic needs, while a small proportion (0.8%) opposed this statement. These findings shed light on the consistency of water sources and their implications for water security, accessibility, and reliability within the community. The high percentage of participants indicating the use of the same water sources for domestic purposes (99.2%) suggests a reliance on a consistent water supply for meeting daily household needs. This is often observed in communities with established municipal water systems, where a single source or network supplies water to most households (Wong & Kerkez, 2016). A reliable water source is critical for everyday life, as it supports essential activities like cooking, cleaning, and sanitation (Hutton & Varughese, 2016).

This consistency can contribute to the stability and predictability of water availability, ensuring that individuals have access to the necessary amount of water for their essential domestic activities. The findings on the high reliance on a single source for domestic use highlight the importance of maintaining the sustainability and quality of this source, as it significantly impacts water security. This aligns with research emphasizing the need for effective water management strategies to ensure the longevity and reliability of water sources (Cook & Bakker, 2012). Dependence on the same water sources for domestic purposes implies a certain level of accessibility and convenience, as individuals can rely on a single water supply infrastructure for their household needs. The small percentage of participants opposing the use of the same water sources for domestic purposes (0.8%) indicates a potential variation in water sources or alternative arrangements within the community. This dissent may arise due to factors such as the use of multiple water sources, reliance on alternative sources for certain domestic activities, or discrepancies in water supply accessibility.

Studies indicated that households may resort to alternative sources when the primary source is insufficient, unreliable, or of poor quality (Onda, LoBuglio & Bartram, 2012). Understanding the reasons behind this diversification can shed light on potential inadequacies in the primary water supply. Water security is closely linked to the availability, accessibility, and reliability of water sources. Access to a consistent and reliable water supply for domestic purposes is vital for maintaining basic hygiene, sanitation, and overall well-being. Dependence on the same water sources can promote stability and predictability in water availability, contributing to the overall water security of the community. However, it is crucial to ensure the sustainability of these water sources, as well as adequate infrastructure maintenance, to avoid disruptions in water supply and maintain long-term water security

5.2.6 Descriptive statistics of the additional questions (currency)

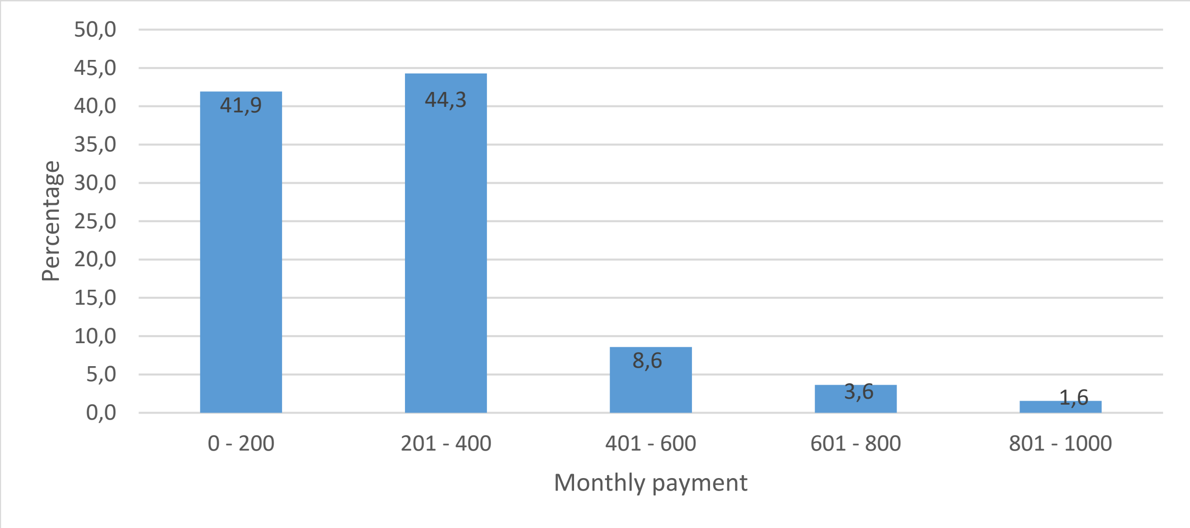
This subsection presents the results of the additional questions. The results are presented using the following tables and charts.

5.2.6.1 Connected to electrical supply

The findings from the 384 respondents who participated provide insights into the participants' access to electricity within the community. According to the data, a majority of participants (83.6%) indicated that they are connected to electricity, while a minority (16.4%) reported being without electricity. These findings shed light on the relationship between electricity access and water security, highlighting the importance of a reliable energy supply for water-related activities and overall community well-being. The high percentage of participants indicating access to electricity (83.6%) suggests a relatively high level of infrastructure development and electrification within the community. This aligns with global trends, where the number of people with electricity access has been increasing, particularly in urban areas (IEA, 2019).

Access to electricity is vital for various aspects of water security, as electricity powers water pumping, treatment, and distribution systems, and household appliances that contribute to water quality and sanitation (Szabo et al., 2015). Electricity is also required for running household appliances, such as water heaters, washing machines, and water purifiers, which contribute to water quality and sanitation. On the other hand, the proportion of participants without electricity (16.4%) highlights a potential disparity in infrastructure access and the associated challenges faced by these individuals. Lack of electricity can hinder access to clean water, as water supply systems often rely on electrically powered pumps and distribution networks (Modisha et al., 2020). It also impacts hygiene practices and sanitation facilities, thereby negatively affecting community health (Prüss-Ustün et al., 2014). Overall, the findings underline the need for improving access to electricity in the community to enhance water security. This is supported by global efforts to achieve universal access to affordable, reliable, sustainable, and modern energy by 2030 under the United Nations' Sustainable Development Goals (UN, 2015).

Figure 5.34: The monthly payment for the electrical supply



Insights into the electricity costs incurred by participants connected to the grid are revealed in Figure 5.34, which presents findings based on data collected from 384 respondents. According to the data, a significant proportion of participants (44.3%) pay between R201 and R400 per month for electricity, while 41.9% indicated that they pay at most R200 per month. The smallest proportion (1.6%) reported paying R801 to R1000 per month. These findings shed light on the financial implications of electricity costs and their connection to water security, emphasizing the importance of affordable energy access for maintaining a reliable water supply and overall community well-being. The high percentage of participants paying between R201 and R400 per month (44.3%) suggests that the majority of the community may afford electricity at this cost level, which in turn enables the operation of water infrastructure such as pumps, treatment facilities, and distribution systems (Alfieri et al., 2017).

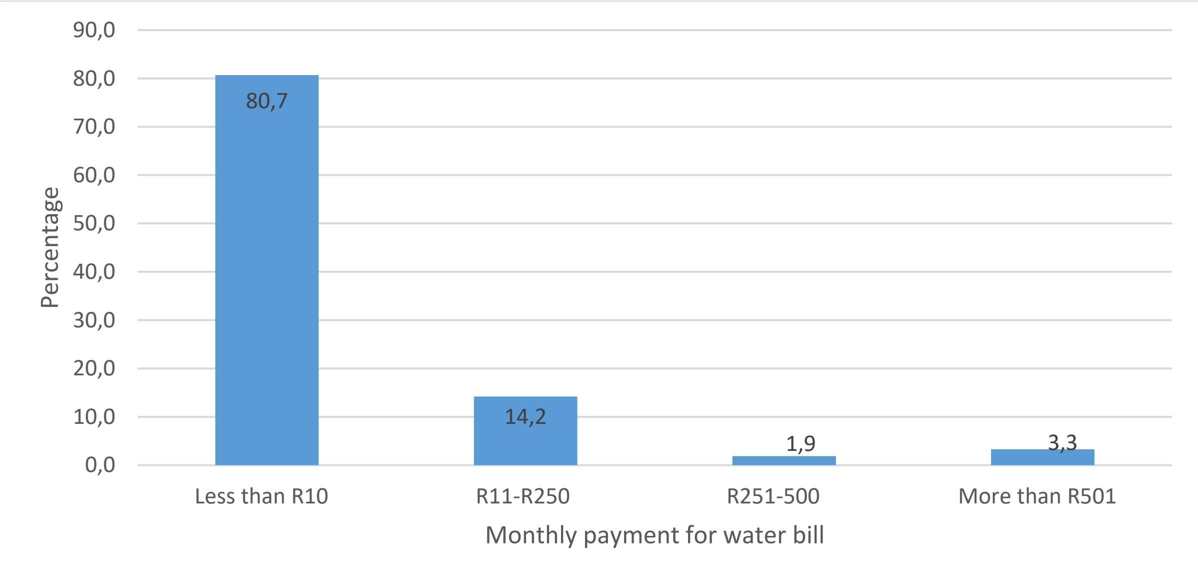
Affordable electricity costs enable individuals and households to maintain a reliable water supply and meet their domestic water needs without financial strain. Electricity is crucial for maintaining a reliable and sustainable water supply (Szabo et al., 2015). Reliable access to electricity is crucial for operating water pumps, treatment facilities, and distribution systems, which are vital components of a secure and sustainable water supply. The significant proportion of participants paying at most R200 per month (41.9%) highlights a focus on managing electricity expenses within a lower range. This finding implies the presence of budget-conscious practices, including energy conservation and efficient use of electrical appliances. Energy-efficient practices can help reduce electricity costs, supporting energy and water conservation efforts (Ürge-Vorsatz et al., 2012). The small proportion of participants paying R801 to R1000 per month (1.6%) suggests that higher electricity costs may be a financial burden for a minority of households. High electricity expenses can strain household budgets, affecting the ability to afford water-related expenses and potentially compromising water security (Modisha et al., 2020). It is important to alleviate the financial burden of high electricity costs through initiatives like energy-saving programs and affordable, sustainable energy solutions (Jamasb & Nepal, 2015).

5.2.6.2 Current status of making monthly payments for water

Insights into the current payment status for water services of the participants were gained from a study involving 384 respondents. According to the data, a significant majority of participants (76.0%) indicated that they are not currently paying a monthly bill for water, while a smaller proportion (24.0%) reported paying a monthly bill for water. These findings shed light on the financial dynamics of water access and its connection to water security, emphasizing the importance of affordability and sustainable financing mechanisms for ensuring reliable and equitable access to water. The high percentage of participants not currently paying a monthly bill for water (76.0%) suggests the presence of non-metered or subsidized water supply arrangements within the community. Non-payment may be attributed to various factors, including government subsidies, communal water supply systems, or alternative financing models. This might be particularly relevant in low-income communities where affordability is a significant barrier to water access (Bakker et al., 2008; Hutton, 2012).

The smaller proportion of participants paying a monthly bill for water (24.0%) indicates a segment of the community that has a formalized billing system in place. This suggests a more structured approach to water service provision, with individuals and households bearing the financial responsibility for their water consumption. Paying for water services ensures the financial viability of water supply infrastructure and encourages responsible water use and conservation practices (Rogers et al., 2002). This model assumes that individuals who bear financial responsibility for their water consumption are more likely to use water responsibly (Ioris, 2018).

Figure 5.35: The monthly payment for the water bill

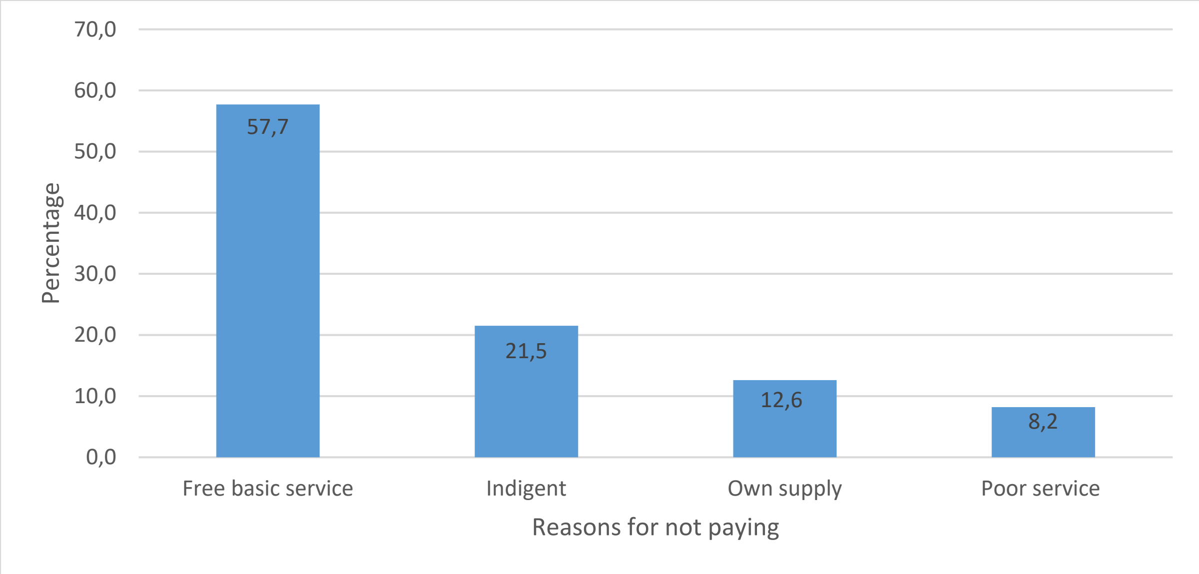


Insights into the payment amounts reported by participants currently paying a monthly bill for water services are derived from the findings of 384 respondents, as depicted in Figure 5.35. According to the data, a significant majority of participants (80.7%) indicated that they pay less than R10 per month for water, while a smaller proportion (14.2%) reported paying between R11 and R250 per month. The smallest percentage (1.9%) indicated paying between R251 and R500 per month. These findings shed light on the affordability of water services and their connection to water security, emphasizing the importance of accessible and equitable payment structures to ensure reliable access to clean and safe water. The high percentage of participants paying less than R10 per month (80.7%) suggests the presence of subsidized or heavily subsidized water services within the community. These low payment amounts indicate that water services are affordable and within reach for the majority of households, reducing financial barriers to accessing a vital resource for daily domestic needs.

Literature supports the notion that water services subsidies can help reduce financial barriers to accessing a vital resource for daily domestic needs (Komives et al., 2005). Affordable water prices contribute to water security by ensuring that households can meet their basic water requirements without significant financial strain (Smits et al., 2008). The proportion of participants paying between R11 and R250 per month (14.2%) represents a middle-range payment category. While higher than the group paying less than R10, this segment still indicates a relatively affordable payment range for water services. Individuals and households in this category may have slightly higher consumption patterns or different tariff structures, leading to moderately higher monthly bills. Nonetheless, the literature suggests that this range is not likely to pose significant affordability challenges (Rogers et al., 2002). The smallest proportion of participants paying between R251 and R500 per month (1.9%) suggests a higher payment category that may indicate higher consumption levels or specific tariff structures. Although this percentage is small, it is important to consider the potential financial burden that higher water bills may pose for these households. Literature suggests that higher water bills may pose financial burdens on these households, indicating a need for fair and affordable water rates for all income groups (Seager et al., 2017).

According to the findings of some studies, households that are paying for water are typically in a better position to have reliable access to water than those households that are not paying (Pinto et al., 2018; Dlamini, 2015; Kujinga et al., 2014). Furthermore, several empirical studies (Kanyoka, et al., 2008; Speelman, et al., 2009; Turpie et al., 2008) have been conducted in South Africa to examine the willingness to pay for water among households. Using a choice modeling approach, Kanyoka et al. (2008) studied the preferences and willingness to pay of rural South African households for multiple-use water services. The Sekororo-Letsoalo region of Limpopo Province was the site of the research. The study's findings show that rural residents are willing to pay more for better water infrastructure. Additionally, Mezgebo and Ewnetu's (2015) probit model research on households' willingness to pay for improved water services in urban areas of Ethiopia confirmed several socio-economic factors that explained households' willingness to pay for such services. A few examples are the price per unit, the inequitable treatment households face when collecting water from the public supply, and the infrequency with which water is available. Based on their descriptive analysis, Mezgebo and Ewnetu (2015) found that 96% of households were willing to pay for the provision of better water service. The probit model found that households' willingness to pay for the provision of improved water services was related to factors such as income, main water source distance to dwelling, water expenditure, proposed bid, educational attainment, existing water satisfaction, marital status, and sex. In light of the foregoing, it is highly pertinent to learn what motivates individuals to pay for water services in their homes, as this will guarantee a steady income stream necessary for a sustainable water supply.

Figure 5.36: The reasons for not paying

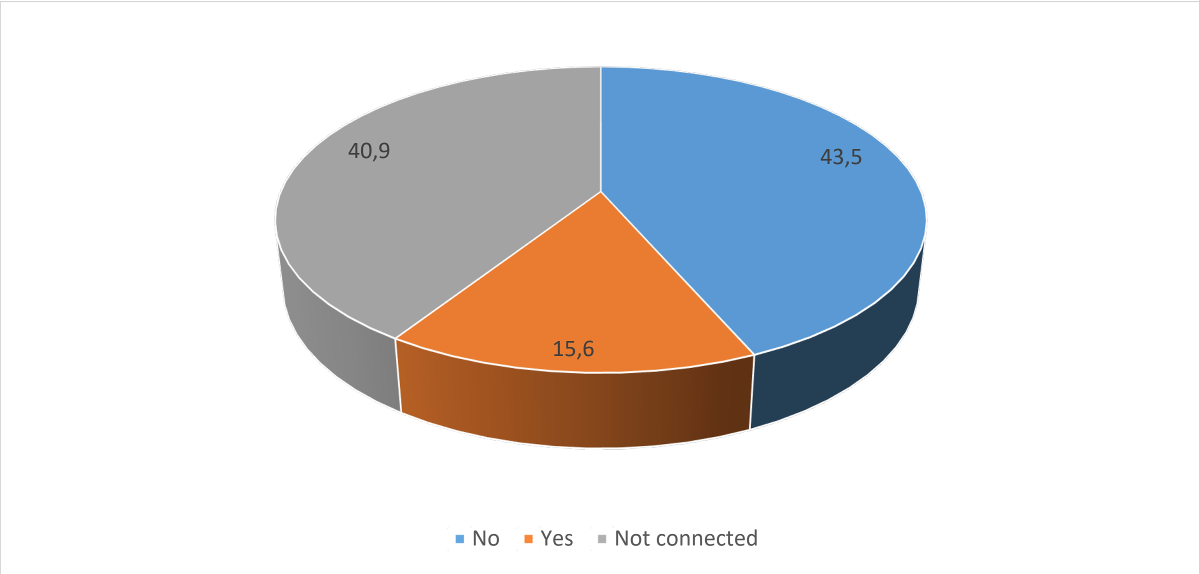


Insights into the reasons why participants who are not currently paying a monthly bill for water do not incur charges were obtained from 384 respondents, whose findings are illustrated in Figure 5.36. According to the data, a majority of participants (57.7%) indicated that they are not paying for water because it is considered a free basic service, while a significant proportion (21.5%) mentioned being indigent as the reason for non-payment. The smallest percentage (8.2%) reported not paying due to poor service. These findings shed light on the dynamics of payment exemption and its implications for water security, emphasizing the importance of equitable access and sustainable financing models for ensuring reliable and affordable water services. The high percentage of participants (57.7%) indicating that water is a free basic service as the reason for non-payment suggests the presence of government policies or programs that provide subsidized or cost-free water to specific segments of the population. This aligns with literature that discusses the role of government subsidies in making basic services like water accessible to all. For instance, the World Bank (2015) acknowledges the importance of government subsidies in making water a basic free service to promote equity and inclusivity.

The proportion of participants (21.5%) mentioning indigence as the reason for non-payment highlights the financial constraints faced by some individuals or households. Indigent individuals may not have the means to afford water charges due to low income levels or other economic challenges. The literature acknowledges that low-income households may struggle to afford basic utilities such as water, underscoring the need for financial support and subsidies

(Pattanayak et al., 2005). It is essential to consider the financial circumstances of these households and provide targeted support mechanisms to ensure their access to water. The smallest percentage of participants (8.2%) reporting poor service as the reason for non-payment indicates dissatisfaction with the quality or reliability of water services provided. Inadequate service delivery can significantly impact water security, as it affects the availability, accessibility, and reliability of clean and safe water. Literature confirms that inadequate service delivery can lead to resistance to paying for such services (Whittington et al., 2008).

Figure 5.37: Paid to be connected to the public or community water network



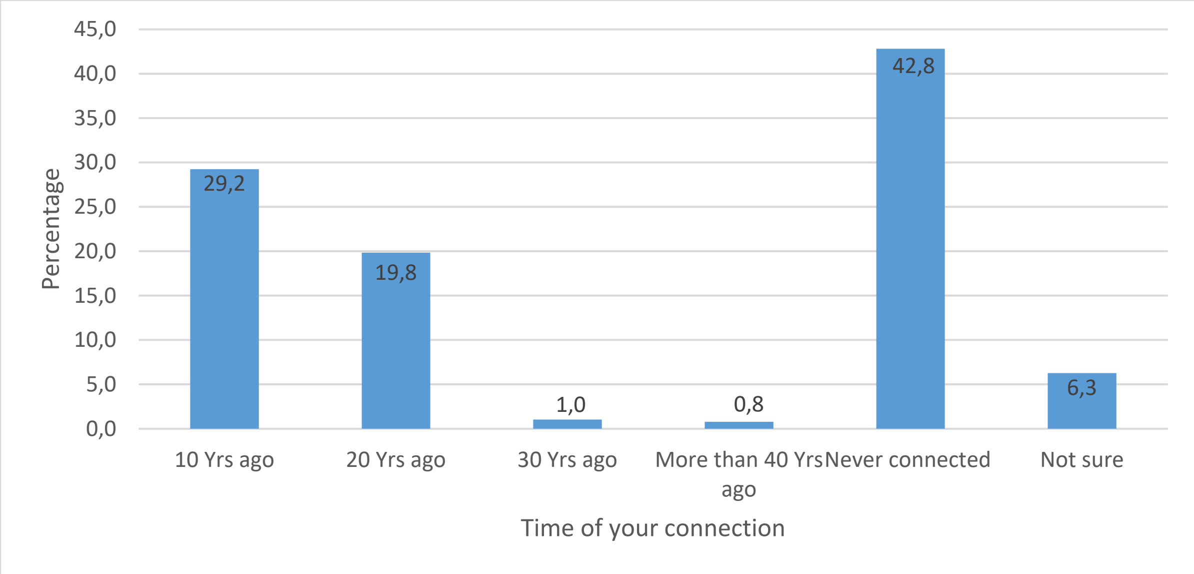
Insights into the connection and payment status of participants to the public or community water network were obtained from 384 respondents, as depicted in Figure 5.37. The findings shed light on the relationship between the participants and their connection to, as well as the payment status for, the public or community water network. According to the data, the majority of participants (43.5%) indicated that they do not pay to be connected to the public or community water network, while 40.9% indicated that they are not connected to the network. A smaller proportion of participants (15.6%) indicated that they pay to be connected to the public or community water network. The high percentage of participants (43.5%) indicating that they do not pay to be connected to the public or community water network suggests that they may have alternative sources of water or are accessing water through informal means. This could include relying on self-built or shared water sources, such as boreholes, wells, or informal water vendors. This finding highlights potential challenges in accessing and affording formal water services, which may impact water security.

The significant proportion of participants (40.9%) indicating that they are not connected to the public or community water network suggests limited access to a reliable and regulated water supply system. This lack of connection may be due to various factors, including geographical location, infrastructure limitations, or affordability constraints. The absence of a formal connection to the water network can contribute to water insecurity, as it may result in reliance on unimproved water sources, inconsistent water availability, and challenges in meeting water-related needs. The smaller percentage of participants (15.6%) indicating that they pay to be connected to the public or community water network indicates a willingness or ability to access formal water services through financial means. Paying for a connection to the water network suggests a level of affordability and recognition of the importance of a reliable and regulated water supply.

5.2.6.3 The amount paid for the connection to the public or community water network

The insights into the payment range for individuals who choose to be connected to the public or community water network can be gleaned from the findings of 384 respondents. According to the data, the majority of participants (97.1%) indicated that they paid at most R1000 for the connection, while a small proportion (0.3%) indicated that they paid between R4001 and R5000. These findings shed light on the financial implications of connecting to the formal water network and their relationship to water security. The high percentage of participants (97.1%) who paid at most R1000 for the connection suggests that the cost of connecting to the public or community water network is relatively affordable for most individuals in the sample. This affordability may be influenced by various factors such as government subsidies, community programs, or favorable pricing structures. The relatively low connection costs indicate that financial barriers to accessing formal water services are not substantial for the majority of participants. The small proportion of participants (0.3%) who paid between R4001 and R5000 for the connection indicates a higher financial burden for a select few individuals. This higher cost may be attributed to various factors, including geographical location, infrastructure complexities, or specific connection requirements. While this proportion is minimal within the sample, it highlights the presence of financial challenges and potential inequalities in accessing water services for a small segment of the population.

Figure 5.38: The time of your connection to the public or community water network



Insights into the participants' connection history to the water network can be gleaned from the findings of 384 respondents, as illustrated in Figure 5.38. These findings shed light on the relationship between the participants and their past involvement with the water network. According to the data, the majority of participants (42.8%) indicated that they were never connected to the water network. A significant proportion (29.2%) reported being connected 10 years ago, followed by 19.8% who indicated being connected 20 years ago. The smallest proportion (0.8%) of participants reported being connected more than 40 years ago. These findings shed light on the historical context of water access and the implications for water security. The high percentage of participants (42.8%) who indicated that they were never connected to the water network suggests a significant lack of access to formal water services among the sample population. The absence of a formal connection to the water network can contribute to water insecurity, as it may result in limited access to clean and safe water, inadequate sanitation facilities, and potential health risks.

The substantial proportion of participants (29.2%) reporting a connection to the water network 10 years ago suggests that some progress has been made in expanding water access over the past decade. This finding implies that efforts have been made to extend water services to previously underserved areas or to households that were not connected in the past. The presence of participants (19.8%) reporting a connection to the water network 20 years ago indicates that water access improvements have been ongoing for a more extended period. This finding suggests that earlier initiatives or infrastructure developments have had a positive impact on expanding water services to a significant number of households. The relatively small proportion (0.8%) of participants reporting a connection to the water network more than 40 years ago indicates long-standing access to formal water services for a few individuals. This finding may reflect communities or areas where water infrastructure has been in place for an extended period, ensuring continuous water access for these households.

Figure 5.39: In the event that you are not currently connected to the public water network, or if your existing connection requires refurbishment, indicate the amount you would be willing to pay as a one-time fee for a new or refurbished connection

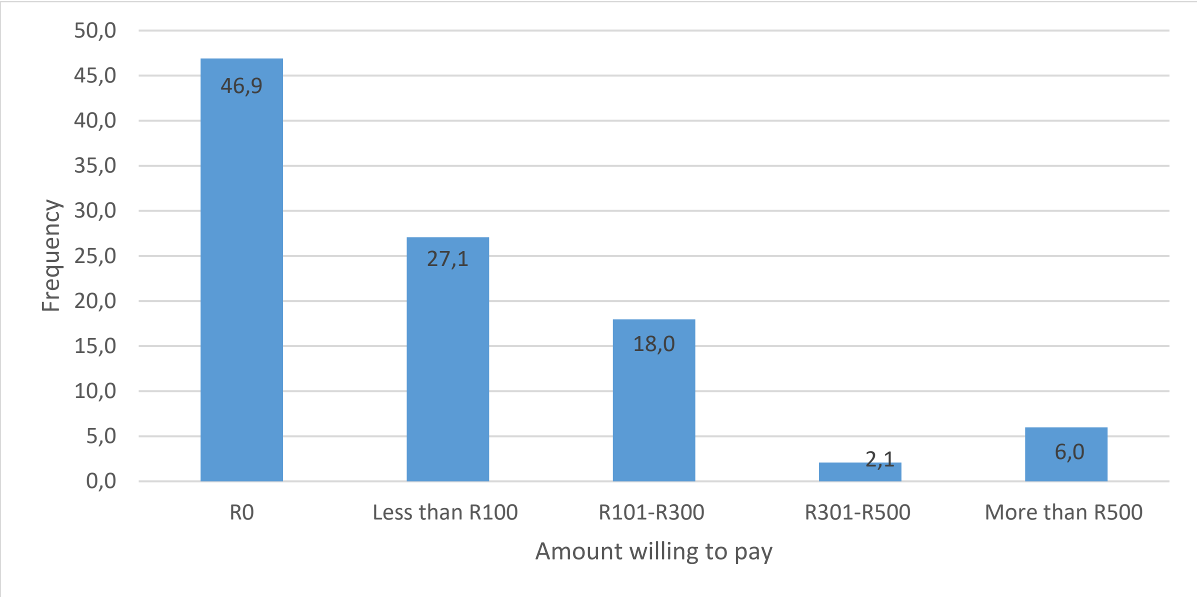


Figure 5.39 displays the insights gained from analyzing responses gathered from a total of 384 participants regarding their willingness to pay for access to the new or renovated water network. According to the data, the majority of participants (46.9%) indicated that they are not willing to pay any amount (once-off payment) for the connection. A significant proportion (27.1%) expressed their willingness to pay less than R100, while a small proportion (2.1%) indicated a willingness to pay between R301 and R500. These findings shed light on the financial considerations and preferences of individuals regarding the costs associated with connecting to the new or refurbished water network and their implications for water security. The high percentage of participants (46.9%) who are not willing to pay any amount for the connection suggests a potential barrier to the expansion of the new or refurbished water network. This finding indicates that a considerable segment of the population may face financial constraints or

perceive the cost of connection as unaffordable. This unwillingness to pay highlights the need for affordable or subsidized options to ensure that water services are accessible to all, particularly for vulnerable households or communities with limited financial resources.

A significant proportion of participants (27.1%) expressing a willingness to pay less than R100 for the connection indicates that affordability is a crucial factor in their decision-making process. This finding suggests that individuals who are willing to pay a nominal fee are more likely to consider connecting to the new or refurbished water network. The small proportion (2.1%) of participants indicating a willingness to pay between R301 and R500 for the connection suggests that some individuals recognize the value and benefits associated with the new or refurbished water network and are willing to invest a relatively higher amount. This finding implies that for certain households, the improved water access, reliability, and quality offered by the upgraded network may outweigh the financial considerations, leading to a willingness to contribute a higher payment.

5.2.7 Descriptive statistics of the water source: canal or river

This subsection presents the results of the water source (canal or river). The results are presented using the following tables and charts.

Figure 5.40: The frequency of water collection per day

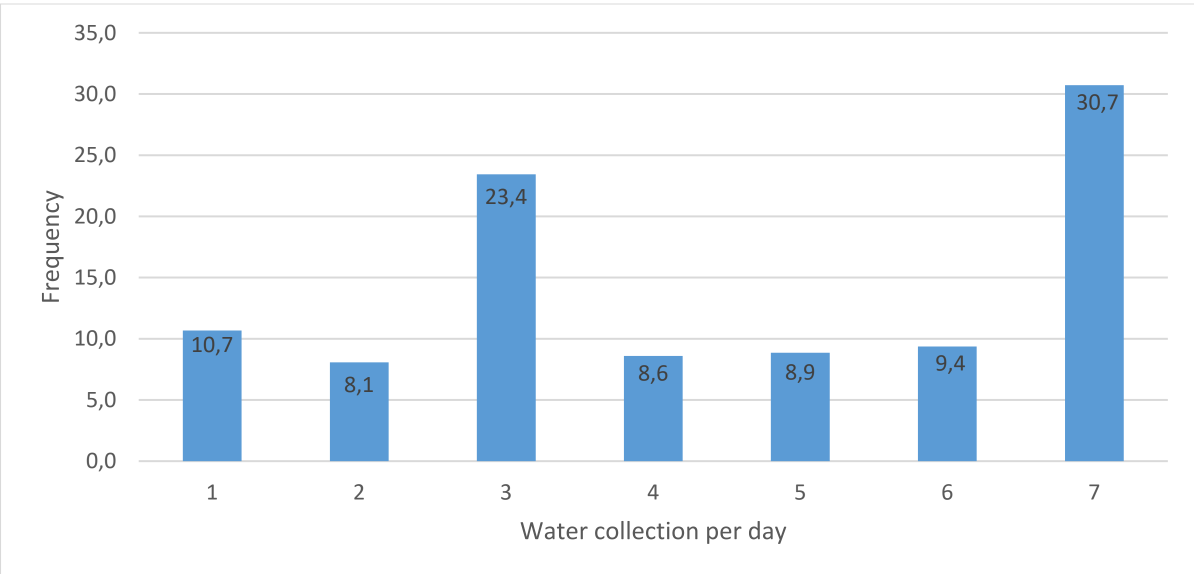
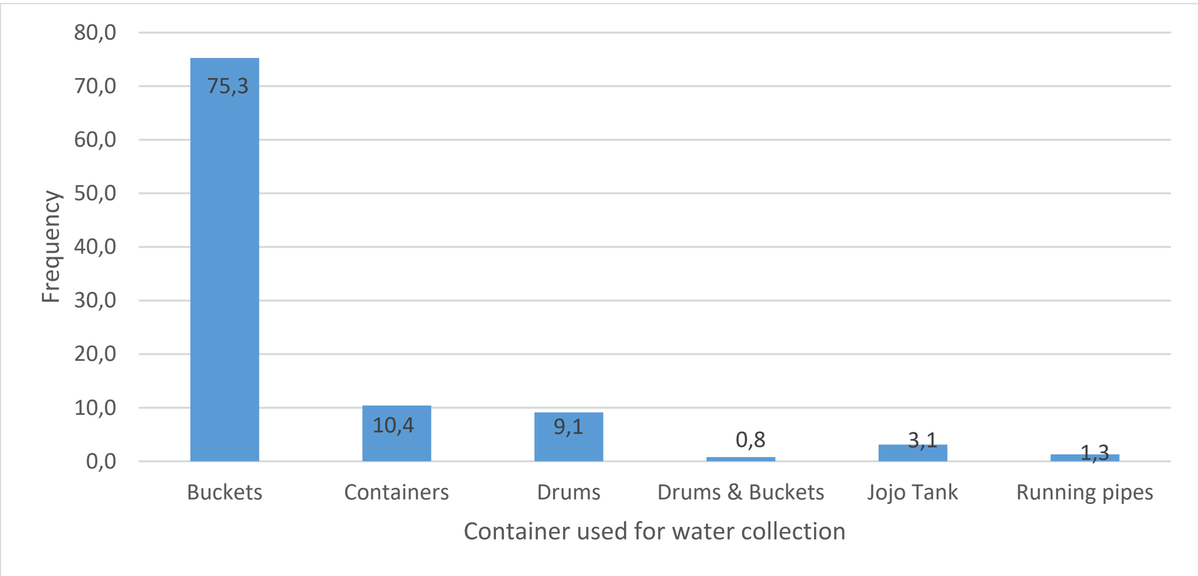


Figure 5.40 reveals valuable insights into the frequency of water collection from a canal or river among the participants, based on the data collected from a total of 384 respondents. These

findings shed light on the patterns and habits surrounding water collection practices in relation to these natural water sources. According to the data, participants who collected water from a canal or a river reported varying frequencies of collection. The majority of participants (30.7%) indicated collecting water 7 times per week, followed by 23.4% who reported collecting water 3 times per week. The smallest proportion (8.1%) of participants reported collecting water 2 times per week. The high percentage of participants (30.7%) who reported collecting water 7 times per week suggests a high frequency of water collection, indicating that these individuals heavily rely on the canal or river as their primary source of water. This finding highlights the challenges faced by households in accessing sufficient water for their daily needs. The need to collect water frequently indicates the limited availability or capacity of the canal or river as a water source, potentially leading to increased time and effort spent on water collection.

The substantial proportion of participants (23.4%) reporting collecting water 3 times per week suggests a lower frequency of water collection compared to the previous group. This finding implies that these individuals have relatively better access to water or employ conservation measures to manage their water needs more efficiently. The smaller proportion (8.1%) of participants reporting collecting water 2 times per week suggests a further reduction in the frequency of water collection. This finding may indicate better access to water sources or the utilization of storage techniques to reduce the frequency of water collection.

Figure 5.41: The type of containers utilized for water collection



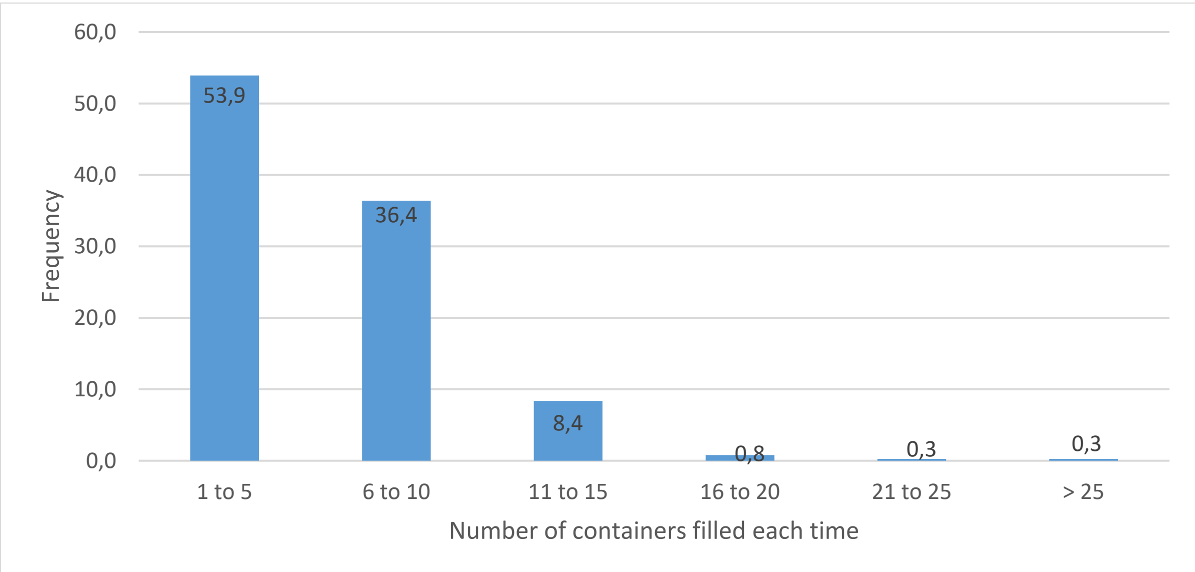
Insights into the containers used by participants to collect water can be derived from the findings of a study that involved 384 respondents. These findings, which are depicted in Figure 5.41, shed light on the specific choices made by individuals when it comes to selecting containers for water collection. According to the data, the majority of participants (75.3%) reported using buckets as their primary container for water collection. A smaller proportion of participants (10.4%) indicated using containers, while the least represented categories were drums and buckets (0.8%). These findings shed light on the types of containers utilized for water collection and their implications for water security. The high percentage of participants (75.3%) using buckets for water collection suggests that this is the most common and readily available container in the study area. Buckets are commonly used due to their affordability, ease of use, and portability. However, it is important to consider the limitations of buckets in terms of their capacity, which may require multiple trips for water collection, especially when water availability is limited or the distance to the water source is significant. This can result in time and energy constraints for individuals and potentially affect their daily routines and productivity.

The proportion of participants (10.4%) using containers for water collection signifies the utilization of alternative containers with potentially larger capacities compared to buckets. Containers offer advantages such as greater storage capacity and stability, allowing individuals to collect larger quantities of water in a single trip. This can contribute to more efficient water collection, reducing the frequency of trips to the water source and potentially freeing up time for other activities. The small proportion (0.8%) of participants using drums and buckets for water collection indicates a less common practice. Drums and buckets may offer larger storage capacities compared to standard buckets, enabling individuals to collect and store larger amounts of water. This can be particularly advantageous in situations where water availability is intermittent or when individuals are preparing for periods of water scarcity. It is essential to address the availability, affordability, and suitability of containers to support effective water management and enhance water security. Policymakers, water service providers, and community organizations should explore strategies to ensure the widespread availability and accessibility of appropriate containers, taking into account the specific needs and contexts of the target population. By addressing container-related challenges, individuals can improve their capacity to collect, store, and manage water, contributing to enhanced water security and overall well-being.

In general, these findings lend credence to a hypothesis put forth by Spiridon et al. (2021) that water is stored in a wide variety of containers around the world. For instance, different containers such as jerry cans, buckets, drums, basins, and native vessels are used to hold water (García-Betancourt, et al., 2015). Also, traditional pots and urns made from clay or gourds coexist with more modern containers made of metals like steel, copper, aluminum, and increasingly plastic. Not all containers for storing water are created equal. The Oxfam bucket, displayed below, which was created by Spiridon et al. (2021) and tested in the field to ensure its safety and functionality, is now widely used around the world.

Source: Oxfam Bucket

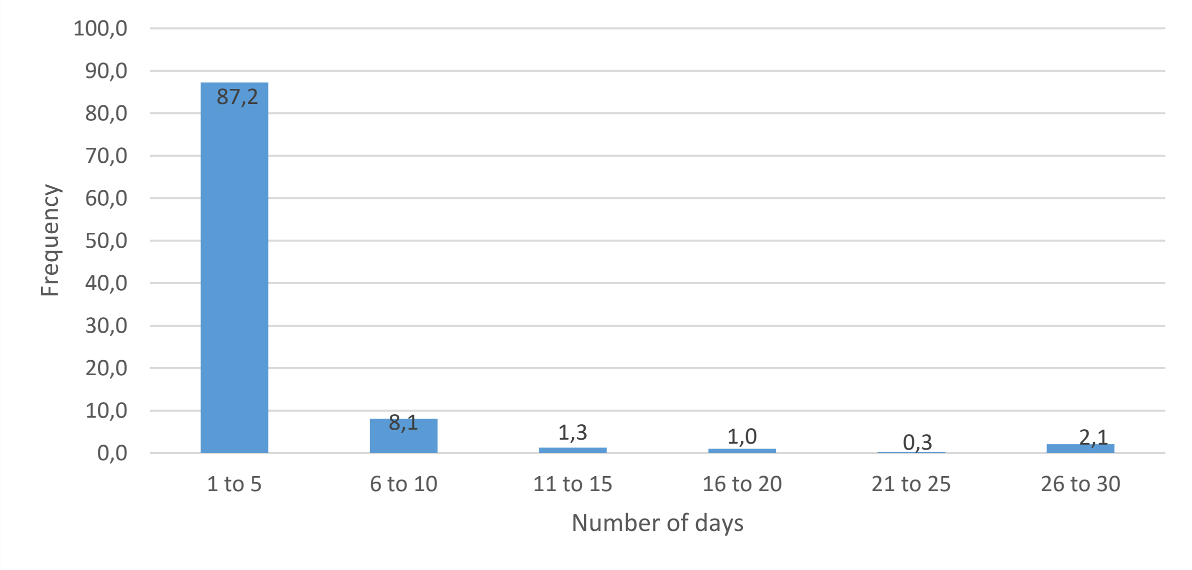
Figure 5.42: Number of containers of this type filled each time



The findings presented in Figure 5.42 provide insights into the number of containers participants fill during each water collection episode. According to the data, the majority of participants (53.9%) indicated that they fill 1 to 5 containers at each time, followed by 36.4% who fill 6 to 10 containers, and a smaller proportion of participants who fill 11 to 15 containers (8.4%). Only a small percentage of participants (1.4%) reported filling at least 16 containers during each water collection episode. The distribution of the number of containers filled suggests variations in water collection practices among the participants. Individuals who fill fewer containers may have access to smaller containers or limit their water collection to meet immediate needs or conserve water. On the other hand, those who fill a larger number of containers may have larger storage capacity requirements or engage in bulk water collection to minimize the frequency of trips to water sources.

Most of the households studied do not meet the minimal service criteria for water, which include access to water 52 weeks a year, a minimum of 1500 liters of water per household per week, and a maximum walking distance of 100 meters between the farthest household and the standpipe (as stated by the Department of Water and Sanitation, 2017). If there were to be a breakdown in the current water system, the criteria for an interim level of service would not be met. The findings related to the number of containers filled during water collection highlight variations in water collection practices among participants. The number of containers filled can impact water storage capacity, flexibility in meeting water needs, and the physical and time burden of water collection. Understanding these variations and their implications is crucial for developing targeted interventions to improve water security. By addressing the challenges associated with water collection and storage, policymakers and stakeholders can enhance access to water and promote sustainable water management practices, ultimately improving water security for individuals and communities.

Figure 5.43: The duration (number of days) that this water lasts



The findings presented in Figure 5.43 provide insights into the duration for which the available water supply lasts among the participants. According to the data, the majority of participants (87.2%) indicated that the water they have available lasts for 1 to 5 days. This suggests that their water supply is limited and needs to be replenished frequently. Additionally, 8.1% of the participants reported that their water supply lasts for 6 to 10 days, indicating a slightly longer duration of water availability. A smaller proportion of participants (1.0%) indicated that their water supply lasts for 16 to 20 days, suggesting a comparatively more secure and sustainable water source.

The duration for which the available water lasts is a crucial aspect of water security. It reflects the ability of individuals or households to meet their daily water needs without experiencing significant shortages or interruptions. Participants who reported a shorter duration of water availability (1 to 5 days) may face challenges in consistently accessing sufficient water for drinking, cooking, sanitation, and other household needs. On the other hand, participants who reported a longer duration of water availability (6 to 10 days and 16 to 20 days) may experience a relatively higher level of water security. Having access to water for an extended period reduces the frequency of water collection trips and the potential stress associated with water scarcity. It allows individuals to plan their water usage more effectively, allocate water resources for various purposes, and potentially engage in water-related activities that promote livelihoods, such as agriculture or small-scale enterprises.

5.2.8 Descriptive statistics of the water source (private borehole)

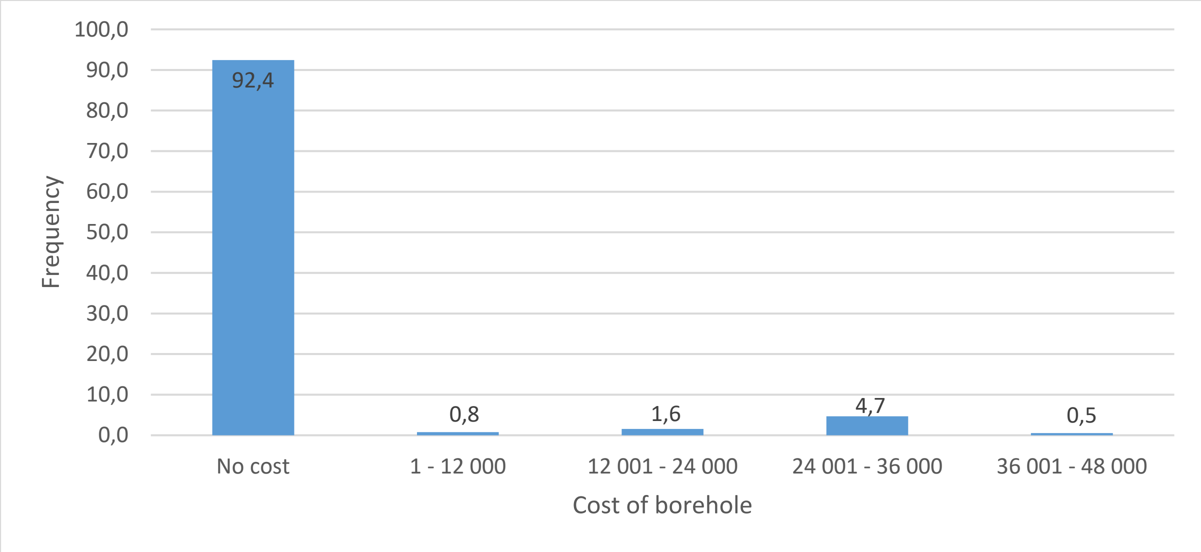
This subsection presents the results of the water source (private borehole). The results are presented using the following tables and charts.

5.2.8.1 Have a borehole

The analysis of data collected from 384 participants sheds light on the prevalence of boreholes among them. By examining the responses provided by these individuals, valuable insights can be gleaned regarding the presence and utilization of boreholes in the study area. According to the data, the majority of participants (92.7%) indicated that they do not have a borehole installed, while a small proportion (7.3%) reported having a borehole. These findings shed light on the availability and access to alternative water sources and their implications for water security. The high percentage of participants (92.7%) without a borehole suggests that the study area may have limited access to this alternative water source. Boreholes are often sought as a reliable and independent water supply, especially in areas where access to a municipal or community water network is limited or unreliable. Their installation allows individuals to tap into groundwater resources, which can serve as a more consistent and accessible water source.

A study by MacDonald et al. (2018) found that boreholes and other forms of groundwater extraction are less common in impoverished areas due to the high upfront costs of installation. This could explain why the majority of participants (92.7%) in this study do not have a borehole. The proportion of participants (7.3%) reporting the presence of a borehole indicates the availability of this alternative water source for a subset of the population. A study by Ocheri and Jwanbot (2018) discusses how boreholes serve as an alternative source of water supply for rural communities in areas with limited access to a municipal water network. It reinforces the finding that a minority of participants (7.3%) reported having a borehole, may offer them a more reliable source of water. In other words, individuals with access to boreholes may experience improved water security due to the reliability and independence provided by this water source. Boreholes can offer a consistent and continuous supply of water, reducing dependence on external water networks and mitigating the impact of water shortages or interruptions.

Figure 5.44: The cost to establish the borehole, if applicable



The findings presented in Figure 5.44 shed light on the cost incurred by participants in establishing a borehole. According to the data, the majority of participants (92.4%) indicated that it did not cost them anything to establish the borehole. This suggests that a significant proportion of participants were able to access or install a borehole without incurring any direct financial expenses. However, a small percentage of participants (4.7%) reported that establishing a borehole involved costs ranging between R24,001 and R36,000. This indicates that some individuals or households had to invest a considerable amount of financial resources to access this alternative water source. The lowest proportion of participants (0.5%) reported even higher costs, specifically between R36,001 and R48,000, indicating a higher financial burden for obtaining a borehole. The findings related to the costs of establishing a borehole highlight the financial considerations associated with accessing alternative water sources. While the majority of participants reported no costs for borehole establishment, a minority faced significant financial burdens. Addressing these financial barriers is essential to ensure equitable access to boreholes and enhance water security for all. By providing financial support, promoting awareness, and offering technical assistance, policymakers and stakeholders can help communities harness the potential of boreholes as a sustainable water resource and improve overall water security

Using boreholes to reach underground water supplies is the norm in rural areas (JMP 2019). Because of this, borehole drilling is becoming increasingly popular as a low-cost strategy to obtain water throughout the year in developing regions. Therefore, drilled boreholes are crucial for achieving SDG 6.1 and providing clean water to all people, especially in Africa. This is the case across the globe. The cost of fitting out a borehole can vary widely. Boreholes with a diameter of two inches cost roughly US$2,000, as reported by Martinez et al. (2017). The equivalent of $20,000 in 2000 dollars is R33,900.60 in South African Rand at the current exchange rate. A four-inch borehole can cost upwards of $6,000 due to factors like higher labor costs and a greater number of possible pumping systems (Martinez, et al., 2017). The cost to drill and outfit a larger diameter borehole varies widely depending on the type of pump used.

5.2.9 Descriptive statistics of the governance, compliance, monitoring, and evaluation

This subsection presents the results of the governance, compliance, monitoring, and evaluation. The results are presented using the following tables and charts.

Table 5.8: The municipality or government collects and monitors data on the following

Characteristics	No	Yes	Not sure
Regulatory compliance water use & discharge purpose	78.6%	9.9%	11.5%
Environmental, social & economic impact on water sources	76.6%	11.4%	12.0%
Factors affecting direct water sources	75.5%	9.9%	14.6%
Stakeholders' Perceptions and concerns related to water issues	72.4%	10.4%	17.2%
N=384			

The results in Table 5.8 reveal that 78.6% of the participants are of the view that the municipality or government does not collect and monitor data on regulatory compliance water use & discharge purposes and 76.6% of the participants indicated that the municipality or government does not collect and monitor data on environmental, social & economic impact on water sources. Furthermore, the results show that 75.5% of the participants indicated that the municipality or government does not collect and monitor data on factors affecting direct water sources and 72.4% of the participants are of the view that the municipality or government does not collect and monitor data on stakeholders perception and concerns related to water issues The study's findings are at odds with those of Li and Liu (2018), who claim that numerous water providers have implemented mechanisms to gather real-time data on water source quality.

The ultimate purpose of data collection and monitoring is to enhance water decision-making and performance over time, leading to measurable outcomes. USAID (2015) defines water monitoring as the process of keeping tabs on rivers, aquifers, reservoirs, and other water sources to assess their levels, currents, and climate conditions. Bulk and individual water consumers could be measured to zero in on usage and discharges. Having this information helps with enforcing allocations, laws, and permits as well as enhancing the efficiency with which water is used. Therefore, collecting and monitoring data for water safety needs to be an ongoing process of monitoring and evaluating information to better inform decision-making and performance and yield better outcomes. The USA Agency for International Development (2015) states that collecting and monitoring data on water availability and quality is crucial to ensuring that water is safe for human consumption, public health, economic development, ecological balance, ecosystems, and the pump variety.

Table 5.9: The municipality or government performs the following

Characteristics	No	Yes	Not sure
Identify & quantify water-related risks in direct operations	66.4%	13.8%	19.8%
Have a publicly available water policy	49.5%	24.5%	26.0%
Set performance standards on water withdrawals/consumption for direct operations	80.2%	12.2%	7.6%
Engage communities on water issues	68.8%	29.2%	2.1%
Address sustainable water management	76.0%	16.4%	7.6%
Develop plans to address local water shortages.	75.3%	12.2%	12.5%
Engage with stakeholders to assist in improving water management.	70.6%	12.2%	17.2%
Make water-related information publicly available	87.5%	8.6%	3.9%
N=384			

The findings presented in Table 5.9 provide insights into the perceptions and experiences of participants regarding the role of the municipality or government in addressing water-related risks and promoting sustainable water management. The data reveals several key areas where participants believe the municipality or government falls short in effectively managing water resources. Firstly, a significant proportion of participants (66.4%) indicated that the municipality or government does not identify and quantify water-related risks in their operations. This suggests a lack of comprehensive understanding and assessment of potential risks to water availability, quality, and sustainability. Moreover, almost half of the participants (49.5%) reported that the municipality or government does not have a publicly available water policy. A publicly available water policy is crucial for providing clear guidelines and standards for water management practices, promoting transparency, and ensuring accountability. The absence of a water policy may lead to inconsistent approaches and inadequate measures to safeguard water resources. Additionally, a large majority of participants (80.2%) expressed that the municipality or government does not set performance standards on water withdrawals or consumption for their direct operations. This indicates a lack of effective regulation and control over water use by governmental entities themselves. Setting and adhering to performance standards are essential for responsible water management and demonstrating leadership in sustainable practices.

Furthermore, the data revealed that a majority of participants believe the municipality or government does not engage communities (68.8%), address sustainable water management (76.0%), develop plans to address local water shortages (75.3%) or engage with stakeholders to improve water management (70.6%). These findings indicate a lack of inclusive and participatory approaches to water governance and decision-making processes. Lastly, a significant proportion of participants (87.5%) pointed out that the municipality or government does not make water-related information publicly available. Access to accurate and timely information about water resources, water quality, and water management practices is vital for informed decision-making and active community engagement. The lack of public availability of such information hampers transparency, public participation, and collaborative efforts to address water challenges effectively. These findings highlight the need for improved governance and policy frameworks to enhance water security. The municipality or government should prioritize actions such as identifying and quantifying water-related risks, developing and implementing publicly available water policies, setting performance standards for water use, and engaging communities and stakeholders in decision-making processes. By promoting transparency, accountability, and community involvement, water management can become more inclusive, sustainable, and responsive to local needs.

5.3 LOGISTIC REGRESSION

The logit regression model was utilized to analyze the factors influencing sustainable water security among households. The Logit Model was utilized for dichotomous results of variables. The dependent variable is dichotomous, namely, Households may be either water-secure or not. The results are summarized below in Table 5.10 and Table 5.11.

Table 5.10: Classification results

Classification Table					
			Predicted		
			Dependent_variable		
Observed			Not water secured	Water secured	Percentage Correct
Step 1	Dependent_variable	Not water secured	76	12	86,4
		Water secured	14	50	78,1
	Overall Percentage				82,9
a. The cut value is .500					

The findings presented in Table 5.10 provide insights into the accuracy and predictive ability of the model used to classify participants as either water-secured or not water-secured based on the independent variables. The model achieved an overall classification accuracy of 82.9%, indicating that it correctly classified the majority of cases. The model's ability to correctly predict the water-secured status of participants was 78.1%, indicating that it accurately identified individuals who are water-secured. Similarly, the model achieved a high prediction rate of 86.4% for those who are not water-secured, correctly identifying individuals in this category. Moreover, the positive predicted value of 80.6% indicates that among all the cases predicted to be water-secured, 80.6% were correctly predicted as such. This suggests that the model performs reasonably well in identifying individuals who are truly water-secured. Similarly, the negative predicted value of 84.4% indicates that among all the cases predicted to be not water-secured, 84.4% were correctly predicted. This indicates that the model is effective in identifying individuals who are not water-secured. Overall, the model's performance in predicting water security status based on the independent variables is quite promising, with high classification accuracy and reasonably high prediction rates for both water-secured and not water-secured individuals. These findings suggest that the independent variables included in the model have a meaningful association with water security.

Linking these findings to water security, it can be inferred that the identified independent variables used in the model play a significant role in determining individuals' water security status. By understanding and considering these variables, policymakers and stakeholders can develop targeted interventions and strategies to enhance water security for those who are not currently water-secured. Additionally, the model's predictive ability can aid in identifying individuals at risk of water insecurity, allowing for timely interventions and support. It is important to note that the model's accuracy and predictive power are dependent on the quality and relevance of the independent variables used. Therefore, continuous evaluation and refinement of the model with additional data and variables may further improve its performance in predicting water security. Generally, the results from Table 5.10 highlight the effectiveness of the model in classifying participants as water-secured or not water-secured. These findings provide valuable insights into the relationship between the independent variables and water security, emphasizing the importance of understanding and addressing these variables in efforts to enhance water security. By leveraging such models and understanding the associated factors, policymakers can implement targeted interventions to ensure sustainable water management and improve overall water security for communities.

Table 5.11: Logistic regression results

Variables in the Equation							
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	No of Dependents	-0.312	0.149	4.355	1	0.037	0.732
	Age	-0.027	0.026	1.064	1	0.302	0.973
	Monthly Income	-0.010	0.155	0.004	1	0.949	0.990
	Head of Household	0.850	0.561	2.296	1	0.130	2.340
	Level of Education	0.318	0.327	0.946	1	0.331	1.374
	Distance to the near water source	-0.074	0.154	0.231	1	0.631	0.929
	Pay for the Source	1.961	0.898	4.766	1	0.029	7.107
	Own a private tap	1.185	0.484	5.983	1	0.014	3.271
	Gender	-0.072	0.492	0.021	1	0.884	0.930
	Get water from this tap	0.631	0.920	0.470	1	0.493	1.879
	Source Secured	2.521	0.744	11.477	1	0.001	12.446
	Water Model Required	-0.049	0.721	0.005	1	0.946	0.953
	Water Quality	1.693	0.586	8.337	1	0.004	5.437

Variables in the Equation							
	Dispute or Disagreement	1.177	1.511	0.607	1	0.436	3.246
	Water Awareness Program	0.923	0.894	1.065	1	0.302	2.516
	Employed	-0.440	0.536	0.675	1	0.411	0.644
	Main Source	1.984	0.667	8.844	1	0.003	7.270
	Constant	-2.655	2.567	1.070	1	0.301	0.070
a. Variable(s) entered on step 1: No of Dependents, Age, Monthly Income, Head of Household, Level of Education, Distance to the near water source, Pay for the Source, Own a private tap, Gender, Get water from this tap, Source Secured, Water Model Required, Water Quality, Dispute or Disagreement, Water Awareness Program, Employed, Main Source.							

The Wald test was used to determine the statistical significance of each of the independent variables as presented in Table 5.11. The results revealed that the number of dependents ($p = 0.037$), pay for a water source ($p = 0.029$), own a private tap ($p = 0.014$), source secured ($p = 0.001$), water quality ($p = 0.004$) and main source ($p = 0.003$) added significantly to the predicted model. Age, Monthly Income, head of household, level of education, distance to the near water source, gender, getting water from this tap, water model required dispute or disagreement, water awareness program, and employed did not add significantly to the model since their p-values are greater than 0.05 level of significance.

The findings presented in Table 5.11 provide insights into the associations between various factors and the likelihood of water security. The analysis highlights both the factors that reduce the likelihood of water security and those that increase it. Firstly, an increasing number of dependents, age, monthly income, distance to the nearest water source, the need for a new water model, and employment status were found to be associated with a reduction in the likelihood of water security. This suggests that households with more dependents, lower income, longer distances to water sources, and limited employment opportunities may face greater challenges in achieving water security. Additionally, age was found to be negatively associated with water security, indicating that older individuals may be less likely to have access to secure water sources. Furthermore, the analysis reveals that males were slightly more likely to be water-secured compared to females, with a likelihood ratio of 0.93. This suggests a subtle gender disparity in water security, where males have a slightly higher likelihood of being water-secured than females. Further investigation is needed to understand the underlying reasons for this gender difference and to address any potential gender-related barriers to water security.

On the other hand, an increase in the head of the household, level of education, payment for the water source, ownership of a private tap, access to water from the private tap, source security, water quality, absence of disputes or disagreements, participation in water awareness programs, and reliance on a main secure water source were associated with an increased likelihood of water security. These factors suggest that households with a responsible head, higher education levels, regular payment for water services, access to private taps with secure water sources, and good water quality are more likely to achieve water security. Additionally, community engagement through water awareness programs and the availability of secure and reliable water sources contribute positively to water security. Linking these findings to water security, it is evident that multiple factors influence the likelihood of achieving water security. Socio-economic factors such as income, education, and employment play a significant role, as do factors related to the availability, quality, and reliability of water sources. Understanding these associations can inform the development of targeted interventions and policies aimed at improving water security. Policymakers should focus on addressing the identified factors that reduce the likelihood of water security, such as income disparities, limited employment opportunities, and distance to water sources. Efforts should be made to provide equitable access to secure and reliable water sources, enhance water quality management, promote community engagement and awareness programs, and address any existing disputes or disagreements related to water access.

5.4 THE FINDINGS BASED ON FOCUS GROUP DISCUSSIONS

The focus group discussions revealed that there are serious water shortages within the Bojanala Region. The water infrastructure is old and dilapidated (more than 15 years), pipes are leaking, the water infrastructure is often vandalized and some components of the infrastructure are stolen. "One of the focus groups mentioned that there are inadequate water distribution systems and poor maintenance and operation of the water infrastructure." The discussions also revealed that the water pressure is often low and there are inadequate water distribution systems. The community has been without adequate water for more than 20 years, there are serious hardships in accessing drinkable water and the residents travel long distances to get water from the source. "One of the focus group alluded that the municipality always redirects the budget allocations that was meant for their water project." There is also sewage spillage as a result of a poor sewage system (the place smells of sewage water). The water is reddish or brownish, smelly, more alkaline, and salty. This often leads to diarrhea and a running stomach. Water shortage has health effects. The community is of the view that the Government is aware of the water problems in the study area because reports and memorandum of demand were sent to the municipality and the ward councilors. "One of the focused groups stated that the government always ignores their concerns especially when the ward councillor is not vocal to advocate for their needs." The municipality held a consultation forum with communities during the IDP processes for service delivery needs. During this consultation process, the community submitted the need for sustainable bulk water supply as a priority project. "One of the focused group's members emphasized that the meetings with municipalities have become more of talk shows and less of action."

The findings from the focus group discussions shed light on the multifaceted impacts of water shortage on various aspects of daily life and livelihoods. The participants highlighted that water shortage significantly affects basic household chores such as bathing, cooking, cleaning, and drinking, which are essential for maintaining health and well-being. The limited availability of water also poses challenges to proper sanitation practices, potentially compromising hygiene and increasing the risk of waterborne diseases. Furthermore, the focus group discussions revealed that water scarcity extends its impact beyond households to agricultural activities and livestock management. Participants expressed concerns about the negative consequences of water shortage on food production, which can undermine food security and livelihoods. Insufficient water supply hampers irrigation and crop cultivation, affecting crop yields and overall agricultural productivity. "One of the focus groups highlighted that they don't see a need to vote, considering the long-standing water challenges that they have been experiencing in the study area. They allege that the apartheid government was harsh but better compared to the current government "

Additionally, livestock rearing and farming activities heavily reliant on water face significant challenges, potentially leading to the loss of livestock and reduced agricultural output. The implications of water scarcity extend to the economic realm as well. The participants highlighted the adverse effects of water shortages on local businesses. Limited water availability can hinder manufacturing processes, disrupt service provision, and increase operational costs for businesses that depend on water as a vital input. This can ultimately lead to reduced productivity, financial losses, and even the closure of some enterprises. The impact on businesses has a ripple effect on employment opportunities, income generation, and overall economic development in the area.

Overall, these findings underscore the critical role of water security in ensuring the well-being and sustainable development of communities. “One of the focus groups posits that water shortages affect their development.”

Policymakers, stakeholders, and local communities need to work collaboratively to develop and implement appropriate interventions that address water scarcity and its multifaceted impacts. This may include investment in water infrastructure development, promoting water-saving practices, diversifying water sources, and enhancing water governance mechanisms. Furthermore, initiatives that prioritize sustainable agricultural practices, support small-scale businesses and encourage economic resilience in the face of water scarcity can contribute to mitigating the negative effects of water shortage.

The discussions held by the focus group discussions highlight several key suggestions and actions that are necessary to address water security concerns in the study area. One of the key suggestions is for the government to provide residents with more boreholes, reservoirs, water tanks, and dams. Increasing the number of water sources can help alleviate water scarcity by diversifying water supply options and reducing reliance on a single source. The availability of multiple water sources enhances the resilience of the water supply system and ensures a more consistent and reliable water supply for the community. Secondly, the discussions highlighted the importance of competent and responsible contractors in water project implementation. Participants expressed concerns about the awarding of water projects to incompetent contractors, which can lead to poor-quality infrastructure and inefficient water supply systems. Ensuring that contractors possess the necessary expertise and capabilities can contribute to the effective implementation and long-term sustainability of water projects.

Thirdly, the maintenance, restoration, and upgrade of existing water sources and infrastructure were identified as crucial measures for improving water security. This includes actions such as maintaining water treatment plants and repairing and upgrading reservoirs, pipelines, and storage facilities. Upgrading and modernizing the existing water supply systems can enhance efficiency, reduce water losses, and improve the overall reliability and quality of the water supply. Fourthly, the discussions emphasized the installation of new water infrastructure as a means to increase the supply of fresh water. This could involve the construction of new water treatment plants, the establishment of additional water storage facilities, and the development of distribution networks to reach underserviced areas. These initiatives aim to expand access to clean and safe water, especially for communities facing acute water shortages.

Fifthly, the participants highlighted the importance of community involvement in advancing water harvesting, water recycling, and reducing water pollution. Encouraging and educating the community about sustainable water management practices can contribute to water conservation efforts and reduce the strain on existing water resources. Sixthly, the discussions emphasized the importance of collaboration between the government and industries/companies to address water security challenges. Industrial activities often have significant water requirements, and partnering with industries can foster responsible water use, implement water-saving technologies, and promote water conservation practices within the industrial sector. Lastly, the discussions emphasized the need for government accountability and integrity in addressing water security issues. Participants expressed concerns about corruption within the system and stressed the importance of removing corrupt officials and replacing them with capable and qualified personnel. “One of the focus group members said that she lost trust and confidence in government.” Transparent and accountable governance can help ensure that water-related projects and initiatives are implemented effectively and efficiently, with a focus on addressing the water security needs of the community. The suggestions arising from the discussions highlight the importance of comprehensive and coordinated efforts to address water security. By prioritizing the expansion and maintenance of water infrastructure, promoting sustainable water management practices, and addressing pollution issues, governments can improve water availability, accessibility, and quality. Collaboration with industries, community involvement, and ensuring government accountability are also essential components of achieving long-term water security. These findings provide valuable insights for policymakers and stakeholders in their efforts to develop and implement effective strategies to address water security challenges and ensure the sustainable management of water resources.

The community's perspective on their water access and coping strategies provides valuable insights into the challenges they face and the factors contributing to water shortages. Additionally, the community's reliance on buying water from water tankers indicates a lack of consistent and reliable access to water. “One of the focus group members indicated that she uses the children’s grant money to buy water, leaving them with the shortage of food.” This reliance on external water sources suggests that the community's water supply infrastructure may not meet their needs adequately. Inconsistent water deliveries from water tankers can further exacerbate water insecurity, as the community cannot rely on a regular and predictable water supply. Boiling contaminated water is another coping strategy employed by the community. This highlights concerns about water quality and the presence of pollutants or contaminants in the available water sources. The need to boil water suggests a lack of access to safe and potable water, forcing community members to take extra measures to ensure the water's suitability for consumption. The community's practice of traveling long distances to neighboring communities to seek water reflects the limited availability of water sources in their immediate vicinity. This indicates that the local water sources, such as boreholes or wells, may be insufficient or unreliable in meeting the community's water needs. Depending on neighboring communities for water can strain existing resources and create additional burdens for both the community and the neighboring communities.

Reusing water and relying on rainwater as alternative sources further highlight the community's resourcefulness and adaptation to water shortages. These practices demonstrate their efforts to make the most of available water resources and minimize wastage. However, these coping mechanisms may not always be sufficient to meet all their water needs, particularly during prolonged periods of water scarcity. “One of the focus groups stated that having access to water is not a favor but their constitutional rights.” The identified factors influencing water shortages in the community encompass a range of interconnected issues. The lack of rainfall, drought, and climate change indicate the vulnerability of the community to natural factors affecting water availability. Insufficient infrastructure and leaking pipes suggest a need for infrastructure maintenance and improvements to minimize water losses and ensure efficient water distribution. Pollution and contaminants are highlighted as factors affecting water quality, which can compromise the safety and suitability of the available water sources. The mention of misuse of water, negligence, and theft of water infrastructure points to social and behavioral aspects that can contribute to water shortages. These factors emphasize the importance of community education, awareness, and responsible water management practices. Population growth and poor planning indicate the challenges of adequately meeting the increasing water demands of a growing community. A lack of political commitment can hinder the implementation of effective water management strategies and infrastructure development. These factors highlight the need for integrated planning, governance, and policy interventions to address water security issues comprehensively.

5.5 THE FINDINGS FROM KEY INFORMANTS INTERVIEWS

The findings from the interviews highlight the disparities in water availability and accessibility within the study area. While water is available in some areas, there are significant challenges in other areas where water scarcity is evident. This variation in water availability indicates an uneven distribution of water resources, which can have implications for water security within the community. The observation that underground water sources are running out and some boreholes are dry raises concerns about the sustainability and resilience of the water supply. This suggests that the community is heavily reliant on groundwater sources, and the over-extraction or inadequate recharge of these sources may be leading to their depletion. The diminishing availability of groundwater poses a significant risk to water security in the affected area. The poor quality of water identified in the interviews highlights a critical aspect of water security, namely water quality. The presence of brown-colored water, mud contamination, and unsuitability for home consumption suggest issues related to water treatment, pollution, or inadequate infrastructure maintenance. Poor water quality not only affects the community's access to safe drinking water but also has implications for health and sanitation, further compromising water security. Water availability and accessibility were consistently mentioned as ongoing challenges in the interviews. This suggests that the community faces persistent difficulties in accessing a reliable and sufficient water supply. The combination of limited availability, poor infrastructure, and water quality issues exacerbates the water security challenges faced by the community. "One of the key informants mentioned that the study area has the bulk of raw water under the custodianship of the Department of Water & Sanitation."

The findings from the interviews further shed light on the interventions and perspectives of the Department of Agriculture regarding water security in the study area. The department's awareness of the water shortage indicates a recognition of the challenges faced by the community and the importance of addressing water security issues. The efforts mentioned by the department, such as drilling and equipping boreholes, demonstrate a proactive approach to ensuring sustainable water security. By investing in infrastructure development, specifically the establishment of boreholes and dams, the department aims to enhance water availability and accessibility in the community. These interventions align with the fundamental aspects of water security, which include reliable access to sufficient water resources. The emphasis on educational water awareness and community training highlights the department's recognition of the importance of community engagement and empowerment. By educating the community about water management practices, the department aims to foster a sense of responsibility and participation in ensuring water security. This approach aligns with the principles of participatory water governance, wherein local communities play an active role in managing and protecting water resources. "One of the key informants explained that drilling beyond 250 m for water might be a sign that the groundwater is drying out as well."

The establishment of effective water committees within the communities is another notable intervention mentioned by the department. Water committees can serve as platforms for community involvement, decision-making, and collaboration in managing water resources. Such committees can facilitate local ownership, cooperation, and collective action toward achieving water security goals. The mention of encouraging farmers to have water rights indicates a focus on sustainable water allocation and management within the agricultural sector. By promoting water rights and responsible water use among farmers, the department recognizes the need to balance water demands for agricultural production with the conservation and equitable distribution of water resources. The department's view that achieving SDG 6, which is equal access to water, is attainable through collective efforts reflects the importance of multi-stakeholder collaboration in addressing water security challenges. The department acknowledges the need for stakeholders, including government agencies, communities, and other relevant actors, to work together towards common goals. "One key informant postulated that government departments must stop working in silos. He further said that government departments must plan together to avoid duplication of work." This collaborative approach is vital for effective water governance, resource management, and infrastructure development.

The findings from the interviews shed light on the perspective of the DWS regarding water security challenges in the study area. The awareness of the water problems by the DWS indicates a recognition of the issues and the need to address them for achieving water security. The identification of poor operations and maintenance of water infrastructure as a key problem highlights the critical role of infrastructure management in ensuring water security. Effective operation and maintenance practices are essential for the proper functioning and longevity of water infrastructure, including treatment plants, distribution networks, and waste treatment works. Neglecting these aspects can lead to deteriorating infrastructure performance and compromises in water availability and quality. Water scarcity and shortages are mentioned as prominent challenges, emphasizing the importance of reliable and sufficient water resources for achieving water security. Water scarcity can arise from various factors such as climate change, population growth, and unsustainable water use practices. The mention of the lack of qualified and skilled personnel points to the importance of human resources in ensuring effective water management. Adequate knowledge, skills, and expertise are essential for the operation, maintenance, and management of water infrastructure and resources. Capacity-building initiatives and training programs can help address this challenge and ensure the availability of qualified personnel to address water security issues effectively.

Inadequate water sources are identified as a factor affecting water security. This suggests that the existing water sources may not be sufficient to meet the demands of the community. Expanding water sources, such as boreholes, and dams, or tapping into alternative water sources, can help improve water availability and resilience. The mention of inconsistent political will and change of management reflects the influence of governance and leadership on water security. Political commitment and stability are crucial for the long-term planning, implementation, and maintenance of water infrastructure. A lack of consistent political will can lead to delays in addressing water challenges and hinder sustainable water management efforts. The inadequate treatment of wastewater and poor waste treatment works mentioned as problems highlight the importance of water quality management. Proper treatment of wastewater is essential to protect water sources from pollution and maintain water quality standards. Addressing these issues can help safeguard public health and ensure the availability of clean and safe water for various uses. The mention of illegal water connections and lack of payment of rates and taxes by the communities points to issues of water governance, equity, and financial sustainability. Illegal connections can strain the water supply system and deprive others of access to water, while the lack of payment undermines the financial resources necessary for maintaining and expanding water infrastructure. The identification of poor planning and delayed response to water challenges emphasizes the importance of proactive and adaptive water management strategies. Comprehensive water resource planning, considering factors such as population growth, climate change, and infrastructure needs, can help mitigate water security risks. Additionally, timely and effective response to emerging water challenges is crucial to minimize the impacts and ensure the resilience of water systems.

According to the interviews, the DWS has water policies. However, the uncontrolled development (unregistered settlement) makes it difficult for the department to achieve the policy objectives. The main objective of the water policy is as follows:

- National Water Policy Review (2013) aims and focuses on overcoming the water challenges faced by the DWS and the whole of South Africa to improve access to water, efficiency, equity, and sustainability (DWA, 2015).
- National Water Act (36) of 1998 ensures that water resources are protected, used, developed, conserved, managed, and controlled in a sustainable, efficient, and equitable manner by establishing suitable institutions (DWA,2015).
- Water Service Act (WSA) of 1997 (act 108 of 1997) ensures the right of access to basic water supply and sanitation and also provides a regulatory framework and establishment of water services institutions.

The study revealed several key factors that contribute to water shortages within the district. These factors can be broadly classified into two categories: infrastructure-related factors and external environmental factors:

One of the major factors identified is the poor maintenance of water infrastructure. Inadequate maintenance practices, including the neglect of repairs, upgrades, and routine inspections, can lead to the deterioration of water supply systems. This can result in leakages, pipe bursts, and inefficient water distribution, ultimately leading to water shortages. Insufficient budget allocation and resource constraints may contribute to the inability to carry out proper maintenance activities. Political interference is another significant factor affecting water shortages. Political factors such as changes in leadership, administrative transitions, and conflicting priorities can disrupt the implementation of water management plans and policies. Inconsistent decision-making and lack of long-term planning can hamper effective water resource management, exacerbating water shortages. Budget constraints often hinder the implementation of necessary infrastructure projects and the allocation of adequate resources for water management. Limited financial resources may impede the development of new water supply systems, maintenance of existing infrastructure, and implementation of water conservation and efficiency measures. Insufficient funding can limit the capacity to address water shortages and ensure a reliable water supply.

The study also highlighted the influence of external environmental factors on water shortages. Lack of rainfall, exacerbated by climate change, can result in reduced water availability in the region. Drought conditions, prolonged dry spells, and changing precipitation patterns can lead to water scarcity and exacerbate existing water shortages. Population growth is an additional factor contributing to water shortages. As the population increases, the demand for water rises, placing additional strain on existing water resources and infrastructure. Rapid urbanization and increased water consumption patterns further exacerbate the challenges of water scarcity. Overall, the findings suggest that addressing water shortages requires a multi-faceted approach. Efforts should focus on improving water infrastructure maintenance practices, ensuring consistent political commitment and effective governance, allocating sufficient financial resources, implementing climate-resilient water management strategies, and promoting water conservation practices. By addressing these factors comprehensively, stakeholders can work towards achieving water security and sustainability within the district.

The study findings underscore the severe implications of chronic water scarcity on people's ability to meet their basic needs and sustain their livelihoods. The inability to access sufficient water for essential activities such as cooking, cleaning, laundry, and gardening has profound consequences, exacerbating poverty and hunger among affected populations. Moreover, the lack of access to clean water further compounds the distress experienced by individuals and communities. To address the pressing issue of water shortage, the interviews revealed several key recommendations. First, it is suggested that water boards assume responsibility for the operation, maintenance, and management of wastewater treatment facilities. This proposal aims to enhance the efficiency and effectiveness of wastewater treatment processes, ensuring that treated water is appropriately managed and reused. The interviews also highlighted the need for a shift in the funding dynamics of water projects. Adequate funding must be provided to undertake significant water infrastructure projects, including the upgrading and modernization of existing systems. Engagement and collaboration among key stakeholders emerged as a crucial aspect of addressing the water shortage challenge. By involving relevant stakeholders, such as government agencies, local communities, non-governmental organizations, and water management authorities, a comprehensive and integrated approach can be fostered. This collective effort is necessary to identify and implement sustainable solutions, including the construction of dams to capture and store runoff water, thereby increasing water availability during periods of scarcity.

5.6 CONCLUSION

In conclusion, understanding the socio-economic characteristics of households is crucial for developing targeted interventions and policies that promote sustainable water practices and ensure long-term water security for all members of society. By recognizing and addressing the specific challenges faced by different demographic groups, policymakers and stakeholders can work towards a more equitable and resilient water future. The study highlighted the importance of robust infrastructure, effective governance, and community engagement in achieving sustainable water security. Addressing the identified challenges requires collaborative efforts from various stakeholders to improve access to safe and reliable water sources, ensure efficient water management practices, and invest in infrastructure upgrades and maintenance. The perception of the poor state of the water supply infrastructure among the majority (51.3%) of participants indicates potential deficiencies in the water supply system, including frequent disruptions, low water pressure, and inadequate maintenance. This highlights the need for investments in infrastructure upgrades, efficient management practices, and proper maintenance to ensure a reliable and efficient water supply. The reasons given by participants for not paying for the operation and maintenance of the water source highlight the complex dynamics of water access, affordability, and service provision. The perception of water provision as a free basic service and the financial constraints faced by some households underscore the need for targeted subsidies and social support mechanisms to ensure equitable access to water services. The perception of poor service delivery as a reason for not paying emphasizes the importance of improving service quality and addressing infrastructure maintenance issues.

The study findings on the frequency of water supply provided valuable insights into the primary sources of water access among participants and their implications for water security and sustainability. The majority (49.7%) of participants indicated boreholes as their main source of water supply, highlighting the significant role of groundwater in meeting water needs within the community. While boreholes offer self-reliance and control over water access, their sustainability depends on the availability and replenishment of groundwater resources. The reliance on municipality supply suggests a centralized approach to water supply, providing consistent access to clean water but facing challenges such as aging infrastructure and water scarcity. The small (0.8%) proportion of participants relying on rivers as their main source highlights the need for proper treatment and management practices to ensure water safety and prevent contamination. The descriptive statistics of the quality of water, as presented in Figure 5.31, highlighted participants' perceptions of water quality ranging from very poor to very good. The majority (30.2%) of participants reported poor or very poor water quality, indicating significant concerns about the safety and suitability of their water supply. Poor water quality can pose health risks and negatively impact daily activities and overall quality of life. To improve water quality and ensure water security, it is crucial to identify and address sources of contamination or degradation through investments in water treatment technologies, regular monitoring, and quality assurance measures. The findings underscore the need for targeted interventions, improved communication, transparency, and stakeholder engagement to ensure access to clean and safe water, address water quality challenges, and promote sustainable water management practices.

The descriptive statistics of the multiple uses of water provided valuable insights into the diverse water needs within the community and their implications for water security, resource management, and sustainability. The findings revealed that a significant majority (62.8%) of participants use water for non-domestic purposes, indicating a range of additional water demands beyond domestic requirements. These non-domestic uses include activities such as gardening, livestock watering, food production, recreation, business operations, and sanitation. The specific uses of water, as indicated in Table 5.7, reflected the priorities and practices within the community. Water is predominantly used for garden watering, while car washing, business operations, and livestock watering are reported to a lesser extent. The utilization of water for growing food underscores its significance in agricultural activities and food production. The low usage of water for recreational purposes suggests potential limitations in access to recreational water bodies or a focus on water conservation. Similarly, the limited usage of water for sanitation and waste disposal may indicate alternative waste management systems or water-efficient sanitation practices. The findings also highlight the consistency of water sources for domestic purposes, with the majority (99.2%) of participants relying on the same water sources. This indicates a reliance on a consistent water supply for meeting daily household needs. However, a small proportion (0.8%) of participants reported using different water sources, suggesting potential variations or alternative arrangements within the community. Understanding the reasons behind this diversification can provide insights into potential inadequacies in the primary water supply and inform improvements in water access and reliability. The findings emphasize the importance of managing water resources holistically, considering both domestic and non-domestic uses, to ensure water security, sustainability, and equitable access. Integrated water management approaches, efficient water use practices, and infrastructure maintenance are crucial for meeting the diverse water needs of the community and promoting long-term water security.

The descriptive statistics of the additional questions regarding electricity and water payments provided insights into the relationship between access to basic services, affordability, and water security. The findings highlighted the importance of affordable and sustainable financing mechanisms, government subsidies, and targeted support programs in ensuring reliable and equitable access to electricity and water. Addressing affordability challenges, improving service delivery, and expanding infrastructure are essential for enhancing water security and promoting community well-being. The descriptive statistics of the water source (canal or river) provide valuable insights into water collection practices, container usage, and water availability duration. The findings highlighted the challenges faced by individuals who rely on canals or rivers as their primary water source, including the need for frequent water collection and the potential limitations of available containers. The frequency of water collection indicates the reliance on these natural water sources and the efforts required to meet daily water needs. The types of containers used, such as buckets and containers reflect affordability, ease of use, and portability considerations. However, the limitations of containers, such as their capacity, can impact the efficiency and convenience of water collection. The number of containers filled during each collection episode varies among participants, suggesting different storage capacities and water conservation practices. The duration of water availability highlights the level of water security experienced by individuals, with shorter duration indicating potential challenges in meeting daily water needs consistently. These findings underscore the importance of addressing water collection practices, container availability, and water storage capacity to improve water security and promote sustainable water management.

The descriptive statistics revealed that boreholes are not widely accessible in the study area, with the majority (92.7%) of participants not having a borehole installed. However, for the small (7.3%) proportion of participants who have a borehole, it serves as a reliable water source, enhancing water security and reliability. The cost of establishing a borehole varies, with most participants indicating no direct financial expenses, but a minority facing significant costs. Regarding governance, compliance, monitoring, and evaluation, the municipality or government's role in managing water resources is perceived to be inadequate. There is limited data collection and monitoring on various aspects, including regulatory compliance, environmental impacts, and stakeholders' concerns. Publicly available water policies, performance standards, community engagement, and stakeholder involvement are lacking. These gaps hinder effective decision-making and performance evaluation. To improve water security, it is crucial to address the financial barriers associated with accessing boreholes and promote equitable access. Additionally, governance frameworks need improvement, including comprehensive data collection, transparent water policies, performance standards, and inclusive community engagement. Transparency, accountability, and stakeholder involvement are vital for sustainable water management and addressing water challenges effectively. Policymakers and stakeholders should prioritize actions such as collecting comprehensive data, developing transparent policies, setting performance standards, and engaging communities and stakeholders. By addressing these gaps, water management can be more sustainable, equitable, and responsive to the needs of individuals and communities, leading to enhanced water security for all

The logistic regression analysis provided valuable insights into the factors influencing sustainable water security among households. The model accurately classifies individuals as water-secured or not water-secured, with an overall accuracy of 82.9%. The findings highlight the significance of various factors in determining water security. Factors such as the number of dependents, payment for the water source, ownership of a private tap, source security, water quality, and reliance on a main secure water source positively contribute to water security. Conversely, factors such as the number of dependents, age, monthly income, distance to the nearest water source, the need for a new water model, and employment status negatively impact water security. Subtle gender disparities are also observed, with males having a slightly higher likelihood of being water-secured than females. These findings emphasize the need to address socioeconomic factors, ensure equitable access to secure water sources, manage water quality effectively, and promote community engagement and awareness programs. Policymakers should focus on reducing income disparities, improving employment opportunities, and addressing the proximity of water sources to enhance water security. Additionally, efforts should be made to provide reliable and secure water sources, resolve disputes related to water access, and promote gender equity in water security. Understanding the associations between these factors and water security informs targeted interventions and evidence-based policies.

The focus group discussions in the Bojanala Region provided valuable insights into the challenges and factors contributing to water shortages. The deteriorating water infrastructure, limited access to drinkable water, poor sewage system, and compromised water quality pose significant hardships for the community. The discussions also highlight the multifaceted impacts of water shortages on daily life, livelihoods, and the local economy. To address water security concerns, suggestions emerged from the discussions, including the provision of additional water sources, maintenance and upgrade of existing infrastructure, collaboration between the government and industries, community involvement in water management, and ensuring government accountability. The community's coping strategies demonstrate the limited availability and quality of local water sources, emphasizing the need for improved water access and infrastructure. These findings emphasize the critical role of water security in the well-being and sustainable development of communities. Comprehensive efforts are needed, including infrastructure development, sustainable practices, pollution prevention, community involvement, and good governance.

The key informant interviews highlighted the factors contributing to water shortages, including infrastructure challenges, external environmental factors, and governance issues. The poor maintenance of water infrastructure, inadequate funding, and political interference are identified as significant barriers to water security. To address water shortages, recommendations include improving infrastructure maintenance, ensuring consistent political commitment, allocating sufficient financial resources, implementing climate-resilient strategies, and promoting water conservation practices. Overall, the findings provide valuable insights for policymakers, stakeholders, and communities in their efforts to address water security challenges. The upcoming chapter delves into a comprehensive analysis and interpretation of the obtained results, drawing insightful conclusions, and formulating valuable recommendations. This section marks a pivotal point in the study as it lays the foundation for the proposed model of sustainable water security

CHAPTER SIX
PROPOSED MODEL, IMPLICATIONS OF THE FINDINGS, CONCLUSION, AND RECOMMENDATIONS

6.1 INTRODUCTION

To develop the proposed descriptive model of sustainable water security, preliminary knowledge of the socio-economic characteristics has been provided through field investigations and data collected from existing secondary sources. The proposed model considered different aspects of water use at the local level and can be extendable at the country level. Households can set priorities for water use within the limits of their available water supply. Like the previous method, it serves as a simulation tool to evaluate measures offered while taking into account detrimental effects on all water needs, and it also reflects the situation of water security at the local level. Additionally, the paradigm promotes consensus in enacting use and conservation measures, allowing for community engagement in decision-making. Compared to other models that favor the use of market processes to reduce water consumption, this one is a radical departure. Ultimately, the proposed approach provides a decent amount of leeway in accommodating varying levels of water quality while still serving the needs of households. To reduce complicated phenomena into quantifiable characteristics that are easily communicated and drive policymaker decisions, a model of sustainable water security was developed taking into account five dimensions. The Sustainable Development Goals for potable water and hygiene served as inspiration for the development of several foundational elements or metrics (SDG6).

The study presented the sustainable water security model as an extension and response to the community-based drinking water systems (CBDWS) to address the issues with water security. Thus, some issues with water security were raised by the participants, and the proposed model was formulated to address those concerns. The model has highlighted some key challenges and opportunities for achieving sustainable water security (Nyam, et al., 2021). No matter how small or large, every part of a system has potential leverage points where the system's behavior can be altered (Kotir, et al., 2017). During the research, a small number of potential points of leverage were identified, such as subpar water quality, longer waiting times, insufficient water pressure, and neglected infrastructure. That is why this study's proposed model is crucial for addressing the leverage points in the area. What is more, the model is not about coming up with brand-new ideas, but rather about bringing together proven methods for bolstering sustainable water security across a range of scientific disciplines. Evaluating and understanding a household's access to clean water for drinking, washing, and other domestic uses, as well as for use in gardening, cooking, and other small-scale economic activities, is essential to the model's efficacy and efficiency. Wurbs (2020) agrees, arguing that accurate water allocation and management require an understanding of the degree to which varying amounts of water are likely to be provided under varying circumstances.

6.2 PROPOSED MODEL

The proposed model is tailored to the needs of the study area and considers a multi-dimensional approach to ensure sustainable availability and accessibility among natural, social, and economic systems in utilizing the water. In addition, the proposed model will enable the development of practical policy-based scenarios regarding water management using real data (Nyam, et al., 2021). The proposed model portrays an organogram figure of five categories or dimensions: economy, social, technical, environment, and effective institution. The five categories or dimensions have been derived from the classification of tangible and intangible resources and they influence water management (Nyam, et al., 2021). Even though many frameworks and models have been proposed for assessing water security, no universally accepted method has yet emerged. In an attempt, the model developed by Mayunga (2007), considers the five types of capital discussed above in addition to natural capital, physical capital, human capital, and economic capital. Subsequently, social resilience, economic resilience, institutional resilience, infrastructure resilience, and environmental resilience are the six pillars of the framework presented by Burton (2012). Social, economic, infrastructural, ecological, and institutional factors have all been taken into account in the aforementioned models. Specifically, Saber, et al., (2021) argue that all relevant factors, including institutional and infrastructure considerations, ecological and health considerations, social and economic factors, and economic evaluations, must be factored into any assessment of sustainable water security.

Based on a few simple characteristics, the model has expanded to include multiple dimensions and indicators that reflect water's physical, social, economic, political, and environmental contexts (Gain, et al., 2016). Human-water interactions are taken into account by these factors, which have been given little consideration in the literature. Since water security varies across geographic locations, this method has been applied to studies ranging in scope from national to international (Hailu, et al., 2020; Doeffinger & Hall, 2021). For this study, numerous core elements were also established based on the Sustainable Development Goals of clean water and sanitation. Essential components reduce complicated phenomena to quantifiable chunks that can be easily communicated and used to guide policy decisions. The findings of the study call for a cooperative and integrated approach to improve the supply and distribution across the district. The discussion on aspects that informed the proposed model provided context to constitute the resources, and activities required to achieve sustainable water security in Bojanala District. For instance, in a water-scarce area like Bojanala District, conducting awareness for activities related to sustainable water security, emphasizing activities such as rainwater collection, seawater desalination, water conservation, efficient use of water, recycling, and reusing are critical for sustainable water security. In other words, to be sustainable, water-supply systems need to continue to deliver the required amounts of water well into the present and the future.

In light of the above, the sustainable water security model is a descriptive apparatus that incorporates a core set of elements and norms derived from a wide range of sources to obtain the necessary quantity of adequate quality water. For future studies, a model like the one created in this study could prove useful, as it would allow researchers to better understand how different types of policies affect water management and the sustainability of water supplies (Nyam, et al., 2021). The model embeds attributes such as community involvement; maintenance and operation; sound decision; stakeholder engagements; enhancement of vegetation and water awareness. In contrast to previous research that has modeled water resources in South Africa using system dynamics, a novel approach was taken to model these systems in this work (Nyam, et al., 2021). For instance, the proposed model is informed by community participation, stakeholder inputs in defining model variables, and data collected from existing secondary sources. Such a descriptive model is acceptable because it supports and promotes sustainable water supply and better utilization of available resources in a sustainable way for households. Imperatively, if such a model is replicated in other similar contexts, it can enhance community resilience in achieving sustainable water security.

Furthermore, the model demonstrates that achieving sustainable water security would require the incorporation of various aspects. It is expected that a study or policy addressing water security will address all these concerns; but, to maintain study feasibility and relevant outcomes, individual studies and policies would inevitably choose a mix of perspectives. The combination of different aspects helps to understand and provides a way to look at how water security manifests itself so differently in varying contexts. Indeed, such a combination is more likely to stimulate efficacy for sustainable water security than either form of intervention alone. According to Varis et al. (2017), different combinations exist for different water security problem settings. Therefore, the plausible combination of this study depended on the problem at hand and the viewpoint taken. The five dimensions of sustainable water security are generic, and their measurements are based on various factors. The factors are categorized into physical/ infrastructural, institutional, and socio-economic (Sharaunga and Mudhara, 2016) and have been identified from the literature as having a bearing on water security.

As posited by Nkiaka (2022), the selection of indicators is based on three main considerations: (1) the availability of data for the indicators; (2) the indicators' representation of the physical water availability and accessibility, climate risk, socio-economic, and prevailing environmental conditions; and (3) the indicators' prominence in water security assessments by global policy institutions and the research community. It should be noted that for this study, some factors were not included due to the complexity of their nature. However, the Sustainable Livelihood Framework (SLF) was implemented to learn more about what factors affect long-term water security. Several researchers have found that this paradigm is a helpful tool for investigating the determinants of impoverished people's access to clean water and their ability to improve their standard of living (Donohue & Biggs, 2015; Carney, 1999). Connecting economic and ecological issues is another strength of the framework (Brocklesby & Fisher, 2003). Notwithstanding the above, factors that influence sustainable water security should aim to address water shortages and supply interventions. Aslam (2013) describes how such factors influence sustainable water security as follows:

- **The water sources** should be **maintained** around their renewable capacities without over-exploitation or depletion, and the quality of sources should be maintained by protecting them from contamination, especially biological contamination, at all times.
- **Infrastructure Development:** Adequate water infrastructure is necessary for reliable water supply and distribution. Investing in infrastructure development, including dams, reservoirs, treatment plants, and distribution networks, should be based on long-term water demand projections and sustainable water management principles.
- **An aware society of consumers** should understand the capacity of the sources in their vicinity, their role towards optimized water use practices, and their impact on the existing water sources and the overall environment.

- A **stable economy** provides the required finances and other resources for operational and maintenance needs without relying on external funding resources. This can be ensured by linking sustainable water security with direct or indirect economic benefits to society.

- **Community institutions** should play an active role in keeping the community alive in its participatory role by ensuring the arrangements for recommended operations and maintenance through adequately trained personnel. These institutions should also have a significant overall financial role for the entire system.

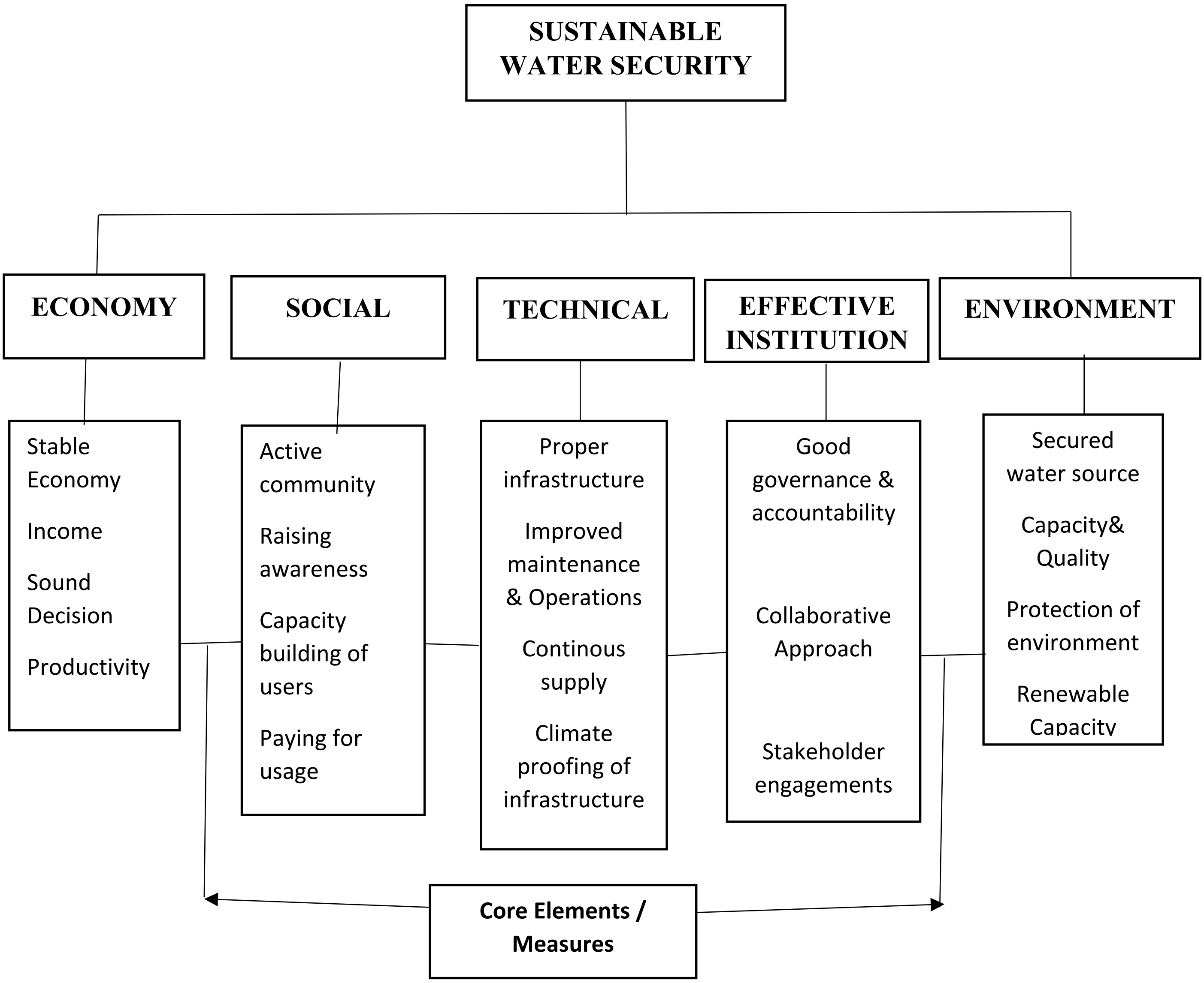
- **Ecosystem Protection:** Healthy ecosystems are essential for water security. Protecting and restoring ecosystems, such as wetlands and watersheds, helps maintain water quality, regulate water flows, and support biodiversity. Integrated approaches that consider ecosystem services are crucial for sustainable water management.
- **Water Demand Management:** Managing water demand plays a critical role in achieving water security. Implementing water-efficient technologies, promoting water conservation practices, and developing effective water pricing mechanisms can help optimize water use and reduce wastage

- **Education and Awareness:** Promoting education and awareness about water conservation, water quality protection, and sustainable water use practices among communities, decision-makers, and water users is vital for long-term behavior change and participation in water management efforts.

By considering these factors, a sustainable water security model can be developed, providing a comprehensive and holistic approach to managing water resources effectively and ensuring water security for current and future generations.

In the past, Aslam (2013) proposed a series of normative requirements for a sustainable CBDWS model, which together make up the “ideal base” of a model with a focus on sustainability. The concept called for a wide range of factors, including access to water, infrastructure, an educated populace, a secure economy, and strong social structures. As a result, the best model for achieving sustainable water security in different scientific fields is not to introduce completely novel concepts but rather to integrate existing effective practices. Therefore, the proposed model requires assessing a household’s ability to obtain the required quantity of suitable quality water for drinking, personal hygiene, other household needs, and minor economic activities. As such, the proposed model was formulated based on some challenges that are affecting the sustainability of drinking water systems in the Bojanala Region as claimed by the participants. The findings of the study revealed that the state of the water supply infrastructure was poor; there have been disputes or disagreements about water shortages, long queues, low water pressure, and poor maintenance of the source and service delivery; the participants are of the view that any of the diseases that existed/exist in their houses are water-related as the quality of water is very poor; the main problem with water quality is mud/sludge, colour, and pollution/contamination. As a result, the study presents the following descriptive model as a possible solution to address the aforementioned problems regarding sustainable water security:

Figure 6.1: Proposed Model for Sustainable Water Security



Source: Author - Proposed Model for Sustainable Water Security

Economic Dimension

The economic dimension of water management revolves around ensuring a continuous and reliable water supply for crucial economic sectors, such as agriculture, power generation, and manufacturing (Marcal et al., 2021). This dimension takes into account various economic factors, including the stability of the economy, income levels, the quality of decision-making processes, and overall productivity. Mayunga (2007) supports the significance of considering economic aspects when addressing water-related issues. One of the essential considerations in the economic dimension is the efficient allocation of water resources for productive purposes. Water is a fundamental factor of production that plays a pivotal role in sustaining various economic activities. In the agricultural sector, water is indispensable for crop cultivation and livestock farming, ensuring food security and supporting rural livelihoods (Chamhuri & Ahmed, 2014). In power generation, water is harnessed for hydropower, a renewable and vital source of energy for many countries. In the manufacturing industry, water is used in various processes, including cooling, cleaning, and production. Neglecting water-related challenges can have a profound negative impact on the economy, jeopardizing people's ability to make a living. Insufficient water supply for industries can lead to production disruptions, reduced output, and economic losses. In the broader context, water-related issues can have cascading effects on the economy, as they influence the availability of resources, impact income distribution, and affect investment decisions. The stability of the economy is closely tied to the efficient management of water resources and the resilience to withstand water-related shocks. By integrating economic considerations into water management strategies, nations can foster sustainable economic growth and enhance their capacity to tackle water-related challenges effectively. Proper water resource management, efficient allocation, and wise water use can optimize economic productivity and bolster overall economic stability.

Social Dimension

The social dimension of water supply systems plays a critical role in understanding the broader impact of management decisions and activities on water consumption, supply, and demand. This dimension delves into people's habits, traditions, and behavior related to water usage, aiming to gain a deeper comprehension of the socio-cultural factors that influence water management. User participation is a pivotal element within the social dimension. Engaging with local communities, stakeholders, and water users allows for the integration of diverse perspectives, needs, and priorities in water management plans. When people are actively involved in decision-making processes, they become advocates for sustainable water use, leading to greater ownership and commitment to the success of water supply initiatives (Lazarus et al., 2017). Water education programs play a pivotal role in enhancing social capacity. Educating communities and individuals about water conservation, efficient water use, and the importance of sustainable management can empower them to actively participate in water governance processes (Dudley et al., 2018). By enhancing knowledge and skills related to water management, communities become better equipped to address water challenges effectively (Islam et al., 2020). Financial remuneration and affordability are key considerations in the social dimension. Equitable access to water services is crucial for social justice and inclusivity. Policies and mechanisms to ensure water services are affordable for all segments of society can help address socio-economic disparities and promote social cohesion (Gupta & Roy, 2019). When viewed holistically, the social dimension contributes to sustainable development goals and indicators. These goals extend beyond purely economic and ecological aspects to encompass societal well-being, happiness, and prosperity. Sustainable water management is not solely about technical efficiency but also about promoting the social welfare of communities. Alshehri (2014) highlights the importance of the social dimension in water resources management, emphasizing the need to integrate social factors with technical and ecological aspects to achieve sustainable outcomes.

Technical Dimension

When it comes to the administration of water supply systems, the technical component plays a pivotal role in ensuring efficient and sustainable water delivery. Figure 6.1 illustrates the comprehensive nature of the technical dimension, encompassing various critical components that collectively contribute to the smooth functioning of water supply systems. This observation is corroborated by an exhaustive literature review and insights gleaned from interviews with experienced professionals in the industry, who have identified the key technical aspects that constitute this dimension. One crucial aspect that demands attention in the technical component is the climate-proofing of water infrastructure. Climate change poses significant challenges to water supply systems, with rising temperatures, changing precipitation patterns, and more frequent extreme weather events impacting water availability and quality. To ensure resilience and adaptability, it is imperative to design, upgrade, and maintain water infrastructure in a climate-resilient manner. This involves implementing measures such as improved storage facilities, water recycling systems, and the use of sustainable water sources to mitigate the effects of climate variability (Smith et al., 2019). Furthermore, the technical dimension emphasizes the importance of enhanced maintenance and operations. Regular maintenance is vital to prevent breakdowns, leaks, and water losses, which can have detrimental effects on the efficiency and effectiveness of the water supply system. Well-trained and skilled personnel must conduct routine checks, repairs, and upgrades to keep the infrastructure in optimal condition. Additionally, investing in advanced technologies, such as remote monitoring and sensor systems, can facilitate real-time data collection and aid in predictive maintenance strategies (Biswas & Tortajada, 2018).

Ensuring an uninterrupted water supply is another crucial aspect of the technical component. Continuous and reliable access to clean water is essential for public health, economic activities, and overall societal well-being. To achieve this, water supply systems must be designed with redundancy and backup mechanisms, ensuring that disruptions, such as power outages or equipment failures, do not lead to prolonged service interruptions. Adequate storage facilities and well-coordinated emergency response plans also play significant roles in guaranteeing uninterrupted water supply (Liemberger & Wyatt, 2018). Moreover, appropriate infrastructure development is a central concern within the technical dimension. Tailoring water supply systems to the specific needs of communities and regions is vital for sustainable water management. This includes choosing suitable water sources, utilizing appropriate treatment technologies, and designing distribution networks that efficiently cater to the demand. Considering the socio-economic and environmental factors of each region helps create the infrastructure that aligns with the local context and ensures long-term sustainability (Kujawa-Roeleveld et al., 2016). Alshehri (2014) provides support for the significance of considering these technical components in decision-making processes related to water supply systems. His research underscores the need for a comprehensive approach that incorporates climate resilience, effective maintenance, uninterrupted supply, and contextually appropriate infrastructure.

Effective Institutions

The institutional dimension of water resources management is a crucial aspect that focuses on the rules, regulations, and frameworks governing the interactions and interdependencies between various stakeholders and water resources. This dimension delves into the numerous agencies, statutory bodies, and regulatory instruments that shape and, at times, constrain operational decisions related to water management. One of the key issues within the institutional dimension is the effectiveness of governance structures. Efficient and accountable governance is vital for ensuring transparent decision-making processes, equitable distribution of water resources, and sustainable management practices. Weak or inadequate governance frameworks may lead to conflicts over water allocation, inefficient resource use, and failure to address the needs of all stakeholders (Sadoff et al., 2015). Collaboration among different actors and stakeholders is another critical aspect of the institutional dimension. Effective water management often requires the coordination of multiple agencies, communities, and private sector entities. Collaborative efforts can enhance resource efficiency, foster innovation, and address complex water challenges more effectively (Fisher et al., 2018). Moreover, dealing with various types of stakeholders presents both challenges and opportunities. Balancing the interests of diverse groups, such as farmers, industries, urban communities, and environmental advocates, requires inclusive and participatory approaches to decision-making. Engaging stakeholders in the water management process fosters a sense of ownership and can lead to better-informed and sustainable decisions (Hauck et al., 2015). However, the absence or inadequacy of institutional frameworks for water resources management is a recurring issue. Inadequate institutions may lack clear mandates, funding, and coordination mechanisms, hampering effective water governance. Strengthening institutional frameworks is essential to address water challenges in a holistic and integrated manner (Jägerskog et al., 2016). To ensure long-term water safety, institutional frameworks should be evaluated based on their ability to accommodate the diverse needs of communities and the environment. Flexibility, adaptive management, and inclusivity are key characteristics of robust institutional frameworks that can effectively address evolving water challenges (Schlager et al., 2017).

Environmental Dimension

The environmental aspect of water resources management focuses on the condition of aquatic ecosystems such as rivers, lakes, wetlands, and groundwater systems, evaluating the progress made in restoring their normal, healthy functioning (Wilhelm et al., 2022). Preserving water supplies, maintaining water quality and capacity, and safeguarding the natural environment all fall under the purview of the environmental dimension. Ensuring water security involves not only meeting human needs but also maintaining the health and integrity of ecosystems. Healthy aquatic ecosystems are vital for supporting biodiversity, regulating water flow, and providing essential ecological services (García-Mollá et al., 2020). A country's water security can be assessed by evaluating its ability to sustain healthy ecosystems. Achieving sustainable water security presents a complex challenge as it requires balancing human water demands with the preservation of local ecosystems. A holistic approach is needed to ensure that human livelihoods are protected while minimizing negative impacts on the environment. This approach recognizes that water is a shared resource, essential for the well-being of both human societies and ecosystems (Aboelnga, 2021).

Sustainable water security emphasizes the need to manage water resources responsibly to avoid depleting or damaging ecosystems. Proper management involves implementing conservation measures, reducing water pollution, and protecting sensitive habitats. Wastewater effluents are a significant source of water pollution that can have detrimental effects on both human health and ecosystems. When wastewater is discharged into the environment without adequate treatment, it can contaminate water bodies, degrade water quality, and harm aquatic life (Qadir et al., 2020). Adopting effective wastewater treatment practices is crucial for preserving water resources and safeguarding the environment. Protecting and preserving ecosystems is not only essential for environmental conservation but also for human health and food security. Aquatic ecosystems provide valuable services, such as purifying water, maintaining biodiversity, and supporting fisheries and agriculture (UN Water, 2018). By safeguarding ecosystems, we ensure the continued availability of clean water and a stable food supply for human populations

6.3 MODEL DESCRIPTION

The proposed model is rooted in empirical findings derived from a comprehensive study specifically focused on domestic water supply. It advocates an integrative approach to water management that aligns with the principles of sustainable development. The model's design is influenced by a set of normative principles that exemplify an ideal type of sustainable-oriented model, as identified by Stubbs and Cocklin (2008). These principles underscore the importance of incorporating environmental, social, and economic dimensions into water administration to achieve sustainable outcomes. By embracing these principles, the model ensures that water management strategies consider not only economic gains but also environmental preservation and social equity. The proposed sustainable water security model makes significant advancements in several aspects of water resource management. Firstly, the model emphasizes a sustainable-oriented approach that considers the importance of community assessment. By involving local communities and understanding their specific needs and challenges, the model tailors interventions to suit the unique context of each community. This community-centric approach ensures that the model's strategies align with the priorities and aspirations of the people it aims to benefit (Schaltegger et al., 2019). Additionally, the model recognizes the significance of engaging various stakeholders in driving and implementing sustainable development systems. Inclusive stakeholder involvement ensures a diversity of perspectives, expertise, and resources, which fosters more comprehensive and effective decision-making processes. By involving stakeholders such as government agencies, NGOs, businesses, and local community members, the model can leverage collective efforts to address complex water security challenges (Schaltegger et al., 2019).

The versatility of the proposed model is a key strength, as it can be adapted to suit various development activities and contexts with similar water challenges. Whether in rural or urban settings, the model's applicability allows for tailor-made solutions that align with the specific needs and circumstances of different communities. The model's focus on environmental, social, and economic aspects of development underscores its relevance in addressing the complex interplay of factors affecting water security. By integrating these dimensions, the model promotes a more balanced and sustainable approach to water resource management. One of the significant benefits of the proposed model is its emphasis on meeting the needs of water-scarce communities. As water scarcity becomes an increasing concern in various regions, the model's ability to cater to the specific challenges faced by such communities is invaluable. It addresses water security comprehensively, considering not only access to water but also the quality and reliability of supply. Moreover, the model serves as a powerful tool for informing the planning, implementation, and monitoring of water security actions. By providing a structured framework, the model supports decision-making processes, enabling stakeholders to prioritize interventions and allocate resources efficiently. Drawing on findings from various studies (Davie et al., 2013; Wada et al., 2013a, b), the proposed model acknowledges the existence of different water security models designed for specific reasons and contexts.

While diversity in models is valuable, the proposed model fills a gap by providing a guide specifically tailored for sustainable water security and supply interventions among households. By focusing on household-level interventions, the model aims to address water security challenges at the grassroots level, where the impact can be most significant (Schaltegger et al., 2019). Overall, the proposed sustainable water security model represents a significant advancement in water resource management. By prioritizing community assessment, stakeholder engagement, innovative approaches for disadvantaged communities, and an integrative methodology, the model promotes sustainable water security while considering the diverse needs of different contexts. Through its household-level focus, the model provides a practical and actionable guide to address water challenges and enhance resilience in water supply at the local level. The model's inclusive and holistic approach paves the way for sustainable water resource management that accounts for the well-being of communities and the environment alike.

6.4 MODEL APPLICATION

The model for sustainable water security is meant to encourage and facilitate a more sustainable water supply and better resource utilization for households in the study area and other similar areas. A fundamental link between social, economic, technical, and efficient institutions and environmental drivers affecting water security is demonstrated by the model (Nyam, et al., 2021). Multiple aspects of water security assessment may benefit from using the model, as stated by Marttunen et al. (2019). It offers a graphical and organized framework for discussing the many facets of water security, and it provides a more tangible understanding of the concept of water security. Extensive use of both secondary and primary data sources, as well as input from relevant parties, went into the model's development. Indicators, frameworks, metrics, and indices for measuring water security and sustainable water use were examined, as were local and international papers addressing sustainable water security. Factors that may affect sustainable water security were also identified. It was crucial for making sound decisions that a complete picture of water issues and their relative importance was understood (Marttunen, et al., 2019). To operationalize the fundamental principles of Integrated Water Resource Management (IWRM), the proposed model integrates the dimensions and key elements into a unified whole (Maganda, 2016). There is an emphasis on openness, disclosure, and participation from the general public and other interested parties in the model's governance structures. The study in general has contributed to enhancing the understanding of the dynamics of sustainable water security.

The implementation of the proposed sustainable water security model involves a comprehensive and participatory approach that considers various dimensions and key elements. Below is a detailed outline for implementing the model:

1. Assess the Study Area: Begin by conducting a thorough assessment of the study area to understand its water-related challenges, existing infrastructure, and water demand. Engage with local communities, stakeholders, and relevant authorities to gather data and insights about water availability, quality, and usage patterns

2. Define the Five Dimensions: Use the organogram figure representing the five dimensions (economy, social, technical, environment, and effective institution) as a framework to guide the implementation process. Identify specific indicators and criteria for each dimension to assess its current status and set desired targets.
3. Stakeholder Engagement: Involve key stakeholders, including community members, government agencies, NGOs, and businesses, in the implementation process. Facilitate workshops, focus group discussions, and consultations to obtain their input and ensure that the model aligns with their needs and priorities.
4. Core Attributes Embedment: Integrate the core attributes of the model, such as community involvement, maintenance and operation, sound decision-making, stakeholder engagements, enhancement of vegetation, and water awareness, into the implementation plan. Develop strategies and action plans for each attribute.
5. Data Collection and Analysis: Collect and analyze both secondary and primary data from various sources to identify water-related issues, challenges, and factors affecting sustainable water security in the study area.
6. Develop Indicators and Metrics: Create indicators, frameworks, metrics, and indices to measure water security and sustainable water use. These indicators will help in tracking progress and evaluating the effectiveness of interventions over time.
7. Operationalize IWRM Principles: Integrate the fundamental principles of Integrated Water Resource Management (IWRM) into the model to ensure a unified and holistic approach to water management. Consider the principles of openness, disclosure, and participation from the public and stakeholders in governance structures.
8. Identify Interventions: Based on the assessment and data analysis, identify specific interventions and projects to address the identified water-related challenges. Prioritize interventions based on their potential impact and feasibility.
9. Develop Action Plans: Develop detailed action plans for each intervention, specifying timelines, responsible parties, required resources, and expected outcomes. Ensure that the plans are aligned with the model's dimensions and core attributes.
10. Implementation and Monitoring: Begin the implementation of the action plans, and closely monitor progress and outcomes. Regularly assess the effectiveness of interventions and make necessary adjustments based on feedback and evaluation.
11. Capacity Building and Awareness: Implement capacity-building programs to enhance local communities' understanding of sustainable water practices. Conduct awareness campaigns to promote responsible water use and environmental conservation.

12. Evaluate and Review: Periodically evaluate the model's effectiveness and its impact on sustainable water security. Review and update the model as needed to adapt to changing circumstances and emerging challenges

By following this step-by-step approach, the proposed sustainable water security model can be effectively implemented to address water challenges, promote resilience, and ensure the sustainable availability and accessibility of water resources in the study area. The model's holistic and participatory nature allows for tailored solutions that consider the needs and priorities of the community, fostering a more sustainable and equitable approach to water resource management.

Collaboratively applying the model with different stakeholders provides an understanding of the different elements of water security, as well as its state and interconnections (Marttunen, et al., 2019). Key considerations for implementing the proposed model embrace and reinforce the principles of IWRM, targets of SDG 6, and Sustainable Livelihood. These include but are not limited to the following:

- Putting IWRM into practice in any respect level, including where necessary through cross-border collaboration.
- Assessing sustainable water security, especially at the local level.
- Understand the factors that influence people’s lives, water administration, and sustainable well-being.
- Improve livelihoods to a wider extent by integrated natural resources administration.
- Water-related habitats, such as mountains, forests, wetlands, rivers, aquifers, and lakes, must be preserved and restored.
- Promoting and enhancing local inhabitants’ involvement in bettering water and sanitation operations.
- Permit communities to develop environmentally, socially, and economically by supporting and promoting better utilization of resources sustainably.
- Expand cooperation and capacity-building support.

6.5 MODEL REQUIREMENTS

The study has identified six key model requirements as indicated below:

- **Effective Water Committee -** The proposed model can be considered a decision-making tool for implementing sustainable practices, concerning water use.
- **Qualified / Skilled Personnel -** Provide technical and management support for ongoing and future field-based activities related to water security program design, planning, and implementation; adhere to the requirements of water-related policies and legislation that are critical in delivering on people's right to have sufficient food and water.
- **Good Governance and accountability** - are essential to achieve sustainable water security, fairly allocate water resources, and avoid disputes. It has social, economic, political, and environmental dimensions, all of which must be carefully considered and addressed.
- **Collaborative Approach -** This seeks to "operationalize" water governance by bringing together collaboration (i.e., working together to achieve shared goals) and water management. All stakeholders are urged to embrace bottom-up processes of collaboration and knowledge sharing to better manage water resources at all levels.
- **Community participation** – Community participation from inception to the end, allows for resource sharing and fosters supportive and active community participation. It is vital to obtain community participation in decision-making at all stages.
- **Stakeholder Orientated -** Encourage participation from key stakeholders to ensure their input into water policy development and implementation is well-informed and focused on achieving desired results. To achieve sustainable water security, it is essential to have input from all relevant parties.

In light of the above, it is apparent that the proposed model may optimize the availability of reliable water supplies of suitable quality for households. Furthermore, the proposed model has led to greater collaboration and coordination among various water users. For instance, the proposed model may help the community, key stakeholders, policymakers, decision-makers, and government officials to prioritize and optimize water usage to ensure that the available water is used to generate sustainable livelihoods equitably. This is why the suggested model requires leaders to take charge and make difficult choices about water's many applications, then see those choices through to completion in the form of policies. In addition, given the importance of water as a critical factor in providing livelihoods, the proposed model can be considered a decision-making tool for implementing sustainable practices regarding water usage. First and foremost, analyzing the effects water policies have in the context of broader socio-economic policies is essential for making decisions in response to ensuring sustainable water security (Muller, et al. 2009). Study results show that our model provides a viable option for society to tap into the existing water supply. In other words, the model supports social and economic activities to the benefit of all, thus improving the livelihood of the communities.

Finally, the importance of this model is underscored by the fact that it can be easily extended and adapted to other similar locations, making it an effective decision-support tool for achieving sustainable water security and addressing the myriad of water security challenges identified in the study and beyond. For this reason, it has been argued that the proposed model can be used as a decision-making tool for introducing environmentally friendly methods of water management by Ratnaweera et al. (2006). In other words, the sustainable water security model is a resource for determining what measures should be taken to save water and save the most money. To the researcher's knowledge, this is the first study to actively consult a wide range of stakeholders in the development of a model for sustainable water for individual households. This research has shown the importance of developing and implementing a model for sustainable water security that will help residents make better use of available resources and ensure a steady supply of clean water for their homes.

6.6 IMPLICATIONS OF THE FINDINGS

The results of this research add to our understanding of the larger picture surrounding the topic of sustainable water security in the region under investigation. The results corroborate the widespread belief that reliable access to clean water is crucial to a wide range of social functions and an essential ingredient for achieving economic growth and personal flourishing. We also think these results offer valuable insights for achieving sustainable water security. In other words, the results have theoretical and practical implications for ensuring sustainable access to water in the future. The study's findings add both theory and practice to the existing body of research knowledge, making them highly significant. The implications of the findings are discussed below:

The present study's first major practical implication is that it provided a model of sustainable water security, complete with several quantitative indicators and criteria. The indicators are broken down into categories such as water productivity, public education, infrastructure development, community involvement, teamwork, environmental safeguards, and water supply reliability, capacity, and quality. Having such a descriptive model that stimulates and integrates crucial dimensions that have the potential to influence sustainable water security is extremely useful. With this research's empirical evidence and understanding of sustainable water security, we can make long-term improvements to our water supply that won't deplete our resources. This model can help with water productivity, efficiency, and supply, all of which are essential to achieving sustainable water security. To further improve sustainable water security, the model can direct governments and policymakers toward innovative new approaches and policies. A society's failure to achieve sustainable water security can have far-reaching consequences, including negative effects on human health, the demise of ecosystems, increased food and energy insecurity, and even armed conflict in water-poor areas (Nkiaka, 2022).

A second major implication of the study is that the sustainable water security model is a powerful diagnostic tool that could direct interventions to improve water security and supply, as well as draw attention to existing problems and encourage the adoption of more environmentally friendly methods of water consumption that take into account the relative importance of various indicators of such security. To better inform policy decisions, indicators are especially helpful for simplifying and condensing large amounts of complex scientific information and intangible concepts into easily understandable and communicable quantitative scores (Jensen & Wu, 2018). Indicators can be used to express the nature of key dimensions, align priorities between development partners, promote evidence-based policymaking, and facilitate regional policy integration. In other words, indicators should mirror the desired results of bolstered water security to guide strategic planning and sound decision-making.

The third implication is that the model promotes consensus in the implementation of use and conservation strategies and that it encourages community participation in decision-making. Making a decision requires taking into account factors unique to the given situation, such as the urgency with which it must be implemented and the scope of its potential effects. Sustainable water security can only be achieved through a comprehensive strategy that incorporates all relevant actors and a variety of methods for addressing the many interrelated challenges that threaten this goal. Issues of water security are now understood to necessitate a heightened level of participation from individuals, communities, institutions, and decision-makers in all facets of water management. To be effective, efforts to better manage water must incorporate both individual and community-level initiatives. Local communities can take significant action, for instance, to better the water situation by implementing a variety of technical interventions.

The use of only one source of water brings up the fourth implication. For instance, most respondents said they obtain their water supply from a public standpipe; however, experts say that to overcome and achieve sustainable water security, we need to shift our focus from quantity to quality, shifting our reliance from a single source of fresh water to a variety of water resources like groundwater, rainwater, tanker water, stone spout, spring water, jar water, and public wells (Fatahi et al., 2021). The rural poor rely heavily on the local natural resource base for sustenance, making a diversity of water resources crucial to their way of life (Baumann, 2002). Even though some reports have reiterated the message that water use efficiency is low in society, it appears that improving water efficiency is becoming one of the most important strategies for achieving sustainable water security. Therefore, greater efficacy may be viewed as a means to better resource management and utilization, and even more equitable water use.

The findings' fifth implication is the broader problems with water security. Natural water stress (physical water scarcity), increasing demand for water due to population growth, better living conditions, industrial and agricultural advancements, deteriorating water quality, and inefficient water infrastructure are just a few of the major obstacles that need to be overcome. As a result of these many obstacles, the quest for sustainable water security, especially in developing regions, has risen to the top of government priorities and global policy institution agendas in recent years and has also taken center stage in the contemporary scientific agenda (Nkiaka, 2022). Water issues come in many forms, but one thing they all have in common is that society must deal with them. Therefore, the water problems should be solved by bringing about necessary shifts and adjustments in how people live and interact with the natural world. Our sustainable water security model is proposed as a solution to these problems, as it maximizes the use of existing water resources. In other words, this model is an essential step toward easing and resolving water security concerns.

Water security is threatened in multiple ways by the deteriorating water infrastructure. One of the most important factors affecting people's access to safe drinking water is the state of the country's water infrastructure. In this case, increased water losses are a direct result of the inefficiencies that are being spread throughout society using the deteriorating infrastructure. High levels of non-revenue water have been reported due to aging and poorly maintained water infrastructure, which has increased the frequency of pipe leaks and breaks. As a result, the state of water infrastructure affects and is deeply intertwined with societal and economic development. In particular, the efficiency with which resources are managed is affected by the condition of water infrastructure.

The information presented above makes it clear that there is a concern regarding the availability of sufficient water to satisfy the requirements of the existing population as well as the population that will exist in the future. Therefore, the conventional choice is to make use of engineering and technology to locate and cultivate alternative sources of water such as groundwater and surface water. This strategy has been effective for quite some time, especially as it has shifted its focus to enhancing access to surface water.

In light of the foregoing, it is clear that insufficient access to clean water poses a serious threat on a regional, national, and international scale. Because of this, it is evident that a new strategy is required to effectively manage water insecurity in a variety of communities. The research has important practical implications because its findings can be used by those responsible for ensuring the long-term reliability of water supplies on a regional, national, and international scale. Researchers, policymakers, decision-makers, and planners are all encouraged to use the descriptive model presented here as part of the comprehensive solution required to address the widespread problems associated with water security and lessen their effects.

6.7 CONCLUSION

Sustainable water security is a significant topic for discussion worldwide, including in South Africa, as it relates to access to acceptable quantity and quality of water as indicated in Sustainable Development Goal 6. Assessing sustainable water security sought to address social and economic activities in a way that will sustain the supply and quality of water for a variety of needs. Only findings that stood out are summarized and reiterated. This is done by relating the findings with the key objectives and questions of the study in an attempt to determine whether the study achieved its purpose.

In line with the statement above, the study's main focus was to assess sustainable water security among households. From the model analysis, study findings, and discussions, the following conclusions are drawn:

The results presented in Chapter 5 show that the 30 to 40-year-old age group dominated the age categories and were mostly flexible to collect water. The age range was also a key factor that distinguished socio-economic characteristics that are associated with access to water for households and may contribute to sustainable water security in the study area. The age category assisted in understanding the dominant age group that may enhance or contribute to sustainable water security in the study area. On the other hand, Geere and Cortobius (2017) argue that there is still a significant amount of reliance on human labor associated with fetching water to access water for domestic consumption. It is widely acknowledged that the practice of fetching water from off-plot sources is more widespread in rural regions, yet it continues to be a major impediment to household water security and sustainable development, especially for rural women. Inequalities in water security and livelihoods may be exacerbated by water-fetching, whose negative effects may be compounded by other personal or family issues that limit the capacity to access and carry water. Those who are less able to get and carry water, such as the elderly, those with impairments, or those who are socially stigmatized, continue to be at risk for household water insecurity (Wrisdale, et al., in press).

The results of the study demonstrated that most females were single and burdened with household chores. The data referent to water security in the study area corroborates the emerging argument that households with single parents are at a disadvantage in all the dimensions of sustainable water security in comparison to households with both parents. It is apparent that women carry out more water-related activities or household chores than their male counterparts. Of the surveyed households, the finding suggests that women are responsible for household chores compared to male partners. This assertion, although not based on quantitative measurement, has brought to the forefront the undue burden placed on women due to the inability to obtain water, a burden often not seen, and the inequality suffered as a result. The burden of water collection and other reproductive roles, such as caring for sick relatives, falls disproportionately on women and keeps them from completing their education or finding gainful employment, which in turn reinforces gender inequality and poverty (Winter, et al., 2021). It seems discrepancies between men and women concerning household chores adversely affect household water security. The tragedy is not just in household chores but also impacts the opportunities for personal growth as the time required for household chores leaves little or no time for self-development.

The study revealed that most household heads were unemployed. Unemployment is one of the major challenges that the majority of participants are faced with currently. Generally, unemployment in South Africa has been escalating, despite the introduction of initiatives by the government to reduce it. Goal 8 of the United Nations' Sustainable Development Agenda is to "ensure that all people may fully participate in, and benefit from, the expansion of productive economic activity" by 2030. This objective is in line with the definition of occupational justice provided by Wilcock and Townsend (2009), which states that "the right of every individual to be able to meet basic needs and have equal opportunities and life chances to reach toward his or her potential, but specific to the individual's engagement in diverse and meaningful occupation" (p. 193). The right to participate in fulfilling occupations is an example of an occupational right, as defined by Whalley Hammell and Iwama (2012). People's health (Geere, 2015), time lost due to water fetching (Geere, Mokoena, Jagals, Poland & Hartley, 2010), and inability to maintain expected standards of personal presentation and hygiene can all be negatively impacted by the lack of safe or limited water and sanitation access. To give just one example, a lack of clean water and sanitary facilities might discourage both school attendance and employment in particular fields (Groce et al., 2011). This implies that if Sustainable Development Goal 8 is to be met and occupational justice is to be achieved, then improvements to the water supply must expand access beyond what is necessary for survival and simple subsistence.

The results of the study show that the majority of the respondents get water from a public standpipe, which does not provide sufficient water to cover the needs of the present population, and the source is not secure. The study established that many households that are unable to afford a household connection rely on public water points, commonly known as standpipes. Usually, the groundwater is pumped from boreholes to reservoirs and from there to the standpipes. Seemingly, the study notes that in most cases the public standpipes are dispersed along the main roads at irregular distances. Such irregular distance limits the water volume that a household can collect from a standpipe in a single day. Generally, public standpipes are the interface of many South African rural water supply systems. Usually, individuals with access to limited water services spend more than 30 minutes per day collecting water from public standpipes. Lebek, et al., (2021) substantiate that for 71% of users of standpipes, water is available for only 5 to 12 hours per day and often standpipes cease to function due to broken pipes which in turn compromises the reliability of the standpipes. The government should prioritize access to water and protect water sources over activities that have a significant and detrimental impact on water security.

The results of the study further show that the state of the water supply infrastructure is poor as highlighted by the majority of the participants. In support of these findings, Eales (2011) identified two primary causes of this unreliability: (a) delays in water infrastructure and the neglect of operations and maintenance of existing infrastructure; and (b) national infrastructure grants that incentivize the construction of new infrastructure but do not include funding for maintenance and operations. Poor management and upkeep contribute to an estimated 35% water loss due to pipe leaks (Department of Water & Sanitation, 2019).

Findings emanating from the study show that most of the participants do not pay for a monthly water bill, operation, and maintenance of the water source. The absurdity is that most household heads are unemployed and thus unable to afford to pay. Even so, various reasons cited for not paying included water being a free basic service, poor water services, and that they are indigent. Costs associated with satisfying water needs, such as the sinking of boreholes, are borne by individual households. Households on the needy register who receive water from a communal water service in South Africa are exempt from water rates because of the country's regulations governing the distribution of water (Department of Water & Sanitation, 2015b). Based on its responsibilities under the National Water Act of 1998 and the Water Services Act of 1997, the Department of Water and Sanitation (DWS) (2015b) is in charge of regulating and supporting the delivery of efficient potable water and sanitary facilities throughout the country. All of this is carried out under the mandates of laws and regulations related to water, which play a fundamental role in realizing people's right to sufficient amounts of nourishment and hydration, fostering economic growth, and combating impoverishment. In this regard, it must be stressed that the policy of providing free basic water ensures the guarantee of a reliable water supply and improves means of water, efficiency, equity, and sustainability. The concern about paying for water services is inextricably linked to the ability or provision of sustainable water supply to meet and control demand.

The analysis revealed that the majority of the participants' main source of water supply is a borehole, with very poor water quality caused by either mud/sludge, color, or pollution/contamination. Contamination is a major threat to scarce water resources and severely affects water quality. Water contamination and inadequate sanitation are known to have negative health effects, as shown by numerous studies (Bartram, Lewis, Lenton & Wright, 2005; Fewtrell, et al., 2005; Prüss-Üstün, Bos, Gore, & Bartram, 2008; Wang and Hunter, 2010). Nguyen et al.

(2006) mention that borehole water in areas with high rainfall and shallow water tables is more vulnerable to contamination from pit latrines. Also, groundwater vulnerability can occur from man-made activities. This may account for the poor water quality of boreholes in the study area. Due to the prevalence of waterborne illnesses, such as diarrhea, the expenses of treating these conditions often fall squarely on the shoulders of participants. Some families have to boil their water to remove bacteria and parasites, adding to the cost of water treatment by requiring them to buy fuels like firewood and electricity (Morocco-World News, 2017). However, the results have demonstrated that a borehole is an effective strategy for ensuring sustainable water security and reducing the demand placed on the municipal water supply**.** Not only does a borehole provide a self-sufficient edge, but it also offers a continuous supply of water at constant pressure. Through the study, results have shown that utilizing a borehole is great as it is a sustainable natural water source and provides access to sufficient water. It should be noted that the advent of boreholes in the study area had a tremendous impact on the lives of participants, however, at times some boreholes had simply gone dry, especially during drought seasons. There was presumably a combination of mechanical failure and environmental reasons, including a falling water table, that led to recurrent water shortages.

Importantly, the people who live in the research region are certain that borehole use or restoration provides major benefits despite the worries that have been raised about them. In sum, the water sources available in the study area were for decades intended to ensure water provision. Unfortunately, it was found that the poor operation and maintenance of the water infrastructure, lack of appropriate skills, lack of rainfall, climate change, drought, and population growth, are among the major factors that affected or influenced water shortages within the study area. These realities continue to threaten water security and must be addressed by a comprehensive and coordinated effort to improve access to clean water and make better use of existing resources in private residences. As a result, there is a pressing need to establish a model of sustainable water security that takes into account the various aspects that affect water security and places greater focus on water supply and demand management techniques for the long term.

The results of the study show that to be water-secured, the majority of the participants store water using buckets or containers. To collaborate with this finding, Lebek et al. (2021) indicate that households collect large amounts of water on the days when it is available and store it at home for the rest of the week. It is evident that the amount of water brought to the households must be used with parsimony and reutilized whenever possible. This assertion indicates that water can constitute a resource whose abundance or restriction can encourage or inhibit some productive activities that are directly dependent on it. Usually, the water is mainly carried in plastic buckets or containers with the capacity to hold 20 to 25 liters. Also, water is often stored in large drums. The study results have shown that storing water serves as insurance against periods of surplus and is a major contributor to sustainable water security.

The results of the analysis revealed that both parents and children often collect water mainly from the low water-pressured public water source that is more than 200m away from their homes. In contrast, the South African government has established that a piped water supply within 200m of a residence is an acceptable basic level of service of safe drinking water (African Ministers' Council on Water, 2011). The association between the public source and long-distance travel to fetch water remains a tiring daily burden and a major barrier to sustainable development and household water security. These results, although preliminary, raise the need for the establishment of more on-site water facilities to provide access to a water source within 200m of the dwelling inhabitants. It is, therefore, essential to ensure proximity to the water source to offer comfort to household members, who often have the responsibility to fetch water. Such interventions could also be applied to other settings in South Africa where access to safe drinking water is problematic. This will advance progress toward the 2030 SDG agenda of offering universal access to safely managed water, which would achieve the progressive realization of a basic water supply. From this study, it is apparent that reducing the distance traveled and time waited in the queue to access the water source will allow participants to engage in other productive activities such as attending to educational prospects, attempting to generate extra income, caring for their households, etc. Also, in doing so, it will be taking a step in the direction of alleviating the burden borne by parents and children. Overall, the evidence is clear that long-distance travel and long queues to collect water have a physical toll and reinforce poverty in multiple ways - by reducing the time participants have available for socio-economic activities, especially executing basic domestic chores and income generation.

6.8 RECOMMENDATIONS

The purpose of this research was to assess the sustainable water security in the Bojanala Region in the North West Province of South Africa. The logit regression model and descriptive statistics were used to analyze the data. Insufficient water resources, poor water infrastructure, and the time it takes to collect water are identified as the primary causes of water insecurity in the study area. The paper concludes that strategies to reduce households' time to collect water should be prioritized to address water insecurity in the study areas. The research also found that some factors improved household water security while others worsened it. The water infrastructure in the study areas needs to be upgraded to increase water security.

It is evident from the research that most inhabitants in the region face multiple obstacles that prevent progress, expansion and a secure way of life. Based on the empirical outcomes and literature review, the following recommendations are drawn and forwarded for action:

The majority of the participants were between the ages of 30 to 40 years which is regarded as active and energetic enough, while the least proportion was in the age group of at least 63 years and above where strength and energy are increasingly deteriorating. Carrying water appears to have direct detrimental impacts on the physical health of the carrier. It is, therefore, recommended that the government should invest in water-related infrastructure to free or ease the burden of fetching water and the detrimental impact on the physical health of the carrier. It is further recommended that the government should prioritize intervention regarding access to water improvements. Consideration should be on empowering young people as promoters in the field of sustainable water security. When trying to find solutions to sustainable water security and ways to improve access to water and sanitation in any given community, youth must become involved, so they can work together in an organized fashion to identify appropriate solutions to the problems, and then take ownership" of the measures to apply those solutions. By allowing them to take ownership with the provision of government support they will be influential in supporting the sustainability agenda.

The results of the study revealed that most females were single and burdened with household chores. These results raise inequalities between men and women in terms of gender issues in household chores. It is evident that women are responsible for domestic water provision, carry out more water-related activities than their male counterparts, and spend time on activities such as fetching water, caring for children, cooking, cleaning, washing, bathing, etc. It is therefore recommended that men in the study area be encouraged to get more involved in household chores. The involvement of men in household chores is strategic in terms of allowing women time to engage in productive work where they can earn income to be empowered. There is potential for men to help with housework that is traditionally reserved for women. Should men not get involved in household chores, women will continue to be burdened and overloaded by household chores. To put more emphasis the government should conduct an awareness campaign on the benefits of role-sharing among household members. As long as there is a lack of awareness of role sharing, women will continue to shoulder the burden of house chores. Conducting awareness of the importance of role sharing will help to reduce the burden and physical agility of women as they handle multiple tasks at home and outside the home. Sharing household chores with the assistance of men has the potential of creating a more cooperative household and giving women the chance to spend more time on other activities such as their education and training – so as not to compromise their future.

Additionally, the study revealed that most household heads were unemployed. Many of the issues facing unemployed household heads revolve around a loss of hope, and such issues were consistent in the study area. The government should put in place initiatives and policies dedicated to reducing the level of unemployment. People should be practically trained with the relevant skills that match the labour market. The study recommends that a community-driven government initiative be designed to provide employment. In short, programs should be designed to equip unemployed people with the skills required by employers in the labour market. There is a need for an entrepreneurship culture to be promoted among the youth to help them become economically involved. The government should improve the employment prospects of lower-skilled men, and enhance public employment programs, such as the Expanded Public Works (EPWP) and Community Work Programme (CWP). Further, the government should encourage self-employment and entrepreneurship among the youth. Government investment programs need to be channeled toward developing infrastructure in rural areas, to help reduce unemployment. Government can use supply-side policies that include entrepreneurship, internships, leadership, and apprenticeships to tackle structural (skills mismatch) unemployment.

Furthermore, the results of the study show that the majority of the respondents get water from a public standpipe that is not secured and does not provide sufficient water to cover the needs of the present population. Generally, a standpipe often provides much-needed flexibility that can be critical to sustainable livelihood strategies. Therefore, it is recommended that free standpipes should be retained to allow households an adequate quantity of water. The public water standpipes should be secured to provide a level of water services that responds to the socio-economic needs of the communities. The municipality should equip and secure standpipes that are within a maximum walking distance of at least 200m from the households. Also, no home can be more than 100m away from a standpipe, as mandated by the Department of Water and Sanitation (2017). When equipping a public standpipe in the study area, the potential sources of water should first be assessed. Consideration should be given to the quantity of water available to meet present and future needs in the supply area, as well as to the quality of the water. A reasonable number of households or people should be served from a standpipe to avoid long queues and waiting periods. Also, the minimum pressure should be reasonable when the standpipes in the area are open.

Findings from the study show that most of the participants do not pay for a monthly water bill, operation, and maintenance of the water source. It is recommended that the government should upgrade and maintain its water infrastructure to safeguard water provisions and encourage payment for water which is necessary for ensuring sustainable water management. In conjunction with efforts to ensure payment for water services, the government should guarantee reliable and sustainable means to water that is both plenty and drinkable. Lastly, in pursuance of paying for water bills, the government should improve water services and prioritize getting water to every household to ensure that those who indicated that they are not paying water bills due to poor water services will start to pay for the water services. Besides, providing integrated water services, management, infrastructure planning, and development remain vital in supporting the sustainable provision of water services.

The analysis revealed that the majority of the participants' main source of water supply is a borehole, with very poor water quality caused by either mud/sludge, color, or pollution/contamination. In general, drinking water must be free of any chemical or radioactive contaminants as well as any bacteria that could pose a health risk to humans. The disease spreads quickly in homes that don't have access to the recommended amount of water (Hove et al., 2019). As a result, the government should make sure the water supply is always safe to drink. It is also recommended that all drinking water, from its origins to its final consumers, adhere to uniformly high-quality quality standards and be devoid of any off flavors, colors, or smells. The water must be of sufficient quality to meet the requirements of SANS 241 (the South African National Standard).

The results of the study also show that the state of the water supply infrastructure is found to be poor. It has been indicated that water infrastructure is affected by amongst others a shortage of technical capacity and skills within the water sector, poor infrastructure management practices, poor financial management, poor operations and maintenance, widespread nepotism, and patronage. The study concludes that improving water infrastructure for water provision is necessary to increase the level of sustainable water security in the study area and comparable areas. A further benefit of improved water accessibility is a reduction in the amount of time spent on water collection. Also, it is recommended that both the government and private sector should build local capacity, train, and transfer skills to the younger generation of professional public water systems require constant vigilance from the government and the institutions responsible for their upkeep to guarantee their smooth running and administration. To keep the water flowing reliably, it is necessary to repair, refurbish, and, if necessary, replace the underlying infrastructure. In addition, the government should implement regulatory and legislative interventions to guarantee the ongoing upkeep and improvement of water supply infrastructure. In addition to taking preventative measures, quick action should be taken against individuals who have been entrusted with the duty of maintaining operational water infrastructure.

6.9 ISSUES FOR FURTHER RESEARCH

This study is explanatory and generates knowledge and discussion points on sustainable water security. The major underpinning of the whole study is an interest in assessing sustainable water security and gaining an understanding of the state of affairs and distinguishing challenges and areas that require attention. More research will be necessary to refine and further elaborate our novel findings. For this reason, we propose a novel approach to water security that will aid policymakers, decision-makers, and water stakeholders in allocating scarce resources toward sustainable water security. Moreover, the government has a constitutional obligation to supply adequate and affordable water services to all citizens within their borders. Furthermore, the conclusions and recommendations from the study are expected to initiate further dialogue on sustainable water security, especially for households.

As part of the dialogue, it is, however, significant to further advance a holistic approach that considers the implementation of new science-based methodologies, and endorsement of principles of Integrated Water Resources Management (IWRM) that can sustainably address various water-related issues. Enable stakeholders to take part in a discussion about different variables that influence sustainable water security among households, their relative importance, and how they interact The discussion on various aspects that influence water security will provide the context to understand how and why water security results in its current state. The dialogue must further provoke a need to conduct a systematic and wider study moving towards better socio-economic water security that is more sustainable and develop policy instruments even if the entire water security might not be fully achieved.

Ultimately, it is our conviction that even though the study findings revealed that public source does not provide sufficient water to cover the needs of the present population, future research should focus on holistic and integrated solutions to achieve water security that goes across key policy tracks to advance the integration of social, economic, and ecological research, and generate outcomes that enable the development of effective policies and practices for IWRM. During policy development, policymakers must strive to improve and extend cooperative institutions to prioritize the sustainability of water resources management. Careful attention will need to be paid to more quantitative studies of the potential socio-economic impacts of policy implementation across all related sectors, to allow for the water policy to be critically reviewed and refined as implementation proceeds. The success of the water policy will depend on strong, sustained, and consistent leadership. Finally, the study suggests that future research employs more all-encompassing methods to guarantee future generations' access to clean water. Furthermore, a paradigm shift in thinking and approach for the benefit of all is required so that future planning takes into account holistic and integrated solutions to achieve sustainable water security. For instance, a holistic approach must go beyond the 2030 horizon. According to the World Water Development Report (WWDR, 2021), everyone on earth must be able to get the water they need, when they need it, in sufficient quantity, and from reliable sources by the year 2050 if mankind is to have any hope of thriving and developing to its full potential. The Sustainable Development Goals are compatible with this concept (SDG 6) (WWAP, 2015). To round off, the researcher does think that the rich results obtained can be universal and replicated in similar contexts or circumstances.

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APPENDICES (I)

DATA COLLECTION TOOL FOR HOUSEHOLD SURVEY:

ASSESSMENT OF SUSTAINABLE WATER SECURITY IN THE BOJANALA DISTRICT IN THE NORTH-WEST PROVINCE IN SOUTH AFRICA

Dear Interview

Thank you so much for your cooperation and commitment to the interview by devoting your precious time. I am conducting a research entitled **Assessment of sustainable water security in the Bojanala District in the North-West Province in South Africa** for academic purposes to earn my doctoral degree (Ph. D.). You are purposely selected to participate in this study because you are the appropriate person to give first-hand information on the issue. I, therefore, kindly, request you to provide genuine information. Please be sure that all the information provided in this questionnaire shall be used for research purposes only and treated with the utmost confidentiality. You are not obliged to answer any interview question that you don’t want to answer. Your participation in this study doesn’t involve any direct risk or benefit for you but it is very useful for the success and completion of the study.

INTERVIEWER’S NAME:________________________

DATE OF INTERVIEW:__________________________

START TIME:___________________________________

END TIME______________________________________

SIGNATURE____________________________________

SECTION 1: HOUSEHOLD SOCIO-ECONOMIC CHARACTERISTICS

1.1 Are you the head of the household?

0) No

1) Yes

1.2 How old are you (years)? ____________________

1.3 Are you employed?

0) No

1) Yes

1.4 What is your gender:

1) Female

2) Male

3) Wish not to disclose

4) Other _______________

1.5 What is your marital status?

1) Single

2) Married

3) Divorced

4) Widow / Widower

5) Separated

6) Cohabit

1.6 What is your education level?

1. None

2) No formal education

3) Primary (Grades 1 to 7)

4) Secondary (Grades 8 to 12)

5) Certificate

6) Diploma / Degree

7) Honours / B-Tech

8) Masters

9) PhD

10) Other

1.7 What is the total number of dependents in your household? _________

1.8 What is the main occupation of the head of the household?

1) Retailer

2) Farmworker / Farmer

3) Construction worker

4) Domestic worker

5) Public sector employee

6) Mining/Industrial worker

7) Unemployed

8) Self-employed

9) Pensioner

10) NGO

11) Private sector employee

12) Other (Specify) ___________

1.9 How much is the household income per month? (Indicate in which category the household's income fall)

1) Less than R500

2) R501 - R1 500

3) R1 501 - R2 600

4) R2 601 - R3 500

5) R3 501 - R6400

6) R6401 – R 10 000

7) More than R10 000

1.10 How much is your household get from the following sources of income?

No	Source	Amount per month
1	Pension	R
2	Grant	R
3	Salary	R
4	Investment	R
5	Remittance	R
6	Retailer	R
7	Piece jobs	R
8	Other (specify)	R
	Total	

SECTION 2: **WATER USE AND CONSUMPTION**

SOURCE OF WATER:

2.1 From where do you get your water? (can be more than 1 source)

No	Water source	Yes = 1; No= 0
1	River/canal	
2	Public standpipe	
3	Yard tap connected to municipal system / DWAF	
4	Yard tap connected to the community system	
5	The yard tap connected to a private borehole	
6	In-house tap connected to municipal system / DWAF /	
7	In-house tap connected to the private borehole	
8	Rainwater	
9	Other (specify)	

2.2 Do you own a private tap?
0) No

1) Yes

2.3 If yes, do you get water from this tap?

0) No

1) Yes

2.4 If no, how far is the water source in which water is being collected?
1) Less than 50m

2) Between 51 and 100m

3) Between 101 to 150m

4) Between 151m to 200m

5) More than 200m

2.5 Does the public source provide sufficient water to cover the needs of the present population?

0) No

1) Yes

2.6 What is the water pressure from the public or private water source?
1) Very Low
2) Low
3) Fair
4) High

2.7 What is the status of the water supply infrastructure?
1) Good: 0 – 10 years
2) Fair: 10 – 20 years
3) Poor: 20 years and above

2.8 Is this source secured?
1) No
1) Yes

2.9 Who is responsible for the operational activities of the source?

1) Pumpman / Valve man
2) Municipality / Government
3) Nobody
4) Not sure
5) Other

2.10 Was there ever a dispute or significant disagreement about the water source?

0) No
1) Yes

2.11 If yes, what were there disputes or disagreements all about?

1) Water shortages
2) Long queues
3) Low water pressure
4) Poor maintenance of the source & service delivery
5) All of the above
6) None of the above
7) Other

2.12 Do you pay anything to your community organization/government for the operation and maintenance of the source?

1) No
2) Yes

2.13 If no; you are not paying because?

1) Free Basic Service
2) Indigent
3) Poor Service Delivery
4) Other (Specify)

2.14 If yes, how much do you pay for the water source?

1) Less than R50
2) Between R51 – R200
3) Between R2001 – R500
4) More than R501

2.15 How often do you pay for the maintenance/operation of the source?

1) When needed
2) Monthly
3) Quarterly
4) Every after six months
5) Annually
6) Never

2.16 Do you think that any of the diseases existing/existed in your house are water-related?

0) No
1) Yes
2) Not sure

2.17 Which of the following diseases/sicknesses are common in your house? Both young & old (Put "1" for most common, "2" for least common but existing, and "0" for nonexistent)

No	Disease	1 Most common; 2 Least Common; 0 None existed
1	Diarrhea	
2	Cholera	
3	Malaria	
4	Tuberculosis	
5	Misc Stomach problems	
6	Covid	
7	Other (Specify)	

2.18 Did you know that the diseases mentioned above are water-related?

0) No

1) Yes

2.19 Has ever been any death in your family due to water-related diseases during the past 15 years?

0) No
1) Yes

STORAGE

2.20 Do you store water?

0) No

1) Yes

2.21 Which of the following water storage do you use?

No	Questions	Yes =1; No=0
1	Bucket	
2	Jojo	
3	Drum	
4	Container	
5	Running Pipe	
6	Other	

QUANTITY:

2.22 How much water is your household currently using per day?

No	Number of liters	Number	Total
1	20 L	2	40
2	25 L		
3	210 L		
4	1000 L and above		
5	Total Water Usage		

2.23 How often do you fill them up?

1) Daily

2) 2 to 3 times a week

3) 3 to 5 times a week

4) Weekly

5) Fort-night

6) Monthly

7) As and when needed

8) Other

2.24 How long does this water last?

1) Daily

2) 2 to 3 days

3) 4 to 6 days

4) Week

5) Fort-night

6) Month

7) Other (Specify)_________________

2.25 Who collects water often or mostly?

1) Head of the household

2) Pensioner

3) Parents / Adults

4) Children (Boy or Girl)

5) Both Parents & Children

6) Other (Specify)_______________

FREQUENCY OF WATER SUPPLY:

2.26 What is your main source of water supply?

1) Municipal

2) Borehole

3) Tankering

4) River

5) Other (Specify)

2.27If borehole which type?

1) Municipal borehole

2) Own borehole

3) Neighbor's borehole

4) Relative's borehole

5) Community borehole

6) Other (Specify)____________________

2.28 How often do you have access to municipal water?

1) Never (0)

2) Occasionally (1-3 days per week)

3) Often (4-6 days per week)

4) Always (daily)

5) Habitually (1 – 4 times a month)

QUALITY:

2.29 What is the quality of your water?

1) Very poor

2) Poor

3) Fair

4) Good

5) Very good

2.30 What are the main problems with water quality?

No	Questions	Yes=1; No=0
1	Salinity	
2	Mud	
3	Colour	
4	Pollution	
5	Other (specify	

2.31 Were water quality tests conducted before?

0)No

1)Yes

2) Don't know

2.32 If yes, when were they tested?

1) Before installing the water source

2) After installing

3) During the installation

4) Not sure

2.33 Do you know about the water awareness program within your area or in the municipality?

0) No

1) Yes

2.34 Do you participate in water awareness programs?

0) No

1) Yes

2.35 Does the existing municipal water policy address the water problem in your area?

0) No

1) Yes

2.36 Do you think a new water model is needed to address the water shortages?

0) No

1) Yes

2.37 Do you think climate change is contributing to your water problems?

0) No

1)Yes

2.38 Do you have a commercial business that uses water?

0) No

1) Yes

2.39 Do you have water management skills

0) No

1) Yes

2.40 Do you sell water as a source of income?

0) No

1) Yes

2.41 Are there any water committees in your area?

0) No

1) Yes

2.42 Does the household have transport to fetch water?

0) No

1) Yes

MULTIPLE USES:

2.43 Are you using water for uses other than domestic ones (such as drinking, cooking, washing, bathing, etc.)?

0) No

1) Yes

2.44 If yes, what are these uses? (can be more than one use)

No	**Questions**	**Yes=1; No= 0**
1	Garden Watering	
2	Car Wash	
3	Business (Specify)	
4	Livestock watering	
5	Growing food	
6	Recreation	
7	Sanitation and waste disposal	
8	Other (specify)	

2.45 For these uses do you use the same sources of water as for domestic uses?

0) No

1) Yes

2.46 If no which sources of water do you use?_______________________________________

ADDITIONAL QUESTIONS (CURRENCY):

2.47 Are you connected to electricity?

0) No

1) Yes

2.48 If yes, how much do you pay per month? ____________________________

2.49 Are you currently paying a monthly bill for water?

0) No

1) Yes

2.50 If yes, how much do you pay per month?

1) Less than R10

2) R11-R250

3) R251-500

4) More than R501

2.51 If no, why not?

1) Free basic service

2) Indigent

3) Own supply

4) Poor service

5) Other (Specify)

2.52 Did you pay to be connected to the public (or community) water network, how much did you pay for the connection?

0) No

1) Yes

2) Not connected

2.53 If yes, how much did you pay for the connection?__________

2.54 When were you connected?

1. 10 Yrs ago

2. 20 Yrs ago

3. 30 Yrs ago

4. More than 40 Yrs ago

5. Never connected

6. Not sure

2.55 If you are currently not connected to the public water network, or if the system you are connected with must be refurbished, how much would you be willing to pay a fee (once-off payment) to be connected to the new/refurbished network?

1) R0

2) Less than R100

3) R101-R300

4) R301-R500

5) More than R500

SECTION 3: WATER SOURCE: CANAL OR RIVER

2.56a If you collect water from a canal or a river

1) How many times per day do you collect water? ________________________

2) Which type of containers do you use? ________________________________

3) How many containers of this type do you fill at each time? ________________________

4) How long (how many days) does this water last? [Quantity = times of collection per day * number of containers at each time * size of containers / how many days] ________

and/or

WATER SOURCE: STANDPIPE OR OTHER PEOPLE

2.56b If you collect water from a standpipe or other people

1) How many days per week do you go collect water? __________________________

2) How many times per day of collection? ___________________________________

3) Which type of water carriers do you use? _____________________________________

4) How many containers of this type do you fill daily? ____________________

5) How long (how many days) does this water last? ____________________________

SOURCE: PRIVATE BOREHOLE

2.57 Do you have a borehole?

0) No

1) Yes

2.58 If yes, how much did it cost to establish the borehole? _________________

SECTION 4: GOVERNANCE, COMPLIANCE, MONITORING, AND EVALUATION

2.59 Does the municipality or government collect and monitor data on…?

No	Characteristics	1=Yes; 0=No; not sure =3
1	Regulatory compliance water use & discharge purpose	
2	Environmental, social & economic impact on water sources	
3	Factors affecting direct water sources	
4	Stakeholder's perceptions and concerns related to water issues	

2.60 Does the Municipality or government…

No	Characteristics	1=Yes; 0=No; 3=not sure
1	Identify & quantify water-related risks in direct operations	
2	Have a publicly available water policy	
3	Set performance standards on water withdrawals/consumption for direct operations	
4	Engage communities on water issues	
5	Address sustainable water management	
6	Develop plans to address local water shortages.	
7	Engage with stakeholders to assist in improving water management.	
8	Make water-related information publicly available	

THANK YOU FOR YOUR PARTICIPATION AND FOR YOUR TIME

THE FOCUS GROUP DISCUSSIONS GUIDE

FGD FACILITATOR:______________________________

FGD SITE/LOCATION:______________________________

START TIME:__________________

END TIME:____________________

SIGNATURE:___________________

1 What is the current status of water security in the study area?

2 What is the current water quality consumed in the community?

3 How is the Government aware of water problems in the study area?

4 How is water shortage affecting the life of residents?

5 What are the challenges facing the residents in accessing water?

6 Which major domestic needs of households are highly affected by water shortages?

7 What can the government do to help (ensure water availability)?

8 How can the communities influence the government to address water shortages rapidly?

9 Why is it necessary for the government to engage other stakeholders such as industries/companies/ water users in addressing water security?

10 How do the communities perceive the occurrence of water shortages?

11 What is the coping mechanism adopted by the residents in the study area?

12 How can the provision of water security be improved efficiently?

13 What is the municipality doing to enhance sustainable water security in the community?

14 Has there been any water-related assistance rendered to the study area in the past?

15 Which major factors affect or influence water shortages in the community?

THANK YOU FOR YOUR PARTICIPATION AND TIME

KEY INFORMANTS INTERVIEW GUIDE

BACKGROUND INFORMATION

Code of the interview___________________

Sex:__________

Age:__________

Educational level:________________________

Name of office:________________________

City:________________________

Position:____________________

Work experience:_____________________

1 What is the current status of water security in the district?

2 What is the current water quality provided by the institution within the district?

3 Is the institution aware of the water problems within the district? If yes, what are the problems and what are you doing about them?

4 What are the specific challenges that the government encounters in providing access to water in the study area?

5 What interventions are required to address the existing water problems?

6 How efficient is the government's process of addressing the current water shortages?

7 What are the future mechanisms assigned for the communities to have proper access to water and sanitation?

8 Is Sustainable Development Goal 6 which is to have equal access to water reachable in the study area?

9 Do you have specific water policies on access to clean drinkable water? If yes, are they achieving their objectives?

10 What is the institution doing to enhance sustainable water security in the community?

11 How can the affected communities influence the institution to address water shortages rapidly?

12 Which major factors affect or influence water shortages within the district?

THANK YOU FOR YOUR PARTICIPATION AND TIME

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number:

Research permission reference number:

ASSESSMENT OF SUSTAINABLE WATER SECURITY IN THE BOJANALA REGION IN THE NORTHWEST PROVINCE IN SOUTH AFRICA

College of Humanities

School of Social Science

Department of Development Studies

2019/09/20

Title: ASSESSMENT OF SUSTAINABLE WATER SECURITY IN BOJANALA REGION IN THE NORTHWEST PROVINCE IN SOUTH AFRICA

Dear Participant.

You are invited to participate in a survey conducted by Neo Mokone under the supervision of Prof Vusi Gumede a Professor at Thabo Mbeki African Leadership Institute, Unisa, and Editor-in-Chief: *Africa Insight* & *Africanus: Journal of Development Studies* towards a Doctorate Degree at the University of South Africa.

WHAT IS THE PURPOSE OF THE STUDY?

The study is designed to assess sustainable water security among households to develop a model of sustainable water security

WHY AM I BEING INVITED TO PARTICIPATE?

It is anticipated that the information we receive from this research will help us to assess sustainable socio-economic water security among households and to develop a model of sustainable water security

You have been selected to participate in this research as a householder member or key informant and this will assist in assessing sustainable socio-economic water security among households. Kindly note you will not be eligible to participate if you are younger than 18 years.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

You will not benefit from your participation as an individual, however, it is envisioned that the findings of this study will benefit the research in terms of improving a responsive curriculum. We do not foresee that you will experience any negative consequences by completing the questionnaire. The researcher(s) undertake to keep any information provided herein confidential, not to let it out of our possession, and to report on the findings from the perspective of the participating group and not from the perspective of an individual.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

The only inconvenience would be the time taken for completing the questionnaire and responding to the interview questions

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Your name will not be recorded anywhere, and no one will be able to connect them to the results. Their results will be given a code number and they will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.

Your responses may be reviewed by people responsible for making sure that research is done properly, including members of the Research Ethics Review Committee.

The anonymous data may be used for other purposes, such as a research report, journal articles, and/or conference proceedings, however, individual participants will not be identifiable in such publications.

HOW WILL THE RESEARCHER PROTECT THE SECURITY OF DATA?

Hard copies of the responses will be stored by the researcher for a minimum period of five years in a locked cupboard in the office of the researcher and will be used for future research or academic purposes. Thereafter, the copies will be shredded. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

No payment or incentive is offered for participation.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study will receive written approval from the Research Ethics Review Committee of the College of Business Management at Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact Mr. Neo Mokone at 076 197 6618 or neomokone@webmail.co.za. The findings are accessible for one year after the completion of the study.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact Mr. Neo Mokone as above.

Should you have concerns about how the research has been conducted, you may contact my Supervisor Prof. Vusi Gumede E-mail: gumedvt@unisa.ac.za

Thank you for taking the time to read this information sheet and for participating in this study.

____

Principal Researcher Neo Mokone

CONSENT TO PARTICIPATE IN THIS STUDY

I, __________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits, and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunities to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications, and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the <insert specific data collection method>.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname………………………………………… (please print)

Participant Signature…………………………………………..Date…………………

Researcher's Name & Surname………………………………………(please print)

Researcher's signature…………………………………………..Date…………………

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FACULTY OF ARTS LANGUAGE CONSULTANCY UNIT (FALCONS): UNIVERSITY OF ZIMBABWE

Date 27 January 2022

Neo William Mokone

University of South Africa

Dear Sir

REF: CONFIRMATION OF EDITING: NEO WILLIAM MOKONE' THESIS TITLED "ASSESSMENT OF SUSTAINABLE WATER SECURITY IN THE BOJANALA REGION IN THE NORTHWEST PROVINCE IN SOUTH AFRICA"

This letter serves to confirm that I have professionally performed language and content editing of the above-mentioned thesis. I am a member of the University of Zimbabwe Faculty of Arts Language Consultancy Unit (FALCONS) of the University of Zimbabwe. Members of this unit are qualified to do professional editing for anyone who requires this service for a fee.

Regards.

Munyaradzi Nyakudya (PhD)
Senior Lecturer and member of
FALCONS, University of Zimbabwe
Email: nyakazm@gmail.com, munya@arts.uz.ac.zw Cell Number: +263772545775

UNISA university of south africa

COLLEGE OF HUMAN SCIENCES RESEARCH ETHICS REVIEW COMMITTEE

23 April 2021

Dear Neo William Mokone

Decision: **Ethics Approval from 23 April 2021 to 23 April 2026**

NHREC Registration # : Rec-240816-052 CREC Reference # : 37346423_CREC_CHS_2021

Researcher(s):	**Name: Neo William Mokone**
	Contact details: 37346423@mylife.unisa.ac.za
Supervisor(s):	**Name: Prof V. Gumede**
	Contact details: vusi@vusigumede.com

Title ***Assessment of sustainable water security in Bojanala region in the Northwest Province in South Africa.***

Degree Purpose: PhD

Thank you for the application for research ethics clearance by the Unisa College of Human Science Ethics Committee. Ethics approval is granted for five year.

The ***Low risk application*** *was reviewed by* College of Human Sciences Research Ethics Committee, in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.

The proposed research may now commence with the provisions that:

1. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
2. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the College Ethics Review Committee.
3. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
4. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
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confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.

5. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
6. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
7. No fieldwork activities may continue after the expiry date **(23 April 2026).** Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

*The reference number **37346423_CREC_CHS_2021** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Signature :

Prof. Ilse Ferns
CHS Ethics Chairperson
Email: fernsi@unisa.ac.za
Tel: (012) 429 8210

Signature : PP

Prof K. Masemola
Exécutive Dean : CHS
E-mail: masemk@unisa.ac.za
Tel: (012) 429 2298

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Office of the Municipal Manager

27 May 2020

Bojanala Platinum District Municipality

The Register

UNISA

RE: PERMISSION FOR MR. NEO MOKONE TO CONDUCT Ph.D. RESEARCH WITHIN BOJANALA PLATINUM DISTRICT MUNICIPALITY

This letter is to serve as a confirmation that Mr. Neo Mokone – student no 37346423 and ID no 8507015625086, a registered Ph.D. student with the University of South Africa has been granted the permission by the Bojanala Platinum District Municipality (BPDM), to conduct the research within Bojanala District. He will receive the necessary support from the District Municipality, Local Municipalities, and other relevant stakeholders.

I hope you find the above in order.

Yours faithfully,

Ms. D Tlhoaele

Acting Municipal Manager

Date: 27 May 2020

Cnr. Beyers Naudé and Fatima Bhayat Drives • PO Box 1993, Rustenburg, 0300, North West Province, South Africa
Tel: +27 14 590 4502 • Fax: +27 14 592 0306 • Website: www.bojanala.gov.za • E-mail: pogisose@bojanala.gov.za

Agriculture &
Rural Development
Department:
Agriculture and Rural Development
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

AgriCentre Building
Cnr. Dr. James Moroka
& Stadium Rd
Private Bag X2039,
Mmabatho 2735

OFFICE OF THE HEAD OF DEPARTMENT

Tel: +27 (18) 389 5953
Fax: +27(18) 392 4377
E-mail:tmokhatla@nwpg.gov.za

Ref: 2/9/1

Mr N. Mokone
College of Human Science Research Ethics Review Committee
University of South Africa
Mackleneuk Ridge,
City of Tshwane
0003

Dear Sir

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH STUDY

The North West Provincial Department of Agriculture and Rural Development wishes to inform you that your request to conduct research towards fulfilment of your research study has been granted with the following conditions:

1. The information gathered must be used solely for purpose of the research topic **"Assessment of sustainable socio-Economic water security in Bojanala Region in the North West Province un South Africa"** only in order to protect unauthorised sharing of Departmental information in line with POPIA Act no 4 of 2013.

2. You must make the necessary appointment with the respective managers that are required to support you during your research to ensure that DARD officials are not disrupted in performing their duties.

3. Your conduct during the duration of your research at DARD must be of a professional nature at all times.

4. The Department must be provided with a copy of your final research report.

I wish to inform you that the Department of Agriculture and Rural Development will not bear any financial and legal liabilities that may arise from your research study. I further wish to bring to your attention that research ethics must be considered and adhered to in this regard.
Given the nature of your research subject, you must contact the **Chief Director- Agricultural Development Services, Ms Bothoboile Pule at** Bothoboile@nwpg.gov.za **/ 018 389 5698** to facilitate your assistance that you require during your research.

Hope you find this in order.

MR T.Z. MOKHATLA
HEAD OF DEPARTMENT
DATE: 09/11/2021.

WE BELONG WE CARE WE SERVE

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

_Enquiries: M Ramafoko
Telephone: 018 387 9504
Reference: 6/2/3

Mr Neo Mokone
Neomokone5@gmail.com

Dear Mr Mokone

REQUEST FOR PERMISSION TO INTERVIEW TWO OFFICIALS

Your email dated 25 November 2021 with the above subject refers.

Permission is hereby granted to interview two officials from the below recommended names

NAME	RANK	CONTACT
Mr Justice Maluleke	Director Water Regulation	082 804 9817
Mr Vincent Qwabe	Director Information and Planning	072 641 9986
Mr John Ratombo	Deputy Director Infrastructure	0731709673

The department would appreciate if you can share the copy of the draft (before publication) as well as the final report

Yours sincerely

Mr CHADWICK LOBAKENG
PROVINCIAL HEAD: NORTH WEST
DATE: 20/12/2021

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